Planning for Facility Installation

General Information

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A facility installation plan shall be designed in such a way that prevention or mitigation of disasters caused by floods and storm surges, etc., improvement and preservation of the river environment, etc., and comprehensive sediment management are properly implemented.
The project facilities must be constructed, improved, maintained, and managed in consideration of the relationship between project costs (including appropriate life-cycle costs) and the beneficial and adverse effects and impacts of the project.
When planning each individual facility installation plan, consistency with other facility installation plans and cooperation with non-structural measures need to be sufficiently taken into consideration.
When designing a facility installation plan, thorough consideration must be given to the natural as well as social characteristics of the river basin and community.

Explanation

Since prevention or mitigation of disasters due to floods and storm surges, etc., improvement and preservation of a healthy river environment, and comprehensive sediment management are closely interrelated with each other, consistency among these must be secured in the development of a facility installation plan. Also, it is necessary to take into consideration consistency with related facility plans and other plans, as well as with excessive external forces. In this part, Chapter 1 describes the improvement and preservation of river environments, etc. and comprehensive sediment management; these are themes common to all sections in Chapter 2 and thereafter, where individual arrangement plans will be discussed.

Chapter 1 Improvement and Preservation of the River Environment and Comprehensive Sediment Management

Section 1 Improvement and Preservation of the River Environment

1.1 Overview

The goals for developing a plan to improve and preserve a river environment, etc. shall be established on the basis of an understanding of the characteristics of the subject river environment, the natural and social environments of the basin and seacoast, and their historical changes. They should also take into consideration consistency with the flood control and water utilization functions, and the measures taken to achieve these goals shall be designed accordingly. In this process, preservation or restoration of a healthy living and growing environment for plants and animals, formation and maintenance of good landscapes, creation and maintenance of places for activities that bring humans into contact with the river, etc., and preservation of good water quality shall be comprehensively considered.

Explanation

When developing a plan for a river environment, bibliographic surveys, field surveys, and discussions with the persons concerned shall be conducted, and the following step-by-step process needs to be followed: 1) based on an analysis of the aforementioned surveys, develop an understanding of the characteristics of the subject river and its basin, as well as their historical transition; 2) determine the direction for improvement and preservation of the river environment.; 3) establish goals for improvement and preservation of the river environment, through a comprehensive examination of this direction and of flood control and water utilization factors; and 4) establish measures for improvement and preservation of the river environment on the basis of these goals.
Establishment of a plan shall follow the process shown below:

Understandings of the characteristics of the river environment, the basin or the seacoast, etc. , as well as those historical changes

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Setting the objective and direction for improvement and preservation of the river environment, etc.

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Establishment of the policy of the improvement and conservation of the river environment, etc.

The following points need special attention in the development of measures for improvement and preservation of the river environment.:

1. A thorough examination of the nature of the individual features of the river shall be conducted, giving due

consideration to the characteristics of the river and the basin, and their historical transition.

2. Surveys of existing documents, field surveys, and discussions with experts, the local entities concerned, civic organizations, shall be adequately conducted.

3. The information obtained from such surveys shall be compiled into a river environment information map (a diagram showing in an easy-to-understand manner the riverbed configurations, vegetation status, living and growing environments for plants and animals, characteristics of the river environment, that is aimed at providing appropriate information about the river environment to define it's characteristics.

4. Environmental considerations, together with considerations about flood control and water utilization, shall be examined from the early stages of plan development onward, not after the flood control and water utilization factors have been examined.

1.2 Understanding the characteristics of the river environment

The characteristics of the subject river environment shall be understood through surveys of the characteristics of the river, seacoast, or mountain stream; the habitats of plants and animals; the utilization of the river, seacoast, or mountain stream; the natural and social environments of the basin and the seacoast; and their historical transition.

The results of these surveys shall be systematically organized for the entire river, and for each area.

Explanation

1. Method of understanding the river environment, etc.

The characteristics of a river environment shall be discovered through investigation of not only the current situation but also the historical transition of the river. In this process, changes in the statuses of gutters, riffles and pools, river forms, river vegetation, rivers and surrounding land uses, as well as changes in the basin status, shall be determined by arranging aerial photos, topographical maps, plane figures, longitudinal profiles, and cross-sections, in chronological order.

On the basis of an analysis of the gathered information, the subject river shall be zoned according to characteristic similarities (e.g. river course, natural environment, social environment characteristics, etc.). A river environment information map shall be prepared for each zone to give an understanding of the characteristics of the river, the typical features of the river, and the problems to be solved.

An effective method to this end is to organize materials about the river course transition, river landscape transition, river zoning, and the relationship between environmental zoning and organisms, and to prepare river environment information maps (overall area, wide area, and section). When the specific contents are being examined, some existing documents [1)] should be useful as references.

2. Method of determining water quality

As part of the information on the river environment, information on water quality in particular shall be organized in terms of its current situation as well as its historical transition, depending on the characteristics of the river. In this process, it is necessary to take into account the local characteristics.

On the basis of the organized information on the current status of water quality, the relationship between the basin and river flows and water quality, and the characteristics of river water quality change, shall be determined. The mechanism of water quality change in the river, as well as the causes for this mechanism, shall be determined through analysis of the current water quality on the basis of the aforementioned information.
Using information such as that on the current water quality, an analysis shall be conducted to forecast how the water quality will change in the future. This analysis shall be conducted by using an appropriate method that should be selected in accordance with the characteristics of the target water body, the required level of accuracy of the prediction, and the data available, etc. Since there are periods when the water quality is important for the lives of organisms and for water utilization, forecasts for not only drought and low-flow periods but also for all year around are necessary.

1.3 Setting goals for improvement and preservation of the river environment

1.3.1 Determining the direction

The direction of improvement and preservation of the river environment shall be determined based on the characteristics of the river environment, basin, or seacoast from the viewpoints of preservation and restoration of healthy habitats for plants and animals; formation and maintenance of good landscapes; creation and maintenance of places for activities that bring humans into contact with the river; and preservation of good water quality.

Explanation

The "direction" means the direction for improvement and preservation of the river environment, etc., determined on the basis of the discovered characteristics of the river environment, etc. and the attributes of the basin. It is important to determine a direction for each zone.
In determining the direction, the following points need to be observed:

- Local opinions obtained through hearings, etc. should be taken into due consideration.
- Historical transition of the river environment, etc. should be taken into due consideration.
- From the viewpoint of the natural environment, the discovery of the "original state" (i.e. original landscape) of the river should be helpful, although it is difficult to determine the original state of the river. The majority of rivers in Japan have been artificially tampered with since ancient times, and, as a result, they have been gradually changed and the riverside land has been utilized accordingly. Therefore, it is impossible to discover what the river and its course used to look like before any artificial tampering. For this reason, discovery of the "original state of the river" before large-scale river improvement projects in recent years and when there was relatively little artificial intervention (e.g. the river shape and environment before large-scale training during the high-growth period of the economy) would be a secondary option. In the case of an urban river, a direction that aims to create a riverine environment that meets the conditions of the current and future social environment should be determined.
- In order to discover the "original state of the river", old topographical maps, longitudinal profiles, and cross-sections, as well as aerial photos, municipal histories, local histories, and interviews with local elders should be helpful as references. Also, the state of a river that is close to the target area and maintains a good

river environment without much artificial intervention, or of a river with similar natural conditions (such as topography, geology, and river shape) that maintains a good river environment without much artificial intervention can be informative.

1. Determining the direction for improvement and preservation of a healthy habitat for plants and animals

The direction for improvement and preservation of a healthy habitat for plants and animals shall be determined based on the following points:

1) Preservation and restoration of the river environment typical of the subject river

Efforts shall be made to preserve and restore the habitat for the animals and plants that the subject river originally had. To this end, the river's original shape shall be preserved and restored by taking full advantage of the river's natural restoring force. It is also important to respect the dynamism of the river.

2) Securing a continuous environment

Some of the creatures living in a river travel between upstream and downstream, between the main stream and branches, canals, or ponds, between the river and its peripheral areas, or even between saltwater and freshwater. Some creatures need both water and land areas, and there are still some other creatures that move around in plant-growing areas. In order not to prevent such creatures from traveling from one place to another, a continuous environment in longitudinal (upstream-downstream) and lateral directions as well as continuity with the surrounding environment shall be secured. Because, in a tidal zone, wave run-up from the sea upstream into the river occurs as the tidal sea level changes, the characteristic ecosystems formed in such an environment need consideration.

3) Preservation and restoration of habitats for plants and animals typical of the subject river

Efforts shall be made to preserve and restore species that are important academically or in view of scarcity, important communities, and notable habitats, and, at the same time, it is important to consider the preservation and restoration of habitats for plants and animals typical of the river by focusing on the plants and animals living and growing in the characteristic environments of the river, including riffles and pools, river beaches, riverside forests, inlets, swamps, etc.

Countermeasures against alien species shall be considered if necessary.

4) Securing the water cycle

Stream flow is closely related to peripheral ground water, and the level of ground water affects the growth of river vegetation. Where there is spring water (which is limpid and often stable in temperature) in the river, an environment different from those in the main stream is formed, substantially adding to the diversity of the river environment. Consequently, it is necessary to secure the water cycle by securing riparian permeability in such a way that the natural water flow is not intercepted.

2. Determining the direction for formation and maintenance of a good landscape

The direction for formation and maintenance of a good landscape shall be determined based on the following points:

1) Respecting the typical dynamic features of the river, such as the river shape, composed of riffles, pools, and river beaches, which are typical characteristics of the subject river; variability in the water volume; continuity, etc.
2) Adequacy of a structure that combines functionality and appropriate structural beauty
3) Preservation of water quality
4) Measures to suppress factors that disturb the river landscape
5) Building and maintenance of a good landscape that produces the distinctive features of the subject locality, coupled with city or town planning based on the area and river as well as the streetscape, etc.

Here “landscapes” include not only places of scenic beauty and major appearances formed by exceptional natural elements, but also neighboring landscapes such as other views and sceneries.

Measures for the formation and maintenance of major appearances shall take into account the typical features of the locality’s landscape, major viewpoints, and landscape resources (natural elements).

3. Determining the direction for creation and maintenance of places for activities that bring people into contact with rivers

The direction for creation and maintenance of places for activities that bring people into contact with rivers shall be determined based on the following points:

1) The river shape, water volume, and water quality, etc. in addition to the living and growing environment for plants and animals.
2) The status of utilization and needs.
3) Comfort and safety for users.
4) Places for experiential activities and environmental learning that take advantage of the natural environment of the river.
5) Local history and culture.

4. Determining the direction of preservation of good water quality

The direction for preservation of good water quality shall be determined based on water utilization, preservation of habitats for plants and animals, securement of places for activities that bring humans into contact with the river, landscape, preservation of living environment, tourism, maintenance of groundwater quality, etc., and indices that represent them shall be set.

Although BOD (biochemical oxygen demand) or COD (chemical oxygen demand) has been widely used as the index for rivers, reservoirs, lakes, or swamps, the following indices shall be selected as appropriate, depending on the river characteristics.

1) In cases where water utilization (use for a water supply system) is the primary element, ammonia, THMFP

(trihalomethane formation potential), 2-MIB (2-methylisoborneol), odor, or chlorine ions, etc. can be used.

2) In cases where preservation of habitats for animals and plants is the primary element, SS (suspended solids), turbidity, DO (dissolved oxygen), chlorine ion content, water temperature, etc. can be used.

3) In cases where the securing of places for activities that bring humans into contact with the river is the primary element, SS, turbidity, color, transparency, coliform count, odor, etc. can be used.

4) In cases where landscape is the primary element, SS, turbidity, color, transparency, etc. can be used.

5) In cases where suppression of internal production is the primary element, chlorophyll a, nutrients, DO, etc. can be used.

6) It is also effective to first set qualitative goals such as the suppression of algal blooms or maintenance of a level of water transparency that enables visualization of the riverbed, and to then set quantitative goals by using indices such as chlorophyll a or transparency to realize the qualitative goals.

1.3.2 Setting goals

Goals for improvement and preservation of a river environment, etc. shall be established for each area zoned on the basis of the characteristics of the river environment, etc. They shall be based on the pursued direction in consideration of a good balance between flood control, water utilization, and environmental factors.

Explanation

A direction to be pursued shall be determined for each of flood control, water utilization, and environment-related endeavors. Then, specific goals shall be established by optimizing trade-offs and other correlations among them.

Goals for improvement and preservation of the river environment, etc. shall be set for each area zoned on the basis of the different characteristics of the river environment, such as those for the upper and lower reaches, etc. In this process, the goals need to be examined through an adequate exchange of information and opinions on the subject region.

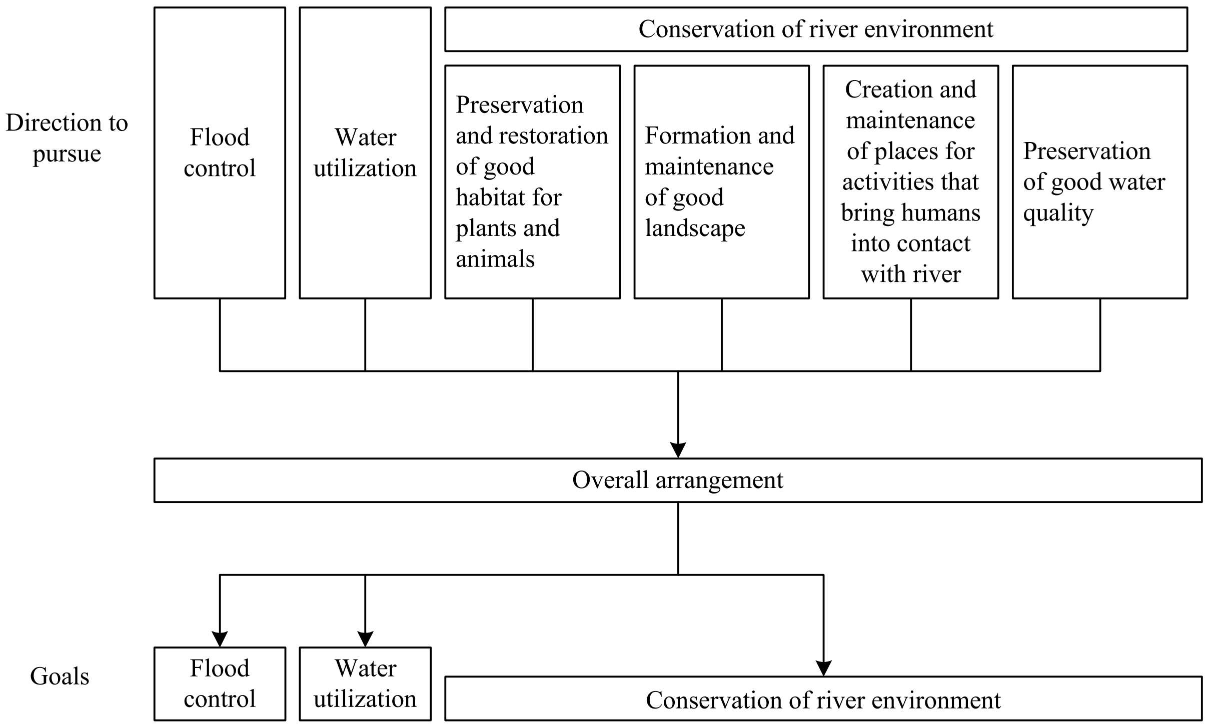


Fig.1-1 Goal-setting Flowchart for improvement and preservation of the river environment

For water quality, target values shall be determined for each index representing the determined direction.
Since the water quality of the river shows longitudinally different properties because of natural as well as anthropogenic factors, in establishing the goals for water quality preservation the river shall be zoned into multiple areas based on the longitudinal properties, and then goals for each area shall be examined.
For reservoirs, lakes, and swamps, too, water area zoning may be required before examination is performed to set the goals.
Target values shall be set in consideration of drought and water utilization periods as well as important periods for the life and growth of animals and plants, as required. In cases where the river flows into a closed water area such as an enclosed bay, goals that take wide-area water quality preservation into consideration shall be investigated, if this is necessary.
In establishing goals for water quality preservation, coordination with relevant organizations and bodies in the basin and consideration of environmental standards are necessary.

1.4 Measures for improvement and preservation of the river environment

Measures that are necessary for achieving the goals for improvement and preservation of the river environment, etc. shall be established.
In examining the measures, cooperation and role-sharing with community members and relevant organizations and bodies in the basin shall be considered.

Explanation

Multiple examination cases shall be set in consideration of flood control, water utilization, and environmental factors as well as the planar, longitudinal, and transverse shapes, and the vegetation, etc., of the river, etc. The channel shape and coefficient of roughness shall be determined for each case examined, in consideration of the future maintenance level and tree vegetation status.

Future channel status (riverbed evolution, etc.) and river environment, etc. shall be predicted for each case, and it is important to conduct a comprehensive assessment of the effects on flood control and water utilization as well as the impacts on the environment. For this reason, it is important to predict how river improvement will affect the river environment by studying the content of the proposed river improvement against river environment information maps.

If significant effects and impacts are predicted, the plan shall be revised, as appropriate, so that the entire plan will be a well balanced one.

In the process of developing a plan, it is desirable that frequent exchange of opinions and information takes place with the local public, as well as with other persons concerned and with civic organizations that are associated with the river.

1. Measures for preservation and restoration of areas that are good habitats for plants and animals

Measures for the preservation and restoration of areas that are good habitats for plants and animals shall be established based on the following:

- Changes in areas that are good habitats for animals and plants should be avoided as much as possible.
- The diversity of the river shape shall be preserved and restored.
- Continuity of habitats in the river shall be secured.
- Expansion of nature in the basin shall be considered.
- Threatened organism species, etc. shall be protected.
- A healthy water cycle shall be secured.
- The dynamism of the river shall be secured.
- Understanding and cooperation shall be obtained from citizens, academics, and experts, and from interested organizations, etc.

The following are specific examples of viewpoints for examination:

- Low-flow channels should have a naturally shaped bed, not an artificially flattened bed.
- The width of a low-flow channel or a gutter shall be determined on the basis of the width of the original river.
- The transverse shape of a low-flow channel shall be determined on the basis of the transverse shape of the low-flow channel of the original river.
- The normal line shape of a low-flow channel shall be a gentle meander, determined on the basis of the normal line shape of the low-flow channel of the original river.
- The longitudinal shape of a riverbed shall be determined on the basis of the longitudinal shape of the original riverbed.
- If the original river had riffles and pools, these shall be formed.
- Riffles in portions of the river where a cliff, a forest, etc. adjoins the river should be preserved if at all

possible.

- Intricately indented portions and curves of the riverbank shall be preserved so that slack water areas are maintained.
- Continuity between branches and canals shall be secured.
- If at all possible, waterside areas should not be covered with concrete.
- The height of a high (higher) water channel shall be determined on the basis of the future vegetation and sediment deposition statuses.
- Riverbed slope gradients shall preferably be as gentle as possible, but there are cases in which a steep gradient will allow the formation of more diverse environments if there are highly restricting conditions related to land use, etc.
- Riverside forests should be preserved and restored to as great an extent as possible.

2. Measures for formation and maintenance of good landscapes

Measures for the formation and maintenance of good landscapes shall be established based on the following:

- Harmony with the characteristics of the subject river landscape shall be maintained.
- Harmony with the subject locality's natural environment shall be maintained.
- Harmony with the history, tradition, and culture of the subject locality shall be maintained.
- The appearance of river structures and permitted structures shall be considered.
- Preservation of a good river landscape shall be induced.
- Understanding and cooperation shall be obtained from citizens, academics, experts, interested organizations, etc.

The following are specific examples of viewpoints for examination:

- There is growth of plants on the riverbed and revetment and has the appearance of a natural environment.
- The river course meanders gently.
- The top of the levee has a rounded surface and a gentle line.
- The high-water channel has trees that arrest the view.
- The river edges are delicately indented where plant growth is luxuriant.
- The flow has planar variation caused by the presence of riffles, pools, and shoals, etc.
- The water is limpid.
- The width of the water surface is large.
- The dry riverbed provides a long walkway and easy access to the waterfront.
- Distant views are secured.
- A continuous mountain ridgeline is visible.
- Anthropogenic structures and objects are colored to blend in with their natural surroundings.
- Objects blocking the landscape view, such as signs, utility poles, and steel towers, are not conspicuous.
- There is a row of trees, or trees or a forest that serve to break the view around the river.
- There is a riverside park.
- There are no elevated roads running along the river.

3. Measures for creation and maintenance of places for activities that bring humans into contact with the river

Measures for the creation and maintenance of places for activities that bring humans into contact with the river, etc. shall be established based on the following:

- Utilization and the natural environment shall be harmonized.
- Good places for activities shall be maintained.
- Access to the waterfront shall be improved.
- Places for activities shall be provided according to the actual utilization and the need for utilization.
- Cooperation and collaboration with local community members and civic organizations, etc. shall be promoted.

The following are specific examples of viewpoints for examination:

- Healthy habitats for plants and animals shall be taken into consideration.
- Consideration of the structure and its materials and finish is necessary so that users (especially the elderly, children, and disabled people) can comfortably use the place without extra physical effort.
- Safety shall be considered.
- Utilization as a place for environmental learning shall be considered.
- Use of natural materials, and their sizes and shapes, shall be considered; they should suit the historical and cultural backgrounds of the locality and the river.
- Economic efficiency and ease of management shall be considered.
- Acts that hamper the activities of the general public should be constrained.

4. Measures for the preservation of good water quality

Since water quality is affected to a large extent by the natural and social environments of the basin, its preservation needs to be dealt with by the entire basin. To this end, close cooperation and collaboration with measures by relevant organizations and bodies in the basin and appropriate role-sharing among them shall be promoted.

Relevant organizations and bodies in the basin include local public entities, local interested organizations, etc. It would be effective to set up a council for each basin through collaboration between these and river administrators.

Since the measures implemented by river administrators and relevant organizations and bodies in the basin have limitations in terms of scope of implementation, coordination among these bodies may be necessary. It is also necessary to give feedback on these measures (role-sharing).

Even for water areas where water quality-related problems are not apparent, plans for the preservation of good water quality need to be established in view of future changes in the basin.

Measures for the preservation of river water quality shall be developed to achieve water quality goals in consideration of the pollution loading distribution in the basin, the characteristics of water quality change, and the effectiveness of basin management, etc.

In the process of developing measures for the preservation of river water quality, measures that are most effective for achieving the water quality preservation goals shall be selected, their efficacy for water purification shall be estimated, and the estimated results will need to be incorporated into considerations concerning role-sharing.

Selection of measures needs to take into account the characteristics of the water to be purified; the impacts on other water quality items and the ecosystem; the maintenance requirements; and the necessary length of the operation in years, etc.

Water quality preservation measures for rivers, reservoirs, and lakes and swamps can be divided into the following functional categories, and measures for preservation of water quality shall be developed by appropriately combining these:

- Load reduction
- Load separation
- Securement of flow volume
- Reinforcement of the purification function of the river
- Water temperature and flow control
- Other

If early achievement of water quality preservation goals is impossible owing to a wide discrepancy between the current water quality and the target quality, or to difficulties with the technical and economic feasibility of implementing the measures, etc., a staged program or alternative plan shall be considered if this is necessary.

Measures to counter the occurrence of water quality hazards caused by abnormal water quality, etc. shall be examined through cooperation and collaboration with relevant organizations and bodies, information gathering, and the preparation of resources and equipment, etc.

Measures for water quality preservation in the basin shall be planned and implemented primarily by relevant organizations and bodies in the basin. It is important to make these measures effective by combining functions and in consideration of the effects on the environment in the lower reaches.

Refer to Chapters 2 through 4 for water quality preservation measures that can be implemented in the basin by river administrators.

Section 2 Comprehensive Sediment Management

2.1 Overview

In the process of developing plans for comprehensive sediment management, the actual state of sediment movement shall be adequately determined on the basis of the characteristics of the river or seacoast, and the necessary surveys shall be conducted in consideration of the relationships between the spatial as well as temporal continuity associated with sediment movement, the quantities and quality (grain size) of the sediment, and the river flow, etc.

Explanation

In a sediment transport system where problems related with sediment movement are apparent, efforts shall be made to understand the characteristics of sediment movement, etc. through determining the characteristics of the river or seacoast and performing monitoring surveys of sediment movement.

Comprehensive sediment management needs to take into consideration spatial continuity such as longitudinal continuity from upstream to downstream of the river or continuity in the longshore direction of the seacoast. Since riverbed configurations are changed by sediment movement not only caused by flooding but also occurring in normal times, sediment movement at normal times should be included in considerations of temporal continuity.

In addition, since a mixture of diverse grain sizes exists in areas from mountain lands and hillside lands to the estuary, and since ecosystems and natural environments that are suitable for grain size distribution and river flow as well as different patterns of utilization of river spaces exist, not just the sediment quantity but the river channel morphology and the quality of sediment (grain size, etc.) need to be considered.

Although sediment travels in a river discontinuously, its primary moving force is flowing water. For this reason, it is important to examine the quantitative characteristics of the river flow regime in the sediment transport system for adequate implementation of sediment management.

2.2 Basics of facility installation planning

If the basin, etc. has apparent problems related to sediment movement, a facility installation plan shall be designed by appropriately combining the multiple measures needed for comprehensive sediment management in the subject sediment transport system.

Explanation

A facility installation plan shall be designed by combining the necessary measures selected from the following:

1. Erosion control by flowing sediment

Measures for the prevention of disasters caused by sediment movement, such as hillside failures, landslides, and debris flows, as well as for the development and preservation of fluvial forest zones as part of the disaster prevention measures, shall be implemented. In addition, the status of the basin, such as its topography and geology, the functions expected of erosion control dikes, and the effects on subjects requiring preservation in the lower reaches shall be comprehensively examined. Thereby, an erosion control dike shall be installed that is capable of capturing hazardous sediment and safely allowing the necessary sediment (in terms of quantity and quality, i.e. grain size) to flow downstream.

2. Reuse of sediment within the sediment transport system

Sediment deposited at river administration facilities such as dams and groundsills, as well as in erosion and sediment control facilities such as erosion control dikes and sediment-retarding basins, shall be removed and carried out within the extent that its purpose and function are not damaged. It shall be reused for a seacoast that needs beach nourishment or for a remarkably degraded river, etc.

3. Sand removal plan for a dam

Measures for discharging sediment from a dam and appropriately flowing sediment downstream without undermining the expected purpose of the dam shall be developed.

4. Appropriate maintenance of river structures

For cross-river structures, etc. whose safety is deteriorating due to riverbed degradation, reinforcement measures such as revetment attachment or bed protection work shall be implemented as appropriate.

Direct supply of the sediment downstream shall also be examined.

5. Appropriate gravel quarrying

For a river that has a sufficient cross-sectional area, if future sediment supply in great amounts is not expected, gravel quarrying must not be carried out because it causes excessive riverbed degradation and has adverse effects on the environment. For a river where sediment deposition is apparent, if no problems are expected to arise in terms of flood control, water utilization, and environment preservation, well-planned gravel quarrying shall be appropriately carried out in consideration of the balance between river channel or seacoast maintenance and sediment supply.

Reference

National Census on River Environment (River Edition) Guide for Surveys for Creation of General Material Concerning River Environment (Draft), 2001 Edition: Supervised by River Environment Division, River Bureau, Ministry of Land, Infrastructure and Transport (MLIT). Issued by Foundation for Riverfront Improvement and Restoration, 2001

Chapter 2 River Facility Installation Planning

Chapter 2–1 River Channel and River Structures

Section 1 River Channel Planning

1.1 Basics of river channel planning

1.1.1 Basics of river channel planning

A river channel plan shall be established for the purpose of safe downstream flow of flow volumes below the design high water discharge and in consideration of the improvement and preservation of the river environment. In the process of plan development, not only the status of land use in riverside areas, but also comprehensive sediment management, if necessary, shall be considered.

Explanation

A "river channel" means the land space in which the water travels, and it usually means the portion surrounded by the embankment or the riverbank and riverbed. Since many changes take place in a river channel, and sediment and other things flow in the water, it is important to thoroughly examine whether the functions related to the planned target can be maintained after the project and what the necessary maintenance will be. For rivers that show obvious sediment movement, this should especially be taken into due consideration. Also, in the case of rivers that are in basins below mountains that actively yield sediment, or that flow to beaches whose sediments are supplied from the river, it is desirable to consider the relationship between these areas and comprehensive sediment management.

River channel planning shall be based on nature-oriented river reconstruction that takes into consideration the diverse channel topography formed by the characteristics of the subject river course, as well as the natural environment and landscapes formed there, and it is necessary to take into consideration river utilization and the diverse aspects of the river, such as its history and culture and the day-to-day relationship between the river and its people.

In the process of developing a river channel plan, it is important to determine the optimal longitudinal and transverse shapes and the planar shape, etc., through a comprehensive examination of quantitative stability (securing of discharge capacity), securing of qualitative stability (safety of river management facilities, safety of infiltration surfaces of embankments, etc. against erosion caused by sediment movement), minimization of total cost, and improvement and preservation of the river environment (preservation and restoration of the natural environment, harmonization with river utilization).

