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Technical guideline on coastal ecological rehabilitation for hazard mitigation — Part 10: Directives for sea dike ecological construction of sea reclamation and enclosure project

海岸带生态减灾修复技术导则 第10部分：围填海工程海堤生态化建设标准

（English Translation）

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Contents

Foreword

This standard is issued for the first time.

This part is drafted in accordance with the rules given in the GB/T 1.1-2009.

This part was proposed by the *Sea and Island Management Department of the Ministry of Natural Resources*.

This was prepared by *Standardization Technical Committee of China Association of Oceanic Engineering*.

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Technical guideline on coastal ecological rehabilitation for hazard mitigation — Part 10: Directives for sea-dike ecological construction of land reclamation and enclosure project

1 Scope

This standard specifies the principles, scope, content, methods, technical requirements and technical indices for sea-dike ecological construction of land reclamation and enclosure projects.

This standard is applicable to new sea-dikes with ecological construction for land reclamation and enclosure projects, and the existing ecological construction, which can be implemented with reference to the guideline.

2 Normative references

The following documents are indispensable for the application of this document. For dated reference documents, only the dated version applies to this document. For undated references, the latest version (including all amendments) applies to this document.

GB 50286-2013 *"Design Guidelines in Embankment Project"*

GB/T 15918-2010 *"Integrated Terminology of Oceanography"*

GB/T 18190-2017 *"Marine Geology in Oceanographic Terms"*

GB/T 51015-2014 *"Design Guidelines in Sea-dike"*

JTS 154-2018 *"Design Guidelines in Breakwater and Revetment"*

3 Terms and definitions

The following terms and definitions are applicable to this standard.

3.1

land reclamation and enclosure project

the construction of dikes to enclose the sea area after which water is then pumped out and the area is subsequently back-filled

3.2

sea-dike

a dike project is built to protect the area from storm surge (flood) water and waves

[GB/T 51015-2014, definition 2.0.1]

3.3

sea-dike ecological construction

ecological protection and restoration activities in front of, on and behind dikes, with objectives to ensure the ability of sea-dikes to prevent tides and disasters, and to optimize the spatial layout of sea-dikes, using ecological materials to restore biological communities

3.4

dike toe line

the boundary line between the front sea slope and the back sea slope of sea-dike and beach or existing ground

NOTE The dike toe line is divided into the foot line of the front sea slope and of the back sea slope. The dike toe line of the front sea slope is the boundary line between the front sea slope of sea-dike and beach surface. The foot line of the back sea slope is the boundary line between the sea slope and the land

3.5

front zone of sea-dike

the area where the dike toe line of the front sea slope faces the sea with a certain width

3.6

body zone of sea dike

the area between the foot line of the front sea slope and the foot line of the back sea slope

3.7

back zone of sea-dike

an area with a certain width from the shore of the sea-dike to the land

3.8

porosity

the percentage of the total voids in the protective facing layer of the facing sea slope to the total volume of the protective facing layer

3.9

comprehensive slope ratio

the ratio of the elevation difference between the outer edge line of the sea-dike top (the top of the sea-dike including the wave wall is the top of the wave wall) and the dike toe line of the front sea slope to the horizontal distance between the two

3.10

vegetation plant cover rate

the ratio of the vertical projection area of plants in a certain area to the whole area, expressed by percentage

3.11

intertidal width proportion

the ratio of the width of the intertidal zone in the front zone of the sea-dike to the width of the entire facing zone

4 General rules

4.1 Construction scope

The scope of sea-dike ecological construction of land reclamation and enclosure project includes three areas: the front of the dike, the levee body, and the back of the dike (see Figure 1).

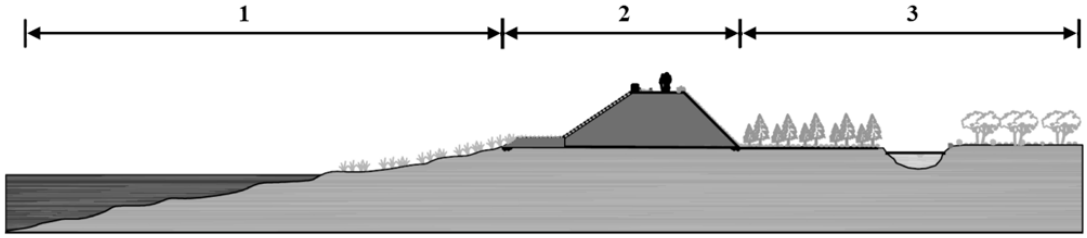
Front zone of the sea-dike—— a level 1 sea-dike is a dike with a width of no less than 300m from the dike toe line of the front sea slope; level 2 and 3 sea-dike are dikes with a width of no less than 200m; level 4 and 5 sea-dike are dikes with a width of no less than 100m.

