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T/CAOE 21.9-2020

Technical guideline on coastal ecological rehabilitation for hazard mitigation — Part 9: Renovation of island-connecting sea wall and coastal engineering

海岸带生态减灾修复技术导则 第9部分：连岛海堤和沿岸工程整治改造

（English Translation）

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Contents

Foreword

The T/CAOE 21 *Technical guideline on coastal ecological rehabilitation for hazard mitigation* consists of the following eleven parts:

——*Part 1: General;*

——*Part 2: Mangroves;*

——*Part 3: Salt marshes;*

——*Part 4: Coral reefs;*

——*Part 5: Seagrass bed;*

——*Part 6: Oyster reef;*

——*Part 7: Sandy coast;*

——*Part 8: Technical guide for the ecological construction of sea walls (trial);*

——*Part 9: Renovation of island-connecting sea wall and coastal engineering;*

——*Part 10: Directives for sea dike ecological construction of sea reclamation and enclosure project;*

——*Part 11: Supervising and monitoring.*

This is Part 9 of the T/CAOE 21.

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

This part was proposed by *the Marine Early Warning and Monitoring Division, Ministry of Natural Resources*.

This standard was prepared by *China Association of Oceanic Engineering.*

This part was drafted by *South China Sea Institute of Planning and Environmental Research, State Oceanic Administration; National Marine Data and Information Service; National Marine Hazard Mitigation Service.*

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Technical guideline on coastal ecological rehabilitation for hazard mitigation — Part 9: Renovation of island-connecting sea wall and coastal engineering

1 Scope

This part of T/CAOE 21 specifies the working procedures, data collection and investigation, suitability evaluation, technical requirements, follow-up monitoring and effect evaluation, quality control, results and archives for the renovation of the built island-connecting sea wall and coastal engineering projects.

This part is applicable to the renovation projects of existing island-connecting sea wall projects and unqualified coastal engineering or ecological rehabilitation projects due to not meeting ecological and/or hazard prevention requirements in the People's Republic of China.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced documents (including any amendments) applies.

GB/T 12763.2, *Specifications for oceanographic survey—Part 2: Marine hydrographic observation*

GB/T 12763.4, *Specifications for oceanographic survey—Part 4: Survey of chemical parameters in seawater*

GB/T 12763.6, *Specifications for oceanographic survey—Part 6: Marine biological survey*

GB/T 12763.7, *Specifications for oceanographic survey— Part 7: Exchange of oceanographic survey data*

GB/T 12763.8, *Specifications for oceanographic survey—Part 8: Marine geology and geophysics survey*

GB/T 12763.9, *Specifications for oceanographic survey—Part 9: Guidelines for marine ecological survey*

GB 17378.2, *The specification for marine monitoring— Part 2: Data processing and quality control of analysis*

GB 17378.4, *The specification for marine monitoring— Part 4: Seawater analysis*

GB 17378.5, *The specification for marine monitoring—Part 5: Sediment analysis*

GB 17378.6, *The specification for marine monitoring— Part 6: Organism analysis*

GB 17378.7, *The specification for marine monitoring—Part 7: Ecological survey for offshore pollution and biological monitoring*

HY/T 147.1, *Code of practice for marine monitoring technology— Part 1: Seawater*

HY/T 147.2, *Code of practice for marine monitoring technology— Part 2: Sediment*

HY/T 147.3, *Code of practice for marine monitoring technology— Part 3: Organism*

HY/T 147.5, *Code of practice for marine monitoring technology— Part 5: Marine ecology*

HY/T 0273, *Technical guidelines for risk assessment and zoning of marine disaster—Part 1: Storm surge*

T/CAOE 20.3, *Technical guideline for investigation and assessment of coastal ecosystem—Part 3: Mangroves*

T/CAOE 21(1-8), *Technical guideline on coastal ecological rehabilitation for hazard mitigation*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

island-connecting sea wall
the sea wall that connects an island to the mainland or other islands

3.2

coastal engineering
the built project located in the sea, coast or connected to the coast, whose main structure is located on either the seaward or landward side of the shoreline

3.3

renovation
engineering measures including sea wall openings, demolition, permeable reconstruction of existing island-connecting sea walls or demolition, permeable transformation of coastal engineering, in order to improve the marine dynamic conditions and enhance the functionality of the marine ecosystem