In conventional expressions such as "design bed slope" and "design bed height", use of the word "design", may lead to a false understanding that uniform longitudinal and transverse heights must be secured; these expressions have therefore been corrected.

1.1.2 Procedure for establishing a river channel plan

In establishing a river channel plan, the following procedure shall be followed to carry out a detailed examination while considering the current issues associated with the channel, the status of the peripheral area, the natural environment of the locality, and the social environment, as well as their historical transition.

1. Determine the design high water level.
2. Determine project sections, depending on the reasons for improvement.
3. Establish multiple examination case studies in regard to the planned line and the longitudinal and transverse shapes of the river channel.
4. Establish plans for river structure construction, etc.
5. Comprehensively assess the possible effects and impacts on flood control, water utilization, and the environment.

On the basis of the comprehensive assessment, the necessary corrections shall be made to the plan until it becomes well-balanced.

Explanation

A river channel plan shall be established in such a way that it meets well the purposes stipulated in "Chapter 1: Basic Policy" of the Basic Planning part. First, the characteristics of the river, including the natural conditions such as topography, soil nature, etc., and the natural and social environments of the locality and their historical transition (based on Chapter 2 in the Basic Planning section) shall be determined. On the basis of these and in consideration of the goals for flood control, water utilization, and environmental preservation, etc. (based on Chapter 2 in the Basic Planning section), a detailed examination of a possible river channel plan shall be carried out. After determining the design high water level on the basis of the concept described in the next section, the question of whether the design high water discharge can flow shall be examined. On the basis of the results of this examination, too, any lack of discharge capacity, the existence of crossings that hinder flood discharge, inadequate traits of the river channel, and causes of past major disasters, etc. shall be investigated, thereby identifying the reasons for improvement and determining the sections of interest. On the basis of these examinations, multiple examination case studies of the planar and longitudinal and transverse shapes of the river channel shall be established.

In each examination case, a plan for the installation of structures to prevent and control erosion, corrosion, and sediment deposition in the channel and thus enable prolonged channel stability through the use of the planar and longitudinal and transverse shapes, etc. that have been determined shall be examined. If necessary, new construction, reconstruction, or elimination and consolidation of weirs, sluices, water gates, and other facilities (including structures whose main purpose is other than flood control) shall be examined. In establishing a measure for river facility installation, the river water behavior at normal times and in times of flood, as well as changes in the riverbed and riverbank shape characteristics, the soil and geological properties, and the sediment transport characteristics, should be taken into due consideration. Its positioning and role in river channel planning, and the criteria used to order the priority and timing for installation shall be clarified. A measure that

draws the expected effects from the minimum necessary construction of new facilities or reconstruction of existing facilities without overly depending on structures, while taking into due consideration the improvement and preservation of a healthy river environment, shall be developed.
The effects and impacts on flood control, water utilization, and the environment shall be comprehensively estimated for each examination case.

1.2 Design high water level

1.2.1 Basics of determining the design high water level

When reviewing a river channel plan for a river for which a design high water level has already been determined, as a general rule, the revised level shall not exceed the existing design high water level. In cases where partial raising of the design high water level is unavoidable, the area for its application shall be kept to a minimum; it is desirable for the design high water level to be kept under the highest high water level of past floods, if at all possible.
When determining a new design high water level for a river for which no such level has been determined (for example, in the case of construction of a new stream such as a cutoff channel or discharge channel, or for a river for which overall river improvement is to be implemented), the design high water level shall be determined in such a way that the height exceeding the riverside ground level is minimized, in consideration of the design high water level of connecting rivers and the regional characteristics, etc. Especially, for a river whose design scale is small and for which a sufficient water surface gradient can be secured in consideration of the conditions of the downstream river channel, the design high water level shall be set approximately to the ground level.

Explanation

The design high water level is the water level below which the design high water discharge can flow, and it is a basic determinant used for various purposes such as determining an embankment height or bridge beam height, or for planning a branch channel and drainage of the inner water. It is also the most important planning factor associated with river management and may even determine the scale of disaster when a flood levee failure occurs. Therefore, in the process of examining a river channel plan, the question of how the design high water level should be determined is the key issue to be examined. The majority of rivers have already had design high water levels set, and river improvement and management have been implemented on the basis of these. Consequently, in this section, the basics of determining the design high water level will be described in the following two cases: 1) when the design high water level has already been determined; and 2) when the design high water level has not been determined, or when it has been determined but full-scale improvement, such as that for a new river (often a medium-sized or small river) is to be implemented.
In the case where a river channel plan is reviewed for a river section for which a design high water level was determined in the past, raising the design high water level would be tantamount to full-scale river improvement. This would be unrealistic, except in cases where the design high water level is raised for limited portions only. It is also contrary to the broad principle of flood control, which is to discharge flood water at a water level as low as possible; therefore, in most cases the existing design high water level is adhered to.
When determining a new design high water level for a river for which a level has not been determined in the past

(for example, in the case of new river improvement, or a river for which the existing design high water level does not have to be adhered to because a full-scale river improvement project is being conducted), the design high water level shall be determined in such a way that the height exceeding the riverside ground level will be minimized, in consideration of the regional characteristics such as topography and land-use status, etc. For a river with a small design scale, especially, since the possibility of flood occurrence exceeding the design high water level is high, positive consideration should be given to planning excavated river channel. In this case, due consideration needs to be given to securing the groundwater level at times of low water discharge, securing the intake level of various service waters, and measures for maintaining the normal functions of river water and preserving the river environment. If the design high water level for an upstream river channel is made excessively low compared with the landside ground level on the basis of considerations of the safety of the entire river system, then the discharge capacity of that section will be substantially enhanced and a flow volume exceeding the design level can be discharged. Therefore, any flow volume exceeding the design level will be discharged to a downstream river channel with embankments, causing a serious problem in terms of downstream river safety. Consequently, it is very desirable to determine a design high water level that is approximately equal to the ground level.

1.2.2 Design high water levels of branches within a backwater section of the main stream

The design high water levels of branches within a backwater section of the main stream shall be determined on the basis of the water level described in the following 1 or 2, whichever is higher:

1. The water level obtained by backwater calculation when a volume of the design high water level is flowed in the main stream and a combined volume corresponding to the peak discharge of the main stream is flowed in the branches.
2. The water level obtained by backwater calculation using, as the starting water level, the water level of the main stream corresponding to the flow volume of the main stream when the design high water discharges from the branches join the main stream.

In cases where the ratio of the design high water levels of the branches to that of the main stream are relatively small, the water level obtained by uniform flow calculation for the design high water discharges of the branches may be used instead of the water level obtained by 2.

Explanation

Ideally, the design high water level of branches within the backwater section of the main stream shall be determined by including the high water levels of the branches based on the flood discharges of the branches corresponding to each water level of the main stream, although, in general, such an extensive examination is not necessary. It is safe to regard the following two cases as criteria: 1) when the main stream flow reaches the design high water level; and 2) when the branch flows reach the design high water discharge.

If the situations in the main stream basin and the branch basin are radically different and seem to have little to do with the peak occurrence, then the backwater of the main stream is presumably almost horizontal. If this is the case, the water level in 1 above shall be that which is horizontal to the water level of the main stream at the confluence.

1.2.3 Design high water level in estuaries

The design high water level in estuaries shall be determined from the hydraulic and meteorological characteristics of the river and sea areas around the estuary and in consideration of the river channel characteristics at, and around, the estuary, as well as of future measures for estuary improvement.

Explanation

With waves, flows, and tides, and the coexistence of freshwater and seawater, the hydraulic phenomena occurring in and around a river estuary are physically very complicated. Therefore, the design high water level for an estuary area needs to be determined in consideration of phenomena such as riverbed deformation in times of flood, the effects of the chloride content of seawater, and the hydraulic phenomena around the estuary, such as sea level departure from normal—whichever are regarded as factors necessary for the plan. If the estuary may be reclaimed or dredged in the future, the resulting effects should be taken into due consideration.

1. Riverbed deformation at times of flood

There are rivers for which the effects on the water level of the presence of a sand spit at the river mouth, topographical deformation of the sand spit at the river mouth, riverbed raising, etc. in times of flood should not be ignored. For such rivers, topographic deformation of the estuary in times of flood needs to be taken into consideration.

2. Effects of chloride content of seawater

In some cases, the density difference between river water and seawater in the estuary causes a saltwater wedge, making it impossible to regard the area between the water surface and the riverbed as an effective cross-sectional area. In such cases, the amount of rise in water level due to the effects of the chloride content of seawater needs to be taken into consideration.

3. Co-occurrence of a flood and storm surge

For rivers where the possibility of simultaneous occurrence of a flood and a storm surge due to a typhoon is high, the relationship between flood peaks and sea level departures from normal in past flood instances shall be analyzed. The design high water level for the estuary shall be determined as appropriate on the basis of the highest high tide level or watermarks in times of flood and the water level that takes into consideration the same probability deviation as the scale of the flood prevention plan. If the hinterland around the river mouth is especially important, it is necessary to also examine water levels that take into consideration the probability deviation corresponding to the scale of the flood prevention plan.

1.3 Planar shape and longitudinal and transverse shapes of a river channel

1.3.1 Basics of the planar shape of a river channel

The planar shape of the project section requiring improvement shall be determined primarily on the basis of the planar shape of the current channel and in accordance with the directions in terms of flood control, water utilization, and environmental preservation. Discharge channels and cutoff channels shall be designed to have appropriate planar shapes in consideration of their effects on the surrounding environment.

Explanation

In general, river improvement works are carried out along the current river channel, taking into consideration the topography, land-use pattern, and difficulty of land acquisition along the current channel. Accordingly, the design planar shape shall be determined primarily from the planar shape of the current channel and in accordance with the directions in terms of flood control, water utilization, and environmental preservation.

In many cases it is more advantageous to determine a planar shape similar to that of the current channel in view of the need to preserve the natural environment. In cases where the area where the river is broadened has a valuable natural environment, however, a different planar shape needs to be examined, depending on the necessity. If the current river course is extremely tortuous, or has a crowded, large-scale residential area along it, it may be necessary to examine a planar shape that includes the construction of a new channel, such as a discharge channel or cutoff channel, etc. In such a case, several planar shapes shall be examined for combinations of the current channel and new channel. From among these, the optimal planar shape shall be selected through examination of topography, geology, current and future land use (note that area separation needs to be considered), administrative divisions or districts, irrigation and drainage canal systems, effects on groundwater, landside water drainage, effects on areas upstream and downstream of the project section, natural environment, landscape, economic efficiency, and maintenance after improvement, etc.

1.3.2 Normal line of the levee

The normal line of the levee (including sections of excavated river channels) shall be determined in a way that the necessary river width is secured in view of various factors, including the design high water discharge, riverside land utilization, natural environment, flow regime in times of flood, current river channel, future maintenance of the river channel, and economic efficiency, etc.

Explanation

The normal line of the levee defines the river width on the basis of which the planar shape of a river necessary for flowing the design high water discharge is determined. It is the most important condition that constrains the use of the landside area. Appropriate river widths vary depending on the water depth, gradient, and riverbed roughness, even if rivers have the same design high water discharge. They also differ depending on the status of the existing levees, the crowdedness of riverside residential houses, the natural environment and river utilization, and the land acquisition status. Therefore, the river width needs to be defined as part of a comprehensive examination of river channel planning. In the process of determining the normal line of the levee, the above-mentioned and the following points must be taken into due consideration:

1. The relationship with the natural environment typical of the subject river and the status of river utilization

shall be taken into due consideration, so that improvement and preservation of the river environment will be facilitated.

2. Even if the current river width is large enough in terms of discharge capacity, it is desirable, in general, to secure a width deemed sufficient to take advantage of the river's storage effect. Although it is the general rule that the flow volume reduction effect due to channel storage is not included in the consideration of the expected effects (because it differs depending on individual flood), this does not mean underestimation of channel storage effect.

3. Various factors such as the securing of levee safety, maintenance of the river channel flow against erosion and sediment deposition, etc. shall be examined in a comprehensive manner on the basis of the flow regime in times of flood. For flash streams, the normal line of the levee is usually defined as a nearly straight line. For slow streams, it does not have to be a straight line, but an extremely tortuous line should be avoided. In some cases, an appropriately meandering line may be used to limit the scope of the need for levee and river bank erosion control.

4. When choosing to use a meandering shape, the current river channel, hinterland topography and geology, and land utilization, etc. shall be taken into consideration, and attention should be given to avoiding locating areas with densely built houses and closure points of the former river at water-collision fronts.

1.3.3 Shape of a tributary confluence

The shape of a tributary confluence, as a general rule, shall be one that allows the tributary to smoothly join the main stream, and it shall be determined in consideration of the flow regime as well as the corrosion and deposition status of the confluence. This is not the case, however, if the design high water discharge of the tributary is much smaller than that of the main stream, thus having only a negligible effect on the confluence. In determining the longitudinal shape of the confluence, consideration should be given to the free migration of aquatic biota.

Explanation

At a tributary confluence, because (more than) two streams that are different in flow direction and velocity join, the flow regime is more complicated than that in a normal channel section. Consequently, this may cause a high flow velocity or the formation of dead water zones along levees, as well as large-scale corrosion and sediment deposition and upstream water level rises due to flow resistance. Therefore, as a general rule, a tributary must be made to join the main stream smoothly. This should stabilize the flood flow before and after the confluence and prevent riverbed corrosion and sediment deposition. This is not the case, however, if the design high water discharge of the tributary is much smaller than that of the main stream, thus having only a negligible effect on the confluence. In addition, since any difference in the level of the beds of the main stream and tributary at the confluence will interfere with free migration of aquatic biota, the longitudinal shape of the confluence shall be determined by taking the freedom of migration of aquatic life into consideration.

1.3.4 Longitudinal shape of a river channel

The longitudinal shape of a river channel shall be determined in relation to the normal line of the levee and the transverse shape of the channel and in consideration of the landside ground level, river environment, riverbed stability, and economic efficiency, etc. In general, the longitudinal shape of the current river channel shall be used as the primary determinant. For ordinary rivers, the riverbed slope is made steep to gentle from upstream to downstream, and consideration shall also be given to the groundwater level, the intake level of service water, and the foundation heights of existing important structures, etc.

Explanation

While the transverse shapes of a riverbed are not of even height owing to the action of flowing water, the longitudinal shape is, in general, determined from the average riverbed height of low water channels (riverbeds not including riverbanks when using single cross-sections), and its gradient is determined as the bed slope. The longitudinal shape of an ordinary river channel shall be determined from the longitudinal shape of the average riverbed height of the current low water channels in accordance with " Research on River Channel Characteristics" (Chapter 19 of the Research volume of the Technical Criteria for River Works [Proposed]). This is because using the current bed slope as a base, in general, is advantageous for future river channel maintenance unless local changes are in progress in the current river channel. It is important that due consideration is given to the foundation heights of important structures, the intake level of service water, the riverbed height of the main stream at the confluence (if the subject river is a tributary), the riverbed heights at points where bedrock is exposed, and the peripheral groundwater levels, etc. Since the longitudinal shape of a river channel is closely related to the freedom of migration for aquatic biota, as well as to the quality of habitat for plants and animals, such as riffles and pools, and to river utilization, etc., river environment factors such as the securing of longitudinal continuity need to be given sufficient consideration.

If it is necessary to partly change the bed slope, as in the case of a cutoff channel, the longitudinal shape shall be determined in consideration of the upstream and downstream bed slopes. When drastically changing the river regime, the longitudinal shape needs to be determined by taking into account the transverse shapes and in consideration of future river channel stability. For an ordinary river, it is the general practice to make the bed slope steep to gentle from upstream to downstream.

If there is a need for riverbed stability, groundsills etc. can be installed, depending on the riverbed status. In this case, the position and direction of installation shall be determined in consideration of the planar shape of the channel as well as the freedom of migration of aquatic life.

Because of riverbed deformation and partial deep corrosion etc. caused by flooding, the actual riverbed height may be lower than the average bed height of the low water channel assumed at the time of planning. For this reason, in deciding the longitudinal shape of the river channel it is important to pay adequate attention to long-term, local riverbed deformation and to determine the bed height needed for structure planning and designing. Especially, for the upstream and downstream areas of groundsills, deepening of embedment and foundation works for peripheral structures shall be examined on the assumption of possible bed deformation occurrence. A groundsill installation plan shall be established in accordance with Section 7 of this chapter. For

the examination of bed deformation, the description in "Sediment Load Research" (Chapter 14 of the Research volume of Technical Criteria for River Works [Draft]) should be useful.
In channels in mountainous land and upstream channels in alluvial fans where sediment yield is active, the riverbed may suddenly rise owing to sediment discharge caused by flooding. Although the occurrence of such a phenomenon is technically hard to predict, comprehensive countermeasures coupled with sediment discharge control by sediment and erosion control facilities needs to be examined on the basis of past experiences. The longitudinal shape of an estuary shall be determined in accordance with Section 8 of this chapter.

1.3.5 Transverse shape of a river channel

The transverse shape of a river channel shall be determined by taking into due consideration various factors such as the longitudinal shape of the channel and the topography, geology, river environment (including habitat for plants and animals), and riverside land utilization, as well as long-term local bed deformation. If there is a low water channel, the design position of the low-water channel bank shall be determined on the basis of the low water channel bank location needed for levee protection (levee protection lines), and, if necessary, the low water channel bank location needed for high-water channel utilization (low-water channel bank management lines).

Explanation

Since the difference between the minimum and maximum flows of rivers in Japan is generally large, compound cross-sections are usually employed for channel stability. In the long run, the transverse shape of a river channel naturally changes because of floods, etc., and local deep corrosion associated with the normal line and longitudinal shape may also occur. The transverse shape shall be determined and the river channel control facilities shall be planned and designed in due consideration of these points.
When a wide, flashy stream has several watercourses that fluctuate, in many cases it is impossible to clearly differentiate between the low water channel and high water channel from the viewpoint of channel maintenance. For a river with a small design high water discharge, the transverse shape is usually a single cross-section.
The "design transverse shape" does not mean that all elements of a transverse shape should be determined as planned items, but it identifies minimum necessary essentials such as the levee height and width, high-water channel height and width, and low water channel bank position, all of which are necessary for river management. It should be noted that the design transverse shape needs to take into consideration various factors such as riverbed deformation caused by natural force.
The transverse shape of a river channel is equally important for preservation of the natural environment, river utilization, etc., and the flow regime at normal times and at times of flood should be determined so that the transverse shape of the river channel that is appropriate in consideration of the effects of natural forces such as flowing water can be determined. If the ratio of the flow section to the cross-section within the set normal line of the levee needs to be relatively large, excavation of a low water channel bed, widening of a low water channel, or excavation of a high water channel shall be considered. Whichever is the case, an appropriate method needs to be employed by comprehensively examining various factors such as river channel stability, effects on river management facilities, river space utilization, and impacts on the river environment, etc. When low water channel excavation is necessary, the transverse shape of the low water channel to be formed needs to be designed

to take a riverbed or riverbank shape that is appropriate for preservation and restoration of riffles and pools as well as healthy habitat for plants and animals, as based on the original state of the river.

The setting of a low water channel is especially important when determining the transverse shape. In the relationship with the planar shape of the river channel, some sections of the channel are more vulnerable to bank erosion due to flooding than other sections, depending on the normal lines or whether they have sand banks. For wide, large rivers, lines for the purpose of levee protection (levee protection lines) and lines for the stabilization of the low water channel bank (low water channel bank management lines) shall be determined, and it is important to designate bank erosion prevention points in consideration of those lines as well as the current profile.

The purpose of levee protection lines is to protect a levee from destruction due to bank erosion caused by floods. Therefore, it is necessary to set these lines for all sections of the subject river that have levees. As a general rule, the positions of levee protection lines shall be determined in a way that the levee will not be endangered by a single flood event. In cases where a necessary high water channel width cannot be secured, bank protection (by, for example, the use of revetments) shall be applied.

Low water channel bank management lines indicate a section of a river where bank erosion needs to be prevented in order to secure the expected functions of the river channel in view of flood control, water utilization, and environment preservation, etc. They shall be set as appropriate for the purpose of low water channel bank stabilization. The location of a planned low water channel bank, as determined from the positions of levee protection lines and low water channel bank management lines, shall be set as the design transverse shape.

1.3.6 Low water channel width and high water channel height

The low water channel width and the high water channel height shall be determined in consideration of river channel maintenance, flood frequency of the high water channel, utilization, and preservation of habitats for plants and animals, etc.

Explanation

The low water channel width shall be generally determined with the emphasis on the current channel shape, and the high water channel height shall be usually determined through estimation that assumes a discharge capacity allowing one flood occurrence per several years. However, since high water channel utilization patterns are diverse and vary from area to area, it is necessary to take into consideration various factors such as importance of preservation and restoration of healthy habitats for animals and plants in the channel and surrounding areas, predicted future transition of vegetation, installation of structures, etc. in determining the low water channel width and high water channel height. While the high water channel height shall be determined based on the historical transition of the longitudinal as well as transverse shapes of the channel and flood frequency and in consideration of the low water channel width, it is not desirable, from the viewpoint of high water channel maintenance, to let the current velocity of the high water channel become excessively high in order to secure its stabilization at times of flood.

1.3.7 Installation of a levee-side riparian forest zone

A levee-side riparian forest zone shall be installed, if necessary, for a section in possible danger of severe damage caused by levee break or flooding.

Explanation

A levee-side riparian forest zone shall be installed to prevent levee break due to prevention of corrosion at times of overflow and to prevent widening of levee break caused by flooding flow at a time of levee break when the subject area is prone to serious damage due to levee break and flooding.

When installing a riparian forest zone, harmonization with the surrounding natural environment including vegetation and utilization of landside area shall be taken into consideration.

1.4 Estuary planning

In developing plans for an estuary, the longitudinal and transverse shapes shall be deliberately determined taking into due consideration both the river and sea conditions so that they satisfy the following conditions.

1. They are well capable of handling the design high water discharge, as well as storm surges and tsunami in case such events should occur.
2. Future maintenance is easy.
3. They do not interfere with water utilization around the estuary at times of low water.
4. Due consideration is given for the natural environment around the estuary.

Explanation

Plans for an estuary are roughly divided into river channel planning and planning for measures against storm surge around the estuary. A channel plan requires examination of the design high water level, longitudinal and transverse shapes, and measures against estuary closure (such as the installation of a guide levee, etc.) or estuary improvement measures. In cases where it is deemed necessary to consider measures against storm surges or tsunamis, such measures need to be consistent with storm surge measures etc. for the seacoast. Measures against storm surges include the installation of a tide gate at the estuary and installation of a dike for the designated high tide section. If a measure against storm surges is required, the most appropriate method shall be chosen through examination of the tide level, flood and wind wave characteristics, economic efficiency, method for estuary improvement, etc.

An estuary receives forces acting from both the river and the sea, and therefore overall consideration of both the river and sea conditions is demanded. In establishing a plan for an estuary, examination based on an appropriate survey shall be conducted in accordance with "Estuary Research" (Chapter 9 of the Research volume of Technical Criteria for River Works [Proposed]). With waves, flows, tides, and the presence of both freshwater and seawater, hydraulic phenomena and sediment movement around an estuary are extremely complicated physically, making it technically difficult to assess the effects and impacts of improvement works, etc. Consequently, river channel planning for an estuary requires examination based on adequate field surveys and in reference to the case of a similar river, and, if necessary, the conducting of a hydraulic model experiment and use

of a numerical simulation.
Although the river width at an estuary is considered to depend on the river flow, bed slope, bed material, and sediment load, etc., there is no definite rule on this point. The present conditions should be maintained to as great an extent as possible, unless river basin adjustment or some other significant changes (such as those in normal flow or low flow) take place. If there is a sand spit at the river mouth and maintenance of the river channel without the sand spit is presumably impossible; or if removal of the sand spit is expected to damage the protection function against wind wave and salt water invasion and bring serious adverse effects; or if the sand spit is playing an important role in the estuary ecosystem, then the sand spit should be maintained in its current condition, if at all possible, and longitudinal and transverse shapes that take the presence of the sand spit into consideration should be determined. Even if there is no sand spit at the river mouth, widening or bed excavation at the estuary must be avoided as much as possible, since this may adversely affect the maintenance and management of the estuary because of its function as a sediment deposition space. If widening or excavation is absolutely necessary, sufficient examination should be conducted to establish adequate measures.
The transverse shape of an estuary is usually determined from the transverse shape of a section slightly upstream, in an area that has river course characteristics identical to those in the estuary. When widening the current river mouth, however, the same considerations are required, because the widening is related to estuary maintenance.
Since an estuary has a river environment with the natural characteristics of a brackish-water region and a tidal flat, estuary planning needs to be harmonized with the local natural environment. However, because we have insufficient physicochemical and ecological knowledge of the environmental characteristics of estuaries, deliberate research and examination based on information on similar rivers, and past experience, are important.

Section 2 Cutoff channel and discharge channel

2.1 Cutoff channel and discharge channel planning

A cutoff channel (or short-cut) is a waterway constructed to short-circuit an extremely tortuous river course.
A discharge channel (or diversion channel) is a waterway that branches part or all of a flood midway along a river and discharges it to another river, back to the main stream, or directly to the sea.
In planning the construction of a new waterway such as a cutoff channel or discharge channel, an appropriate plan shall be established that ensures safe flow of the flood, taking into consideration various factors such as the environment of and around the new channel; the present and future social environment; the groundwater levels of the surrounding area; the quality of the groundwater; any irrigation and drainage canal systems; the landside water drainage, and post-construction river course maintenance, as well as impacts on the environments of the destination water body and the source river.

Explanation

1. Cutoff channel and discharge channel
Many large-scale cutoff channels were constructed in the past for large rivers that had numerous meandering and tortuous sections. Today, however, because the planar shapes of the major sections of large rivers have mostly been fixed as a result of river improvement endeavors, there are few cases of large-scale cutoff channel

construction. On the other hand, many cutoff channels were built until recently as part of river improvement works for extremely tortuous sections of medium-sized and small rivers.
Also, especially in large cities, the unavoidable use of tunnel structures to construct discharge channels because of topographic- and land-use–related constraints is not rare.
There are other cases of new channel construction, such as when moving a confluence to another location to reduce the effects of back water from the main stream, or to short-circuit the flood flow from the mountainous watershed of a tributary.

2. New channel construction planning

(1) The bed slope of a cutoff channel is steeper than that of the main stream owing to shortening of the channel extension. For a meandering river with a stabilized bed, bed stability will be lost. For example, increased current velocities in the upper reaches may cause corrosion, endangering upstream structures, as well as sediment deposition in the lower reaches, resulting in rises in water level.
For this reason, in the process of cutoff channel construction planning, the bed slope and trait of the river channel shall be determined and a plan for improvement of the transverse shape shall be established for not only the cutoff channel section but also the upstream and downstream sections that will be affected.
Therefore, if the need arises, investigations shall be conducted on the channel shapes of the short-cut section and the upstream and downstream sections to be affected, as well as on the bed slope, river structures, bed material, and bed fluctuation. The bed fluctuation based on the projected channel shall be predicted, and an optimal plan shall be developed through predicted corrections to the new channel and repeated prediction calculations.

(2) A discharge channel construction plan shall be designed in such a way that the flood discharge can be safely flowed and in consideration of the surrounding environment, social environment, groundwater level, groundwater quality, irrigation and drainage canal systems, landside water drainage, and maintenance of the new channel, etc. A thorough examination shall also be conducted into the possible impacts on the environments of the destination water body and the source river, and of the economic efficiency.

a) It shall be determined whether natural diversion or artificial diversion by the use of a structure such as a fixed crest weir or a water gate is to be applied. When a structure is to be installed, it shall be determined whether the structure is necessary on the main stream side, the discharge channel side, or both sides.
b) In terms of the longitudinal shape, as in the case of cutoff channels the discharge channel section is steeper than in the upstream and downstream sections; in many cases it has a larger bed fluctuation owing to differences in bed materials. Accordingly, a thorough examination is necessary when determining a method for reducing flood energy, and structural safety measures through embedment deepening etc. shall be examined with deliberation.
c) Although low water diversion is not commonly carried out in the case of a discharge channel used for high water diversion (in order not to limit the utilization of water in the main stream), river functions at normal times shall also be examined (for example, in the case of the need to convey water for purification in times

of high water).

(3) When cutting a new channel such as a cutoff channel or discharge channel, efforts should be made to prevent new landside water problems by taking landside water drainage into due consideration. To this end, it is important to gain sufficient knowledge and understanding of the existing discharge canal systems in riverside areas.
Measures for landside water drainage shall be developed for the leveed section such that the current drainability is not damaged. Also, if the condition of the upstream and downstream channels permits, excavated river channel should be planned, if this is at all possible. In this case, inflow from riverside areas along the new channel shall be included in the design high water discharge.
Furthermore, to avoid significant trouble, adequate surveys shall be conducted to predict any potential effects on groundwater level and quality.