Levee body——the area between the dike toe line of the front sea slope and of the back sea slope.

Back zone of sea-dike——the area with a certain width from the sea slope and the dike toe line of the embankment to the land side. If there are water systems and green land in the area, all of them shall be included in the back zone of sea-dike.

If there are special requirements for the construction of the rear land area, the construction scope may not include the back zone of sea-dike.

The special sea-dike for protection of nuclear power stations, chemicals, ports, oil fields and other special engineering projects shall refer to this standard and combine the relevant regulations of various industries to determine the scope of ecological construction.



Description:

1- Front zone of the sea-dike; 2- levee body; 3- Back zone of sea-dike

Figure 1 Schematic diagram of the ecological construction scope of sea-dike

4.2 Construction principles

a) Security principles. The ecological construction of sea-dike is based on the premise of ensuring the safety requirements of disaster prevention and mitigation of sea-dike, and the ecological construction shall be considered on the basis of meeting the safety requirements.

b) Ecological principles. The ecological construction of sea-dike should aim at restoring the ecological functions of the coast, and reducing the negative impact of humans on the sea ecosystem during the construction of sea-dike.

c) The principle of suitability. Adhering to the concept of ecological protection and adapting measures to local conditions, different structures and materials are used to scientifically design sea-dike based on regional geological and geomorphic characteristics, hydrodynamic conditions, and climate characteristics.

4.3 Construction content

Under the premise of ensuring the function of sea-dike disaster prevention and mitigation, the combination of coastal protection engineering facilities, ecological protection and restoration measures can realize the ecologicalization of sea-dikes and restore certain ecological functions of the sea area. The ecological construction of sea-dikes should generally cover three parts: the front zone of the dike, the levee body, and the back of the dike. Each part should have the following structural features and functions:

a) The front zone of the dike has a certain beach width, a stable bank composition, and a suitable biological community.

b) The levee body has embankment structures meeting safety standards, and has certain material exchange and energy flow capabilities.

c) The back zone of sea-dike has a certain land-directional radiation width and a stable ecosystem.

The contents of the ecological construction of sea-dike in different regions and types of coasts are listed in Table 1.

Table 1-Ecological construction content of sea-dike

Construction Content			Coast type					
			Estuary, bay area			Open sea area		
			Silty mud	Sand (gravel)	Bedrock	Silty mud	Sand (gravel)	Bedrock
Front zone	Landform restoration		★	★	☆	★	★	☆
	Habitat restoration		★	★	☆	★	☆	☆
Levee body	Front sea slope	Ecological structure	★	★	★	★	★	★
		Material ecological	★	★	★	☆	☆	☆
		Vegetation cover	☆	☆	☆	☆	☆	☆
	Back sea slope	Vegetation cover	★	★	★	★	★	★
back zone	Ecological space creation		☆	☆	☆	☆	☆	☆

NOTE ★Key construction content; ☆Optional construction content.

NOTE If the construction of sea-dike occupies mangroves, coral reefs, seagrass beds, etc., “habitat

restoration” should be selected as key construction content.

5 Technical requirements

5.1 Front zone of the dike

5.1.1 Silty mud coast

a) Landform restoration in front of the embankment. The landform in front of the embankment should mainly be composed of protection and natural restoration, and artificial restoration measures should be taken when necessary; the coastal sea area before the project should be restored as much as possible; ecological methods should be adopted according to the natural environmental conditions of the coast to promote sedimentation. For shore sections with unstable beach profiles, engineering measures such as submerged dikes, jetties, and spur dikes can be used for geomorphological restoration; when there are breeding ponds, abandoned dikes and other nearby structures and facilities that do not have safety and ecological functions on the outside of sea-dikes, measures such as leveling and dismantling can be taken to restore the original shape of the coast, expand the wetland area of the intertidal zone, improve the hydrodynamic conditions, and restore and enhance the ecological functions of the beach.

b) Habitat restoration. The addition of porous ecological materials in front of the embankment can be used to provide a good habitat and reproductive environment for organisms; for areas with damaged habitats, measures such as removing foreign species and improving substrates can be taken according to the characteristics of the natural conditions of the area to improve their ecological functions.