3.4

sea wall opening
engineering measures that dismantle part of a sea wall in order to connect waters on both sides of the sea wall

3.5

permeable reconstruction
engineering measures that alter the inland-connecting sea wall or coastal engineering into permeable bridges or sluices

3.6

marine ecosystem integrity
the integrity of components and properties of marine ecosystems, which promotes the whole marine ecosystem to maintain a balanced and stable evolutionary state under normal conditions

4 Work procedure

The working procedures for the renovation of the island-connecting sea wall and coastal engineering may include preparation, investigation, suitability assessment, renovation implementation, and effect evaluation.

a) preparation. The basic information of engineering project, the historical data of the sea area or island where it is located and the results of the previous work are collected. The development and utilization status, sensitive targets, and marine disaster risk characteristics of the sea areas surrounding the project are understood, and the investigation and evaluation content are determined accordingly.
b) investigation phase. The survey plan is prepared. The content, time, method and etc. of survey are clarified. Surveys of the basic situation of the engineering project, the marine ecological status, marine disaster risk and etc. are planned and carried out.

c) suitability assessment stage. The marine ecological environment elements and regional disaster defense capabilities of the engineering project are compared and analyzed before and after the renovation, based on the collected data and survey data. Then, impacts of the renovation on the marine ecosystem and its marine disaster defense capabilities are evaluated. The ecological hazard mitigation problems caused by the engineering project are scientifically analyzed, and the suitability assessment of the renovation is conducted accordingly.
d) renovation implementation stage. Based on the suitability assessment and feasibility study results of the renovation project, the appropriate renovation measures are determined and the renovation is implemented.
e) effect evaluation of the renovation. Evaluation indicators are established based on the collected data and monitoring data. These indicators are compared and analyzed before and after the implementation of the renovation. The marine ecosystem integrity is analyzed, and the effect of the renovation of the island-connecting sea wall and coastal engineering project is assessed accordingly.

5 Data collection and investigation

5.1 General requirements

The general requirements for data collection and survey are as follows:
a) the data for suitability assessment and effect evaluation of the renovation and the historical data shall be objective, reliable and effective.
b) test data for analyzing marine ecological status shall be provided by institutions with metrological certification or accredited laboratory with qualification.
c) the historical data shall be processed with data processing analysis and quality control procedures, according to methods and requirements of various data processing analysis, quality control, and survey data processing as specified in GB 17378.2 and GB/T 12763.7. Data may only be used after qualified processing.

5.2 Data collection

The collected data includes:
a) historical environmental data, including observation data of meteorology, storm surge, wave, sea-level change and etc., for the last 20 years.
b) project-related data, including its purpose and function, the main structural form and scale, elevation information, typical sectional profile, surface settlement and etc. The following information shall also be obtained, including the relationship between the project elevation datum and the national vertical datum 1985 / the local theoretical lowest tidal level; basic parameters and characteristics of protective engineering design, the design reproduction period, design basis, and design parameters of the main protective structures.
c) information about the sea area where the project is located, including ecological/environmental characteristics, ecological value, development status of surrounding sea areas, sensitive targets, regional disaster intensity before and after the construction of the project.
d) information of the connected island, including the its administrative ownership, development and utilization status, intertidal biology, vegetation status, etc.
e) monitoring data, data collected from the monitoring activity carried out along with the renovation project.