2.2 River tunnel structures

2.2.1 Basics of planning

A river tunnel structure should not be installed unless it is unavoidable in light of topographic features or for other special reasons. The route shall be determined from surveys of topographic and geological conditions, overground land use, and underground installations and utilities, etc. The alignment of the river tunnel structure should not being extremely tortuous, if at all possible.
The current river course shall be maintained, except in cases where this is impossible for unavoidable reasons.

Explanation

Compared with ordinary rivers, rivers with tunnel structures present many more problems in terms of channel maintenance, such as cross-section occlusion caused by falling objects in times of flood. There are also management-related problems caused by human error, etc. For these reasons, when planning cutoff channel or discharge channel construction as part of a river course plan, it is desirable to avoid a plan that calls for the construction of tunnels. However, if the lower reaches of the river are urbanized, making adequate channel widening impossible, or if a diversion channel has to be installed through a built-up area, or if the topography does not permit the choice of an open channel, an examination, including a comparison with alternative plans, must be carried out. The examination must take into due consideration various factors, such as the possible effects of channel widening on urban functions etc., the urgency of the flood control project, the improvement of the river environment, constraints on construction, and economic efficiency, etc.
After the introduction of the tunnel structure channel, unless it is absolutely necessary to demolish the structure the current channel should be maintained so that the situation will not become worse than at present, even if the new channel becomes unusable for some reason. Securing of the current channel is also important in terms of preservation of valuable waterfront space in urbanized areas. Compared with other urban land uses, rivers in urbanized areas form spaces that are far superior in scale and continuity and richer in diverse environmental functions. Therefore, it is not at all desirable to demolish or reduce the size of the current channel simply for intensive land use after the construction of the tunnel structure channel.

2.2.2 Cross-section and longitudinal slope

The tunnel cross-section needs to be large enough to include, as a rule, a sufficient vacant area in addition to a sectional area necessary for the design flow.
The tunnel longitudinal slope shall be the most appropriate from the viewpoints of securing the flood control function, hydraulic stability, and maintenance.

Explanation

1. Cross-section

In the case of free-flow channel-type tunnels, driftwood, suspended debris, etc. can cause discharge failures, and high-speed currents cause reductions in air pressure. To compensate for this, a vacant area based on a value of not less than approximately 15% of the cross-sectional area necessary for the design flow shall be secured so that there is sufficient air supply to permit airflow.

In the case of penstock-type tunnels, the cross-sectional shape shall be determined in consideration of discharge capacity, aeration rate, negative pressure occurrence, cutoff performance, surging, and lining plans, etc., and an inverted arch shall be introduced, depending on the maintenance plans. In planning for the construction of a penstock-type tunnel, the details of its aeration conditions shall be determined through model experiments. If necessary, an appropriately expanded cross-sectional area shall be planned on the basis of the characteristics of the locality, including the presence of sediments, driftwood, and suspended debris. Furthermore, the intake or inflow should be shaped appropriately to minimize aeration, and infrastructure for air removal from inside the tube shall be implemented.

2. Longitudinal slope

An inappropriate longitudinal slope in the tunnel may cause sediment deposition in low-gradient sections. Therefore, the longitudinal slope needs to take into consideration the balance of scouring forces over the entire section.

Because the flow velocity inside a penstock-type tunnel is related to the hydraulic gradient and is not dependent on the waterway gradient, the longitudinal slope is normally determined from the viewpoint of tunnel maintenance.

If the residual water in the penstock-type tunnel after a flood is to be drained from a downstream pumping station, it is desirable to form the slope in such a way that the downstream side is down.

Section 3 Reservoir (Dam)

3.1 Flood control planning

3.1.1 Design high water discharge for dams

If the hydrograph for the dam location corresponding to the design flood determined in 2.7 of Section 2 in Chapter 2 of the Basic Planning part, and the dam location itself, are the design control points, the design high water discharge for the dam shall be determined rationally through examination of the peak discharge in the hydrograph and the flood control capacity of the dam location.

Explanation

The design high water discharge for a dam is the basic quantity of a flood control plan for the dam, and it shall be determined for each individual dam. Expected effects of the dam on the design flood of downstream design control points, those on the channel directly beneath the dam location, and the harmony with flood control facility planning for the entire river system shall be examined in a comprehensive manner.

The design high water discharge for a dam site, as a general rule, shall be determined on the basis of the hydrograph with the largest peak discharge selected from among the following:

1. The hydrograph with the largest peak discharge and the one with the highest flood control capacity for the dam location; these hydrographs are selected from among the hydrographs corresponding to the group used to determine the design flood.

2. The hydrograph with the largest peak discharge and the one with the highest flood control capacity; these are selected from among the group of hydrographs for the dam location obtained from the subject rainfall of the dam area.

3.1.2 Flood control method

A dam-based flood control method shall be selected from among methods that can ensure the expected flood control effectiveness of the downstream design control points in consideration of flood runoff characteristics, control efficiency, sureness of operation, and ease of maintenance, etc.

Explanation

The most certain and effective method of dam-based flood control must be selected in consideration of the river condition, hydrologic characteristics of flood runoff, storage capacity, outlets, purpose of control, control efficiency, sureness of operation, ease of maintenance, and channel improvement downstream of the dam, etc.

Dam-based flood control methods include the following:

1. Constant rate discharge method

When the inflow exceeds the flood control start-flow volume, this control method discharges a fixed rate of the inflow until the peak flow is reached, and a fixed volume after the peak flow is reached. A great control effect can also be expected for medium-sized and small floods. Generally, this method is suitable for rivers where the flood discharge from downstream of the dam constitutes a substantial portion of the flood discharge at the downstream design control point, or for rivers whose channels leave much to be improved.

2. Constant discharge method

Because this is a peak-cut method that discharges a fixed quantity of flood volume regardless of the flood hydrograph, etc., high control effects can be expected from this method. This is especially the case for rivers whose channels have been improved to a considerable level, although the control effect of this method is relatively weak for medium-sized and small floods.

3. Natural regulation method

This method does not usually use a flood control gate, or, even when it does use one, the opening of the gate is kept fixed and not operated for discharge control. Although a large flood control capacity is needed, because this method does not require human operation it is easy to manage and is used primarily for small-scale dams with fast release.

4. Adaptive release-rate method

This method is adopted when there is a time lag of discharge between the dam location and the downstream sector and control is needed, especially for the first or latter part of a flood, or when there is a need for storing maximum flow.

For small-scale dams (approximately 20 km^2 or smaller) or dams with a small flood control capacity (equivalent rainfall* of approximately 50 mm or less), it is desirable to adopt the adaptive release-rate method in order to avoid cumbersome gate operation. For dams with an equivalent rainfall of approximately 100 mm or less, adoption of the natural regulation method should be considered.

Although the adaptive release-rate method is superior in efficiency, it demands accurate prediction of flood hydrographs.

All existing dams were constructed in response to the flood control or water utilization needs that arose at the time of their construction. When multiple dams are constructed and operated within a single river system, operation of individual dams does not always result in optimal operation of a group of dams in the area. If the group of dams includes dams that are advantageous in terms of flood control and ones that are advantageous in terms of water utilization, depending on such conditions as rainfall or catchment area, better effects may be obtained by not just reconstructing them but also reallocating the flood control and water utilization capacities of existing dams and revising the administration rules, instead of operating the dams individually. The choice of flood control method for existing as well as new dams needs to be examined from this point of view.

*Flood control capacity / catchment area: represented in mm.

3.1.3 Flood control capacity

The storage capacity for flood control (flood control capacity) shall be determined on the basis of the hydrographs and the control methods applicable to flood control planning. An approximately 20% margin capacity shall be included.

Explanation

For optimized utilization of the limited storage capacity, if a preliminary release system (which maintains the flood control capacity by preliminarily releasing water to lower the reservoir level at the time flood occurrence is forecast) is to be adopted to secure the flood control capacity, a thorough examination of the sureness of the operation and the effects of the operation on the downstream sector should be conducted.

The flood control capacity of a reservoir, as a general rule, shall be determined by conducting flood control calculations for the hydrograph for the dam location corresponding to the group of hydrographs used to determine the design flood and the group of hydrographs for the dam location obtained from the subject rainfall of the dam area, then selecting the one with the largest control capacity needed

3.2 Other plans

3.2.1 Planning for sediment inflow control

A plan for sediment inflow control shall be established for the maintenance of a reservoir functions, comprehensive sediment management, and improvement and preservation of the river environment, etc., as appropriate.

Explanation

Measures for removal of sediment from a reservoir and the proper flow of sediment downstream without detriment to the original purpose of the dam are important for comprehensive sediment management.

To this end, if the need arises, a sediment inflow control plan shall be established. It shall take into due consideration impacts on the river environment as well as the life cycle cost by combining various measures such as the control of sediment inflow into the reservoir (installation of a sediment trap dam immediately upstream of the reservoir; stabilization of slopes around the reservoir, etc.); dredging and digging of sediment in the reservoir; and the installation of a sand-discharge pipe, a sand-trap scour gate, or a sand-discharge bypass

3.2.2 Planning for prevention of landslides around a reservoir

If necessary, appropriate landslide prevention works for land in or adjacent to the reservoir shall be planned in order to prevent landslides caused by the storage of flowing water.

Explanation

To maintain the functions of the reservoir and secure safety around the reservoir it is necessary to prevent landslides caused by the storage of flowing water.

For this purpose, landslide surveys shall be conducted around the reservoir in the investigation stage, as appropriate.

3.2.3 Planning to prevent leakage around a reservoir

If necessary, leakage prevention works for land adjacent to the reservoir shall be planned to protect the reservoir functions against leakage from the reservoir as a result of flowing water storage.

Explanation

Leakage from the reservoir to its neighboring land as a result of the storage of flowing water shall be prevented in order to maintain the functions of the reservoir.

For this purpose, geological surveys shall be conducted around the reservoir in the investigation stage, as appropriate.

3.2.4 Planning for private hydropower generation

Installation of a private hydropower generation facility shall be examined for the rationalization of dam management and the proper utilization of hydraulic energy resources from the dam.

Explanation

Electric power generated by private hydraulic facilities is used to run the dam maintenance facility, to power aeration drainage to preserve the reservoir water quality, and to power fountains in the reservoir. Also, the cost of dam management can be reduced by the sale of surplus power.

3.3 Environmental considerations

In dam construction planning, due consideration shall be given to environmental factors such as the water and soil regimes, healthy habitats for plants and animals, activities that bring humans into contact with the river, and burdens on the environment.

Especially, it is necessary to thoroughly examine how changes in the flow regime after dam construction may affect the lower reaches of the river.

In addition, on the basis of the natural and social environments of the basin, consideration should be given to preventing or reducing impacts on the environment and the creation of a new environment.

Explanation

1. The following items need to be considered in dam construction planning.

1) Preservation of the environment, including water and soil regimes

In dam construction planning, the following items need to be taken into consideration to prevent or reduce the possible impacts of the dam on the water and soil regimes:

- Changes in water quality, as indicated by indices of the water environment (e.g. turbid water by sediment, water temperature, eutrophication, amount of dissolved oxygen, hydrogen ion concentration)
- Modifications to the topography, geology, ground, and soil, and changes in groundwater

2) Preservation of healthy habitats for plants and animals

In dam construction planning, the following items need to be taken into consideration in order to preserve healthy habitats for plants and animals:

(1) Animals

- Modifications to major habitats such as breeding places of important species
- Destruction of migratory pathways of important species
- Modifications to noteworthy habitats
- Environmental changes in the habitats of important species and noteworthy habitats (environmental changes around the modified area, and changes in the bed material, flow regime, and water quality of the reaches downstream of the dam)

(2) Plants

- Modifications to the habitats of important species and communities

- Changes in the habitats of important species and communities (environmental changes around the changed area, and changes in the bed material, flow regime, and water quality of the reaches downstream of the dam)

(3) Ecosystems

a) Modifications and changes to remarkable species of high rank aspect

- Modifications to habitats such as breeding places
- Destruction of migratory pathways
- Changes in habitats (changes in the bed material, flow regime, and water quality of the reaches downstream of the dam)

b) Modifications and changes to remarkable species of typical aspect

- Modifications to habitats
- Changes in habitats (construction of a reservoir, changes in habitats due to sediment deposition in the reservoir, changes in the bed material, flow regime, and water quality of the reaches downstream of the dam)

c) Modifications and changes to remarkable species of special aspect

- Modifications to habitats
- Changes in habitats (change in groundwater level, environmental changes around the modified area, changes in the bed material, flow regime, and water quality of the reaches downstream of the dam)

d) Modifications and changes to remarkable migratory species

- Destruction of migratory pathways

3) Maintenance of places for activities that bring humans into contact with the river

(1) Maintenance of a good landscape

In dam construction planning, the following items need to be taken into consideration in order to maintain good landscapes:

- Degree of modification to major viewing points and landscape resources
- Major changes in appearance
- Considerations in regard to the topography, geology, and cultural assets

(2) Maintenance of places for activities that bring humans into contact with the river

In dam construction planning, the following items need to be taken into consideration in order to secure places for activities that bring humans into contact with the river.

- Degree of modification (annihilation, reduction) to places for activities that bring humans into contact with the river and natural resources
- Changes in the usability of places for activities that bring humans into contact with the river
- Changes in the amenity of places for activities that bring humans into contact with the river

4) Amount of environmental burden

A dam construction plan shall be established on the basis of the degree of environmental burden and in consideration of the following items:

- Amounts of construction byproducts (waste, recycling resources)

2. Securing of a flow volume necessary for the lower reaches downstream of the dam and changes in the flow regime are the basis for dam construction planning and need to be thoroughly considered in the planning stage.

- Changes in the bed material due to changes in the flow regime (armoring)
- Changes in flood frequency
- Sections with easy access to the water
- Migratory fish upstream
- Changes in underground water due to changes in river level

3. Not only the viewpoint of preservation of the environment but also the viewpoint of creation of a new environment needs to be considered in the planning stage.
   - Improvement of the water source area in harmony with the surrounding environment
   - Landscape design of the dam site
   - Formation of places for activities that bring humans into contact with the environment and that have been changed by the appearance of the dam site, quarry site, and muck-disposal yard.

Section 4 Retarding Basins etc.

4.1 Basics of planning

Planning for retarding basins etc. should consider the target landform, land-use situation, groundwater level, river situation, natural environment, river flow regulation condition, overflow frequency, economic efficiency, maintenance, etc.

Explanation

Retarding basins etc. are mostly established not only to decrease the downstream peak runoff by storing part of the flood waters but also, in flat areas, to perform some degree of water or effluent treatment prior to discharge into the receiving channel.

Types of retarding basins include those that surround the reservoir with a levee, a detention reservoir partition levee, or an overflow levee by taking advantage of natural landforms; those that ensure storage function by excavation of the land; and those that ensure the storage function of underground space.

It is necessary to consider using the space occupied by a retarding basin for other aims in addition to the aim of flood control. Especially, in planning a multipurpose retarding basin that has a reservoir function, Chapter 2–3 should be referred to.

4.2 Site selection for retarding basins etc.

Retarding basins etc. should be established in places where flood control at the target site is certain and the storage capacity is easily ensured.

Explanation

Although in many cases it is difficult to make an arbitrary selection of a retarding basin because of differences in geographic characteristics, it is desirable to establish the basin as close to the target site as possible in consideration of its flood regulation effect. However, the hydrograph of the target flood becomes progressively flatter with distance downstream, so a retarding basin in a downstream area will need to be more capacious than the amount that can be cut. Thus, its area will need to be increased because it cannot have a water depth as great as that of a reservoir in a mountainous area. Also, peripheral areas are conspicuously urbanized in downstream sites, and site acquisition becomes more difficult, so these factors must be comprehensively considered.

4.3 Flood control planning

4.3.1 Flood control facility planning

Control facilities such as retarding basins should be planned to have sufficient control function to have different effects for different purposes.

Explanation

Generally, unlike dams etc., in many cases these facilities have side overflows from river channels.

The items to consider in the control facility planning are given below:

1. Height and length of the overflow levee

Although the height of the overflow levee is directly related to the flow at the start of control, the height and length exert an influence on its control effect and control the figure of hydrograph after control, so the establishment of the overflow levee needs to be carefully examined in consideration of its control purpose.

2. River channel

River planning near an overflow levee needs to carefully consider the flow conditions in times of riverbed fluctuation or flood.

4.3.2 Flow at the start of control

The flow at the start of control should be determined so as to ensure the desired effect in consideration of the control effect and the characteristics of the flood runoff.

Explanation

The flow at the start of control is the one at the time inflow starts from overflow levees etc. into retarding basins etc. Considering this flow as large, or making the overflow levee high, can produce a large effect against the design-scale flood but is less likely to have a sufficient effect against a small or medium-sized flood. Conversely, making the flow small or the overflow levee lower can have a sufficient control effect against a small or medium-sized flood, but the control effect against the design-scale flood will in many cases tend to decrease. Thus, the flow at the start of control must be determined so as to ensure the desired effect in consideration of the control purpose, flood runoff characteristics, retarding basin capacity, etc.

Section 5 Weirs, Water Gates, and Sluiceways

5.1 Establishment basis

The establishment sites of weirs, water gates, and sluiceways (hereinafter called weirs etc.) should be selected

according to their own purposes. River bends, places with a small bed cross-section, and places with unstable river regimes should be avoided if at all possible, in comprehensive consideration of the aspects of flood control, beneficial water use, and environment. Also, these structures should be unified, when possible, to decrease the number of establishment sites needed.

Explanation

Weirs are classified into diversion weirs, final baffling weirs, and intake weirs according to their own establishment purposes, or into fixed weirs and movable weirs according to their structures.

Water gates and sluiceways are facilities with embankment functions that are established across a river.

In selecting establishment sites for weirs etc., besides the fact that these structures should be selected so as to sufficiently accomplish their aims, it is desirable to select a site with little velocity variation because of its straight stream axis and with little bed variation because of its stable stream axis. This is because the installation of, in particular, a weir, tends to cause disorder in the regime; the weir may act as an obstacle to water discharge in times of flood. Although some people think that the installation of a weir in a narrow stream may be profitable in terms of savings in construction costs, installation in such places must be avoided as far as possible because it requires special consideration of safe flow during flood or because the weir itself will be a condition constraining the riverbed in the future.

Planning for the installation of weirs, etc., should comprehensively consider the direction to be taken in terms of flood control, beneficial water use, and environment on the basis of the natural and social environments of the site of concern and their historical development. It should also examine the advantages, effects, and influence on the water and soil environments, the habitats and growing environments of living things, the landscape, and places for activities that bring humans into contact with the rivers, so that the most suitable project is chosen.

Structural objects such as weirs etc. may be weaknesses of embankments; it is also desirable to decrease their numbers in consideration of their maintenance, so their unification needs to be attempted as far as possible.

Additionally, in the case of planning for the installation of multipurpose weirs for their reservoir function, see Chapters 2 and 3.

5.2 Weir flooding level

The weir flooding level should not only be at least 50 cm lower than the height of the flood plain; it should also be the same amount lower than the inland ground level.

However, this is not the case when proper measures such as fitting etc. are taken.

Explanation

When the site and design flood level of a weir are specified, it is necessary to sufficiently consider changes in the groundwater level and such problems as ill-drained inland. In some cases, owing to the topographic conditions etc., it will be necessary to take appropriate measures such as embankment in the inland ground or flood plain.

5.3 Fishways in weirs

When there is concern that the establishment of a weir could hinder the movements of fish up and down the stream, a fishway should be installed.

Explanation

To minimize the effect of the establishment of a weir on the habitats of fish etc., it is desirable to install a fishway for those fish that run up and down the river. Target fish not only include hat are considered important resources.

The fishway plan should specify the target flow, water level, placement and so on so that the target fish can run up and down the river and may not erratically enter the weir. It should consider the flow condition of the target site, the extent of water level fluctuation on the downstream side of the weir, the time at which and the course over which each target fish runs up and down, the manipulation of intake and discharge from the weir, etc.

Section 6 River Projects for Flow Regime Adjustment

Rivers requiring flow regime adjustment could be connected to two or more other rivers. Adjustments may be needed for flood treatment; for conveying water to maintain flows by using the rivers' mutual residual discharges; for the development of new water uses; and for conveying water developed by other facilities.

To designing proper projects, the planning should examine the effects on the environment of the sites to and from which water is conveyed. It should also consider the environment within a new river and its surrounding environment, its present and future social environments, the level and quality of the surrounding groundwater, the irrigation and drainage system, and the landside water drainage control.

Explanation

When a river requiring flow regime adjustment is related to a reservoir facility such as a dam, it is necessary to show their mutual supply relationship during the actual preparation of the project so that the amount of developed water does not overlap.

Also, in specifying the amount of raw water conveyance sufficient research must be done to ensure that the normal discharge or water use of the river from which the water is conveyed is not disturbed.

Section 7 Channel Control Facilities

7.1 Basis of a channel control facility design program

In planning facilities to control embankment or riverside erosion and riverbed scour or sedimentation, the facility type, the normal line of the embankment to be established, and the establishment site and its extension should be decided on, giving sufficient consideration to long-term or local riverbed variations. These decisions should be based on channel longitudinal and cross-sectional profiles, channel characteristics, flow conditions such as flooding, and soil properties, river environments, etc.

Explanation

Facilities that control embankment or riverside erosion and riverbed scour or sedimentation need to take into account variations in river characteristics such as erosion, scour, and sedimentation on the basis of the longitudinal and cross-sectional profiles, channel properties, and flow conditions (e.g. during flood) in the target river section. At the same time, for a full understanding of the characteristics of each potential facility, each one needs to be examined, as do the combination of facilities to be established, the establishment site and its extension, etc.

It is also necessary to attempt to maintain a desirable channel for the river environment, by fully examining the advantages of the channel or its influence on the river environment and considering the fact that variations in the river's characteristics have a close relationship with the river's natural environment.

Channel control facilities include revetments, bed groins, consolidation work (bed girdles and drops), etc. In selecting the facilities it is necessary to understand the characteristics of these facilities sufficiently and to select one facility or some facilities in combination that is/are the most economical and suitable for the channel control aim. Especially because river channels change locally and secularly, it is necessary to gain a sufficient understanding of their characteristics so as to plan each facility. Also, the establishment of a facility should be fully catered for from the perspective of security in times of flood or of river environmental conservation, because it is likely to promote the erosion of the surrounding riverbed and sides. The functions of such structural objects in river channel planning, or their effects on the river environment (especially in small and medium-sized rivers) are large, so it is necessary to plan proper structural objects in reference to past experience, the conditions in similar rivers, the literature, and so on.

7.2 Revetment planning

Revetments are established for the purpose of protecting dikes etc. (landside areas in the cases of excavated channels) from erosion by flowing water by the use of flood planes and structural objects. In the installation of revetments, their necessity (and the sites for their establishment) and their normal lines and extensions should be specified with a good grasp of the channel cross-sectional profile, including the flood plane width, flow conditions in times of flood, water route variation, etc. Also, since bank protection is strongly associated with river environment improvement, revetment installation should consider the conservation and restoration of a good habitat and growing environment for living things and the maintenance and formation of a good landscape and places that bring humans into contact with the river.

Explanation

Revetments, commonly constructed by sediment, are established according to need to prevent dikes from being eroded by flowing water. However, since revetments that are often established in places such as river edges important to the natural environment of the channel have a strong relationship with the river environment, the need for their construction should be sufficiently considered. Additionally, the plan should be suitable for the conservation and restoration of a good habitat and growing environment for living things and the maintenance and formation of a good landscape and places that bring humans into contact with the river by letting the facility work together with the flood plane and groin. It is important to seek economical bank protection works that fully

consider the river environment by taking an inventive approach in accordance with the river's characteristics. Revetments are classified into high water revetments to protect the dike's front slope and low water revetments to protect the river side of the flood plane or the landside ground of an excavated channel. An integrated combination of high water revetment and low water revetment is called a levee revetment. The revetment planning should consider the flood velocity near a levee or riverside, flood plane width, water route secular change, etc., and should specify the work type, the establishment site, and any extension. Also, note that the establishment of a revetment moves the water-collision front downstream in many cases.
Meanwhile, it is desirable to make the normal line as smooth as possible; this is determined by the trait profile of the revetment, because a high water channel revetment is established along the trait of the revetment. Whereas the normal line of a high water channel revetment should be the one that is suitable for the flow direction of high and low water, it should be determined with sufficient consideration of the width of the flood plane and of the river environment. (See "1.3.5 Channel cross-sectional profile.")

Additionally, the necessary revetments should be established above and below a structural object such as a bridge, sluiceway, water gate, weir, consolidation work, etc., in accordance with the Cabinet Order concerning Structural Standards for River Management Facility, etc. and the associated Ministry of Construction Ordinance. It is desirable to make the configuration of these approach revetments as smooth as possible so that they cannot cause the formation of vortices and dead water zones.

7.3 Groin planning

Groins are constructed along with flood planes and structural objects to protect embankments (landslide areas, in the case of excavated channels) from erosion by flowing water. Also, they are sometimes established to ensure a navigable route or to improve and conserve river environments. Groin planning should sufficiently consider the effects of the groin on the habitat and growing environment of animals and plants; the landscape; the flow capacity; and the areas upstream, downstream, and on opposite sides of each groin, on the basis of the plane and longitudinal and cross-sectional profiles of the river, the channel characteristics, and the river environment.

Explanation

Since groin planning is closely related to river channel or revetment planning, it is necessary to prepare different plans for different channel characteristics and purposes, taking note of the mutual relationship, while considering their effects on the upstream, downstream, and opposite sides of each facility and the improvement and conservation of the river environment.

The differences between revetment and groin are described below:

1. A revetment, which directly covers the riverside to prevent erosion, facilitates the accomplishment of its aim.
2. The groin aims to indirectly protect the riverside by its water-rejecting and velocity-decreasing effects, so if its placement and construction type are not properly decided on, then in some cases it cannot achieve a sufficient effect.

3. Proper groin installation can narrow the river and thus increase the river depth when the water is at normal flow levels.
4. Since the groin approach to a revetment and its downstream side are likely to be eroded by complex flow in times of flood, these areas will need attention.
5. Note that the space between groins, on which sediment is deposited, can be a good habitat, breeding site, or shelter for water creatures such as fish, as well as a good growing environment for plants.

As described above, since a groin has a riverside protection function and landform and river water control function that differ from those of a revetment, it is necessary to plan the installation etc., sufficiently in consideration of the required flood control effect and the advantages of, and influence on, river environment improvement and conservation.

7.4 Consolidation work planning

Consolidation works, which are conducted when unavoidable for riverbed stability, should be planned in sufficient consideration of their effects on the surrounding riversides and river control facilities, as well as on maintenance, fish runs, etc.

Explanation

When a riverbed is eroded and lowered by flowing water, the revetment foundation floats up, causing dangerous conditions for flood control. In addition, the lowered riverbed makes it difficult to take all sorts of service water. In this case, so as to maintain the riverbed as high as is required for river control, and to stabilize it, a groundsill is installed across the river. The groundsill has a significant effect on the river environment, and the stability of the surrounding riverbed should also be sufficiently considered, so it is desirable to avoid installing the groundsill if at all possible. The groundsill interrupts the continuity of water flowing upstream and downstream and thus blocks fish from moving up and down. Therefore, in the establishment of a groundsill, consideration should be given not only to meeting the need for fish to move up and down by careful consideration of its structure and the installation of a fishway, but also to its future maintenance.

7.5 Fishways for groundsills

When there is concern that the construction of a groundsill will have a significant effect on fish movements, a fishway should be established.

Explanation

To decrease the effect of the establishment of a groundsill on the habitat of fish etc. as far as possible, it is desirable to establish a fishway for fish that need to move up- and downstream. Target fish should not only include those that are considered important resources.

The fishway plan should determine the target flow, water level, installation, etc., in sufficiently consideration of the stream flow conditions at the target site, the range of water level variation above and below the groundsill, and the time at which, and the course whereby, each target fish species moves up and down the river.

Section 8 River mouth Improvement

8.1 River mouth improvement planning

River mouth improvement planning should seek to maintain a balance with nature, sufficiently considering both the river and sea conditions, allowing floods to flow in safety against river-mouth closures etc., preventing disasters caused by flood tides, and increasing river utilization as the occasion demands.

To specify an estuary improvement plan, the following items should be considered:

1. Functional and economic balance over the whole channel plan
2. Avoidance of disturbance of navigation etc.
3. Future maintenance kept as easy as possible
4. Avoidance of second damage through loss of the natural balance between estuary and sea (due to sediment supply from the river to the seashore)
5. Avoidance of damage to good habitats or growing environments for the animals and plans of the estuary or its adjacent sea, good landscapes, and good places that bring humans into contact with the river.

Explanation

River mouth improvement is roughly classified into channel planning at the river-mouth and storm surge control. The channel plan should examine the methods that are used for estuary improvement, specifying the design high water level in the river-mouth, giving details of any excavation and dredging of the river-mouth part, and including measures, such as the use of jetties, to deal with rivermouth closure.