5.1.2 Sand (gravel) coast

a) Landform restoration in front of the embankment. Certain artificial measures can be adopted to resist the erosion of the coast and maintain the stability of the beach; when necessary, engineering measures such as artificial sand replenishment and beach maintenance can be adopted to protect and restore the natural form of sand (gravel) coasts, improve the quality of beaches, and restore the beach function.

b) Habitat restoration. Mainly to natural restoration, and the area with suitable conditions can be replanted with native sandy plants.

5.1.3 Bedrock coast

The ecological construction in the front of the bedrock coast dike focuses on natural restoration.

5.2 Levee body

5.2.1 General provisions

a) The sea-dike ecological construction should give full play to the role of natural restoration, and focus on improving the space for biological growth and habitat activities.

b) The plane shape of the sea-dike should be combined with the topography and geomorphology to avoid significant changes in hydrodynamic conditions. Simple linearization and regularization should be avoided as much as possible.

c) The plane form of the sea-dike can consider a variety of combined layouts. The main embankment is combined with the offshore embankment, jetty, submerged embankment, and tidal flat vegetation to form a comprehensive system of ecological protection and disaster prevention and reduction.

5.2.2 Ecological structure

a) In addition to satisfying the comprehensive functions of the sea-dike, the section type of the sea-dike should pay attention to the protection of the original ecology and maintain the coordination with the surrounding environment.

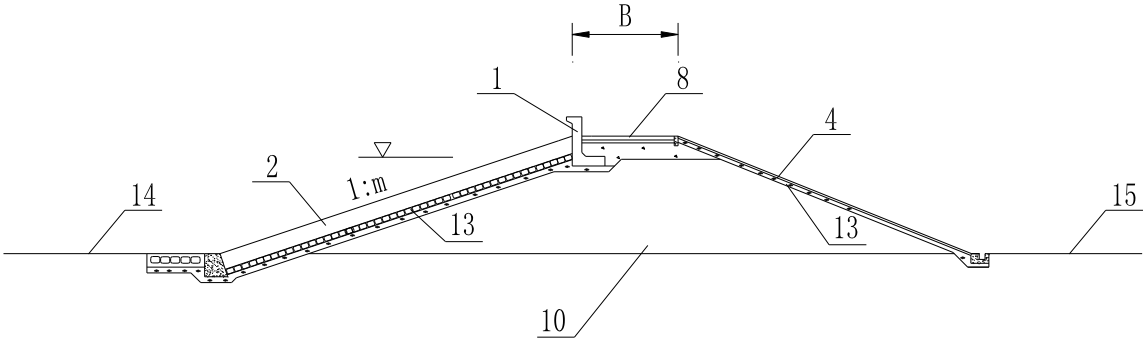
b) The structure of the sea-dike should be based on topography, geology, wave and tide characteristics, ecological requirements, and include the selection an appropriate type of embankment to ensure the stability of the bank slope and conserve both water and soil.

c) Pay attention to the comparison and selection of structural sections. The section type should be conducive to the gentle slope into the sea. It can be selected according to the following order: slope section, compound section, vertical section, various typical section types are shown in Figures 2, 3, and 4.

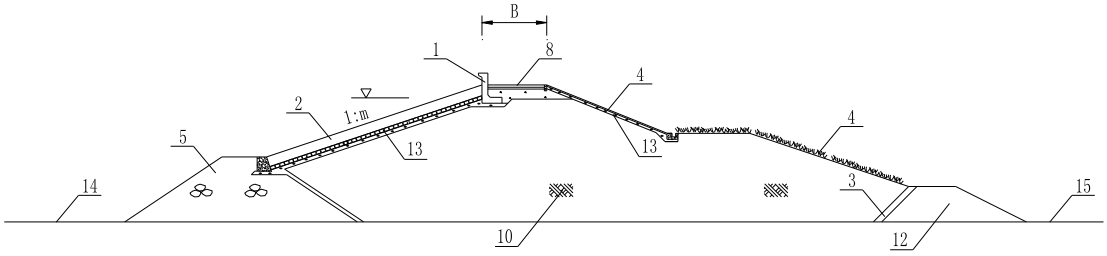
d) Priority is given to the safety of the protective facing, the suppression layer, and the dike toe line. The ecological and economic factors are merely integrated, and the structure with multiple voids and rough surface is adopted.

e) In sea areas with strong wave energy, various wave-eliminating measures should be adopted to reduce the elevation of the top of the embankment and enhance the ecological function of the levee body.