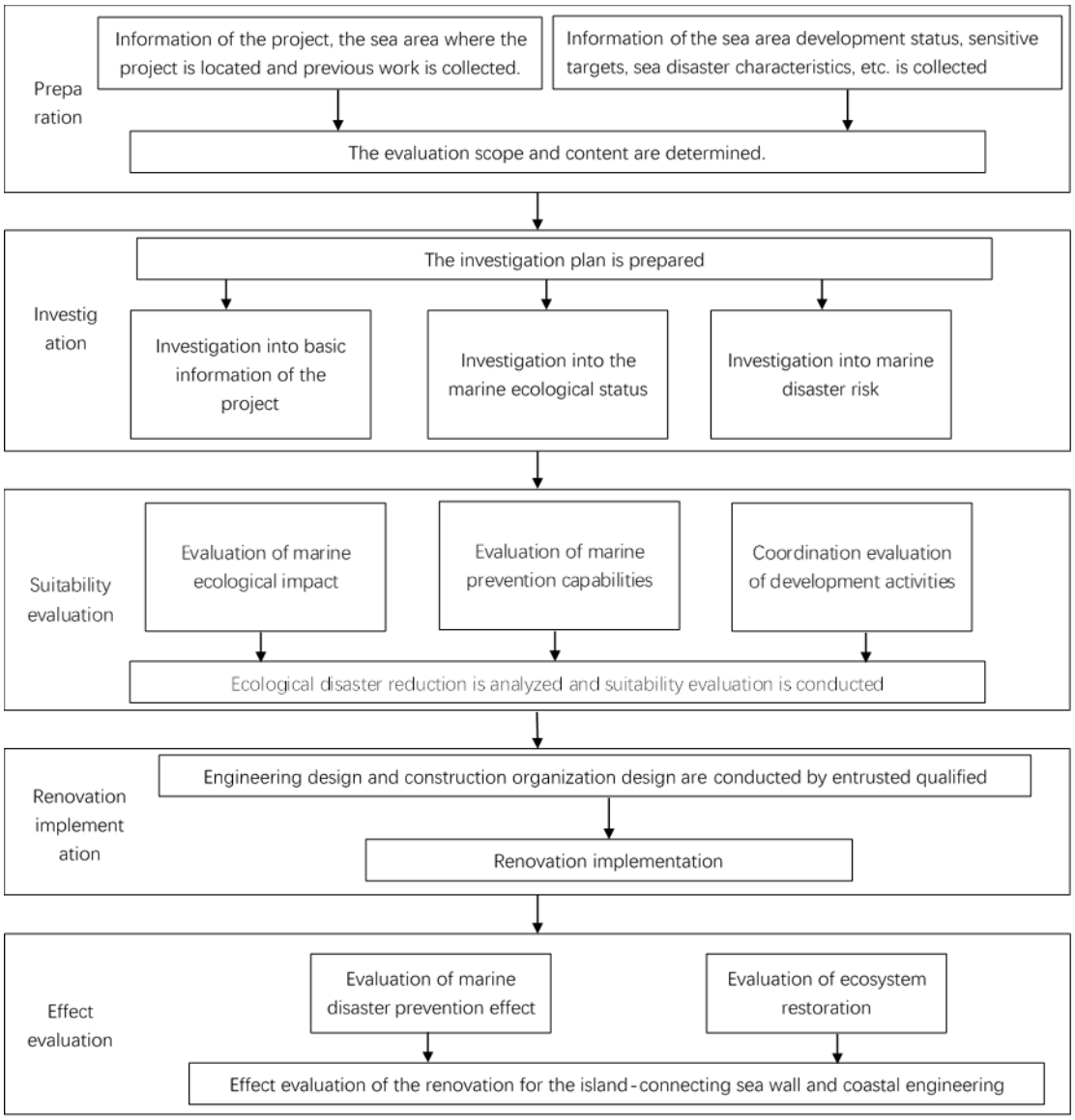

Figure 1 —Workflow of the renovation for the island-connecting sea wall and coastal engineering

5.3 Field survey

5.3.1 Project survey

The project survey mainly includes:

a) the geographical coordinates, structure and scale, elevation, slope, construction material and damaged condition of the island-connecting sea wall.
b) for coastal engineering project, construction content and operation situation shall be investigated, besides the geographical coordinates, structure, and scale, elevation, slope, construction material, damaged condition, etc.
c) the coordinate uses CGCS2000, and the elevation datum uses the national vertical datum 1985.

5.3.2 Island survey

For island-connecting sea wall and coastal engineering projects related with islands, the investigation of the coastlines, vegetation, and intertidal zones in the project area shall be conducted. And the specific requirements are listed as follows:

a) field investigation into the development and utilization status, and types of the coastlines is conducted. Locations of the characteristic points of the coastlines are measured using the CGCS2000 coordinate system.
b) investigation into the intertidal zone, including biological species, abundance, and their vertical/horizontal distribution is conducted. The survey method may conform to requirements as specified in GB17378.7.
c) investigation into vegetation in the island, including their types, components, spatial location, population quantity, community dominant species, coverage, etc. is conducted. The survey method includes visual identification, sample plot & quadrat method and may conform to requirements as specified in T/CAOE 20.3.