Because the river mouth, as the boundary between sea and river, is influenced by both, its management becomes complicated, unlike that of the upper reaches of the river.

In some estuaries, a sand spit develops at the river mouth and hinders the free flow of water. This phenomenon is called river-mouth closure, and it causes different problems depending on the type of closure. These problems are roughly classified as follows:

1. Since the depth and watercourse cannot be stable at the river mouth, navigation becomes difficult.
2. At the river mouth, silting of the harbor can cause problems of unreliable arrival of vessels because of insufficient depth.
3. Flood discharge is blocked.
4. Poor drainage occurs in the hinterland of the river mouth.

Methods of removing the problems caused by river-mouth closure are:

1. Jetty
2. Water gate, blind ditch, and detached breakwater
3. Artificial canalization.

Consideration should be given to the maintenance of the rivermouth improvement plan under complicated external forces such as seasonal changes in river flow or tide.

In the actual estuary improvement, it is necessary to give sufficient consideration to important factors such as saline wetlands, tidal flats, and brackish-water regions, and to the effects of coastal drift sands and saltwater intrusion, so as not to cause heavy damage to the natural balance at the river mouth.

Also, in the examination of the river-mouth improvement planning, it is important to understand the behavior of any sand spit at the river mouth under normal water levels or in times of flood. Additionally, the phenomenon should be examined by hydraulic model testing and numerical simulation, as the occasion demands, to check the planning.

8.2 Selection of rivermouth improvement methods

The methods used for rivermouth improvement should be determined in consideration of river characteristics such as flow changes, adjacent sea characteristics such as sand drift tide flows, the natural environment at the river mouth, economic efficiency, future maintenance, etc.

Explanation

At the river mouth, where various phenomena that happen in both river and seacoast simultaneously or separately interact with each other to make it a very complicated place, it is not easy to simply select and plan measures and construction methods for rivermouth improvement. Thus, in designing facilities, it is necessary to fully consider their effects on the river mouth.

The construction methods used for rivermouth improvement include jetty, water gate, blind ditch, detached breakwater, artificial canalization at a shore bar, etc.; these are described below.

1. Jetty

Jetties should be planned so that their different functions for different purposes can be fulfilled or so that their effects on the adjacent seaside can be reduced as much as possible.

(1) Functions of jetties

Although the functions of jetties, i.e.

a. Fixation of the site of the river mouth
b. Stabilization of the water’s course
c. Maintenance of rivermouth depth
d. Lowering of the water level, both at times of normal water level and in times of flood

are referred to here, in planning a jetty it is necessary to design it to serve its purpose.

(2) Length of the jetty

Although the length of a jetty differs depending on the purpose of the rivermouth improvement and the scale of the river mouth, it is generally possible to state the following.

When the rivermouth position has not drifted and the opening position is fixed within the channel width, it is necessary to install two jetties from the shoreline at the time of normal tide into the sea, extending across the width of the channel, in consideration of the seasonal change in the shoreline. When only one jetty on one side is installed, it is extended to some extent into the sea so that the water's course can be fixed, even if the jetty is installed either up- or downstream of the prevailing direction of longshore sediment transport.

When the river mouth has been deepened considerably and the width of the opening maintained, it is necessary to project two jetties into points in the water that are at considerable depth. The results of examinations of the depth and bed fluctuation of jetty apical points in all class A rivers across the country show that if the apical point depth of the jetty is 4 to 5 m in rivers facing the open sea, the depth can be almost ensured; if it is 2 to 3 m, then the mouth will become shallow; and if it is less than 1 m a bar will develop.

The foundations of a jetty should be attached to the bank or, in principle, to the revetment, if one exists. In the case of natural seacoasts and a middle jetty, it is necessary to extend the foundations in the direction of the channel to a position where waves cannot reach the back of the foundations in times of flood.

(3) Interval between two jetties

When rivermouth closure is prevented, the narrower the interval between the two jetties, the greater the tractive force and its resultant flash effect. However, from the viewpoint of flood discharge, a narrow width raises the water level at the river's mouth and sometimes causes problems with channel planning, so it is necessary to specify the rivermouth width on the basis of changes in the water level at the river mouth and the results of an examination of the relationship between jetty interval and the bed height in the jetty interval.

(4) Direction of the jetty

In principle, the jetty should be made perpendicular to the shoreline. However, it does not matter if it is curved gently or is angled offshore. If it is curved sharply, the main stream will bump into it in times of flood, causing problems such as deep excavation. Also, if the direction of the jetty is largely bent toward the shoreline, then the waves reflected by the jetty will cause the shoreline to back away in some cases.

River with large sediment discharges supply the discharged sediment in only one direction, changing the sediment balance at the beach near the river mouth, so sufficient countermeasures are required.

(5) Height of the jetty

The jetty needs to be at least 1 m higher than the highest bar height so that waves cannot get over the jetty's dam crest and take sand into the channel. Where there is large amount of sand drift by wind, it is also necessary to prepare countermeasures against the blown sand. In terms of the height of the tip of the jetty, even if wave overtopping is permissible, it is generally specified to be at least 2 m than high water in many cases.

(6) Width and construction of the jetty

The width of a jetty is determined by its construction. It should have such a strong construction that it cannot be broken in times of flood, and it should be equipped with foot protection and wave dissipation works, as the occasion demands. Impermeable construction is effective because it is more likely to facilitate fixation of the river mouth's position and can prevent sediment translation. However, a permeable jetty can have the same effect if its width is enlarged and void is lessened.

2. Water gates

When a water gate is planned, care should be taken that the discharge capacity is enough for flowing the design flood.

A water gate is established to maintain the river mouth by the effect of flashing and to minimize corrosion of any construction facade by waves. Additionally, in many cases the gates are likely to have a combined purpose of preventing saltwater, waves, and high water from entering and maintaining water levels.

Whether the sand spit at river mouth is flashed by the addition of a gate needs to be judged by using the degree of flashing of the bar in times of flood without a gate and by referring to an example of a river of the same scale and grade scale of beach material as the target river. Model experiments are useful for examining this. Also, at a beach where the shoreline changes sharply it will be necessary to give sufficient consideration to where the gate is to be established.

In the case of many small rivers, a water gate is established with a pump slightly up from the river mouth, which doubles as pump drainage.

3. Blind ditch and detached breakwater

A blind ditch built to pass through a sand spit should be planned to fulfill its function of discharging river water into the sea almost without relation to the fluctuation of the sand spit at the river's mouth.

This construction method is mainly applicable to inner water discharges in small rivers. In rivermouth improvement, a single blind ditch is more effective if is combined with other constructions, such as a water gate at the upstream end to boost the flash effect against sedimentation within the blind ditch, or a detached breakwater to reduce the height of the waves reaching the periphery of the river mouth and make the height of the sand spit, behind which the blind ditch is constructed, lower, etc.

(1) Direction of establishment of the blind ditch

In principle, the blind ditch should be placed perpendicular to the shoreline of the beach, with the exception of cases with special conditions in which the length of the ditch itself can be the shortest possible and thus its construction cost the least. The opening of the blind ditch is curved so that waves cannot directly invade it. At beaches where longshore sediment transport dominates, the opening of the blind ditch should be directed toward the downstream side of the sediment transport. When the longshore sediment transport changes in accordance with the fluctuation in wave entry angle, it is desirable to place two or four trains of blind ditches, with their openings at both ends.

(2) Length of the blind ditch

The upstream end of the blind ditch should be placed at the upstream side of the beach, which is not influenced by wave run-up. The higher the blind ditch foundations, the better for sedimentation prevention within the ditch.

The tip of the blind ditch should be placed in a position where the opening cannot be buried, in accordance with the shoreline fluctuation. When the upstream channel bed of spit sand is too low to make the blind ditch higher, the tip will need to be extended far into the water, where it can be higher than the sea bed. Then, in the absence of a large difference between the river water level and tidal water level in times of flood, it will be necessary to take care that the blind ditch is not flashed by the sediment within it. Also, the tip of the blind ditch will be scoured conspicuously by waves, so sufficient countermeasures need to be taken. In extending the blind ditch into, especially, a sandy beach with a steep slope, the downstream side of the sediment transport will be eroded, so it will be necessary to give sufficient consideration to this point in the planning stage.

4. Artificial bar open-cut methods

Artificial bar open-cut methods should be planned with sufficient consideration of the need for long-term maintenance and the effects of the bar on the natural environment of the river. They have the following purposes:

(1) To ensure the depth and width of a river by a large-scale excavation at the river mouth

(2) To prevent the water level at the river mouth from rising by open-cutting part of the sand spit at the river mouth, thus facilitating flashing of the bar in times of flood.

The method of ensuring the cross-sectional area of a river by large-scale excavation at the river mouth is suitable for case such as inland seas, in which there is little sedimentation at the river mouth because of the relatively small wave action. At river mouths where wave action is strong and sand drift causes the riverbed to rise, it is necessary to use it and a jetty at the same time. Because, with this method, sand drift is discharged from the river by wave and sediment action, it is necessary to consider the degree to which the excavated channel can be maintained. Also, since such a large-scale excavation will lead to erosion of the surrounding beach, it will be necessary to take countermeasures, such as supplying the excavated sediment to the eroded beach.

The artificial open-cut is designed to facilitate flashing of the rivermouth bar in the early stages of a flood by making the bar crest height of the whole, or part, of the bar lower than that under natural conditions. However, in the case of flood due to typhoons, as on the Pacific coast, the bar open-cut part is soon filled in by the swell before the flood, so it is quite difficult to execute this method in large rivers.

When bar open-cut is included in the plan for rivermouth improvement, the open-cut part needs constant supervision. If a large change is caused by wave action, then it will be necessary to promptly maintain it so that its height and cross-sectional profile can remain the same as the design height and cross-sectional profile.

Section 9 Super broad levee with multiple functions

9.1 High-standard embankment installation section

In the selection of a section requiring the installation of a high-standard embankment, it is necessary to determine a series of sections, comprehensively considering past major floods and high waters, the disaster states that resulted, and the meteorological, topographic, geographic, and developmental conditions of the basin and region in which the disaster needs to be prevented. It is also necessary to take into consideration the balances between upstream and downstream and between the right and left sides of the river in order to prevent catastrophic damage due to the breaching of dikes.

Explanation

Although an embankment should be improved so that its structure is safe against the normal action of a flow whose water level is less than the design high water level, flood is caused by natural phenomena such as rainfall, etc., so there is usually a possibility that a flood that exceeds the design high water level will occur. When such an excess flood occurs, there is an increased risk of the occurrence of a very severe disaster due to dike breaching as a result of overflow, etc. A breach in a dike that protects, especially, a large city with a very dense aggregation of population and property, and with central administrative functions, etc., will not only do enormous damage to the area but will also greatly shock the society and economy of the whole country.

For this, high-standard embankments should be developed such that they cannot be breached by excess flooding that may occur beyond the design, even if channel development has been completed. The river channel plan should determine the section in which such excess flood countermeasures need to be taken.

The high-standard embankment planning should determine the sections where these embankments need to be installed and then develop them. To determine these sections, the following items should be sufficiently considered:

1. The states of accumulation of population, property, etc. within the flood prone area
2. The level of social and economical effects that dike breach would have on the whole country
3. The damage pattern, as estimated by the relationship between the design high water level and the landform of the design flood area
4. The trend in land use along the river.

In an embankment section that may be damaged by a flood occurring in the same area if the dikes are breached from one cliff-and-wood–surrounded section to another, or from a cliff-and-wood–surrounded section to the river mouth, it will be necessary to decide on the high-standard embankment section as a series of sections.

Also, conventionally, river embankments etc. should be constructed by balancing the upstream and downstream areas or the right and left sides of the river. The high-standard embankment section should be determined such that the opposite side or downstream side of the section, along which an embankment against excess flood action is established, has an embankment structure that is similar in principle.

9.2 Height of high-standard embankments

The height of a high-standard embankment should be as prescribed by the Cabinet Order Concerning Structural Standards for River Management Facilities, etc.

Explanation

Usually, the height of an embankment should be prescribed chiefly for two purposes: 1) to ensure an appropriate allowance against a temporary rise in water level by wave, swell, and jump at times of flood in order to prevent overflow less than the design high water amount; and 2) to ensure an appropriate allowance to meet various needs such as river patrol in times of flood, security for flood control activities, countermeasures against woody debris etc. High-standard embankments should not only fulfill the functions that normal levees have, but should also be able to stand up to a flood action whose height exceeds the design high water amount.

Also, high-standard embankments are commonly developed not in succession but separately in many cases in combination with urban development, park improvement, farmland consolidation, etc. It is therefore necessary to develop them so that their structures can be coherent with those of the normal embankments near them. Also, even after a series of sections have been completed, cutting down their height is not desirable in terms of their coherence with the height of other downstream and upstream embankments, so the high-standard embankments will need to be as high as the height prescribed by the Cabinet Order Concerning Structural Standards for River Management Facilities, etc.

9.3 Backwater sections of branches flowing into sections where high-standard embankment is to be installed

In the backwater section of branches flowing into the section where the high-standard embankment is to be installed, the excess flood countermeasures needed will nearly equal those at the confluence of the main river.

Explanation

In times of excess flood, when backwaters occurs in a branch flowing into the main river in an area where a high-standard embankment is to be installed, breaching of the dike of the branch by the backwaters will lead to the same damage as that in the main river. In other words, the embankment of the backwater section of a branch fulfills the function of the embankment of a main river and must similarly be able to stand up to excess flood action.

This, however, does not apply to such a section that can prevent backwaters from building up through facilities to control backward flow, such as water gates etc. In this case, a water gate or sluice established as a facility to prevent backward flow fulfills the embankment function of the main river, so it must be able to bear the excess flood action.

Also, when a backwater levee is applied, since it is assumed that the impact extent of excess flood can reach the point at which the main river high-standard embankment design water level (see 3.1.3 of Chapter 1 in the Design volume of Technical Criteria for River Works [Proposed]) is about to catch up with the design water level of the branch, in the branch facility planning, etc. it will be necessary to give sufficient consideration to the sections beyond the backwater section.

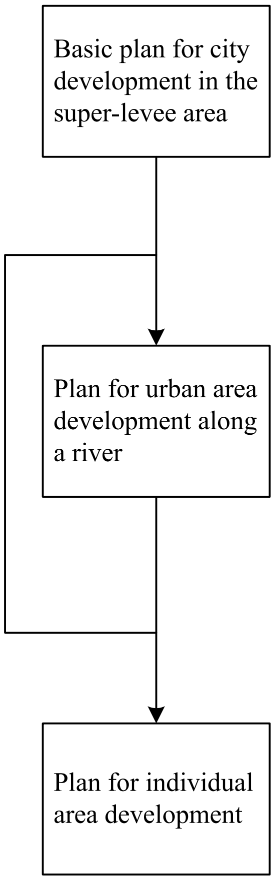
9.4 Adjustment for projects associated with regional management

The high-standard embankment is based on normal land use, which is often developed in combination with urban development, park improvement, farmland consolidation, etc. It will therefore be necessary to make sufficient adjustments to suit any regional management projects along the river.

Explanation

A high-standard embankment is developed without acquiring land, except in cases in which it is necessary for river administration, in anticipation that most of the site will be subject to normal land use. It is therefore essential to develop the embankment consistently with the trend in urban development of the concerned area. Thus, there will be a need for active involvement in coordination among the relevant organizations and bodies at the preparation stage of planning for regional management. Urban development, especially, often takes a great deal of time to be actually started, so it will be necessary to work with a coalition of local authorities' city planning departments to make a "basic plan for city development in the super-levee area" as a master plan for the high-standard embankment. The basic plan should decide on the river embankment's master plan and the particulars concerning the local regions to preferentially promote improvements on the basis of the city planning and urbanization trend in the target area.

Also, in terms of the area in which preferential improvement is decided on by the basic plan for city development in the super-levee area, when local authorities formulate a "plan for urban area development along the river" in relation to the high-standard embankment and urban development in consultation with river administrators, the high-standard embankment should be developed on the basis of this plan.



- The basic plan will concern the integrated development of the high-standard embankment and the urban area along the river
- It is drawn up by committees set up in every prefecture or every river area
- It is made on a conjoint basis at least between river administrators and local authorities
- It should specify the master plan for development along the river and areas in which the development should be promoted preferentially

- This plan is drawn Up for areas suitable for urban development integrated with a high-standard embankment, it concerns areas in which preferential development is prescribed by the basic plan for city development in the super-levee area
- Local authorities should draw up the plan in consultation with river administrators
- It should specify the section in which integrated development should be attempted, the land use policy, the installation of main city facilities, the policy of project execution, the plan for project implementation, etc.

- This plan should be drawn up in corporation with landowners and constructors of urban development project
- IT should specify The longitudinal and cross-sectional profiles of the areas of concern, as well as the implementation schedule, cost burden, etc.

Fig. 2.1–2 Steps in drawing up the plan to enforce the high-standard embankment and urban development in an integrated manner

References

1) Japan Institute of Construction Engineering. *Manual for River Planning Consideration*,. Ed. Japan Institute of Construction Engineering. February, 2002.

2) National Association of Disaster Prevention. *Basic Policy for Disaster Restoration to Protect Beautiful Mountains and Rivers*, June, 2002.

3) Japan Institute of Construction Engineering. *Dynamic Revetment Design Method*. Ed. Japan Institute of Construction Engineering. February, 1999.

4) Japan Institute of Construction Engineering. *The Research and Countermeasures of Landslide around Reservoir*. General Edition. River Bureau of Ministry of Land, Infrastructure and Transport. July, 1997

5) Kashima Laboratory of Public Works Research Institute, Ministry of Land, Infrastructure and Transport Japan. 'River Mouth Improvement Theory [I].' *Public Works Research Institute Document* 1395, May 1977.

6) Japan River. *Revised Description and Cabinet Order concerning Structural Standards for River Management Facilities, etc*. Ed. Japan Institute of Construction Engineering, November, 2001.

7) River Study Room of Public Works Research Institute, Ministry of Land, Infrastructure and Transport Japan. 'One Dimensional Analysis for River Bed Variation' ISSN0386–5878, P*ublic Works Research Institute Document* 3099, March, 1992.

8) Japan Society of Civil Engineer. *The Collected Hydraulic Formulas (1999 Version)*. Ed. Japan Society of

Civil Engineers' Hydraulic Council, Hydraulic Formula Revision Subcommittee. May, 2000.

9) Japan Institute of Construction Engineering. *Manual for Urban River Planning: Steric River Facility Design Edition.* Ed. Japan Institute of Construction Engineering. April, 1995.

10) Foundation for Riverfront Improvement and Restoration. *Project for Creation of Rivers Richly Endowed with Nature in Medium and Small Size Rivers*. Ed. Study Group of Project for Creation of Rivers Richly Endowed with Nature in Medium-sized and Small Rivers. October, 2000.

11) Water Resources Environment Technology Center. *A Discussion of Analytical Forms of the Environmental Effects on the River Project Planning Phase*. Ed. Exploratory Committee concerning Analytical Forms of the Environmental Effects on the River Project Planning Phase (River Planning Division, River Bureau, Ministry Land, Infrastructure and Transport Japan). December, 2002.

Chapter 2–2 Drainage Facilities for the Inner Water

Section 1 General Information

An inner water drainage plan shall be established in due consideration of the characteristics of the landside water in the subject landside river basin and past disasters caused by landside water.

Explanation

An understanding of the landside water characteristics in the subject landside river basin and of past disasters caused by landside water is indispensable for the establishment of an inner water drainage plan. Landside water characteristics in the narrow sense mean the characteristics of the landside water phenomenon itself, but in the broad sense they also mean the presumption of possible causes of the landside water flows. To fully elucidate the landside water characteristics, it is necessary to not just determine the current characteristics but also their historical chronological changes, as well as the causes of such changes. For example, if a constantly high outer water level is the cause of landside water flooding, improvement of the landside river by using a self-flow levee system for inner water drainage will not be very effective; channel improvement by the full-back or semi-back method or the drainage-pumping method will be much more effective. In this case, because the scale of landside water is regarded as depending solely on the landside river basin yield, the design landside water shall be that at the time of heavy rainfall (yield) in the landside river basin, and a probability assessment can also be conducted by using the rainfall data for the landside river basin.

The damage caused by landside water will depend on the flood characteristics and asset distribution. For example, if most of the damage is to farm products, the design scale may be reduced compared with that for an urban area. If damage to ordinary houses takes place on the perimeter of the water-covered area and the depth of submergence is small, it is possible to prevent damage to houses by slightly reducing the total submerged depth. However, when there are several houses near the lowest point of ground in the water-covered area, it is impossible to completely prevent damage by drainage-pumping; therefore, measures to improve the flood-resistance of these houses may be more advantageous in terms of investment effect. Also, in recent years, damage due to landside water has occurred frequently in heavily populated large cities. This is the result of the occurrence of flow volumes exceeding the design flow volume of facilities, in association with urbanization of the basin, and also the occurrence of landside water along rivers in association with the construction and improvement of sewerage systems. In addition, the Tokai flood disaster and the inundation of underground spaces in Fukuoka City, which were caused by short-term torrential rainfall exceeding the design scale, caused tremendous damage owing to spill overtopping from sewerage systems. Therefore, for landside rivers in highly urbanized basins, it is important to determine the design scale on the basis of prediction of changes in flow regime, to consider the balance between sewerage systems and the level of river improvement, and to adjust the progress of improvement.

If landside water covers an extensive area, then it will be necessary, in the process of planning, to differentiate between the landside water removal zone (the area where landside waters should be actively drained) and the retarding zone (the area whose retarding function needs to be maintained by minimizing landside water drainage). In this process, it is necessary to enhance the safety level of flood control of the entire basin while taking into consideration flood damage to asset distribution in the region.

Descriptions of landside water surveys and the creation of landside water analysis models can be found in Section 3 of Chapter 8 in the Research volume of the Technical Criteria for River Works (Draft). Refer to other documents etc. in developing a specific plan for inner water drainage.

Section 2 Determination of Inner water drainage Method

The method of inner water drainage shall be selected from alternatives that are economically and socially feasible and expected to bring results in terms of the topography; land use; drainage; improvement plans for the landside river and main stream; plans for related projects; landside water flood characteristics; landside water flood damage characteristics of the subject landside river basin; and the presumed flooding area, through a comprehensive assessment of the difficulties of facility management and the extent of damage in times of excess flooding.

Explanation

The inner water drainage method shall be determined through the selection of alternative methods that are applicable to the subject area and a comparative review of them.

The primary items to be considered in determining the inner water drainage method include the following:

- Proportion of river basin in mountainous terrain
- Bed slope of the landside river
- Distance to the destination river
- Discharge capacity of the destination river
- Land use, depth of water, and filling time of the presumed flooding area.

In the comparative review of inner water drainage methods, the scale of facilities necessary for each treatment method shall be determined and the necessary cost of the project and its beneficial and adverse effects shall be assessed through consideration of the social conditions of the subject area and difficulty of management, etc. Anticipated damage at times of excess flooding shall also be taken into consideration.

The choice of inner water drainage method should differ depending on the characteristics of the subject landside river, and it is not necessary to fix on the choice of a uniform method. In the process of choosing a method, landside river improvement planning needs to be developed simultaneously, and, in this sense, the method of landside river improvement is included as part of the inner water drainage method. The inner water drainage plan to be determined here shall include not only structural measures such as river improvement, installation of a drainage pump station, and installation of a retarding basin, etc., but also non-structural based measures such as land use management and land utilization guides, as well as a combination of structural and non-structural measures.

Inner water drainage methods are roughly classified as shown below.

1. Classification based on method of implementing measures

(1) Structural measures

(2) Non-structural measures

2. Classification based on measure implementation target area

(1) Measures for the discharge basin

(2) Measures for a landside water area

(3) Measures for the main stream

3. Classification based on drainage method

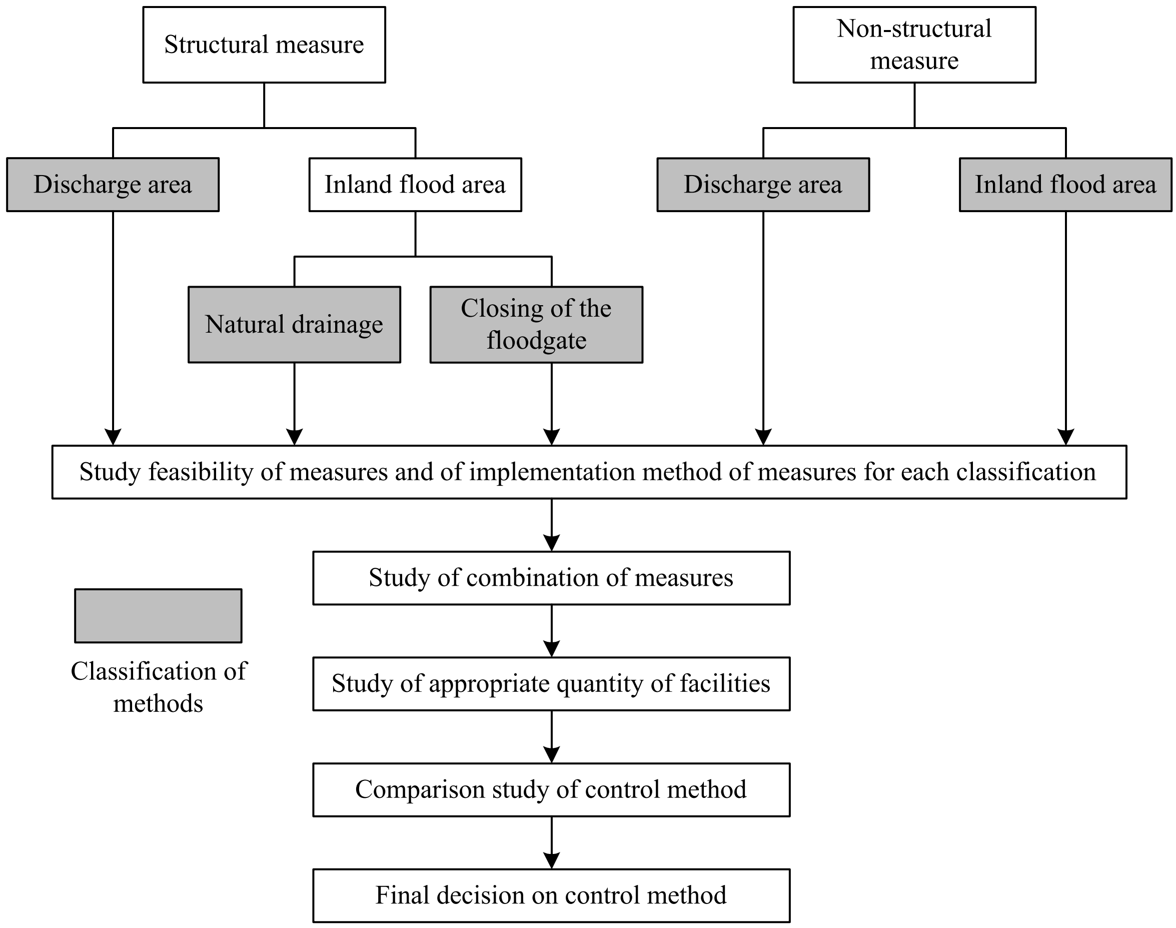
(1) Regional outlet channel

(2) Water-gate closure method

Figures 2.2–1 and 2.2–2 show these three classifications as they are examined in the actual process of landside water planning.

Fig.2.2-1 Classification of methods of inland flood control

In order to decide on the optimal inner water drainage method, different methods shall be examined on the basis of the classification shown in Fig. 2.2–1. Possible measures and specific measures shall be first investigated for inner water drainage method classification, and then a combination of these measures shall be investigated as shown in Fig. 2.2–2. After an examination of the scale of facilities for each measure, the finalized measure shall be determined through comparative review in terms of effectiveness and economic efficiency, etc. It is desirable that non-structural measures are developed through close cooperation and collaboration with relevant organizations and bodies in order to avoid placing too much weight on structural measures.



Note1. Some of the classification above may not be applicable, depending on the subject river.
Note2. These measures can bring out expected effects individually or in combination with other measures.

Fig.2.2-2 Process of study of inland flood control

Section 3 Selection of Landside Waters for Examination

Several landside waters for examination shall be chosen in consideration of historical rainfall, outer water levels, and flooding, and depending on past damage and the availability of hydrological data. These should include the one that caused the largest recorded damage.

Explanation

The landside waters for examination are used for the following purposes:

1. Verification of landside water analysis models (landside water for verification)
2. Examination of inner water drainage method and facility scale (landside water for planning)

It is desirable to use the same landside water for both 1 and 2, but different landside waters may be used, depending on the availability of hydrological data.