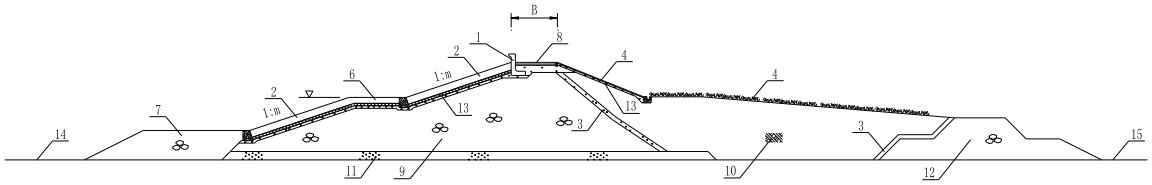
f) The design of the sea-dike section should take into account the hydrophilicity, the slope of the protective facing should be appropriately lower down, and the stepped protective facing can be added to the bank section where conditions permitted.



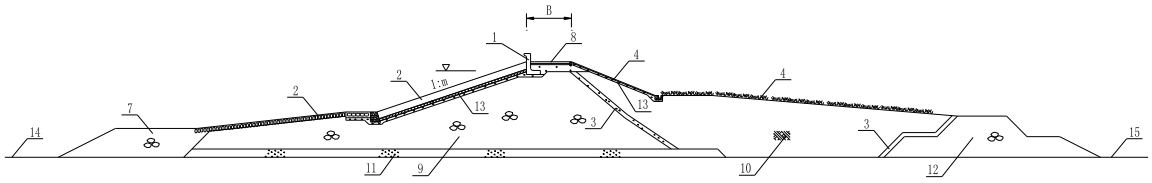
a) Slope dike



b) Slope dike with rock-filled prism



c) Slope dike with wave-damping platform



d) Sloping dike with suppression platform

Description:

1- parapet wall; 2- Seaside slope protection; 3- reverse filter; 4- Slope protection on the back sea side; 5- prism; 6-wave-damping platform; 7- toe protection; 8-top of embankment;

9- levee riprapping; 10- Embankment fill; 11-Drainage cushion layer; 12-Sub-dike; 13-Slope protection cushion; 14- foreshore; 15-Back beach

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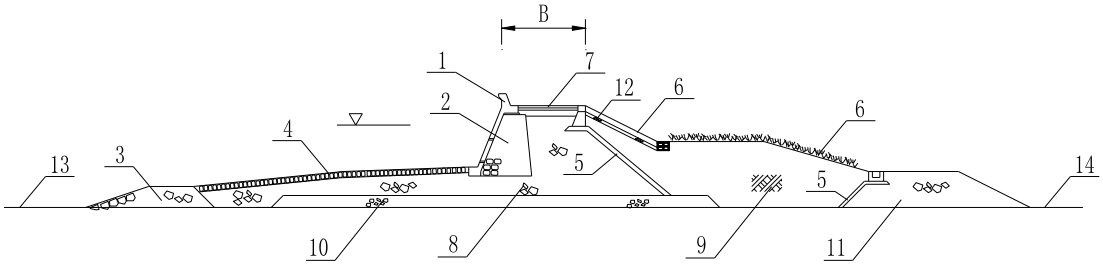
Figure 2 Cross-section view of typical slope sea-dike