5.3.3 Marine ecological environment survey.

Detailed investigation into the hydrodynamic environment, topography and scouring environment, water quality environment, sedimental environment and marine ecology, etc., shall be conducted in the sea areas where the island-connecting sea wall and coastal engineering are located before and after the renovation. The field survey shall be carried out conforming to requirements as specified in *Technical guidelines on sea area use demonstration*, GB/T 12763.2, GB/T 12763.4, GB/T 12763.6, GB/T 12763.8, GB/T 12763.9, GB 17378.4~GB 17378.7 and HY/T 147.1~HY/T 147.3, HY/T 147.5.

5.3.4 Survey of marine development activities

Development activities in the sea area of the renovation project are investigated, including their content, scale, sea area usage, and project location.

6 Suitability evaluation of the renovation

6.1 Disaster prevention capability evaluation

6.1.1 Island-connecting sea wall

Using numerical simulation, the maximum possible submerged area, water depth distribution, and significant wave height distribution caused by the storm surge shall be analyzed before and after different renovation measures are applied to the island-connecting sea wall. With the vulnerability level of storm surge hazard-affected body taken into consideration, the storm surge hazard risk levels, the intensity levels and the range of offshore wave before and after different renovation measures are evaluated. The storm surge hazard risk levels may be evaluated with the city scale evaluation method as specified in HY/T 0273. The offshore wave intensity levels may be classified as specified in *Technical guidelines for wave hazard risk assessment*.

6.1.2 Coastal engineering

The recurrence interval of storm surge and wave disaster defended by the coastal engineering is determined. Whether the actual protection standard of coastal engineering meets the requirements of resisting the storm surge and wave disaster in the determined recurrence period is analyzed. Whether the coastal engineering benefits to marine disaster prevention in the area is evaluated accordingly.

6.2 Marine ecological evaluation

6.2.1 Island-connecting sea wall

The marine ecological assessment for island-connecting sea walls shall note the following,

a) using numerical simulation or physical experiments, changes of environment characteristics, including tidal current (velocity and direction), tidal level, and wave, before and after different renovation measures are compared and analyzed. Changes of tidal

flux and water exchange capacity/rate before and after different renovation measures are compared and analyzed. Whether these renovation measures benefit to increase the tidal flux or water exchange capacity or improve the marine environment is evaluated. Before the dismantlement of island-connecting sea walls constructed over 5 years or with length longer than 5km, physical modeling experiments shall be conducted to demonstrate the hydrological dynamic change before and after the dismantlement.

b) numerical simulation is carried out to analyze the change of topography (including change of the coastline), characteristics of sand transport nearshore, sediment transport trend, the variation of erosion and deposition, etc., due to the renovation measures. Whether these changes are beneficial to the beach stability of the island, the improvement of the regional scouring and silting rate, and the reduction of shoreline erosion and deposition in estuaries/bays, etc. is analyzed accordingly.

c) according to the purpose and function of the island-connecting sea wall, whether the renovation is consistent with development activities in the surrounding area is analyzed with its impacts taken into consideration.

6.2.2 Coastal engineering

The marine ecological assessment for coastal engineering shall note the following,

a) using numerical simulation, changes of environment characteristics, including tidal current (velocity and direction), tidal level, and wave, before and after different renovation measures are compared and analyzed. Whether these renovation measures are beneficial to increase water exchange capacity and improve the marine environment is evaluated.

b) changes of topography (including change of the coastline), characteristics of sand transport nearshore, sediment transport trend, variation of erosion and deposition, etc., due to the renovation measures are compared and analyzed. Whether these changes are beneficial to the beach stability of the island, improvement of the regional scouring and silting rate, and the reduction of shoreline erosion and deposition in estuaries/bays, etc. are analyzed.

c) according to the purpose and function of the coastal engineering, ecological impact assessment, including the water quality environment, sediment environment, environment-sensitive targets, etc., shall be carried out to determine whether the coastal engineering meets ecological and environmental requirements.

d) according to impacts of the renovation on development activities in the surrounding area, whether the renovation is consistent with these development activities is analyzed