To examine the selection of an inner water drainage method, as landside waters for examination it is desirable to select those waters that have various hyetographs and outer water hydrographs and a diverse relative relationship between them. On the basis of this idea, four to six landside waters for examination, including the one that caused the largest record damage, are usually selected on the basis of historical data, the extent of damage, and the availability of hydrological data. It is also important to select those landside waters that have caused the most recent damage in view of exemplifying the subject area. Past inner water drainage plans have taken the following points into consideration in the selection of landside waters for examination:

(1) Landside water that caused serious damage

(2) Landside water with large amounts of rainfall in the landside river basin

(3) Landside water with large amounts of rainfall in the landside river basin and a high outer water level

(4) Landside water with a high flood level

(5) Landside water with a long flooding time

(6) Landside water for which there are sufficient hydrological data available

(7) Other (subject floods for a main stream improvement plan, etc. or representative floods in the main stream, etc.)

Section 4 Determination of the Probability Assessment Method

The method for probability assessment of the landside water scale in an inner water drainage plan should be selected in consideration of the characteristics of the landside water in the area for examination. Depending on the availability of hydrological data, it should be chosen from among the following methods on the basis of an understanding of each method's features:

1. Probability assessment based on the amount of rainfall in the landside river basin
2. Probability assessment based on the amount of rainfall over the landside water occurrence period
3. Probability assessment based on the amount of submerged water

Explanation

An examination performed to select a probability assessment method aims to accurately assess the annual exceedance probability of the landside water scale, and it shall be conducted on the basis of the characteristics of the subject landside river basin.

The scale of the landside water is determined by the runoff in the landside river basin, the outer water hydrograph, and the relative temporal relationship between them. Because a landside water probability is a probability not for a single variable but for multiple variables, this complicates inner water drainage planning. Also, because the runoff in the landside river basin, the outer water hydrographs, and the relative relationship between them are determined not by natural conditions only, but also by human actions such as river improvement, changes in land use, and construction of sewerage systems, this adds to the complication of probability assessment of the landside water scale. Therefore, in order to accurately determine the flood safety level of the landside water area and the proper facility scale, a probability assessment method that is suitable for the study area has to be determined on the basis of the landside water characteristics, hydrological data, etc.

In an ordinary flood control plan, a method that calculates the design scale external force from probability assessment of rainfall and conversion of this into a runoff is employed. In an inner water drainage plan, too, the design external force of a facility (channel, water-gate, sluice, etc.) that determines the flow capacity of the landside river is determined on the basis of the peak discharge, and probability assessment of rainfall is usually used.

On the other hand, the scale of the existing landside water itself and the design external force of the inner water drainage facilities (drainage pump station, flood control basin, etc.) should be assessed by using the amount of submerged water, not the peak discharge. Since landside water flooding is caused by multiple factors intricately intertwined with each other, there may be various methods for probability assessment of the amount of submerged water. The most direct method for probability assessment is one that uses actual values of flood level or the amount of submerged water for past landside waters. However, since such data usually has limited availability, and the amount of submerged water varies under the same rainfall conditions owing to human action, in many cases this method cannot be used to assess the landside water scale probability.

Because a probability assessment based on the amount of rainfall over the landside water occurrence period represents the amount of submerged water as determined from the amount of rainfall over this period (the period of time during which the landside water area is presumed to be flooded), such an assessment can be applied if the landside river basin is extremely small and the concentration time is short. However, because the application of this method requires data on outer water levels or data on opening and closing of the water gates, if such data is not sufficiently available then the method cannot be employed, even if the landside river basin is small.

Probability assessment based on the amount of submerged water can be employed when sufficient data on the actual amounts of submerged water is available and there is no major change taking place in the basin and channel of the landside river, or in the main stream, during the periods of time for which the statistics are required. When there are major changes taking place in the basin and channel of the landside river, as well as in the main stream during the time of collection of statistics, probability assessment based on actual amounts of submerged water cannot be used, but probability assessment based on calculated amounts of submerged water can be used. The calculated amount of submerged water is obtained from a landside water analysis model; this analysis requires outer water hydrographs and the amount of rainfall in the landside river basin for landside waters presumed to have caused the maximum amount of submerged water in each year of the time period used to gather statistics.

Probability assessment based on the amount of rainfall in the landside river basin is a method that is employed when the above methods cannot be used owing to constraints such as insufficient availability of hydrological data, and it is used relatively often because of the simplicity of the work involved. However, the time period for the subject rainfall should be determined in consideration of the basin size, flood concentration time, flood characteristics, and availability of hydrological data, etc.

Since the scale of landside water generally depends on three elements—the runoff of the landside river basin, the outer water hydrograph, and the relative relationship between them—the landside water probability of the subject area may be represented more accurately through probability assessment using multiple variables that represent these elements. There may be a weak correlation between the rainfall in the landside river reaches and the outer water level in past landside water occurrences, for example, when the scale of the main stream basin at the flow end is much larger than the scale of the landside river basin. In such cases, complex probability assessment using multiple variables may be more effective than probability assessment using a single variable. Since the use of two variables is a practical limitation, it is necessary to determine two variables that represent the landside water scale in consideration of the landside water characteristics of the subject area. In cases where two representative variables cannot be extracted, however, this method is not very effective. For example, if the peak outer water level and the rainfall in the landside river basin are used as the two variables, the occurrence probability of the combination of these two can be obtained. However, the resulting probability does not necessarily represent the scale of the landside water. This is because the scale of the landside water depends heavily on the time lag between the outer water hydrograph and the rainfall in the landside water area.

Section 5 Determination of the Scale of Inner water drainage Facilities

The design scale of the inner water drainage facility shall be determined in consideration of various factors, such as the importance of the landside water area, the actual damages caused by past landside waters, the balance against the project scale of the main stream, and the balance against the project scale of neighboring landside water areas, etc. A facility scale that ensures a degree of safety corresponding to that at the project scale against flood in the landside water area shall be determined.
However, the scale of drainage pumping, as a general rule, shall be determined on the basis of a cost-benefit evaluation.

Explanation

If the plan uses a regional outlet channel, the scale shall be determined in the same manner as for general river improvement.

If the plan uses a water-gate closure method, the scale shall be determined in consideration of various factors, including the social and economic importance of the landside water area, the actual damage in past landside waters, the economic efficiency, the balance between the project scale of the landside water area and that of both the main stream and the neighboring landside water areas, etc.

If it is impossible to construct an inner water drainage facility equivalent to the project scale from the beginning, owing to constraints concerning consistency with the safety level of flood control of the main stream, balance against the safety level of flood control of neighboring landside water areas, and financial constraints, etc., staged construction shall be implemented.

1. Design scales of the landside river and inner water drainage facility

As described above, there is a significant difference in the damage structure between outer water and landside water. Although it is rational to determine different safety levels of flood control for outer water flooding and landside water flooding, in establishing the design scale for an inner water drainage facility it is necessary to take into due consideration the balance against the project scale of the main stream.

In addition, the design scale for the landside river channel and that for the inner water drainage facility do not have to be the same.

2. Importance of the region

The importance of the region can be judged mainly from the land use of, and concentration of assets in, the landside water area. In general, the asset concentration in agricultural areas such as paddy fields and upland fields is lower than that of urban areas by two or three orders, and their damage potentials are very different. Therefore, it is regarded as rational to change the design scale of the inner water drainage facility depending on the land use of the landside water area. However, a probable flood area is rarely composed of a single land category such as paddy field, upland field, or urban area; instead, it usually has land of mixed categories. In addition, the predominant land category of the subject area for landside water removal is also different owing to the distribution of these land uses by elevation.

Generally, when a landside water area is mainly urban, the target design scale of the inner water drainage facility shall be more than 30 years; in the case of other land uses it shall be more than 10 years.

3. Damage prediction when floods exceed the design scale

Since there is a possibility of occurrence of landside water exceeding the design scale, it is desirable to conduct damage prediction for such an occurrence, as required, in order to prevent serious damage.

If the necessary facility scale is very different, depending on the subject landside water, it is desirable to reexamine whether there is any technical irrationality in the relationship with the adopted probability assessment method or in the process of expansion to the design scale. Also, it is necessary to examine the effects of flood control of past eminent landside waters in determining the facility scale.

In the case of drainage pumping, however, examination from an economic viewpoint is important, and the scale shall be determined, as a general rule, on the basis of a cost-benefit evaluation. For cost-benefit evaluation, refer to "Chapter 20: River Economics Research" in the Research volume of Technical Criteria for River Works (Draft). In this case, the depreciation period for the machine and equipment shall be determined to be 20 years.

Reference

1) Guide to Inner water drainage Planning: Supervised by Flood Control Division, River Bureau of the Ministry of Construction, Edited by Japan Institute of Construction Engineering, February 1995

Chapter 2–3 Multi-purpose Facilities

Section 1 General Information

1.1 Definition

Multi-purpose facilities include dams, flood control basins, weirs, channels for adjusting river flow, etc. with multiple purposes related to flood control, water utilization, environmental preservation, etc.

1.2 Basics of multi-purpose facility planning

In planning a multi-purpose facility, necessity in terms of flood control, water utilization, and the environment; economic efficiency; and ease and efficiency of facility operation and its impacts on natural and social environments, etc. shall be examined.

1.3 Multi-purpose facility location

A multi-purpose facility shall be positioned at a location that ensures that the expected functions can be fulfilled and, where necessary, storage capacity can be advantageously secured. The location shall be determined through comprehensive examination of different factors, such as the results of topographic, geological, and environmental surveys, the status of submerged areas, and economic efficiency, etc.

Explanation

A multi-purpose facility should be located at the most appropriate position selected in consideration of multiple factors such as the results of topographic, geological, and environmental research, the status of submerged areas, and economic efficiency, etc. from among multiple candidate sites that are presumed to ensure the expected flood control and water utilization functions as well as the necessary storage capacity. Environmental surveys are indispensable to gain an understanding of the status of healthy habitats for plants and animals around the reservoir and to preserve them, and to provide important information used for the selection of the reservoir location.

Whether a single reservoir or a group of reservoirs is to be constructed shall be determined in consideration of the sureness of flood control, combination of purposes, topographic and geological conditions, the environment surrounding the reservoir, and economic efficiency, etc.

Because redevelopment of an existing dam through enlargement, combined use of existing dams, etc. may be able to achieve the expected flood control and water utilization effects with less cost and impacts on the environment compared with new dam construction, positive examination of the possibility of efficient use of existing dams should be promoted.

In view of effectiveness of flood control, it is desirable to determine a location that is close to the major flood control area projected in the flood control plan and to use as few large capacity reservoirs as possible for flood control. In developing a flood control plan by using a group of reservoirs, if the need arises from the viewpoint of water utilization, then allocation of adjustment flow volumes to each reservoir shall be examined through various combinations with water utilization purposes.

Section 2 Facility Basic Plan

2.1 Plan adjustment

In developing a multi-purpose facility plan, the manner of operation of the facility must be examined in order to avoid conflicts between purposes.

Explanation

In the use of a facility, especially a reservoir, flood control and water utilization initially conflict with each other in terms of water management. For this reason, the flood control capacity shall be secured by setting a flood season control level, and a water utilization plan must be established in consideration of this. In the case of a multi-purpose dam with a power generation facility, because the water used for power generation can be reused for water supply and irrigation, etc., such uses rarely present conflicts of purpose. However, when the power generation scale is large and the facility has a capacity for exclusive use for power generation, the capacity for other uses of water may be reduced, and adjustment between the multiple purposes will be necessary. Flood control capacity, especially, must be secured with priority over other purposes, and a method that requires overlapping of the capacity for preliminary release flood control and water utilization capacity must not be adopted except in special circumstances. It is necessary to actively consider plans for the redevelopment of existing dams from a new point of view. Preservation of, and harmony with, the natural environment, etc. should be considered.

2.2 Consideration of economic efficiency (cost-benefit analysis)

In the process of establishing a multi-purpose facility plan, the economic efficiency of each purpose should be investigated. As a general rule, the total benefits obtained by project implementation must exceed the total cost required.
An appropriate method of total benefit evaluation shall be selected in consideration of the project and the characteristics of the subject area, etc.

Explanation

In establishing a multi-purpose facility plan, examination from the viewpoint of technical possibility is an absolute necessity. Examination not only from the viewpoint of rationality of reservoir use for securing the capacity needed to meet demand, but also from the viewpoint of economic efficiency, is also necessary.
An appropriate analytical method shall be selected through consideration of the subject project and the characteristics of the subject area, and the reason for selecting the method must be clarified.

2.3 Multi-purpose reservoir planning

2.3.1 Evaluation of necessary capacity and its allocation

The storage capacity shall be allocated to various uses, including flood control and maintenance of normal functions of the river water, as well as new uses of water, etc. for the effective use of limited facility sites in consideration of various factors such as demand for flood control, water demand, and the scales of the reservoirs, etc.

Explanation

The necessary capacity for each purpose shall be calculated in accordance with 2.3.2–2.3.7 of this section.

The calculations of the capacity necessary for maintenance of the normal functions of the river water and new uses of water shall be done by using information collected from existing hydrological data covering as long a period as possible (basically 20–30 years, but approximately 10 years if the data are limited). As a general rule, the calculations shall be based on the flow regime at the time of the largest drought in 10 years (second-largest drought in 20 years, or third-largest drought in 30 years).

In recent years there have been cases in which the storage capacity for water for melting, clearing, and removing snow and the storage capacity for drought for mitigating the damage caused by extraordinary drought exceeding the design scale have been determined.

2.3.2 Flood control capacity

The flood control capacity shall be determined in accordance with Section 3.1.3 of Chapter 2–1.

2.3.3 Capacity for maintenance of normal functions of river water (unspecified capacity)

The capacity for maintenance of normal functions of the river water (hereinafter referred to as "unspecified capacity") shall be sufficient to secure "a necessary discharge for the maintenance of normal functions of the river water (hereinafter referred to as ‘normal discharge’)".

The unspecified capacity shall be obtained by calculation of the excess and deficiency between the normal discharge and the natural flow at the design control point.

Explanation

An unspecified capacity is a capacity necessary for the maintenance of the river and the maintenance of normal functions of the river water, such as protection of vested water rights. It should be secured preferentially in a new water-resource development project.

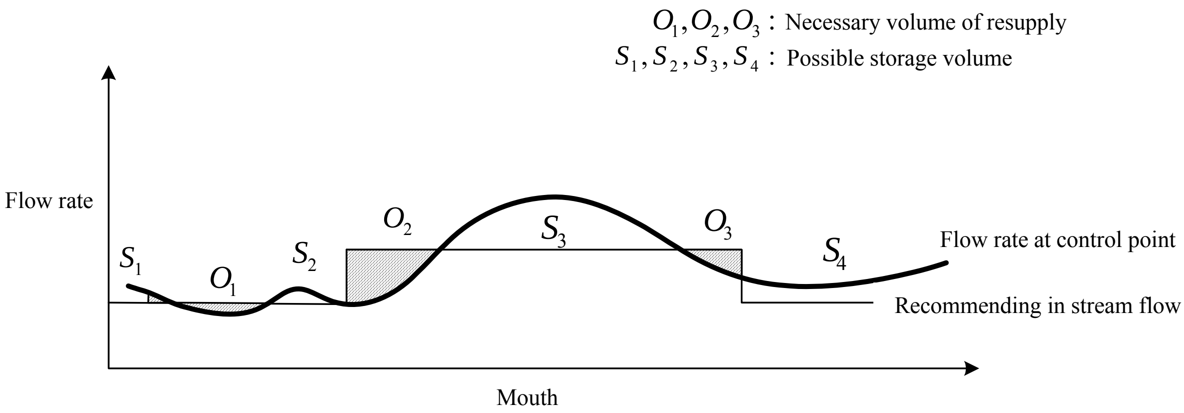


Fig.2.3-1 Resupply plan diagram of recommending in stream flow

2.3.4 Capacity for irrigation

The capacity for irrigation shall be determined through calculation of excess and deficiency between the design intake flow and normal discharge at the intake point and the discharge at the intake point after consideration of storage restrictions and other conditions for the reference dry year. The design intake flow of irrigation water shall be determined in consideration of the necessary water volume for each area and period of the replenishment zone and the vested water rights and effective rainfall of that zone, and the necessary intake flow for the intake point shall be determined for each period.

Explanation

Irrigation waters include water for the growth of farm products, water for rice nurseries, and water for land preparation; the amounts of water needed differ depending on the period of the irrigation season. Since the soil properties, climate, kinds of crop, and growth period, etc. differ from area to area, the necessary water volume differs, and it will be necessary to estimate the necessary water volumes by conducting surveys in field locations over several years.

The indication for the water rights volume consists of the indication of the seasonal maximum water intake volume (represented by m^3/s) that controls the maximum water intake volume for each season and the total water intake volume (represented by m^3) that controls the total water intake volume. The necessary water volume is taken within these ranges. Consequently, as a general rule, calculations to determine the necessary capacity for irrigation should be based on the necessary water intake volumes in the reference year (effective rainfall should be deducted), not the seasonal maximum water intake volume obtained from the water rights volume.

Because it is necessary to make adjustments between the different water uses that are the subjects of the multi-purpose facility plan, as a general rule the plan shall be developed on the basis of a common reference dry year.

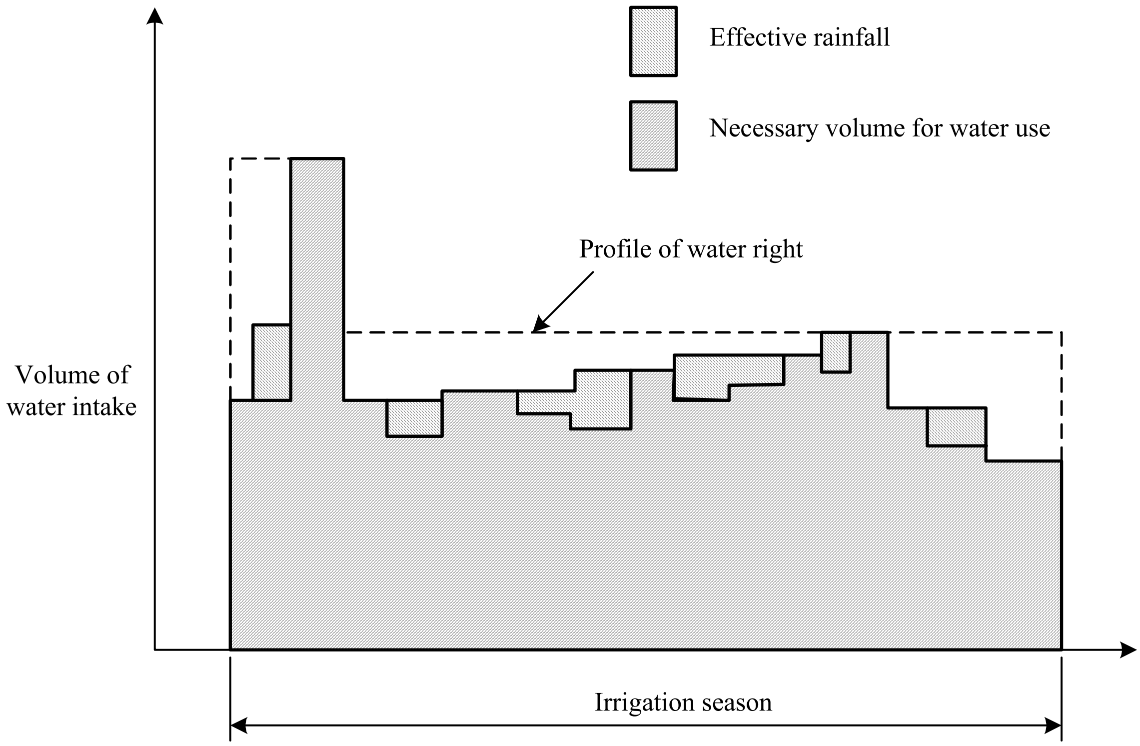


Fig2.3-2 Intake water volume diagram

2.3.5 Capacity for municipal water

The capacity for municipal water shall be calculated by determining the necessary intake volumes for municipal water for different periods, and by calculating the excess and deficiency against the flow regime at the intake point after including the normal discharge and storage constraint conditions at the intake point in the reference dry year.

Explanation

"Municipal water" is a general term for the water used for water supply and industrial water. The necessary capacity for municipal water shall be obtained from the necessary supply volume against the necessary intake volume for a flow regime that gives priority consideration to the normal discharge.

In normal cases, the necessary intake volumes for municipal water, irrigation water, etc. shall be calculated in the same manner.

2.3.6 Capacity for power generation

The capacity for power generation shall be determined in consideration of fluctuation in the use of electricity and through adjustment with other purposes in such a way that efficient power generation is possible.

Explanation

The capacity for power generation should be determined in consideration of power demand and fluctuation in use of electricity and through adjustment with other purposes in such a way that economically efficient power generation is possible.

When there is already a power station downstream in the river, since improvement in the flow regime at normal times may cause increased power generation (increase in downstream), the effect of this also needs to be considered.

Calculations in a power station construction plan are based on discharge data for 10 or more years, and the maximum high water level for power generation during a flood season must not exceed the control level. When the water level is lowered to the control level before a flood season, ineffective release when release of more than the turbine discharge is necessary shall be considered in advance. The capacity shall be determined in such a way that storage can be started after the flood season and finished during the demand period.

2.3.7 Storage capacity for sedimentation

Normally the sediment deposition estimated for the next 100 years is used as the storage capacity for sedimentation. However, the design sediment storage can be reduced in the case of a facility that flows sediment from a flood spillway, one that removes inflow sediment in the reservoir, or other facilities for which special measures have been implemented.

Explanation

It is desirable to estimate the sediment deposition of the reservoir from the sediment deposition of an existing reservoir in a similar area. It should be determined in consideration of the sediment and erosion control plans for the upper reaches, the size of the basin, the geology, and the forest physiognomy, etc. and in reference to the results of calculation of the estimated sediment deposition. However, the design sediment storage can be reduced by the estimated sedimentation deposition for the next 100 years in the case of a facility that flows sediment from a flood spillway, one that removes inflow sediment in the reservoir, or other facilities for which special measures have been implemented.

Chapter 2–4 Water Quality Preservation Facilities

Section 1 General Information

A plan for the construction of facilities, etc. in a river, reservoir, or lake and swamp that are aimed at preserving the water quality of a river, etc. shall be established on the basis of the current water quality and the natural and social environments of the basin and their historical transition. It shall also take into consideration consistency with the various functions of the river related to flood control, water utilization, and the environment.

Explanation

Cooperation between the river administrator and relevant organizations and bodies, etc. in the basin is necessary to develop multiple alternatives, conduct comparative reviews of them on the basis of the location where a measure is to be implemented, the method to be used, and the expected effects, and finalize the measure.

In determining the measure, it is necessary to take into consideration the time lag before the measure will actually take effect.

Multiple alternatives for the water quality preservation measures allocated individually to the river, reservoir, lake, swamp, and basin in view of role-sharing based on "Measures for the preservation of good water quality" (Explanation 4, 1.4 of Chapter 1) shall be examined in consideration of the characteristics of each measure. The best measure shall be selected.

The basic procedure for selection of a water quality preservation measure is as shown below.

1. Selection of the location where the measure is to be implemented

The most polluted area, feeder river and discharge channel shall be selected on the basis of a change in water quality in the flow direction and distribution of loading.

2. Selection of multiple alternative measures

Appropriate measures shall be selected in consideration of applicable conditions for the subject water quality items.

3. Determination of the scale of measures

The scale for the selected alternatives shall be determined by comparing the predicted results and target values for water quality preservation at representative locations.

4. Selection of a measure

The optimal measure shall be selected from among the selected alternatives and the facility installation shall be determined through comparison of the locational factor, economic efficiency, and ease of maintenance, etc.

Facility installation needs to consider the condition of habitats for plants and animals and harmony with the surrounding environment.

Since the need to maintain any water quality preservation measures must be weighted heavily among considerations, it is desirable to select a measure that is easily managed and has a low running cost.

Section 2 River Water Quality Preservation Measures

River water quality preservation measures include reduction of loading, separation of loading, securing of flow, and reinforcement of the purification function of the river, etc. The measure shall be established by first preparing multiple alternative plans by combining these functions, and then through comparative examination based on the location where the measure is to be implemented, the method, and the expected effects, etc. In determining the measure, the target water quality, effects, economic efficiency, ease of maintenance, and impacts on the environment, etc. shall be taken into consideration.

Explanation

The following points require consideration in a river water quality preservation measure:

1. When selecting a method for loading reduction, disposal and utilization of bottom sediment and sludge, etc. also need to be considered on the basis of the water quality factors of the subject water and the properties of that water.

The facility location shall be one where loading can be efficiently reduced.

2. When selecting the method of loading separation, it is necessary to consider the impacts on the lower reaches.

3. When selecting the method for securing the necessary flow volume, it is necessary to consider the flow regime of the raw water source, water quality, water utilization plans, geographical condition, and impacts on the river environment downstream of the raw water transmission point.

4. When determining the measure for reinforcing the purification function of the river, a location that facilitates efficient reinforcement of the purification function shall be selected in consideration of the longitudinal distribution of water qualities, current velocity, and the condition of the bottom sediment, etc.

(1) Reduction of loading

a) Water quality preservation by river flow purification

When planning a water quality improvement measure that uses a river flow purification method, the hydraulic and water quality characteristics of the subject water body and the site for facility construction shall be investigated, and the optimal method and scale for the characteristics of the water body shall be determined.

When a river flow purification method is used, a purification method suitable for the hydraulic and water quality characteristics of the subject water body shall be selected. The choice of a purification method depends, for example, on the ratio of grains and soluble matter. Since a river flow purification method requires sludge management, it is desirable to select a measure that facilitates sludge management and requires a low running cost. The subject water volume, which is a key determinant of the size of the purification facility, shall be determined on the basis of the goal achievement frequency, etc.

The site for facility construction should be thoroughly investigated, because the purification method and intake and release method depend on the location (landside area, high water channel, channel, etc.), area, shape, height difference, and habitats for plants and animals.

The following chart shows major methods of river flow purification.

Reference: methods for purification of river water

Purification methods	Purification mechanism	Subject for purification	Feature
Contact oxidation	Biological oxidation Precipitation	Organic matter, SS, NH_4-N	Decomposition of organic matter by growth of microorganisms attached to contact media such as grovel, plastic, etc.
Water purification by soil	Filtration Absorption	Organic matter, Nutrient salts, SS, Turbidity	Water purification by soil capability of absorption, decomposition and filtration, and absorption function of vegetation
Oxidation pond	Biological oxidation Precipitation	Organic matter, Nutrient salts, SS	Decomposition of organic matter and intake of nutrient salts by microorganisms in the pond, and depositing of SS maters owing to decreased water flow velocity
Water purification by vegetation	Absorbed Vegetation Precipitation	Organic matter, Nutrient salts, SS	Uptake of nutrient by vegetation, depositing of SS maters owing to decreased water flow velocity, and absorption by soil. The vegetated area perform as a habitat

Among various river flow purification methods, the contact oxidation method has been used most widely. The contact oxidation method takes advantage of the self-purification function of the river, utilizing filtration by contact media such as gravel and organic matter decomposition by attached organisms.

b) Dredging of bottom sediments

In bottom sediment dredging planning, the range and amount of dredging, the dredging method, and the timing shall be determined, and a bottom sediment treatment and soil allocation plan shall be established.

In determining the range and amount of dredging, the nutrient salt concentration of the bottom sediment to be dredged and the range and depth (amount) of dredging shall be determined on the basis of the results of a bed material investigation and the relationship between nutrient salt concentration and the solution rate, etc.

The dredging method shall be determined depending on the hydraulic condition of the subject water body and the characteristics of the bottom sediment. When dredging, it is important to avoid cluttering the bottom sediment as much as possible. Especially for bottom sediment that has an amount of harmful substance exceeding the level for removal, a method that prevents its flow loss and dispersal shall be planned, and it must be detoxified and allocated to a controlled disposal site.

In determining the timing for dredging, it is necessary to take into consideration harvest times for seaweeds and fish, and the timing of odor occurrence from the bottom sediment.

In the process of establishing a plan for bottom sediment treatment and allocation, the method of treatment shall be selected from among solidification at the stockyard, air drying, etc. and the final disposal site shall be planned.

c) Water quality preservation measures in the basin

Measures implemented in the basin by the river administrator include river flow purification in an ordinary river, etc.

(2) Separation of loading

Methods for loading separation include the use of a flow conservation channel.

A flow conservation channel aims to separate river water from polluted water.

In establishing a plan, an appropriate method of river water separation shall be determined in consideration of the volume of polluted water inflow, the intake location for the water supply system, the presence of harmful substances in the basin, and the water quality of the final effluent, etc. The subject area, route, and treatment method, etc. shall be determined.

Since a flow conservation channel is a low-water channel that separates river water from polluted water within the river channel, it is an effective water quality preservation measure for rivers where water for the water supply system is taken from the lower reaches, as well as for rivers to which many branches and discharge channels carrying polluted water are connected.

When water treatment is necessary in a flow conservation channel, the target quality of the final effluent water shall be determined on the basis of the water quality and standards of the receiving river, and a treatment method suitable for the determined water quality items and target values shall be selected.

When it is necessary to flow polluted water downstream, the impacts at the release location shall be assessed and a water quality improvement measure shall be implemented as required.