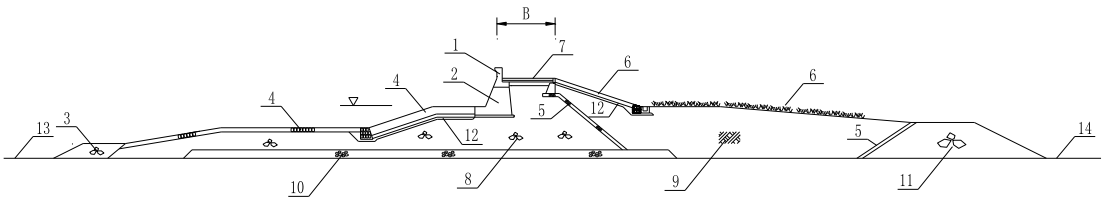


Description:

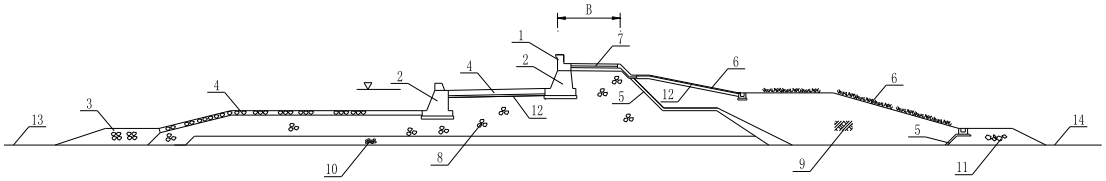
1- parapet wall; 2- wall body; 3- toe protection; 4- sea side slope protection; 5- reverse filter; 6 Slope protection on the back sea side; 7- levee top;

8- Levee riprapping; 9- Embankment fill; 10- Drainage cushion layer; 11- Sub-dike; 12- Slope protection cushion; 13- foreshore; 14 Back beach

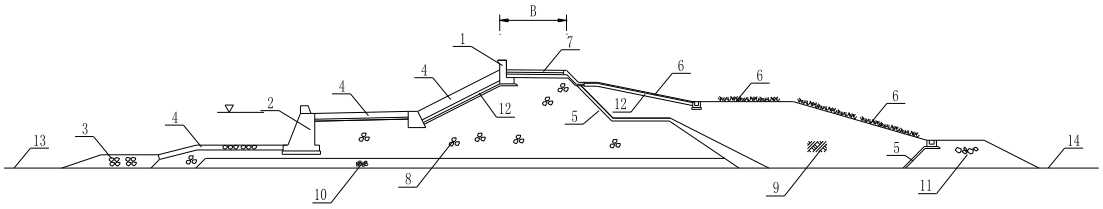
Figure 3 Cross-section view of typical vertical sea-dike



a) The compound cross section with sloping lower part and upright upper part



b) The compound cross section with vertical upper and lower parts



c) The compound cross section with upright lower part and sloping upper part

Description:

1- parapet wall; 2- wall body; 3- toe protection; 4- sea side slope protection; 5- reverse filter; 6 Slope protection on the back sea side; 7- levee top;

8- Levee riprapping; 9- Embankment fill; 10- Drainage cushion layer; 11- Sub-dike; 12- Slope protection cushion; 13- foreshore; 14 Back beach

Figure 4 Cross-sectional view of a typical compound sea-dike

5.2.3 Material ecologicalization

a) Environmentally friendly and harmless building materials suitable for the local sea ecosystem should benefit to plant growth and the attachment of algae and shellfish, and to promote the restoration of biodiversity.

b) Surface protection materials should be selected in the following order: biological, natural stone, artificial block; new porous and permeable materials are encouraged.

c) The embankment section where the toe of the slope has impact-resistance requirements should be shielded from materials such as boulders, frames, and artificial blocks.

5.2.4 Vegetation coverage

a) The selection of species should be based on the local nature.

b) Planting on the front sea slope. The front sea slope suitable for planting plants should be covered with vegetation.

c) Planting of plants on the back sea slope. The back-sea slope is covered by vegetation in a combination of shrub and grass on the premise of meeting the anti-scouring requirements of the overtopping water.

5.3 Back zone of sea-dike

The requirements for ecological construction behind the embankment should be determined based on the local conditions. The ecological space includes wetland, water system, green space, etc. within the range behind the embankment.

6 Technical index

Table 2 displays the controlling parameters of sea-dike ecological construction.

6.1 Technical index of front zone of sea-dike

6.1.1 Silty mud coast

The silty mud coastal landform profile is shown in Figure 5.

