Study on Life Extension of Offshore Breakwaters and Other Offshore Facilities
--- Revision of the Coast Protection Facilities Maintenance Manual ---

(Study period: FY2019)

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1. Introduction

In response to the progress of aging in the infrastructure that was intensively developed in Japan after the high-growth era, the MLIT formulated the Infrastructure Life Extension Plan (Action Plan)" in May 2014 to promote systematic maintenance, renewal, etc. of such infrastructure.

For coast protection facilities provided in Article 2 of the Coast Act, systematic maintenance, renewal, etc. have been promoted in accordance with the "Coast Protection Facilities Maintenance Manual (May 2018)" (the "present Manual"). Of the facilities defined in the present Manual, reference to other guidelines etc. are required for offshore breakwaters, submerged breakwaters, artificial leafs, piers and headlands (collectively, "offshore breakwaters etc."). We are therefore studying standard facility management procedures from a viewpoint of preventive maintenance aiming to strengthen the management of offshore breakwaters etc.

2. Status of the maintenance of offshore breakwaters etc.

Of the coast protection facilities, dikes were rapidly constructed in the rapid economic growth and the dikes that have elapsed over 50 years since the start of operation account for about 40% as of 2015. Meanwhile, there is also a concern about rapid decline of the functions for offshore breakwaters, of which development was promoted following dikes, as shown in Fig. 1.

In addition, as Fig. 2 shows, formulation of a life extension plan for offshore breakwaters etc. is behind as compared with coastal dikes etc. because of the shortage of budget and personnel, as well as shortage of know-how and no formulation of inspection and assessment procedures.

Hence, in order to promote systematic maintenance, renewal, etc. of offshore breakwaters etc., technical support is required, such as setting of inspection and soundness assessment standards.

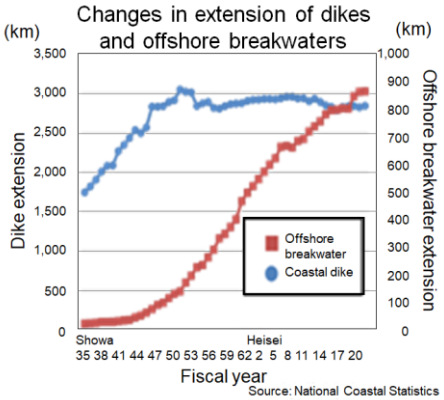

Fig. 1 Changes in extension of dikes and offshore breakwaters

Formulation of the life extension plan

Target facilities	Dike	Sluice gate, water gate, etc.	Offshore break water	Pier
Formulation rate	75 %	61 %	46 %	46 %

Reasons for non-formulation of life extension plan for offshore breakwaters etc.

Reasons	Shortage of budget	Shortage of personnel	No technical know-how	No description of inspection or assessment procedures in the manual etc.	No specific guidance from the State etc.
Ratio (%)	31	18	16	21	14

Fig. 2 Formulation of a life extension plan and reasons for non-formulation

3. Study contents

In reference to the description of dikes, revetments, etc. in the present Manual, we studied chain of deformation flow, inspection items and soundness assessment standards, collection and organization of examples for inspection procedures, countermeasure construction method, etc. and deterioration prediction line. The following describes the outline of study for each item.

(1) Study on the chain of deformation flow

In inspection and soundness assessment of facilities, it

is necessary to consider the processes of facilities such as deformation factors and form. We therefore collected 146 examples for deformation and damage across the country ("Disaster Recovery Guidelines for Protecting Beautiful Coasts (Draft)" Table A-B, etc.) and classified / organized the factors and forms to organize them into New Chain of Deformation Flow for offshore breakwaters etc. (Draft)."

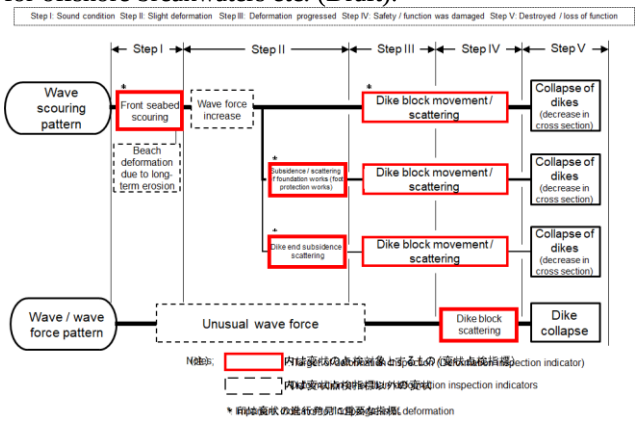

Fig. 3 Chain of deformation flow for offshore breakwaters etc. (Draft).