(3) Securing of flow volume
The effects of securing flow volume include dilution of polluted water, improvement of dissolved oxygen, and reduction of detention time in the water body.

In planning the introduction of purification water, the necessary water volume for purification shall be determined through investigation of the water quality and flow volume of the subject water body. It is also necessary to balance the plan against flood and water utilization plans.

Methods of securing flow volume include the conveyance of purification water from another river, etc. and the securing of maintenance flow discharge by using a dam, etc. Here, the securing of purification water by water conveyance will be described.

In the process of planning, since the amount of purification water differs depending on the use of river water and the status of the sewerage system, it is necessary to clarify the estimated effects at different times by thoroughly considering the current state as well as future changes. In determining the water conveyance capacity of the source river, use of the source river and preservation of the river environment shall be taken into consideration. It is also necessary to confirm the discharge capacity of the channel that receives the purification water.

In determining the locations for the intake and the discharge outlet for water conveyance, it is necessary to take the habitats of plants and animals into consideration.

Plans for construction or installation of a reservoir, diversion canal, lift pump, etc. need to be well balanced with facility construction plans for flood control and water utilization. Facilities that can be used commonly for their purposes shall be planned through adjustment.

Conveyance of sewage-treated water, seawater, etc. is effective for small urban rivers that do not have a reservoir area nearby. The water quality of the supplying water body shall be improved, and, if necessary, treatment of the conveyed water should be considered.

(4) Reinforcement of the purification function of the river
At locations such as a tidal area, dam, or weir where water stagnates in a filling area, lack of oxygen prevents the progress of organic matter decomposition. The oxidizing power of these locations can be enhanced by supplying oxygen by aeration or by the use of a fountain.

When this method is to be adopted, the necessary scale shall be determined by investigating the hydraulic and hydrological characteristics of the subject water body, the status of the channel, and the facility installation site, etc.

The addition of riffles, pools, bends, and other variations to a monotonous river channel is also an effective way of preserving water quality, as is the construction of a vegetated zone along the river.

Section 3 Water Quality Preservation Measures for Reservoirs, Lakes, etc.

Water quality preservation measures for reservoirs, lakes, etc. include water temperature and flow control, reduction of loading, separation of loading, and water conveyance, etc. A measure shall be determined on the basis of multiple alternatives combining these functions and by conducting a comparative review of these in view of the location, method, and expected effects, etc. of the measure. In determining the measure, the target water quality, effects, ease of maintenance, and impacts on the environment, etc. shall be taken into consideration.

Explanation

Water quality preservation measures for reservoirs, lakes, etc. include those for water quality preservation of the reservoir area and those for mitigation of impacts on the downstream sector. Reservoirs, lakes, etc. include weir reservoir ponds and regulating reservoirs, in addition to reservoirs and lakes.

For reservoirs and lakes there are appropriate individual measures for cold water problems, problems of long-term persistence of turbid water, and eutrophication problems. Some of these problems are effective for water quality problems other than the expected water quality problem. For example, a selective water intake facility used as a measure against a cold water problem is also effective for the problem of long-term persistence of turbid water when it is used at a time of flood and after.

On the other hand, there are cases in which a measure for improving a certain water quality problem will affect some other water quality problem. For example, if a selective water intake facility places too much emphasis on the cold water problem and surface water intake, a turbid water mass that flows in at the time of flood may remain in the reservoir during and after the flood, causing prolonged turbidity of the water. Inappropriate control of water temperature and turbidity may worsen eutrophication problems.

For these reasons, selection of water quality preservation measures requires thorough examination from the viewpoints of measure combination and prevention of influence.

The following points need to be considered in the development of function-based water quality preservation measures for reservoirs, lakes, etc.

1. Selection of a method for water temperature and flow control should be based on the vertical distribution of water temperatures, which indicates the thermal stratification of the reservoir. The reservoir turnover and the diffusion of inflow water in the reservoir need to be taken into consideration.

The facility location shall depend on the shape of the reservoir, and its scale shall be determined on the basis of an estimation of thermocline formation and its effects, as obtained from water discharge and meteorological conditions, etc.

2. Selection of a method for reduction of loading should be based on the water quality items of the water to be purified and the water's characteristics. Treatment, utilization, etc. of bottom sediment and sludge should be

taken into consideration.

A location that enables efficient reduction of loading shall be selected as the facility site.

3. In selecting a method of separation of loading, effects on the lower reaches should be taken into consideration.

A location where the facility length can be minimized shall be determined as the facility site.

4. In selecting a channel for water conveyance, it is necessary to take into consideration the flow regime, water quality, water utilization plans, and geographical condition of the source river.

If other measures are necessary, an appropriate method should be selected on the basis of the concept described above.

1. Controlling the water temperature and flow
(1) Selective water intake facility
A selective water intake facility is applicable as a measure against cold water, long-term persistence of turbid water, and eutrophication. In all of these applications, stratification of the reservoir is a prerequisite, and the method of operation should depend on the temperature and water quality characteristics and turbidity distribution of the reservoir, as well as the water quality characteristics of the inflow water.

(2) Aerating circulation facility
An aerating circulation facility is applicable as a measure against cold water, long-term persistence of turbid water, and eutrophication. A method, location, and scale, etc. that is suitable for the purpose of aerating circulation shall be determined from the characteristics of the reservoir and water quality properties.

Greater effectiveness may be expected by combining an aerating circulation facility with a selective water intake facility.

2. Reduction of loading
(1) Measures for inflow water quality
A measure for inflow water quality is applicable as a measure against eutrophication and is effective for reducing nutrient salts. Possible purification methods include vegetation purification and soil purification. The method, location, and scale, etc. shall be determined from the water quality and amount of pollution loading of the polluted tributary and in consideration of the subject flow volume, site condition, ease of maintenance, and cost, etc.

(2) Front reservoir
A front reservoir, which is a dam, etc. where water can be temporarily stored before it flows into a reservoir,

thereby precipitating nutrient salts, is applicable as a measure against eutrophication.

The facility scale (capacity) and location shall be determined on the basis of the characteristics of the nutrient salt (ratio of dissolved matter to particle matter, etc.) and the characteristics of the inflow loading amount, as well as the retention time necessary for nutrient salt precipitation and subject flow volume, and in consideration of the site condition, economic efficiency, etc.

(3) Bottom sediment dredging

Bottom sediment dredging, which aims to suppress oxygen consumption by bottom sediment and to prevent nutrient salt elution, is applicable as a measure against eutrophication.

The procedure and considerations in bottom sediment dredging planning are the same as those for bottom sediment dredging as a water quality preservation measure for a river (see Section 2: River Water Quality Preservation Measures).

(4) Water quality preservation measures in the basin

Measures that the river administrator can implement include the following:

a) River flow purification for non-classified rivers.

b) Installation of an “environment preservation zone” with a wooden corridor in the peripheral area of a reservoir with markedly turbid water, eutrophication, etc.

3. Separation of loading

Construction of a bypass is applicable as a measure against long-term persistence of turbid water and eutrophication. Measures against long-term persistence of turbid water include a method that bypasses highly turbid water contained in the feeder river, and a method that takes in clear water that flows in from the upstream end of the reservoir and bypasses the reservoir (clear water bypass). To suppress eutrophication, phytoplankton growth shall be suppressed by not letting nutrient salts, a phytoplankton growth factor, enter the reservoir.

In any such measures, the plan needs to be developed on the basis of the water quality and loading amount properties of the feeder river, and in consideration of the reservoir operation and the water volume, water quality, and environment of the river downstream of the reservoir. A measure for sediment control at the time of flooding needs to be considered.

4. Water conveyance

Water conveyance is applicable as a measure against eutrophication. This method increases the turnover of a lake, etc. and suppresses the growth of phytoplankton by conveying water from another water source. It is necessary to take heed of the nutrient salt concentration of the conveyed water.

In planning a measure that uses a water conveyance method, the water quality and flow volume of the subject water body and conveyed water shall be investigated, and sufficient examination shall be conducted so as to maintain a balance between flood control and water utilization plans, before the water volume to be conveyed is determined.

Measures against coloration (red water, black water), accumulation and elution of harmful substances, etc. include bottom sediment control (dredging, sand cover), and bottom layer DO improvement by aerating circulation, etc.

Chapter 3 Installation Plan for Erosion and Sediment Control Facilities

Chapter 3–1 General Information

The installation plan for erosion and sediment control facilities, etc. consists of the installation plans for erosion and sediment control facilities (drawn up on the basis of the erosion and sediment control master plan), landslide prevention facilities (drawn up on the basis of landslide control master plan), steep slope failure prevention facilities (drawn up on the basis of steep slope failure control master plan), avalanche control facilities (drawn up on the basis of the avalanche control master plan), and comprehensive sediment disaster control facilities (drawn up on the basis of the comprehensive sediment disaster control master plan).

Devising installation plans for facilities entails the consideration of the effects on the natural environment including the landscape that the intended facilities would cause. In a basin with obvious problems associated with sediment movement, such plans need to devised, in addition, from the viewpoint of comprehensive sediment treatment over the entire sedimentary system.

Chapter 3–2 Installation Plan for Erosion and Sediment Control Facilities

Section 1 General Information

The installation plan for erosion and sediment control facilities drawn up on the basis of the erosion and sediment control master plan consists of installation plans for sediment yield control facilities, sediment transport control facilities, woody debris control facilities, and volcanic sediment and erosion control facilities.

The installation plan for erosion and sediment control facilities is based on the river system erosion and sediment control plan and is combined with the installation plan for sediment yield control facilities, and debris flow prevention plan, which is combined with the plan for the installation of sediment transport control facilities.

Table 3–1 categorizes the locations of sediment yield and sediment transport and the types of erosion control works to be implemented at those locations in accordance with the installation plans for sediment yield control facilities and sediment transport control facilities, as part of the installation plan for erosion and sediment control facilities.

In this revision, from the viewpoints of the structure and its function, the phrase “erosion control dike” shall be adopted as the common designation for any facility installed across a torrent instead of the phrase “erosion control dam" as has been conventionally stipulated in the Manual for River Works in Japan (draft version). This is because of the recent rapid advances in the introduction and spread of erosion and sedimentation facilities with permeable steel structures, in addition to the fact that many dikes were introduced before the publication of the Manual for River Works in Japan (draft version).

Table 3–1 Main installation plans for erosion and sediment control facilities including types of works

Classification of installation plans for erosion and sediment control facilities on the basis of the plans of river system erosion and sediment control and debris flow prevention	Locations of sediment yield and sediment transport	Types of works
Installation plan for sediment yield control facilities	Hillsides	Foundation works for erosion control afforestation, planting works, hillside slope reinforcement works, hillside conservation works
	Riverbeds and riversides	Erosion control dike construction, consolidation works, bed girdle construction, anti-erosion works, torrent-preservation works
Installation plan for sediment transport control facilities	Torrents and rivers	Erosion control dike construction, consolidation works, bed girdle construction, anti-erosion works, groyne construction, torrent-preservation works, training dike, sand-retarding basin works

Section 2 Installation Plan for Sediment Yield Control Facilities

2.1 Overview

The installation plan for sediment yield control facilities, which is based on the plans of river system erosion and sediment control and debris flow prevention, aims to install erosion and sediment control facilities for the purposes of protecting hillsides, riversides, and riverbeds and preventing sediment yield. Care need be taken during the installation of sediment yield control facilities to ensure that function of each facility appropriately and adequately fulfilled.

Explanation

The installation plan for sediment yield control facilities is devised appropriately giving due consideration to works in relation to erosion and sediment control such as hillside preservation works, erosion control dikes, torrent-preservation works, etc. at sources of sediment yield, e.g. hillsides, riverbanks, and riverbeds.

2.1 Hillside preservation works

2.2.1 Overview

Hillside preservation works aimed at controlling floods consist of hillside works and hillside conservation works. The former works stabilize slopes by cutting and filling or by earthwork construction on denuded lands or bare slopes to prevent or reduce the triggering or aggravation of surface erosion or shallow slides by the introduction of a vegetal cover while the latter works boost the function of the former by nurturing the introduced vegetal cover.

The hillside preservation works consist of foundation works for erosion control afforestation, planting works, and hillside slope reinforcement works.

Explanation

"Denuded land" refers to land that is bare as a result of hillside collapse.

"Bare slope land" refers to hillside slopes on which the vegetation has entirely or partly vanished or declined.

In view of the fact that persistent sediment yields from denuded lands or bare slopes are contributory in causing landslide disasters at downstream sites during flood, hillside preservation works are considered very important in conjunction with erosion control against flood.

The degree to which hillside preservation works could control the triggering or aggravation of shallow slides generally depends, in terms of general construction, on the extent of foundation; in terms of vegetation, it depends on the extent of the roots' ability to reinforce the soil. Thus, evaluation of the effects of hillside preservation works on deep-seated collapses or landslides is a future task.

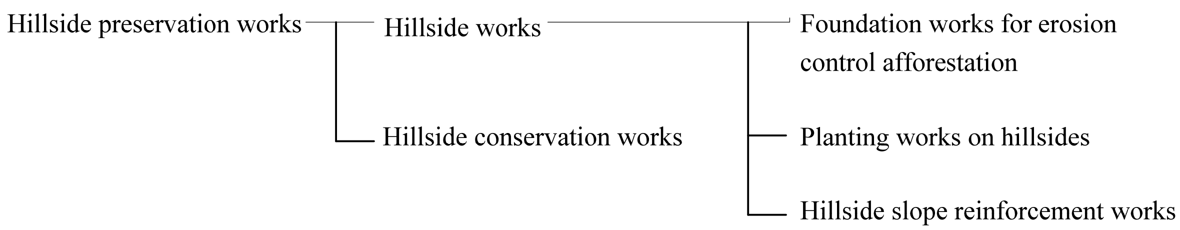


Fig. 3–1 System of hillside preservation works

2.2.2 Hillside works

Hillside works are categorized into three groups: 1) foundation works for erosion control afforestation to stabilize hillside slopes and/or to prevent slope erosion; 2) planting works on hillsides to prevent or reduce the triggering or aggravation of sheet erosion or shallow slides by introducing a vegetal cover on denuded lands or bare slope lands; and 3) hillside slope reinforcement works to increase the shear resistance of the slope as a whole against collapse by carrying out concrete crib works or reinforced concrete insertion works on denuded lands or hillside slopes that approaching or at the verge of failure. Utilizing a single measure or a combination of the aforementioned techniques sediment yield shall be controlled; Topography, geology, soil, climate, and vegetal cover in the design area and its surroundings and the effects of intended facilities on the existing erosion control facilities shall be sufficiently researched to determine the appropriate type of work/s needed. In particular, while deciding vegetal cover, sufficient consideration must be given on the compatibility with the surrounding vegetation.

Explanation

1. Foundation works for erosion control afforestation

Foundation works for erosion control afforestation are aimed at stabilizing hillside slopes by cutting, fitting, or establishing small check dams and to prevent slope erosion due to overland flows by constructing channel works. Laying of foundations for future planting or hillside slope reinforcement works at the site in question is intended.

2. Planting works on hillsides

Planting works on hillsides are aimed at introducing vegetal cover in the region of interest. It includes hurdle works, terracing works with seeding, and simple terracing works that introduce a vegetal cover and thereby to prevent the topsoil from moving. The vegetation type shall be carefully chosen in such a way that it is integrated with the surrounding vegetation, in consideration of its secular change.

3. Hillside slope reinforcement works

Denuded land or hillsides that are at the verge of failure and where stabilization works are deemed necessary with immediate effect or where the triggering or aggravation of slope failure cannot be prevented or reduced by foundation works for erosion control afforestation or planting works alone, hillside slope reinforcement works can enhance the resistance of the slope as a whole against collapse by carrying out concrete crib works or reinforced concrete insertion works on hillsides.

A vegetal cover cannot be introduced naturally on a steep denuded slope, for instance, as the topsoil frequently moves. In such a case, generally, after the slope has been stabilized (mainly by the use of foundation works by erosion control through afforestation to control the movement of the topsoil), vegetal cover is introduced by planting works on the hillside. On the other hand, if the site borders on a slope and has to be stabilized as soon as possible, then hillside slope reinforcement works are introduced.

In landforms with poor soil but relatively gentle slopes such as bare slope lands, planting works are the primary type of remedial measure in many cases.

These types of works, which are often used in combination on sites with colluvial soils, should be properly combined in the actual planning. In the actual planning on hillsides with large sediment yields, such as on eroded areas bordering torrents, the combination of hillside works, erosion control dikes, and torrent-preservation works, for example, in which an erosion control dike aimed at stabilizing the foot of the mountain is used as the foundation works for erosion control afforestation, is sometimes introduced.

2.2.3 Hillside conservation works

Hillside conservation works following hillside works shall promote proper growth of vegetation on a hillside slope, aiming to prevent the triggering and/or aggravation of surface erosion or collapse or to increase the abatement function of the vegetation.

Planning of hillside works shall include guidelines for conservation of hillside in accordance with its purpose and on the workflow.

Explanation

Since the vegetal cover to be introduced by hillside planting works—unlike concrete structures—require a specified period of time to exert its influence, it is important to stipulate guidelines on the same.

Usually, the first hillside planting works cover the bare land with plants or pioneer trees (soil-improving trees) to prevent the surface soil from moving or eroding and to form the growing foundation of a forest. After this initiation of disaster prevention activity by the hillside conservation works, the identified vegetation is cultivated in such a way that it can harmonize with the surrounding natural vegetation.

Moreover, when the introduced vegetation is remarkably different from the surrounding vegetation at a site where hillside works are executed, or when the greenbelt is not expected to be affected by pest control or sediment controls because the introduced trees are homogenous with the surrounding vegetation, then, at a point when the colony has grown to a certain level, the type of tree or forest may be changed to increase the function of the hillside works as deemed necessary.

2.3 Erosion control dikes

An erosion control dike as a sediment yield control facility is one that aims to 1) prevent or reduce the triggering or aggravation of hillside collapse by mountain foot fixation; 2) prevent or reduce riverbed longitudinal erosion; or 3) prevent or reduce the runoff of unstable sediment accumulated on the riverbed.

While planning to construct the facility, its scale and structure should be selected according to its purpose.

An erosion control dike as a sediment control facility should be arranged in consideration of its expected effects, the topography and geology of the design site, and the stability status of the debris.

Thus, in principle, the dike should be arranged in the stream just beneath a hillside at the verge of failure in the case of 1); in the case of 2, just beneath a vertical erosion area; and in the case of 3), just beneath unstable riverbed sediment

Explanation

While planning for the installation of sediment yield control facilities, in many cases the erosion control dikes are intended to control sediment transport as well as sediment yield. The function of the erosion control dike, aimed at mountain foot fixation, is to accumulate sediment at the upstream side of the established dam; this in turn raises the riverbed and fixes the mountain foot to prevent the hillside from collapsing or stop a hillside collapse from spreading. The erosion control dike aimed at controlling longitudinal erosion accumulates sediment on the upstream side of the established dam to prevent longitudinal erosion of the riverbed.

The erosion control dike, aimed at preventing unstable sediment accumulated on the riverbed from discharging, accomplishes its purpose by establishing an erosion control dike.

The scale of the erosion control dike for longitudinal erosion control or of the one for controlling the runoff of instable sediment accumulated on the riverbed can be estimated by riverbed variation calculations or by hydraulic model experiments. The conditions necessary for these riverbed variation calculations or hydraulic model experiments, such as the time variations of flow and sediment runoff, the parcel size distribution of sediment accumulated on the riverbed, etc., need to be properly established. It is desirable that erosion control dikes be established at locations exposed with bedrock on the riverbed or riverbank; this ensures the security of the structure and, particularly, the prevention of basement corrosion and wing bank runoff.

Moreover, the decision on whether to establish a single erosion control dike or a cluster of low dikes in sequence depends on the characteristics of the sediment yield type and the difficulty of execution and maintenance at the design site.

Erosion control dikes are classified by their types, structures, and materials, which should be selected on the basis of their surrounding situations or economic efficiency. They are divided into two types: permeable and impermeable. In terms of the structure, they are further divided into two types: gravity and arch. Concrete, steel, and soil–cement are mentioned as materials. Moreover, it should be kept in mind that the permeable type is not always suitable for erosion control dikes as debris production control facilities in terms of the functions required of such dikes, which should take into account sediment yield type, the topography, and the geology of the area.

2.4 Consolidation works

Consolidation works are facilities that are intended not only to stabilize the riverbed by controlling riverbed longitudinal erosion or preventing the riverbed sediment from moving again, but also to prevent or reduce riverbank erosion or collapse. Additionally, they function to prevent foundations, such as anti-erosion works, from being scoured and to protect them.

The following shall be considered in selecting the places where consolidation works should be installed:

1.Consolidation works shall be set up locations under threat by riverbed degradation.

2.When they aim to protect the foundations of structures, they shall be established in the lower reaches of these structures.

3.In places with riverside erosion, collapse, and landslide, they shall, in principle, be established in the lower reaches.

Explanation

The height of consolidation works is, commonly, less than about 5 m.

Consolidation works function to control the occurrence of debris flow by preventing the riverbed from being lowered by the tractive force of the flow and arresting unstable sediment from moving. They also prevent and reduce erosion and collapse of the riverbanks by preventing lowering of the riverbed, making the riverside slopes milder, and controlling turbulent flow.

When a section is encountered with problems such as riverbank erosion or collapse and extensive longitudinal erosion is, a combination of consolidation works shall be formulated and carried out in order to stabilize the riverbed and banks.

2.5 Riverbed girdles

The riverbed girdle is a facility that is intended to prevent longitudinal erosion.

It is set up at the downstream side of a single consolidation work and at a place where the interval between consolidation works is large or where longitudinal erosion had taken place or is likely to take place.

The riverbed girdle shall be planned in such a way that its crest is as high as the computed height of the riverbed so as to eliminate the gap between the bed and the girdle.

2.6 Anti-erosion works

Anti-erosion works are facilities which prevent riverside erosion and collapse.

They shall be set up in places such as water-collision fronts, in which riverside erosion or collapse has taken place or is likely to take place because of debris movement or flow, or at locations where mountain foot fixation or erosion prevention is required.

Explanation

Since anti-erosion works may make the waterfront environment monotonous, it is desirable to increase the natural appearance of the waterline by keeping the range over which the works are established to the necessary minimum.

2.7 Torrent-preservation works

Torrent-preservation works are facilities that are intended not only to prevent riverside erosion and collapse by controlling turbulent flow or drift currents in the torrent across a mountainous plain or fan, but also to prevent riverbed or bank erosion by regulating the longitudinal slope. The torrent works are a combination of consolidation works, riverbed girdles, anti-erosion works, groynes etc.

The torrent-preservation works shall be planned to install riverbed girdles and groynes, and carry out consolidation, ,and anti-erosion works, as deemed necessary, taking advantage of natural landforms such as unconstrained and constrained areas preserving the various torrential spaces and ecosystems and apply natural sediment control functions

Explanation

The slope of the stream bed of a torrent is determined by the flow discharge: that is, the flow velocity, the water depth, and the resistance of the stream bed. Thus, the design slope of the stream bed upstream of consolidation works should be determined by considering the occurrence of erosion and sediments, in addition to the above-mentioned factors, and then referring to the dynamic and statistical equilibrium gradients of the discharged sediment. On the other hand, in the actual preparation of torrent-preservation works, it is necessary to properly locate the erosion and sediment facilities only in the places where they are required to be set up, while taking advantage of the natural landscape. Note that the channel consolidation works dealt with in the Manual for River Works in Japan (draft version) are included in the torrent-preservation works because of the suitable nature of their purposes and functions.

Section 3 Planning for Sediment Transport Control Facilities

3.1 Overview

A plan for the installation of sediment transport control facilities should prescribe the installation of such facilities for the purpose of controlling sediment that is discharged in sediment transport sections. This planning should be done on the basis of the river system sediment and erosion plan, and the debris flow measures.
In the actual planning of the sediment transport control facility installation, the purpose of each facility should be made clear so that each function can be brought into play.

Explanation

Sediment transport control facilities include erosion control dikes and sand-retarding basins to hold and regulate sediment yields.
A plan for the installation of sediment transport control facilities prescribes the proper installation of these facilities in the sediment transport sections.

3.2 Erosion control dikes

Erosion control dikes for sediment transport are facilities designed to: 1) control or regulate sediment discharge; or 2) hold or dissipate debris flow. There are two types: impermeable and permeable. In the actual planning, the facility's type, scale, and structure should be selected according to its installation purpose. An erosion control dike for sediment transport should be located in an effective place, such as in a constrained stream whose upstream width is large, or in a lower stream just beneath the confluence of the bank tributary; the decision should be based on the expected effects of the erosion control dike and on the topography of the design site.

Explanation

In planning for the installation of sediment transport control facilities, erosion control dikes are often planned for the purpose of controlling sediment yield as well as sediment transport.
An erosion control dike that aims to prevent sediment discharge can accomplish its purpose effectively by storing sediment discharge equivalent to its capacity. However, if in the planning stage the capacity is anticipated to be lost by advanced sedimentation, it is necessary to prepare debris-exclusion works in advance.
Because a large amount of sediment inflow into the sediment area of an erosion control dike makes the slope of the stream bed gentler, and consequently the bed width greater, than it would be in the absence of an erosion control dike, sediment is accumulated temporarily by any slope (dynamic equilibrium gradient) that is steeper than a stable slope (static equilibrium gradient). By this means, an erosion control dike that aims to regulate sediment discharge also performs its part effectively. Moreover, a permeable erosion control dike that aims to control sediment discharge can do so, especially at the peak of discharge, if large grain-sized stones are fixed with a grid and the flood is dammed back. Additionally, the use of a permeable erosion control dike can ensure the consistency of a stream by the cross-section of the part through which water flows.
When it is full of sand, an erosion control dike that is intended to hold debris flow and dissipate its energy can do

this by temporarily accumulating sediment into a sediment holding area via the action of a slope that is steeper than a stable slope. On the other hand, although the dike directs debris flow into the holding area, this holding capacity is lost when advanced sedimentation occurs. Thus, if such a loss is anticipated in planning, the holding capacity will have to be restored by debris-exclusion works. On the other hand, if the slope of the stream bed is mitigated and consequently debris flow is transformed into bed load transport, then an erosion control dike can also dissipate the energy of the debris flow. Fundamentally, a permeable erosion control dike that is intended to hold debris flow and dissipate its energy can hold debris flow by filling up the permeable part through which the water flows with the debris itself.

It is desirable to establish an erosion control dike in a place with bedrock on the riverbed and banks in order to ensure the security of construction, and especially to prevent the foundations of the dike from being scoured and the wing bank from running off. Additionally, the choice between a single erosion control dike and a cluster of erosion control dikes will depend on the characteristics of sediment transport in the area and the difficulty of execution or maintenance.

Erosion control dikes are classified according to type, structure, and materials, all of which should be specified on the basis of the surrounding environment at the design site, the economic efficiency of each option, etc.

Erosion control dikes are of two types: permeable and impermeable. Their structural types are also divided into two types: gravity and arch. Their materials include concrete, steel materials, and soil–cement.

In principle, permeable erosion control dikes should not be located in such places that require foot fixation.

3.3 Consolidation works

See Chapter 3–2, section 2, 2.4

3.4 Riverbed girdles

See Chapter 3–2, section 2, 2.5

3.5 Groins

Groins are facilities that prevent riverside erosion and collapse by controlling the direction of running water or restricting the width of a channel. Their function is not only to accumulate sediment by dissipating the energy of running water, but also to protect the riverbanks.

In principle, groins should be set up in turbulent flow sections without a steep slope on the stream bed, such as in the lower reaches of a torrent, debris-cone areas, fans, etc. Even in the upper reaches of a torrent, however, they should be established in places such as at the foot of an area of denuded land, as the occasion demands, to prevent the extension of collapse due to the impact of running water.

Explanation

When a groin is set up on one side of a river (say, at the foot of an area of denuded land), because the other side can often serve as a water-collision front it is necessary to be aware of the situation on the other side.

3.6 Anti-erosion works

See Chapter 3–2, section 2, 2.6.

3.7 Sand-retarding basin works

Sand-retarding basin works are facilities used to widen part of a river by excavation and to thereby accumulate debris to control transported sediment. They should be commonly established on the downstream side of the exit of a valley, where space for the accumulated sediment can be ensured. On the other hand, although they should be arranged with an erosion control dike on the upstream side and a consolidation work on the downstream side, they should be combined properly with low water channels, training levees, erosion control greenbelts, etc.

Explanation

When woody debris threatens to flow out from sand-retarding basin works, it is necessary to consider installing a woody debris control facility, for example, by adding a riverbed girdle at a dam downstream to catch woody debris.

Notwithstanding the debris flow control function of debris-exclusion works, such works are generally referred to as sand-catching works.

3.8 Torrent-preservation works

See Chapter 3–2, section 2, 27.