6.1.1.1 Proportion of width of intertidal zone

Try to restore the width of the intertidal zone by natural siltation or artificial measures.

a) If the toe line of the front sea slope of the sea-dike is above the middle-tide level, the width of the intertidal zone should account for 100%.

b) If the toe line of the front sea slope of the sea-dike is between the middle-tide level and the average low tide level, the width of the intertidal zone should account for more than 50%.

c) If the toe line of the front sea slope of the sea-dike is below the average low tide level and the front of the embankment does not have the conditions for ecological construction, there is no requirement for the width of the intertidal zone.

d) For the coastal area in front of the sea-dike with special purposes such as navigation channels and with unsuitable natural slope ratio of the frontier underwater terrain, there are no requirements for the width of the intertidal zone.

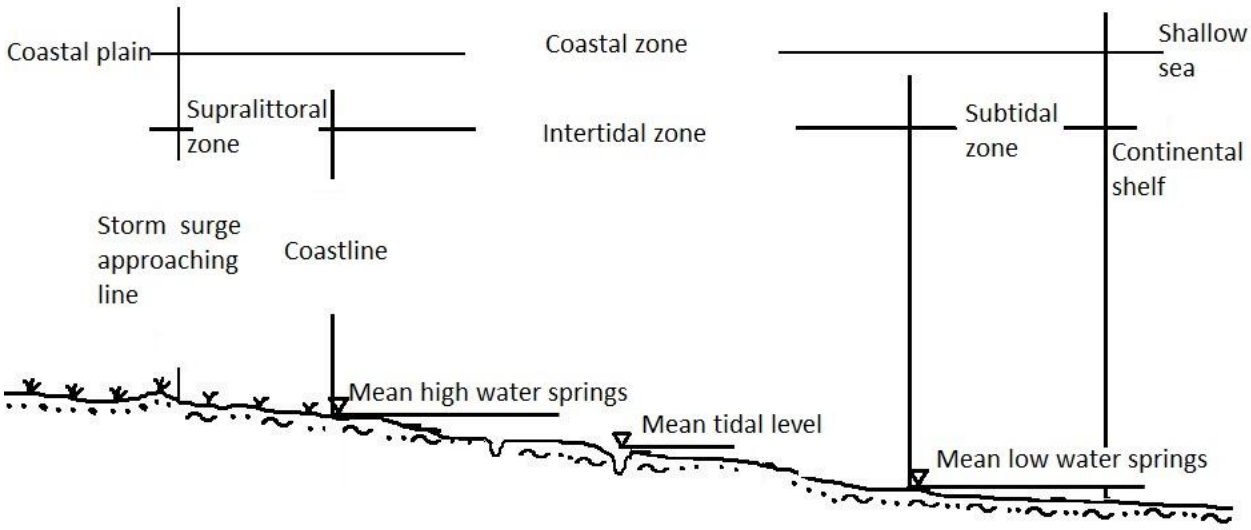


Figure 5 Schematic diagram of the silty mud coastal landform profile

6.1.1.2 Beach stability

The front zone of sea-dike should maintain stable beach surface to prevent erosion.

6.1.1.3 Vegetation coverage rate

Vegetation restoration should be carried out if the sea area occupied by the sea-dike is covered by native vegetation, and the vegetation coverage in the area above the tide level in the estuary and bay area is suggested to be more than 30%.

6.1.1.4 Habitat restoration

Measures should be taken to restore the habitat of animals and plants before the construction of the new sea-dike, and to maintain the stability of the biological community structure in front of the dike.

6.1.2 Sand (gravel) coast

The profile of sandy (gravel) coast is shown in Figure 6.

The original sand (gravel) coast should be kept intact and the width of the intertidal zone should not be reduced to prevent beach erosion.