6.3 Comprehensive suitability evaluation

According to the ecological function orientation, regional environmental characteristics, marine disaster prevention requirements, and the actual conditions of the project, comprehensive suitability evaluation is carried out in terms of improving the hydrodynamic condition / sedimental environment, restoring natural shorelines, creating an ecological coast, without reducing marine disaster prevention capability, and causing major conflicts of interest, etc. Specific measures and purposes of the renovation shall be proposed clearly. To determine renovation measures, the followings shall be considered:

a) under the premise of not reducing marine disaster prevention capabilities, the demolition scheme is preferred for the renovation of the island-connecting sea wall. The seawall opening scheme may be adopted for other situations.

b) for island-connecting sea walls that allow transportation to go through, sea wall opening scheme may be adopted, and interface to future renovation projects shall be considered.

c) for coastal engineering that doesn't meet the ecological and environmental protection requirements or is not beneficial to disaster prevention, demolition schemes shall be preferred.
d) for coastal engineering that doesn't meet the ecological and environmental protection requirements but need to retain existing functionality, the permeable reconstruction is preferred.

7 Technical requirements for the renovation

7.1 The scope of the renovation

According to the implementation requirements of the coastal zone protection and restoration projects, the renovation of the island-connecting sea wall and coastal engineering mainly includes the following,

a) for the historically constructed island-connecting sea walls, the sea wall opening and dismantling are considered in order to restore the marine ecosystem integrity. If sea wall opening is considered, transformation into the bridge, sluice, etc., is also included.
b) coastal engineering that doesn't meet the ecological and environmental requirements or is not beneficial to disaster prevention shall be reconstructed into permeable structures or even dismantled.

7.2 Demolition

Demolition is mainly applicable to the dismantling of the island-connecting sea wall and coastal engineering. Specific requirements are as follows,

a) the necessity for demolition shall be fully demonstrated. The disaster mitigation benefits, ecological benefits, economic benefits, and social benefits of the demolition are analyzed in detail.
b) Appropriate demolition method is chosen to minimize impact on the ecological environment of the surrounding sea area.
c) Construction waste from demolition shall be completely cleared to avoid adverse impacts on the ecological environment of the surrounding sea area.

7.3 Reconstruction

Specific requirements for opening or reconstruction of island-connecting sea walls into the bridge, sluice etc., and reconstruction of coastal engineering into permeable construction are as follows,

a) appropriate location and scale of opening or reconstruction are chosen. For island-connecting sea walls, the location where water from both sides connects most easily is preferred. For coastal engineering, the location where the depth of water is maximum in the sea passage and the flow is unimpeded before construction is preferred.
b) appropriate method of reconstruction is chosen to minimize impact on the ecological environment of the surrounding sea area.
c) interface to follow-up project and the utilization of residue part shall be considered in the reconstruction project.
d) materials produced by the reconstruction shall be fully utilized.
e) the construction site is cleaned in time to ensure smooth flow of water.

7.4 Renovation implementation

During implementation of renovation and construction of island-connecting sea walls and coastal engineering that involves complete demolition or reconstruction into bridges, sluices, etc., engineering feasibility studies shall be conducted in accordance with relevant design

standards, and specific implementation plans are then determined. If soil/rock excavation is required during the demolition, appropriate construction technique shall be selected based on the actual situation, and the following requirements are paid attention to:

a) types of construction machinery are determined according to the project structure scale, the nature of earthwork, and construction conditions.
b) types and quantity of construction machinery are selected according to the construction period and operation condition of the renovation.
c) the construction method is determined according to the engineering structure, nature of the earthwork, and working surface conditions. Generally, excavators are used for construction from sea towards land on the water part, and the underwater part is cleared by grab dredgers. Demolition or partial excavation by the blasting method is not encouraged. If it really needs to be used, small multiple directional blasting shall be preferred to minimize the impact range.

8 Follow-up monitoring and effect evaluation

8.1 Follow-up monitoring

Follow-up monitoring shall be conducted in the renovation of the island-connecting sea wall and coastal engineering. The monitor items shall be selected according to Table 1. Appropriate increase or decrease of monitoring indicators may be made according to actual conditions and monitoring objectives. Follow-up monitoring shall be conducted before, during and after the implementation of renovation. Monitoring is conducted at least one-time before and during the renovation. Monitoring shall be carried out continuously for 2 to 3 years after the renovation. Monitoring may be conducted at least one time each year after the conduction and shall be in the representative seasons.