3.9 Training dikes

The training dike is a facility for safely training debris flow in its lower reach to prevent it from directly hitting the preservation target in time of flood. In the absence of a training dike, the debris flow is usually caught and accumulates upstream of the preservation target. Under more difficult topographical conditions, however, a training dike should be established to provide a space that allows the debris flow to safely accumulate in its lower reach. Initially, establish an erosion control dike or sand-retarding basin works to catch the debris flow. Subsequently, establish the training dike as an addition to the previously built facility. In principle this is done by excavation, in order to train the debris flow into the space in which it can be safely accumulated. Additionally, when the site conditions make it difficult to excavate, a training levee can be established to control the direction of debris flow and safely train the debris downstream.

Explanation

Planning of the training dike must include an examination of the grain size of the discharged sediment in case the debris accumulates within the training dike, causing overflow or flooding.

On the other hand, when the design debris flow can be sufficiently treated on the upstream side of the planned facility, normal torrent-preservation works should be planned.

Section 4 Planning the Installation of Woody Debris Control Facilities

4.1 Overview

The plan for the installation of woody debris control facilities, which is based on the woody debris control plan, should properly locate woody debris control facilities in accordance with the planned amount of woody debris. The plan should also consider woody debris behavior, corresponding to debris occurrence and its flow morphology, in the section in which woody debris is formed in response to variations in sediment yield and transport.

Facilities are roughly divided into woody debris occurrence control facilities that are intended to prevent the occurrence of woody debris and woody debris trapping facilities that are intended to trap woody debris into torrents so that it cannot flow out to their lower reaches.

Additionally, the woody debris control facilities should be consistent with any erosion and sediment works installed as part of the plan for the installation of sediment yield control facilities or the plan for the installation of sediment transport control facilities.

4.2 Woodendebris control facilities

4.2.1 Facilities for the control of wooden debris

Facilities for the control of wooden debris should control and reduce the wooden debris that occurs with sediment by protecting hillsides, riversides, and riverbeds to prevent sediment yields. They should be sited in areas that are potential sources of sediment and wooden debris.

Explanation

Facilities for controlling wooden debris should include hillside preservation works established in areas likely to produce wooden debris and sediment, such as on denuded lands; hillside preservation works, erosion control dikes, consolidation works, and anti-erosion works established in stretches of the river where debris flow occurs; and torrent-preservation works and anti-erosion works located in stretches thorough which mainly river debris is transported by traction.

4.2.2 Wooden debris trapping facilities

Wooden debris trapping facilities to hold woody debris flowing with the sediment should be established on hillside slopes where fallen trees have accumulated or in torrents where debris and wooden debris flow downstream. Additionally, in the actual preparation of a wooden debris trapping facility, consideration must be given to the fact that the trapping function in the debris-flow stretch of the river will differs from that in the traction stretch.

Explanation

Wooden debris trapping facilities catch debris and wooden debris in one lump in the debris flow stretch but separately in the traction stretch.

Facilities for trapping wooden debris include log boom works established on hillsides to prevent fallen trees accumulated on the hillsides from entering torrents; erosion control dikes and partly permeable erosion control dikes established in the debris flow stretch; sub-partly permeable erosion control dikes of the impermeable erosion control dikes established in the traction stretch; and log boom works and permeable erosion control dikes placed in the lower reaches of sand-retarding basin works.

Section 5 Planning Volcanic Sediment and Erosion Control Facilities

5.1 Overview

Planning for the installation of volcanic sediment and erosion control facilities, which is done on the basis of the volcanic sediment and erosion control plan, should be aimed at preventing and alleviating sediment disasters caused by rainfall and volcanic action in volcanic sediment and erosion areas. The planning should specify the work type, work method, and facility scale of the design facility, considering the characteristics of the sediment movement phenomenon and the regional plan of the target site.

In terms of the debris flow caused by rainfall etc., installation of facilities should be prepared according to the plan for installation of sediment yield control facilities (see section 2 of this chapter), the plan for installation of sediment transport control facilities (section 3), and the plan for installation of wooden debris control facilities (section 4).

A plan for the installation of volcanic mudflow control facilities should be prepared to deal with volcanic mudflow directly caused by volcanic action. At the time of an eruption, when emergency measures must be taken, it may be necessary to use an unmanned construction system to install debris-exclusion works (such as an erosion control dike, a training dike, or a sand-retarding basin) that will remove the debris within the sediment area.

Explanation

Facilities for the control of volcanic sediments and erosion are planned according to the volcanic sediment and erosion plan and include erosion control dikes, torrent-preservation works, consolidation works, riverbed girdles, anti-erosion works, sand-retarding basin works, and hillside works.

In terms of the targeted lava flows and pyroclastic flows, the actual planning should combine properly, if necessary, some volcanic sediment and erosion control facilities, which should individually have such functions as runoff control and training. The decision to make these inclusions will be made on the basis of the scale of the phenomenon, the efficacy of the artificial controls, and cost effectiveness.

5.2 Planning for volcanic mudflow control facilities

Installation of volcanic mudflow control facilities should be planned for the stretch where volcanic mudflow is likely to flow down and accumulate. In the actual planning, some of the following facilities should be properly combined: sediment yield control facilities that prevent volcanic mudflows from developing through erosion; sediment transport control facilities that trap discharged debris or reduce peak flow amounts; and other facilities that function in training and wooden debris trapping.

Additionally, the plan for installation of volcanic mudflow control facilities should be set up in accordance with the plan for the installation of sediment yield control facilities (section 2 of this chapter), the plan for the installation of sediment yield control facilities (section 3), and the plan for the installation of wooden debris control facilities (section 4).

5.3 Planning for lava flow control facilities

The plan for the installation of lava flow control facilities should be established according to the scale of the lava flow, the efficacy of any artificial controls, and cost effectiveness. If necessary, it should properly combine some of the sediment and erosion control facilities that function in runoff control, flow direction control, and training of lava flows.

Explanation

Runoff control of lava flow means the reduction of the amount of lava flow through the storage of lava.

Thus, it is necessary to prepare an erosion control dike that is intended to store lava flows in the river adjacent to the section where the lava flow discharges. On the other hand, a sand-retarding basin should be prepared in the stretch where the lava flow is discharged and accumulates.

Lava flow direction control involves artificially controlling the flow direction of the lava. Additionally, lava flow training involves directing lava flows to areas that is far enough not to pose any danger to local residents. For flow direction control and training, training dikes are the main items referred to.

Chapter 3–3 Planning Landslide Control Facilities

Section 1 General Information

The plan for the installation of landslide control facilities should specify the installation of landslide control facilities for the purpose of maintaining security against disasters due to landslides. It should be based on the landslide control plan.

Explanation

Landslides often consist of separate movement blocks that interact with each other. In planning the installation of landslide control facilities, it is necessary to prioritize measures taken to deal with each block in accordance with the movement range and stability of the block; the interaction among blocks; and the position and importance of the preservation target as the situation demands. It is also necessary to efficiently improve the stability of the target landslide area.

Since the preliminary survey cannot always show the whole picture of the landslide, the project can be reviewed by gathering further information whenever necessary.

Section 2 Planning Landslide Control Facilities

2.1 Basis of planning landslide control facilities

The plan for the installation of landslide control facilities should specify the proper installation of each facility to prevent landslide disasters, while considering the effect of each facility in accordance with the scale, occurrence, and mechanism of the landslides.

Explanation

The scale of the plan for the installation of landslide control facilities, which is generally shown by the design safety factor, is calculated by stability analysis of every unit of the movement blocks, which are supposedly moving as one. In the actual determination of design safety factors, it is necessary to comprehensively consider the phenomenon and scale of the landslide, the significance of the preservation target, the level of the disaster that will supposedly be caused by the landslide, the level of emergency created by the landslide, and so on. In many cases, however, design safety factors are calculated on the basis of the present safety factors that are assumed in accordance with the movement state of the landslide. Thus, it must be noted that the design safety factors represent only those safety factors that have been improved by prevention works and do not always represent the stability of the slope after construction.

The stability analysis can be used to determine the scale of the landslide control facility through the proper procedures, in accordance with the characteristics of the landslide (plane shape, slide plane shape, movement state).

2.2 Selection of construction methods

In the plan for the installation of landslide control facilities, construction methods should be chosen in

consideration of the scale, occurrence, and movement mechanism of landslide, the situation of the preservation target, and the economic efficiency of the method. The plan should properly combine control works and prevention works.

Explanation

A landslide is a complex phenomenon caused by a combination of causative factors such as topography, geology, soil properties, etc., and by inducements such as climatic conditions (e.g. rainfall and thaw), ground water conditions, artificial works such as cutting, earthquakes, etc. Thus, an effective plan for the installation of landslide control facilities should perform an adequate preliminary survey and show the cause, mechanism, and occurrence of the landslide, the type of preservation target, and the positional relationship between the landslide and the preservation target. From this information, the plan should, in turn, select the proper prevention works and specify the installation of the facilities in the proper positions. Especially, in the actual selection of construction methods, the plan should sufficiently consider the relationship between rainfall, ground water, and landslide movement; the scale of the landslide; the properties of the landslide soil clods; the velocity of the landslide, block section; the position of the control work; and the emergency control method. The timing of execution of the chosen works should be judged from the occurrence mechanism and movement state of the landslide, the level of influence of artificial inducements, etc.

Landslide control facilities are divided into control works and prevention works:

1. Control works aim to mitigate or stop the landslide movement by changing natural conditions such as the landslide topography and groundwater situation.
2. Prevention works aim to stop landslide movement by using the resisting power of the established construction.

In the actual selection of control works and prevention works, the following points must be noted:

1. In planning, the characteristics of both control works and prevention works should be reasonably combined.
2. The main construction methods should be groundwater drainage works, landing embankment works, and earth removal works. When stabilization of movement blocks is attempted to directly protect houses or public facilities, pile works or anchor works should be introduced.
3. If landslide movement continues, in principle, control works should not be conducted in advance of prevention works. In other words, they should never be introduced until prevention works have mitigated or stopped the landslide.

Section 3 Control works

The control work plan should be prepared in such a way that landslide movement can be effectively controlled by changing the natural conditions such as the topography, geology, and groundwater.

Explanation

The control works include surface water drainage works, groundwater drainage works, earth removal works, loading embankment works, and erosion control works through river-related constructions. On the basis of the characteristics of each work, the plan should also designate the optimum site and number of facilities needed to control the landslide.

1. Surface drainage works (channel works and infiltration control works)
   These works aim to prevent landslides from being induced by infiltration and re-infiltration within or outside the landslide area, for example by rainfall, surface water, and water from wells, ponds or channels.
2. Shallow groundwater drainage works (closed conduits, open conduits, horizontal drilling works)
   These works drain shallow ground water to prevent it from being supplied near the slide surface of a slope.
3. Deep groundwater drainage works (side-boring works, drainage-well works, drainage tunnel works)
   These works drain deep ground water to reduce the pore water pressure (groundwater level) near the slide surface.
4. Earth removal works (cutting works)
   In principle, these works are set up at the head of the landslide to decrease the ability of the land to slip off (landslide sliding power). It is necessary to pay attention to changes in typographic conditions so as not to induce further landslides.
5. Loading embankment works
   In principle, these works should be set up at the end of the landslide to increase resistance to landslide sliding power. As in the case of earth removal works, it is necessary to be careful of changes in the topographic conditions that could induce further landslides.
6. Erosion control works through river-related constructions (slope protection works, erosion control dikes, and anti-erosion works)
   These works are aimed at preventing the erosion and collapse that may result from the presence of running water (e.g. river water or rainwater) and may induce landslides. The sediments trapped by the erosion control dikes established in the stretch of river just beneath a landslide site can prevent erosion and collapse at the landslide end. The effect is expected to be the same as that of loading embankment works.

Section 4 Prevention works

Prevention works should include structures that are safe against sliding force so that landslides can be prevented by their resisting power. They should be planned to have sufficient effects on clod movement.

Explanation

Prevention works include pile works, shaft works, and anchor works. It is necessary to estimate the proper positioning and number of these works to prevent a landslide, on the basis of the characteristics of each type of works.

1. Pile works
   These works aim to directly resist the sliding force of the landslide through the added shear resistance and bending resistance of the piles, which are inserted into unmoved ground.

2. Shaft works (caisson pile method)

   Shaft works involve the excavation of a shaft 2.5 to 6.5 m in diameter that reaches a solid foundation. The concrete pile is then poured in place. When it is difficult to ensure the designated design safety factor because the landslide has a large amount of sliding force but there is a good solid foundation, these works should be set up.

3. Anchor works

   Taking advantage of the tenacity of steel materials fixed within the unmoved ground, these works aim to resist the sliding power of a landslide. They should be set up in a position in which their detaining and/or fastening effects can be produced effectively.

Chapter 3–4 Planning for Steep Slope Failure Prevention Facilities

Section 1 General Information

The plan for the installation of steep slope failure prevention facilities should be set up on the basis of the steep slope failure prevention facility plan, for the purpose of ensuring security against disasters caused by steep slope failure.

Explanation

Steep slope failure prevention works are classified into construction works that are conducted directly on slopes to improve their degree of safety and construction works that attempt to mitigate disasters in the prevention target, preventing or reducing the debris produced at the target even if slope collapse has occurred.

Section 2 Planning Steep Slope Failure Prevention Facilities

2.1 Basis of planning steep slope failure prevention facilities

The plan for the installation of steep slope failure prevention facilities should be properly arranged in accordance with the scale and phenomenon of the estimated collapse, for the purpose of preventing the damage that could be caused by failure.

Explanation

To improve the degree of safety of slopes by using steep slope failure prevention facilities, it is necessary to remove unstable clods and decrease the force of collapse or sliding, or to add resistance to collapse or sliding.

Examination of the slope stability level is the most fundamental factor in estimating collapse forms and designing control works. In the actual evaluation of slope safety level, the following items must be noted:

1. Examination of the degree of safety, based on comparisons with conventional experience, the actual conditions of the slope, and the standard slope gradient
2. Examination on the basis of anticipated collapse forms by on-site surveys
3. Examination of safety levels by stability analyses

The design safety factor determined by stability analysis is based on in the content of Chapter 3–3, section 2, “Planning the Installation of Landslide Prevention Facilities.”
To prevent and mitigate sediment access to the prevention target, debris that has fallen from slopes needs to be received safely and surely.
It is necessary to keep a close watch on the condition of the foundations during construction. If phenomena unexpected in the planning phase occur, measures to change the initial planning must be instituted promptly as the occasion demands.
Any countermeasure works performed in the construction stage should be done in such a way as to not conspicuously decrease the degree of safety.

2.2 Selection of construction methods

The plan for the installation of steep slope failure control facilities should consider the causes, forms, and scales of the anticipated collapses, the situations of the prevention targets, and the economic efficiency of the works. The plan should properly combine construction methods to control slope collapse or sliding by changing natural conditions such as the topography, geology, and groundwater state at the site, and construction methods to prevent collapse by providing resistance from structural objects.

Explanation

In the selection of control methods, various work types should be combined as the occasion demands. When conditions such as the topography, geology, and types of housing in a series of sites are not identical, it is necessary to select a construction method suitable to each of the characteristics of the section, even if the section

is short, while sufficiently considering the aspects of the slope.
In particular, because slopes requiring such steep slope failure prevention works are often near houses, the planning should not just ensure the security and durability of the work sufficiently, but should also consider harmony with the surrounding environment.

Chapter 3–5 Planning for Avalanche Control Facilities

Section 1 General Information

The plan for the installation of avalanche control facilities should specify the installation of avalanche control facilities in such a way as to ensure security against avalanche disasters. It should be based on the avalanche control plan.

Explanation

Avalanche control facilities are classified into prevention works to establish structural objects within the section of avalanche occurrence to prevent the occurrence of avalanches, and protection works that establish objects in the avalanche path or in sedimentary areas to protect the preservation targets from avalanches that have just occurred.

The plan for the installation of avalanche control facilities should consider the effects of each facility and specify its proper installation properly.

Section 2 Planning for Avalanche Control Facilities

2.1 Basis of the plan for avalanche control facilities

In planning for the installation of avalanche control facilities, the facilities should be properly arranged to prevent disasters caused by avalanches, in accordance with the anticipated scales and characteristics of the avalanches.

Explanation

For avalanche control facilities to prevent the occurrence of avalanches, resistance to deposited snow movement (creeping or gliding) on a slope should be added.

In order to prevent avalanches from reaching the prevention targets, it is necessary to divide the energy of an avalanche that has occurred, dissipate its speed, guide its direction, and finally stop it.

The actual planning should consider the effects of each facility in accordance with the type, occurrence site, and reach-range of the anticipated avalanche, on the basis of the results of preliminary surveys. The aim is to make each facility suitable to the situation of the preservation target.

2.2 Selection of construction methods

The plan for the installation of avalanche control facilities should select construction methods in consideration of the causes, form, and scale of the avalanches, the situation of the preservation target, the economic efficiency of the method, etc. It should properly combine prevention works and protection works.

Explanation

Prevention works are classified into occurrence prevention works that prevent deposited-snow movement phenomena (creeping or gliding) from starting on a slope, and snow cornice prevention works that prevent the formation of the snow cornices that causes avalanches.

In turn, the protection works are classified into interception works that intercept the avalanche on its way to the prevention target, energy dissipation works that disperse the energy of the avalanche to reduce its speed, and guidance works that change the course of the avalanche.

In installing avalanche control facilities, proper construction methods should be chosen in consideration of security, durability, installation possibility, and the surrounding environment, in accordance with the types, occurrence areas, and reach-ranges of anticipated avalanches and on the basis of the results of previous research.

In the actual selection of avalanche control facilities, although priority should be given to the examination of prevention works that prevent avalanches from occurring just in the occurrence areas, other methods can be combined as the occasion demands.

In the actual planning of the installation of avalanche control facilities, it is desirable to consider the surrounding environment in terms of environmental measures, landscape measures, and so on.

2.3 Prevention works

Prevention works should be set up in occurrence areas to prevent avalanches from occurring.

2.4 Protection works

Protection works should be set up in avalanche paths or sediment areas to protect the preservation targets from avalanches that have just occurred.

Chapter 3–6 Planning Comprehensive Sediment Disaster Control Facilities

Section 1 Basis of Planning for Comprehensive Sediment Disaster Control Facilities

The plan for the installation of comprehensive sediment disaster control facilities should determine the proper location of sediment and erosion facilities, landslide prevention facilities, steep slope failure prevention facilities, etc. It should be based on the comprehensive sediment disaster control plan and should be aimed at preventing and reducing sediment disasters that may convergently occur.

Section 2 Basis of Planning for Urbanized Foothill Greenbelt Facilities

In the plan for the installation of urbanized piedmont greenbelt facilities, sediment and erosion facilities, landslide prevention facilities, steep slope failure control facilities, etc. should be properly located to promote the development and conservation of trees as per urbanized piedmont greenbelt development projects.

Explanation

As prescribed by urbanized piedmont greenbelt development projects, the plan for the installation of urbanized piedmont greenbelt facilities should determine the conservation guidelines that will be used to control the development of the greenbelt by law. The plan should prevent the greenbelt from being neglected and should maintain healthy trees, specifying items associated with the development of erosion control facilities and facilities for sediment yield and transport control. These will include hillside works and erosion control dikes, landslide prevention facilities, and steep slope failure control facilities. In the actual installation, it will be necessary to make a point of maintaining healthy trees above all else.

Facilities must be located in harmony with the conditions of the environment and landscape that are prescribed by urbanized piedmont greenbelt development projects.

Chapter 4 Planning Coastal Protection Facilities

Section 1 General Description

Coastal protection facility plans should specify the type, scale, and arrangement of coastal protection facilities in the seacoast preservation project.

Planning for the installation of coastal protection facilities must meet the three purposes of coastal protection, coastal environment development and protection, and proper coastal utilization by the public.

In coastal protection facility installation planning, it is essential to consider the continuity of the seaside in its coastal direction from the viewpoint of comprehensive sediment control, making the seaside fulfill its functions of coastal protection, environmental conservation, and utilization.

Explanation

The facilities, which are classified into “erosion control facilities,” “storm surge protection facilities,” and “seismic protection facilities” for the purposes of description, must be comprehensively considered in coastal protection facility planning, because erosion, storm surges, and seismic disasters can be intricately intertwined with each other on some coasts.

Because conventional coastal protection facilities have placed stress on disaster-prevention measures, sea embankments have sometimes prevented access to the seaside, gentle slopes built to ensure access have sometimes promoted the disappearance of coastal vegetation, and detached breakwaters or wave-dissipation works have sometimes spoiled coastal landscapes.

In planning for the installation of coastal protection facilities, coastal protection, environmental conservation, and utilization must be harmonized in respect of the coastal environment and utilization in the seacoast preservation project. It is therefore necessary to consider the continuity of the seaside in a coastal direction from the viewpoint of comprehensive sediment control.

Above all, sandy beaches function in disaster prevention by mitigating external wave forces and preventing waves from entering continental areas. Additionally, since it promotes seawater purification by its zoobenthos or aeration action, which provides good habitats for living creatures, beach sand is also considered an important factor in terms of the coastal environment. Planning for the installation of coastal protection facilities must preserve and utilize natural beaches and not damage their functions.

Section 2 Erosion Control Facilities, etc.

2.1 Overview

Erosion control facility arrangement planning should determine the allocation between sediment transport control facilities and beach nourishment in order to ensure the parameters of the design beach profile and maintain them in the long term, while specifying the fundamental conditions for a sediment control facility to fulfill its required sediment transport control function.

Explanation

Erosion control aims to ensure the parameters of the design beach profile and maintain them in the long run. In projects for the installation of coastal erosion control facilities, etc., sediment transport control facilities aim to control sediment transport rates and beach nourishment for the purpose of ensuring the design coastal form and supply sediment inflow, which is insufficient compared with the sediment discharge.

This section will specify the conditions needed to select the most suitable combination of ideas about the allocation between sediment transport control facilities and beach nourishment and for the facilities to fulfill their anticipated functions.

The conditions required for the stability of sediment transport facilities, etc. will be specified in the calculation section.

2.2 Allocation between sediment transport facilities and beach nourishment

The allocation between sediment transport facilities and beach nourishment should be specified by considering the economic efficiency, environment, and usage properties, the wave extinguishing effect, and the feasibility of seaside preservation after taking measures to rectify or mitigate the discontinuity or change of sediment dynamics.

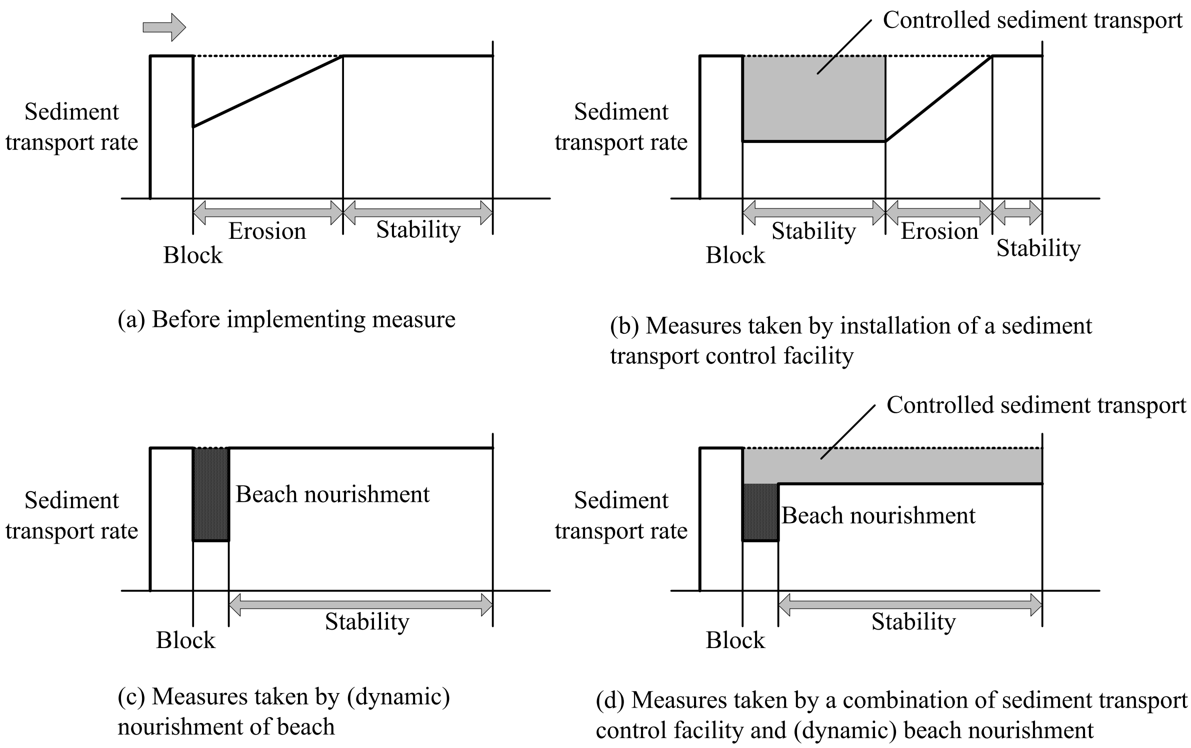
Explanation

In specifying the allocation between sediment transport facilities and beach nourishment, it is necessary to determine future sediment dynamics. To do this, the cooperation of relevant organizations and bodies across the basin and coast beyond the jurisdiction of each coastal manager is required.

To examine the approaches to improving sediment dynamics with the relevant organizations and bodies, it is necessary to elucidate a grain size group and the amount of sediment supplied from rivers on the basis of past sediment transport rates and the texture of the bed materials when stable. When the amount of sediment supplied from a river has decreased because of gravel quarrying, river bed excavation, and sediment flow prevention by a dam or erosion control dike, measures should be considered to ensure an adequate amount of sediment is supplied to the coastal system from the perspective of consistent management of the entire sedimentary system. When the continuity of coastal drift is hindered by coastal structures such as jetties, breakwaters, and landfill sites, it is necessary to consider sand bypasses etc. When coastal erosion is caused by gravel quarrying within a sediment transport system, the coastal gravel-quarrying site should be relocated to a marine area or at the terminal end of the sediment transport system. On the other hand, because sediment of a particular grain size group dredged from channels and composing the shoreline has fundamentally the same effects on the seaside as the gravel from quarrying in the sea, it should be considered reusable as a material for beach nourishment. When coastal erosion is caused by coastal landforms such as submarine canyons, social infrastructure such as existing coastal structures, and works such as gravel quarrying that were conducted in the past, the estimated increase in the amount of sediment as a result of the improvement of sediment dynamics cannot make up for the sediment shortage and therefore sometimes cannot maintain the parameters of the design beach profile. In this case, the design beach profile should be maintained by the combination of sediment transport control facilities and beach nourishment.

Figure 4–1 shows the sediment transport rate distribution with a combination of sediment transport control facilities and beach nourishment. In plan (a), the sediment transport, which originally flows from left to right without imbalance (with the sediment transport rate leveling off), is blocked by a coastal structure. As a result, on the downstream side the sediment transport rate is decreased and imbalance and erosion are caused. In plan (b), the sediment transport rate is decreased by the presence of the sediment transport control facility and so can be equivalent to a reduced sediment transport rate. In this case, since the imbalance of sediment transport rate occurs downstream of the section where development of the sediment transport control facility occurs, the whole sediment transport system will have to be controlled by a sediment transport facility in the future. In plan (c), a reduced sediment transport rate is ensured by (dynamic) beach nourishment. In plan (d), a sediment transport facility is combined with (dynamic) beach nourishment, and its facility scale can be smaller than in (b) and its beach nourishment rate less than in (c). With various options like these, the combination balance between sediment transport facilities and beach nourishment that is suitable for the characteristics of the design areas should be specified in accordance with the lifecycle cost of the sediment transport facilities, the maintenance cost of the beach nourishment, and the characteristics of the preserved beach.

When the parameters of the design beach profile cannot be temporarily maintained during the design period, or when the sediment transport rate cannot reach the equilibrium state at the last point in time of the design period, the temporal improvement of sediment dynamics by (dynamic) beach nourishment should be also considered.



(a) Before implementing measure

(b) Measures taken by installation of a sediment transport control facility

(c) Measures taken by (dynamic) nourishment of beach

(d) Measures taken by a combination of sediment transport control facility and (dynamic) beach nourishment

Fig.4-1 Conceptual diagram of sediment transport distribution by the pattern of measures against beach erosion

2.3 Sediment transport control facilities

2.3.1 Selection of facilities

The sediment transport control facilities should be selected on the basis of their required performances in sediment transport control; their effects on the coastal environment or utilization; their economic efficiency; and the constraints of construction, etc.

Explanation

Sediment transport control facilities are detached breakwaters, artificial reefs, and headlands (including jetties). Sediment transport control systems such as detached breakwaters or artificial reefs should dissipate the waves, cause diffraction of waves from the opening, and control the coastal sediment transport rate via the resulting tombolos that form from the effects of dissipated or diffract waves. However, it is necessary to pay attention to the decreased rate of transport of the sediment flowing into the lower reaches and the movement of sediment from the surrounding coast to the back of any detached breakwater due to the waves diffracted at its edge. The sediment transport control system of a headland should transform the beach surrounded by a headland into a stabilized shape in which the sediment transport rate can be proportioned to the inflow sediment rate, consequently controlling the shoreline regression rate. The jetty is an auxiliary work to control seasonal shoreline changes.