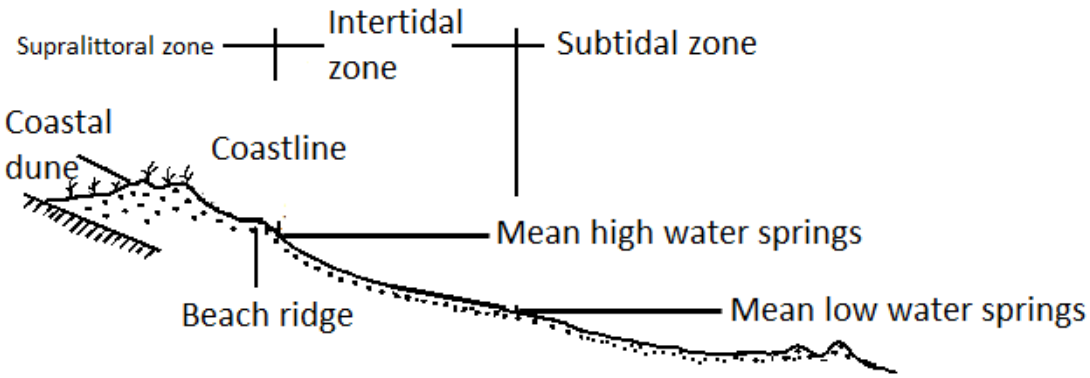


Figure 6 Sketch of sand (gravel) coast topography profile

6.2 Technical index of levee body

6.2.1 Front sea slope

6.2.1.1 Porosity

In order to ensure the habitat space of organisms, natural block stones or artificial block bodies should be used for protection, and mortar, grouted block stones and concrete panels should not be used. The porosity of the protective facing using artificial blocks should be above 40%, and the porosity of the protective facing using natural block stone or vegetation can be ignored.

6.2.1.2 Integrated ratio

The section type of the sea-dike should adopt a slope or a compound structure, and the integrated ratio should be 1:1.5 to 1:5.

When sand (gravel) coasts, bedrock coasts, mangroves and other biological coasts, seawalls of pile foundations or space constraints cannot meet the requirements, the integrated ratio may be appropriately relaxed after sufficient comprehensive argumentation.

6.2.1.3 Vegetation coverage rate

In the bay and the estuary, for the front sea slope where the protective facing is suitable for planting plants, suitable area can be covered with vegetation.

6.2.1.4 Proportion of ecological material protection

Ecological materials refer to various materials that are green and environmentally friendly and are profitable to the ecological function of sea-dike, such as plants, natural blocks, biological reefs, porous concrete parts, etc. and their combinations.

In estuaries and bays, where it is suitable to use ecological materials for surface protection (including the suppression layer and the toe protection surface layer), the ratio of the surface area of the ecological material protection surface to the total surface area of the facing sea should be more than 30%.

6.2.2 Back sea slope

The vegetation coverage rate of the back sea slope should be above 50%.

6.3 Technical indexes behind the embankment

Ecological construction should be carried out if the conditions for ecological space construction are met.

Table 2-Controlling parameters of sea-dike ecological construction

area		Technical index	Silty mud coast	Sandy (gravel) coast	Bedrock Coast
Front zone		Intertidal width Percentage	① If the foot line of the front sea slope of the sea-dike is above the mid-tide level, the width of the intertidal zone should account for 100% ②If the foot line of the front sea slope of the sea-dike is located between the mid-tide level and the average low tide level, the width of the intertidal zone should account for more than 50% ③If the foot line of the frontal slope of the sea-dike is below the average low tide level and the area in front of the embankment does not have the conditions for ecological construction, there is no requirement for the width of the intertidal zone ④ If the coastal area in front of the sea-dike is used for special purposes such as navigation channels, and the natural slope ratio of the frontal underwater terrain is not suitable, after strict demonstration, the width of the intertidal zone is not required	Intertidal zone Width does not decrease	——
		Beach stability	Prevent scouring in front of the embankment	Prevent Beach erosion	——
		Vegetation coverage*	The vegetation coverage rate in the area above the middle-tide level in the estuary and bay area in front of the embankment should be above 30%	——	——
Levee body	Front sea slope	Porosity	The porosity of the protective facing should be more than 40% (except for the dry natural block stone and vegetation protective facing)	Same as "Silty mud coast" requirements	Same as "Silty mud coast" requirements

area		Technical index	Silty mud coast	Sandy (gravel) coast	Bedrock Coast
		Integrated ratio	The type of the seaside dike should adopt a slope or a compound structure, and the integrated ratio should be 1:1.5 to 1:5	——	——
		Material ecological protection Percentage	If it is suitable to use ecological materials for ecological protection, the ratio of the surface area of the protection surface of the ecological materials to the total surface area of the facing sea should be more than 30%	Same as "Silty mud coast" requirements	Same as "Silty mud coast" requirements
	Back sea slope	Vegetation coverage	Vegetation coverage accounts for more than 50%	Same as "Silty mud coast" requirements	Same as "Silty mud coast" requirements
Back zone of sea-dike		Ecological space creation	Ecological construction should be carried out if the conditions for ecological space construction are met		
Note: This index is suitable if the sea area occupied by the sea-dike is covered by native vegetation.					