Table 1— Monitoring indicators for the island-connecting sea wall and coastal engineering

Monitoring items	Monitoring indicators	Monitoring/analysis method
Engineering status*	Construction scope, demolition area, construction status	Remote sensing survey, field monitoring
Hydrology*	Velocity, flow direction, marine condition	Field monitoring
Topography and erosion or deposition	Underwater topography, shoreline position, sediment grain size, sediment concentration, etc.	
Water environment*	Dissolved oxygen, nutritive salt, chlorophyll a	
Sediment environment*	Organic carbon, sulfide	
Vegetation*	Types, distribution, coverage and density of mangrove, salt marsh, etc.	Remote sensing survey, field monitoring
Biological ecology*	Types and abundance of phytoplankton	Field monitoring
	Types and population density of zooplankter	
	Types and biomass of benthos	
	Types and biomass of intertidal organisms	
NOTE The indicators with * is compulsory, others subject to the project requirements and actual situation.		

8.2 Effect evaluation

8.2.1 Evaluation indicators

Effect evaluation is carried out considering hydrodynamic condition, topography, erosion and deposition condition, biological and ecological factors, and environmental factors. For specific indicators, see Table 2.

Table 2—Evaluation indicators

Evaluation content	Evaluation factors	Evaluation indicators	Note
Disaster prevention capability	Storm surge, wave	Recurrence interval	—
Hydrodynamic condition	Change features	Rate of velocity change	—
		Tidal prism (in bay)	Being advantageous if increases
		Water exchange period	Being advantageous if decreases
Topography, erosion and deposition condition	Essential characteristic	Change of sediment size	—
	Beach stability	Rate of shoreline change Rate of sediment erosion and deposition	—
Biological and ecological factors	Vegetation	Area	Being advantageous if increases
		Coverage	Being advantageous if increases
	Chlorophyll a	Density	Being advantageous if increases
	Phytoplankton	Abundance	Being advantageous if increases
		Biodiversity	Being advantageous if increases
		Uniformity index	Being advantageous if increases
	Zooplankter	Population density	Being advantageous if increases
		Biodiversity	Being advantageous if increases
		Uniformity index	Being advantageous if increases
	Intertidal organisms, benthos	Biomass	Being advantageous if increases
		Biodiversity	Being advantageous if increases
		Uniformity index	Being advantageous if increases
Environmental factors	Water environment	Dissolved oxygen	Being advantageous if increases
		Nutritive salt	Being advantageous if decreases

Evaluation content	Evaluation factors	Evaluation indicators	Note
	Sediment environment	Organic carbon	Being advantageous if decreases
		Sulfide	Being advantageous if decreases
NOTE Disaster prevention capability, hydrodynamic condition, topography, and erosion and deposition condition are only evaluated separately and not included in the comprehensive evaluation.			

8.2.2 Evaluation method

8.2.2.1 Comparative analysis

Evaluation indicators are selected according to the renovation features of the island-connecting sea wall and coastal engineering. Evaluation indicators before and after the renovation are compared and analyzed using comparative analysis and effects of renovation are evaluated accordingly. The change rate before and after the project is calculated as Equation (1),

$$V_i = \frac{A_i - A_{0i}}{A_{0i}} \times 100\% \quad (1)$$

where,

V_i Change rate of the i-th indicators before and after the renovation.

A_i The measured value of the i-th indicator after the renovation.

A_{0i} The measured value of the i-th indicator before the renovation.

For the classification and score of evaluation indicators, see Table 3.

Table 3— Classification and score of evaluation indicators for renovation

Evaluation indicator	Score		
	80 (Significantly improved)	60 (Improved)	30 (Not improved)
Change of vegetation area	≥10%	>5%~<10%	≤5%
Change of vegetation coverage	≥10%	>5%~<10%	≤5%
Change of chlorophyll a	≥10%	>5%~<10%	≤5%
Change of abundance of phytoplankton	≥10%	>5%~<10%	≤5%
Change of diversity index of phytoplankton	≥20%	>10%~<20%	≤10%
Change of uniformity index of phytoplankton	≥20%	>10%~<20%	≤10%
Change of population density of zooplankter	≥10%	>5%~<10%	≤5%
Change of diversity index of zooplankter	≥20%	>10%~<20%	≤10%
Change of uniformity index of zooplankter	≥20%	>10%~<20%	≤10%
Change of biomass of intertidal organisms	≥10%	>10%~<20%	≤5%
Change of diversity index of intertidal organisms	≥20%	>10%~<20%	≤10%
Change of uniformity index of intertidal organisms	≥20%	>10%~<20%	≤10%