(2) Study on inspection items and soundness assessment standards

In studying the inspection items and soundness assessment standards above considering the aforementioned chain of deformation flow (draft), we organized the data on the inspection and soundness assessment of offshore breakwaters etc. by each coast administrator and organized inspection items and assessment standards (draft) available on the site, including identification of inspection items that "must be implemented", such as organization of deformation cases and visual inspection from land, and inspection items that "should be implemented as needed", such as submersible survey. (Figs. 4 and 5)

Unit	Implementation necessity	Deformation phenomenon / Location of inspection		Deformation level (Extent of deformation confirmed) a	b	c	d
Each facility	Certainly implement	Dike	Movement Subsidence Scattering	The cross section of the dike decreased at least one layer of blocks across the dike.	The cross section of the dike decreased across the dike. (less than one layer of blocks)	Part of the blocks moved, scattered, or subsided.	Slight or no deformation.
			Block breakage	At least one-fourth of the blocks are broken.	Broken blocks are less than one-fourth.	A few blocks are broken.	Minor or no cracks.
Each component	Implement if necessary.	Seabed ground Foot protection work	Scouring	Widely eroded and the front of the foot of rubble mound slope is scoured over 1 m. The mound etc. are affected by scouring.	Widely eroded and the front of the foot of rubble mound slope is scoured 0.5 m or more but less than 1 m.	Scoured less than 0.5 m in depth.	Slight or no deformation.
			Movement Subsidence Scattering	Flow loss, destruction, or missing.	Minor movement or subsidence.	-	Slight or no deformation.
		Dike	Movement Subsidence Scattering	The cross section of the dike decreased at least one layer of blocks across the dike.	The cross section of the dike decreased across the dike. (less than one layer of blocks) The cross section of the dike decreased at least one layer of blocks in half of the dike.	Part of the blocks moved, scattered, or subsided.	Slight or no deformation.
			Block breakage	At least one-fourth of the blocks are broken.	Broken blocks are less than one-fourth.	A few blocks are broken.	Minor or no cracks.

Fig. 4 Deformation level assessment standards for offshore breakwaters (Draft)

Inspection point	Inspection item	Item to check	Implementation	Inspection method expected
Front Seabed ground	Scouring	Whether the front is scoured	Implement if necessary.	Sounding Diving survey Underwater camera survey
Foundation work (foot protection work)	Movement Subsidence Scattering	Whether the foundation rubble, block, etc. are moved, subsided, or scattered.		
Dike	Movement Subsidence Scattering	Whether the blocks moved, subsided, or scattered.	Certainly implement	Visual inspection (land) or similar method
			Implement if necessary.	Visual inspection (on water) method Sounding Diving survey Underwater camera survey Aerial photo (UAV etc.)
	Block breakage	Whether the blocks have cracks / damage.	Certainly implement	Visual inspection (land) or similar method
			Implement if necessary.	Visual inspection (on water) method Diving survey Underwater camera survey Aerial photo (UAV etc.)

Fig. 5 Primary inspection items / procedures for offshore breakwaters (Draft)

(3) Example collection and organization for inspection methods, countermeasure construction methods, etc.

Since all or part of such facilities as offshore breakwaters etc. are submerged under the sea, it is difficult to grasp all deformations only with visual inspection from land, which is applied to dikes, revetments, etc.

We therefore collected and organized examples of inspection methods and countermeasure construction methods focused on new technologies in order to promote utilization of new technologies that replace visual inspection from land. (Fig. 6)

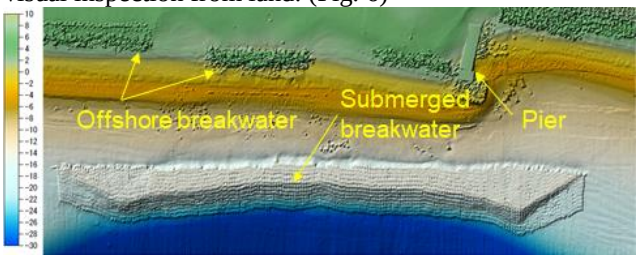

Fig. 6 Example of 3D geographic measurement with ALB and narrow multibeam

(4) Study on deterioration prediction line

For systematic maintenance and renewal, it is necessary to predict the time of deterioration and deformation in facilities and to consider repair / renewal plans for facilities.

However, in comparison with dikes, revetments, etc., which mainly suffer temporal deterioration, offshore breakwaters etc. may suffer sudden deformation caused by unusual waves, etc. since they are located off the shore line. With this taken into consideration, we are continuing the study.

4. Future schedule

We are going to reflect the results of study including the opinions of academics and coast administrators in the revision of the present Manual.

☞See the following for details.

1) Committee for Revision of the Coast Protection Facilities Maintenance Manual
http://www.mlit.go.jp/river/shinngikai_blog/kaiganhozen/index.html