7 Sea-dike ecological construction

The sea-dike ecological construction should investigate and analyze local hydrology, geology, topography, biology and other natural conditions, to optimize the design of sea-dike engineering, and engineering and biological measures should be adopted to reduce the adverse effects of the construction of sea-dike on the ecosystem.

The sea-dike ecological construction department shall prepare a sea-dike ecological construction plan according to the requirements of this standard. The plan shall include the specific ecological design contents of the front zone of sea-dike, the levee body, and the back zone of the sea-dike, as well as compliance with the various indices of this standard. The ecological effects of the construction plan should be analyzed and evaluated. The construction plan should include the main text and corresponding drawings, atlases and related attachments; the text should be concise and fluent, and the report drawings, tables and attachments should be complete, clear and beautiful.

Annex A
(annex informative)
Calculation method of porosity of cover layer

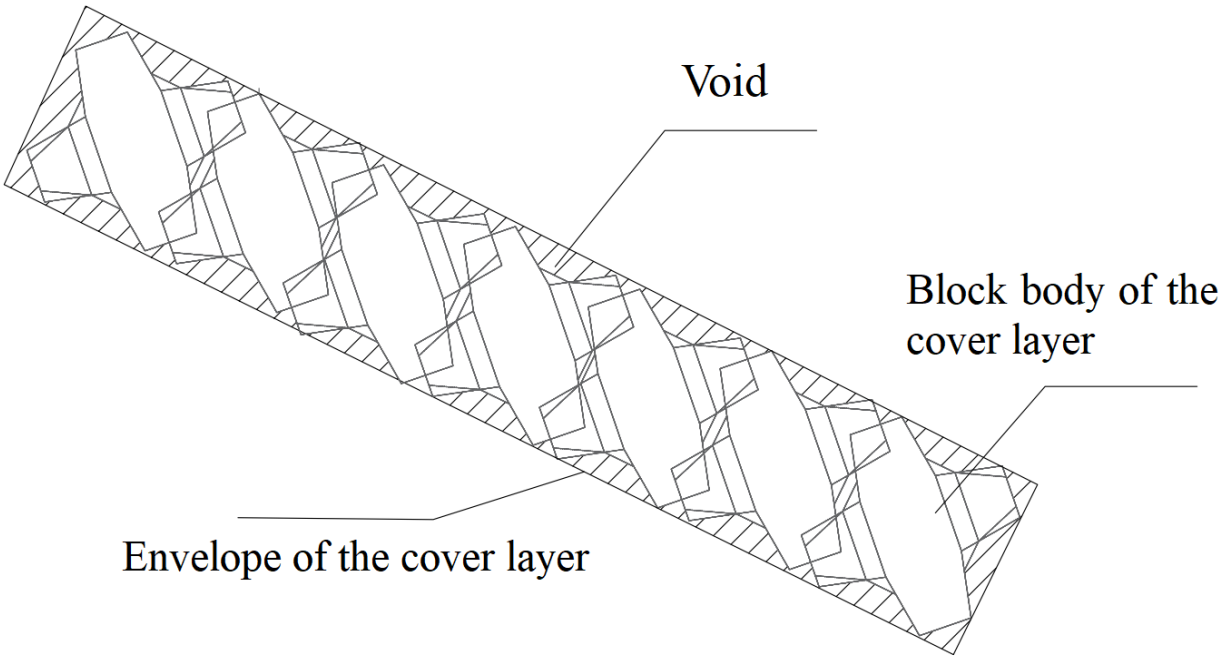


Figure A.1 Typical profile of the cover layer

The porosity calculation formula is as follows:

$$P = \frac{V_0 - V_1}{V_0} \times 100\%$$

P——Porosity of the cover layer;

V_0——the total volume of the envelope of the cover layer;

V_1——the volume occupied by the block body of the cover layer, the product of the volume of a single facing block body and the total number.