Change of biomass of benthos	≥10%	>5%~<10%	≤5%
Change of diversity index of benthos	≥20%	>10%~<20%	≤10%
Change of uniformity index of benthos	≥20%	>10%~<20%	≤10%
Change of dissolved oxygen in water	≥10%	>0~<10%	≤0
Change of nutritive salt in water	≤-20%	>-20%~<-10%	≥-10%
Change of organic carbon in sediment	≤-20%	>-20%~<-10%	≥-10%
Change of sulfide in sediment	≤-20%	>-20%~<-10%	≥-10%

8.2.2.2 Comprehensive evaluation

Evaluation indexes of the renovation effect are calculated as Equation (2),

$$R = \sum_{i=1}^{n} R_i \Big/ n \quad (2)$$

where

R The evaluation index of the renovation effect.

R_i The score of the ith indicator.

n The number of the evaluation indexes.

Evaluation of the renovation in terms of the hydrodynamic condition, topography, and erosion and deposition condition is required to be performed comprehensively based on characteristics of the sea area near the project. Therefore, the comparative analysis method and the comprehensive evaluation method are not applicable to the effect evaluation of the hydrodynamic condition, topography and erosion and deposition condition after the renovation. Instead, it is only applicable to effect evaluation of the marine environmental factors, biological and ecological factors after the renovation.

8.2.3 Evaluation of disaster prevention effect

According to the regional status after renovation, the maximum recurrence period of the storm surge and wave disasters the coastal engineering is able to resist after the renovation is calculated. Whether the disaster prevention capabilities have decreased is analyzed.

8.2.4 Effect evaluation of the renovation

8.2.4.1 Evaluation of marine hydrodynamic environments

According to the hydrodynamic observation data and follow-up monitoring data before and after the renovation of the island-connecting sea wall and coastal engineering, based on marine characteristics and numerical simulations, the change rate of velocity, tidal prisms, water exchange capability, etc. are compared. Improvement of the marine hydrodynamics and water connectivity is analyzed.

8.2.4.2 Evaluation of topography and erosion and deposition environment

According to the shoreline location and bathymetric topographic data before and after the renovation of the island-connecting sea wall and coastal engineering, the change rate of shoreline, topography, erosion, and deposition is analyzed using numerical simulation. Whether the shoreline and beach reach the expected stability is evaluated.

8.2.4.3 Evaluation of seawater quality and sediment environment

According to the investigation data and follow-up monitoring data before and after the renovation of the island-connecting sea wall and coastal engineering, based on the regulatory requirements of the sea area control where the island-connecting sea wall and coastal engineering are located, whether the seawater quality and sediment environment meet the regional environmental protection requirements after the renovation and better than before are evaluated. The change rate of evaluation indicators, including the dissolved oxygen, nutrients in the water quality environment, and the evaluation indicators such as organic carbon and sulfide in the sediment environment before and after the implementation of the renovation are calculated according to Equation (1).

8.2.4.4 Evaluation of biological and ecological conditions

According to the marine biological, ecological investigation data and follow-up monitoring data before and after the renovation of the island-connecting sea wall and coastal engineering, the change rate of indicators including chlorophyll concentration, abundance, biodiversity, uniformity index of phytoplankton and population density, biodiversity, uniformity index of zooplankter, biomass, biodiversity, uniformity index of benthos and intertidal organisms as well as vegetation area and coverage in the project area before and after the renovation are calculated using Equation (1).

For island-connecting sea wall, the change of the structure and succession of biomes shall also be concerned before and after the renovation. The biodiversity (including dominance index and biodiversity index), uniformity, abundance, types, community similarity, etc., are analyzed and the marine ecosystem integrity is evaluated accordingly.

8.2.4.5 Comprehensive evaluation of the renovation effects

According to scores of evaluation indicators after the renovation, the comprehensive index of the renovation effect shall be calculated using Equation (2). The effect is divided into three classifications: the I class means very significant effect; the II class means significant effect; the III class means no significant change. For specific evaluation indicators, see Table 4.

The change of the factors is analyzed and the renovation effect is evaluated comprehensively. Relevant measures are proposed accordingly.

Table 4 —Effect evaluation of the renovation

Comprehensive index for the renovation R	⩾60	⩾40~<60	<40
Classification	Very significant	Significant	Not significant
	I	II	III

9 Quality control

Quality control is carried out according to requirements as specified in T/CAOE 21.1.

10 Results and archives

10.1 Results

10.1.1 Reports

Reports include the suitability evaluation reports and effect evaluation reports of the renovation for the island-connecting sea wall and coastal engineering. The reports shall have detailed data and clear conclusions. The outline of suitability evaluation reports of the renovation shall conform to requirements in Annex A, and the outline of effect evaluation reports shall conform to requirements in Annex B.

10.1.2 Thematic maps

Thematic maps shall include attached figures in reports.

10.1.3 Data set

Data set shall include collected and investigation data, follow-up monitoring data, photos, videos, etc.

10.2 Archives

Archives shall be carried out by requirements as specified in T/CAOE 21.1.

Annex A
(annex normative)
Suitability evaluation report of the renovation for Project

A.1 Text format

A.1.1 Size specification

The page size of the report shall be A4 （210mm×297mm）.

A.1.2 Cover format

The first line: Project of ## in bold, centered Song characters with size 1.

The second line: Suitability evaluation report of the renovation in bold, centered Song characters with size 1.

The third line: the full name of the organization that prepares the report.

The fourth line: date in yyyy/mm format in bold, centered Song characters with smaller size 3.

The distance between these lines shall be appropriate to keep the cover tight and beautiful.

A.1.3 Content of the envelope

The full name of the organization that prepares the evaluation report (with official seal), the name of writers, reviewers, etc., shall be included on the envelope.

A.2 Outline of the suitability evaluation report of the renovation for Project

The suitability evaluation report of the renovation shall be organized as Table A.1. Appropriate additions and subtractions can be made to relevant clauses based on engineering characteristics and regional characteristics.

Table A.1 —Outline of the suitability evaluation report of the renovation for Project ##

1 Overview
2 Status of the project and the surrounding sea area
  2.1 Basic information
  2.2 Construction purposes and functions
  2.3 Status of the surrounding sea area
3 Evaluation of disaster prevention capabilities
  3.1 Marine disaster calculation and analysis
  3.2 Evaluation of engineering defense capability
4 Marine ecology assessment
  4.1 Hydrodynamic environmental impact
  4.2 Erosion and deposition environment impact
  4.3 Sea water quality impact
  4.4 Marine sediment impact
  4.5 Marine organism and ecology impact
5 Evaluation of coordination of sea area development activities
6 Comprehensive suitability evaluation (including renovation measures and purposes)
7 Conclusion and suggestion

Annex B
(annex normative)
Effect evaluation report of the renovation for Project

B.1 Text formatting

B.1.1 Size specification

The page size of the report shall be A4 （210mm×297mm）.

B.1.2 Cover formatting

The first line: Project of ## in bold, centered Song characters with size 1.

The second line: Effect evaluation report of the renovation in bold, centered Song characters with size 1.

The third line: the full name of the organization that prepares the report.

The fourth line: date in yyyy/mm format in bold, centered Song characters with smaller size 3.

The distance between these lines shall be appropriate to keep the cover tight and beautiful.

B.1.3 Content of the envelope

The full name of the organization that prepares the evaluation report (with official seal), the name of writers, reviewers, etc., shall be included in the envelope.

B.2 Outline of the effect evaluation report of the renovation

The effect evaluation report of the renovation shall be organized as Table B.1. Appropriate additions and subtractions can be made to the relevant clauses based on engineering characteristics and regional characteristics.

Table B.1 —Outline of the effect evaluation report of the renovation for Project ##

1 Overview
2 Status of the renovation project and the surrounding sea area
2.1 Basic information
2.2 Status of the surrounding sea area
3 Follow-up monitoring results
4 Evaluation of disaster prevention capabilities
5 Effect evaluation of the renovation
5.1 Marine hydrodynamic environmental evaluation
5.2 Marine topography, erosion, and deposition environment evaluation
5.3 Sea water quality evaluation
5.4 Sediment environment evaluation
5.5 Evaluation of biological and ecological status
5.6 Comprehensive effect evaluation of the renovation
6 Conclusion and suggestion

Bibliography

[1] Technical guidelines for wave hazard risk assessment and zoning
[2] Technical guidelines for demonstration of sea area use