The detached breakwater, the artificial reef landscape, and the coastal environment and utilization will be described in “Explanation” in Section 3.4 “Wave-dissipation facilities.” The establishment of headlands may transform a straight beachline into a bow-shaped one, although headlands, established with a wide interval between them, have few effects on the landscape. Additionally, since the headland itself is likely to be a large construction, sufficient consideration must be given to its establishment.

In terms of economic efficiency, as evaluated only by the initial construction cost, headlands are generally the most cost-efficient on a long beach, as are detached breakwaters on a pocket beach (a bow-shaped beach whose sediment balance is closed because the ends are surrounded by capes etc. that prevent coastal drift sands from passing through them) or a comparatively short beach. In the evaluation of economic efficiency, headlands need to be compared in terms of not only other construction forms with the same functions of coastal protection, environmental conservation, and utilization, but also their lifecycle costs. Thus, it is not appropriate to evaluate them by only each construction cost at the initial stage.

Their constraints of construction depend on their foundations or the wave conditions. On poor ground or homogeneous fine sand ground, the foundations need to be taken as far as the detached breakwater, whose dam site weighs a great amount.

2.3.2 Detached breakwaters

The plane configuration, dam crest height, and structure of the detached breakwater should be designed in consideration of beach nourishment. The parameters of the design beach profile should be ensured. In planning a detached breakwater, it is necessary to consider the coastal environment and utilization.

Explanation

Detached breakwaters are classified into continuous levees and discontinuous ones by their landforms and into permeable levees and impermeable ones by their permeability to waves. Generally, impermeable and discontinuous levees with easy construction constraints are often used in expectation that a tombolo can be formed behind them. With continuous levees the formation of a tombolo cannot be expected; nor can dissipation of the coastal sediment transport rate by shoreline changes. Additionally, with continuous levees, it is necessary to pay attention to the deterioration in water quality on the landward side due to lack of seawater exchange. Impermeable levees are used when a wave-extinguishing effect higher than that achieved with permeable levees is required.

The sediment transport control effect of a detached breakwater depends on structural parameters such as the height and width of the dam crest, the depth of execution, the width of the opening, the distance from the shore, etc.

In the actual examination, the *Design Manual for Detached Breakwaters* should be referred to.

2.3.3 Artificial reefs

The plane configuration and dam crest depth of an artificial reef should be designed in such a way that the parameters of the design beach profile can be maintained, taking into account beach nourishment.

In designing the reef, its effects on the coastal environment and its utilization should be considered.

Explanation

The plane configuration and dam crest depth of an artificial reef should be determined in anticipation of its effect in decreasing the sediment transport rate by making circulation flow behind it, as well as its effect in decreasing wave action.

The effect in decreasing sediment transport rate by decreasing wave effects is the same in the case of a detached breakwater. The wave decreasing effect can be specified by the width and depth of the dam crest. To make water circulation flow behind an artificial reef, it is necessary to pay attention to the balance in the proportions of the opening width, the dam length, and the distance form the shore. In order to widen the opening, it is necessary to ensure the powerful effect of extinguishing waves (making the dam crest depth shallow). For the resulting sediment transport control effect to be evaluated, a 3-D model for beach profile change, by which the changes in flow conditions can be considered, or a model for shoreline profile change, by which wave changes can be properly considered, can be used. However, it is desirable to regulate and properly arrange the opening or levee width in accordance with the shoreline changes at the site.

In the actual examination, refer to the *Design Manual for Artificial Reefs*.

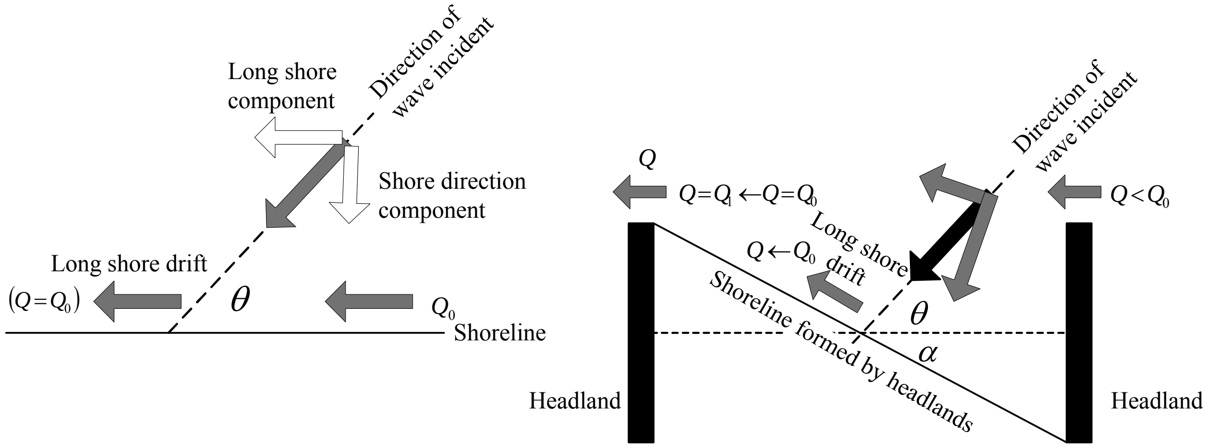
2.3.4 Headlands

The plane configuration and dam crest height of a headland should be designed so that the parameters of the design beach profile can be maintained, on the basis of beach nourishment.

In the actual design, the coastal environment and its utilization should be considered.

Explanation

Figure 4–2 shows the sediment transport control mechanism of a headland. The longshore direction component among wave energy fluxes contributes to the longshore sediment transport rate. Under natural conditions, the shoreline is stabilized because the inflowing sediment transport rate Q_0 is balanced with the transport sediment rate Q, which is determined at the relevant site (refer to Fig. 4–2 (a)). On such a beach, when the inflowing sediment transport rate decreases from Q_0 to Q, headland works are introduced as a countermeasure. In other words, the headland works incline the shoreline by α to decrease the sediment transport rate Q that occurs at the site from Q_0 to Q_1 and balance it with the inflowing sediment transport rate Q_1 (Fig. 4–2(b)). Since a long beach, divided by headlands, has a stable profile in each section, the shoreline regression rate can be dispersed and its maximum value made smaller.



(a) Wave direction and long shore drift rate (b) Erosion control by headlands

Fig.4-2 Mechanism of long shore drift control by headlands

The sediment transport control effect of a headland is determined by the dam length and dam crest length of the headland. Figure 4–3 shows the relationships among the dam lengths of the headland, its execution interval, the shoreline position at the upper side of sediment transport between the headlands, and the shoreline profile formed between the headlands, when no (static) beach nourishment is introduced. When no (static) beach nourishment is introduced, since sediment movement occurs between headlands, the shoreline is retrograded at the upper side of sediment transport. The larger the permissible regression width is (i.e. the wider the space of the design beach profile compared with the present one), the wider the interval between the headlands and the longer the dam length. On the other hand, when the shoreline cannot meet the parameters of the design beach profile with a certain interval between the headlands, the necessary dam length of a headland and the parameters of the design beach profile should be ensured by beach nourishment.

In many cases, the height of the dam crest of a headland commonly serves as the backshore height. The side-dam site of a headland, which prevents the longshore current that occurs between headlands from changing into an off-shore current and consequently prevents sediment from running off, forms an interception to mitigate fluctuation of the shoreline. A small jetty is sometimes adopted as an auxiliary work to control a local fluctuation of shoreline.

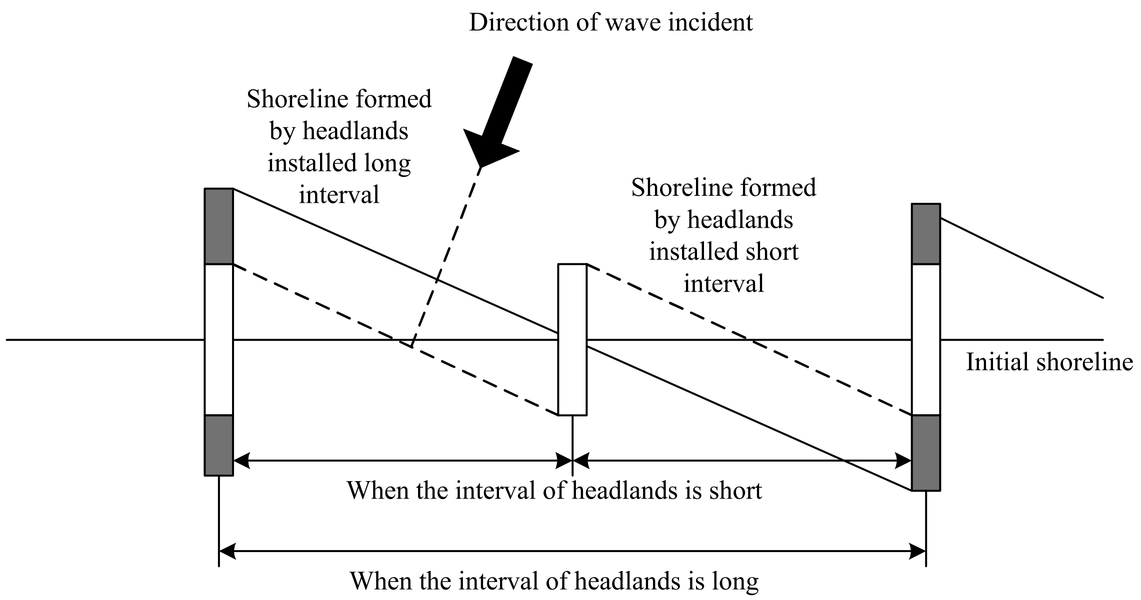


Fig.4-3 Headland interval and shoreline regression rate

2.4 Beach nourishment

Beach nourishment is classified into the (static) beach nourishment that is necessary to ensure the parameters of the design beach profile and the (dynamic) beach nourishment that is necessary to maintain the parameters of the design beach profile in consideration of the effects of the sediment transport facilities.

In the actual planning for beach nourishment, its effects on coastal protection, environmental conservation, and utilization should be considered.

Explanation

Beach nourishment is classified into (static) beach nourishment to ensure the parameters of the design beach profile and (dynamic) beach nourishment to increase the inflow sediment rate and maintain the design beach profile. For example, in terms of headlands, (static) beach nourishment is the one that is needed initially to ensure the shoreline profile of the design beach profile at the upper side of a headland (Fig. 4–4 (a)). The inflow sediment transport rate that is needed to maintain this shoreline profile is decreased from the sediment rate Q_0, necessary for the initial shoreline, to Q_1. On the other hand, (dynamic) beach nourishment should continuously make up the difference, $\Delta Q = Q_1 - Q$, between the inflow sediment transport rate Q and the longshore sediment transport Q_1 that is required to maintain the shoreline profile on the upper side of a headland. Moreover, if the shoreline profile of the design beach profile is formed by headlands and by (statistic) beach nourishment in such a way that the sediment transport rate is $Q_2 = Q$ (Fig. 4–4(b)), then (dynamic) beach nourishment will become unnecessary.

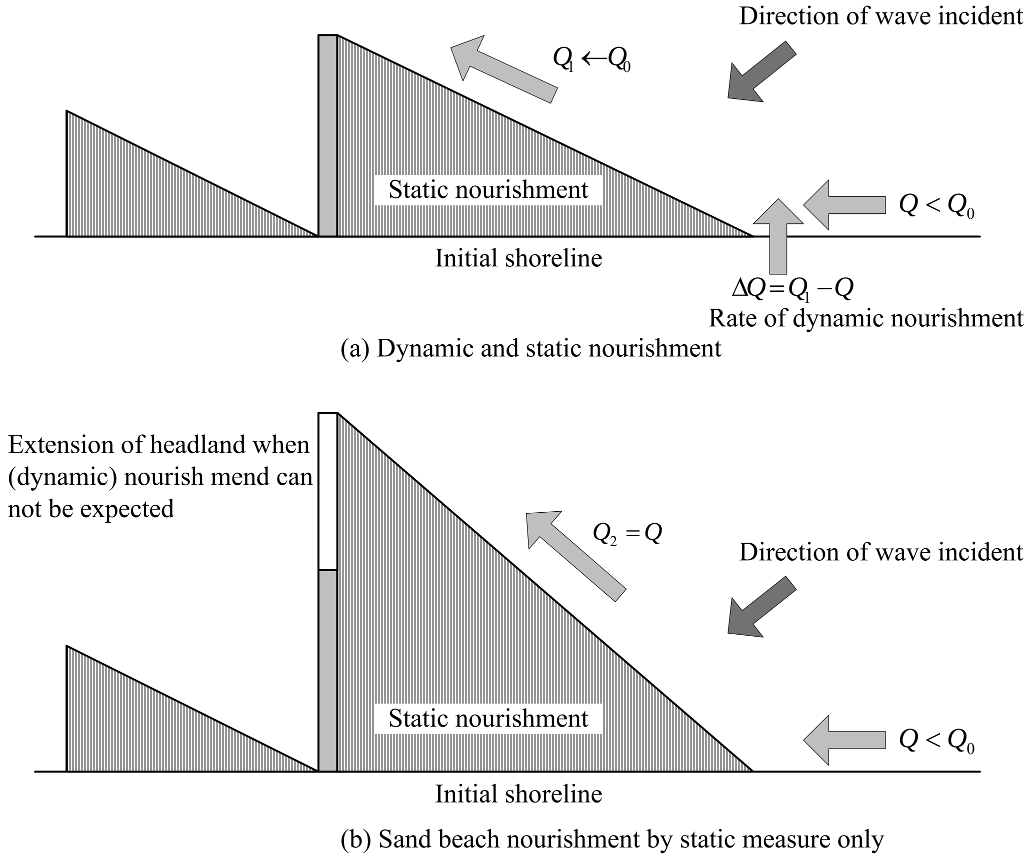


Fig.4-4 (Static) and (Dynamic) sand beach nourishment

The sand-grain diameter of the materials for beach nourishment should be as large as, or a little larger than, that of the sand that is native to the site. After beach nourishment, fines run off into the sea and make it muddy, so materials with the smallest amount of fines possible should be selected.

(Dynamic) beach nourishment should be set up at the upper side of the sediment transport if possible. Just after beach nourishment the sediment is discharged offshore until stability is obtained (Fig. 4–5). When beach nourishment is executed too far offshore, the amount of sediment that is discharged offshore is increased. To avoid this, nourishment should be executed in the longshore direction. Since the amount of sediment that is discharged in the longshore direction depends on sea phenomena, it is desirable to ensure sufficient beach nourishment at the early stage. The time and amount of the materials that are supplied later should be decided according to cost-effectiveness and the available amount of materials, as well as the state of the coastline. Furthermore, the dam crest height of the (dynamically) nourished beach should be lower than the backshore height, assuming that the materials for beach nourishment should be discharged when the waves are high.

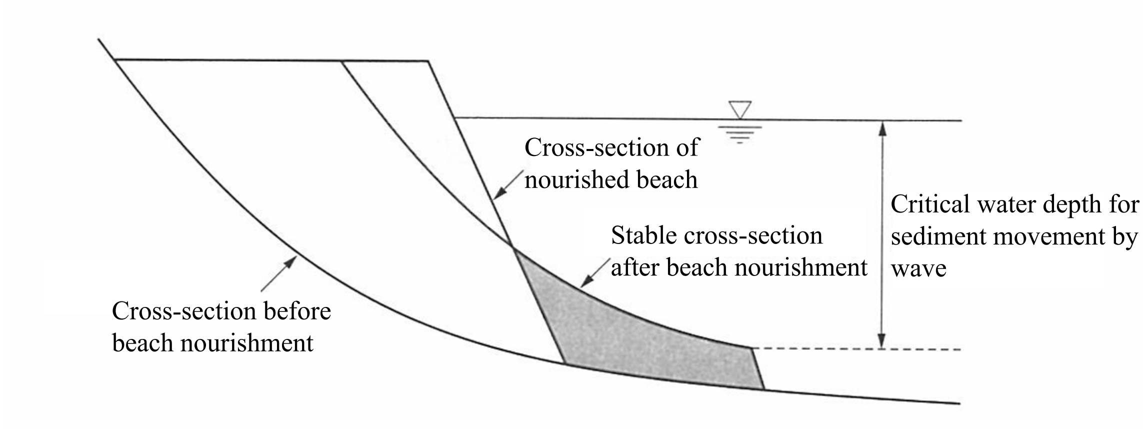
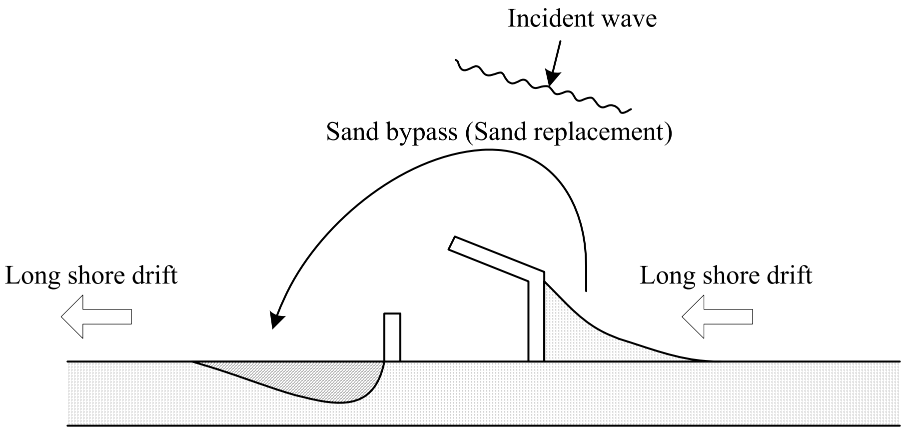
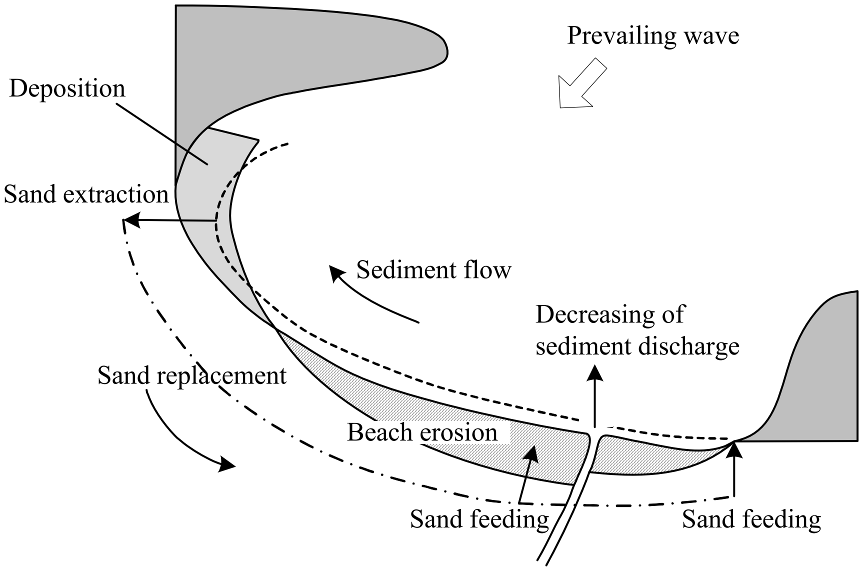


Fig.4-5 Early discharge of beach nourishment materials

In examining a nourished beach as a countermeasure against erosion, it is necessary to consider the amount and method of transport of materials for stable supply. Sand bypasses (Fig. 4–6 (a)) and sand recycling (Fig. 4–6 (b)) are mentioned as effective methods of supplying the materials for beach nourishment.



(a) Sand bypass



(b) Sand recycling

Fig.4-6 Variation of (dynamic) beach nourishment

Section 3 Storm Surge Protection Facilities

3.1 Overview

Planning for the installation of storm surge protection facilities should specify not only the allocation between dikes or revetments and wave-dissipation facilities but also the basic conditions for getting the best disaster-prevention performance out of these structures.

Explanation

In storm surge protection projects, the use of distributed protection methods that combine a number of facilities is becoming the norm.

This chapter will select the most suitable combination from the existing ideas for multiple allocations among dikes or revetments and wave-dissipation facilities and will then specify the conditions for optimizing the disaster-prevention performance of these combinations.

The conditions for the stability of a facility and others will be specified according to the design edition of the *Manual for River Works* (Draft).

3.2 Allocation of dikes or revetments and wave-dissipation facilities

The allocation of dikes or revetments and wave-dissipation facilities should be established based on their safety; economic efficiency; constraints of construction, effects on hinterlands, waters, and beaches; and the status of the neighboring coast.

Explanation

In planning a storm surge protection facility, it is necessary to comprehensively consider the attenuation of a wave that occurs when it goes up the slope of a dike or revetment, as well as the attenuation caused by a wave-dissipation facility.

Generally, the higher the dike, the greater its disaster-prevention effects. In some cases, however, it is desirable to make the dike as low as possible from the viewpoints of coastal utilization, land use of hinterlands, landscapes, etc. Additionally, the fishery can be lost and the beach width decreased by increasing the allocation of a wave-dissipation facility. Thus, the combination of dikes or revetments and wave dissipating facilities should be decided on after these options have been examined sufficiently in terms of their related coastal environment and utilization.

Although the liner protection method by a combination of dikes or revetments and wave dissipating facilities was conventionally used in many cases, it spoiled the landscape and the beach access, and the non-point protection method that combines dikes or revetments, offshore wave-dissipation facilities, and beach nourishment is often used now. The use of a combination of multiple facilities is tough and profitable from the viewpoint of disaster prevention.

The combination of dikes or revetments and wave dissipating facilities offers a variety of measures for disaster prevention. These disaster-prevention measures are compared from the viewpoints of economic efficiency, coastal environment and utilization, and effects on society to select the most suitable project.

3.3 Dikes or revetments

3.3.1 Types of dikes or revetments

In choosing the types of dikes or revetments, it is necessary to consider the natural conditions, the level of importance of a hinterland, the neighboring coastal prevention facilities, the status of the land or water surface use, etc.

Explanation

The types of dikes or revetments can be classified into upright-type breakwaters, mound-type breakwaters, and composite-type breakwaters, according to the gradient of their front slopes. The upright-type breakwaters should have a gradient of under 10%, and mound-type breakwaters a gradient of over 10%. A breakwater with a gradient of over 30% is called a gentle slope-type coastal dike. In composite-type breakwaters upright-type construction such as a caisson or block is placed on the top of a mound-type structure such as a rockfill mound. Types of dikes or revetments are shown in Figure 4–7.

The conditions generally appropriate to each type are given below.

1. Upright-type breakwaters
a. Used when the foundation ground is relatively solid
b. Used when the site for a breakwater cannot be easily prepared

Since the land side of an upright-type breakwater can sometimes be separated from the seashore, stepladders or ramps have to be set up for access if necessary.

On the seashore, where the foot of the dike is usually exposed to the waves, because the foot of the dike is likely to be scoured by reflected waves, it needs to be protected.

2. Mounted-type breakwaters
a. Used when the foundation ground is relatively weak
b. Used when the site for the breakwater can be easily prepared
c. Used when there is a strong need for utilization of the beach

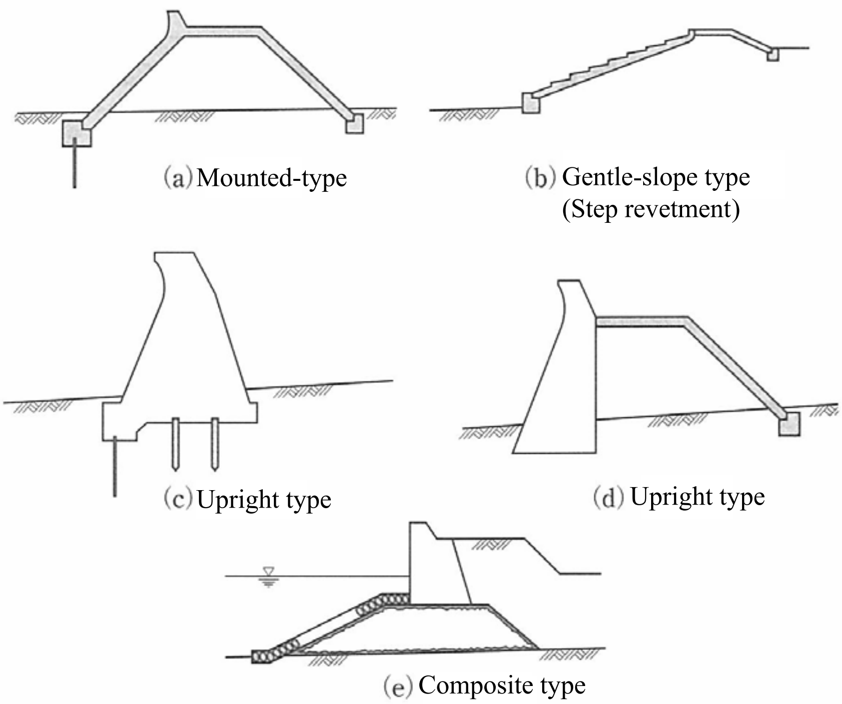


Fig.4-7 Types of dikes

Since the site dike is generally at the beach, the dam base usually covers part of the beach, thus threatening the coastal vegetation.

In terms of the structure of the dike, mound-type breakwaters have an advantage over upright-type breakwaters against waves. If they are constructed on sandy ground near the shoreline, however, erosion and waves are likely to change the foundations of the dike, or reflected waves are likely to scour its foot, so the foot of the dike must be protected. On the other hand, since the foot of the dike is covered by weeds and is likely to be slippery, threatening to make access to the beach difficult, the dike must be well maintained.

When utilization of the beach is the aim, some of the sections of mound-type breakwaters should be set up to allow lines of access by beachgoers and also to suit the slope situation.

3. Composite-type breakwaters

a. Used when the foundation is built in the sea and construction is difficult
b. Used when the site cannot be easily prepared
c. Used when the foundation ground is not very solid

3.3.2 Normal line of dikes or revetments

The normal line should be drawn so gently that it can run parallel to the coastal landform.

Explanation

The coastal landform is commonly harmonized with natural conditions such as the waves or the sediment supply. Thus, drawing the normal line parallel to the coastal landform will lessen its effects on the seashore and thus disperse the waves so that they do not concentrate on a particular point. In contrast, the normal line drawn non-parallel to the coastal landform will transform the beach along the dike, lose part of the sandy beach, and cause wave concentration, so it is necessary to take note of the way to set up a normal line.

When the foot of the dike is under the water, it is likely to be affected by the waves and scoured by reflected waves. Thus, it is necessary to examine a normal line inside the landside area and to consider the need to protect the foot of the dike.

3.3.3 Gradient of Foreshore

The gradient of the front slope should be established by taking into account the stability of the dike and its effects on the coastal environment and utilization.

Explanation

By making the gradient of the foreshore gentler, access to the beach is improved and the runup height reduced, so that even if the height of the dam crest is lowered, the dam base can be widened, sometimes leading to disappearance of the beach. On the other hand, when the toe of the slope is underwater, reflection of the waves

occurs constantly, not only increasing the possibility of scouring but also causing weed overgrowth, which makes the toe slippery and obstructs access to the seashore.
Therefore, in the actual planning, it is necessary to consider the position of the toe of the slope.

3.3.4 Design runup height and design wave-overtopping rate

The design runup height and the design wave-overtopping rate should be properly determined in consideration of the effect of a wave-dissipation facility when the design tide level and the design wave work on a beach that has the parameters of the design beach profile.

Explanation

The wave runup height varies with the wave height, wave period, the sea-bottom form, the form and water depth of the dike, and the presence of wave-dissipation facilities. Additionally, evaluation of the wave-overtopping rate is also conducted if necessary.

3.3.5 Freeboard

Freeboard should be allowed in dikes or revetments.

Explanation

In the specification of the height of the dam crest of a dike or revetment, freeboard should be allowed on the basis of the design tide level, the design wave, and the uncertainty of settlement. It should be also specified appropriately in consideration of the social and economical importance of its hinterland, sea phenomena, and topographical conditions.

3.3.6 Height of the design dike or revetment

The height of the design dyke or revetment should be made up of the design runup height and the freeboard. In other words, it is made up of the height whose wave-overtopping rate is less than the allowable overtopping rate, and the freeboard. The design dike or revetment height should be estimated by considering the economic efficiency, the land use situation of the hinterland, the coastal use situation, the height of the neighboring dike or revetment, etc.

Explanation

The dam crest height of a dike or revetment varies depending on the parameters of the design coastal profile, the scales of the wave-dissipation facilities, and the gradient of the slope of a dike or revetment, which are combined to offer many options. Generally, as the scale of a wave-dissipation facility is made larger, the height of the dam crest of a dike or revetment is made lower. The low dam crest is favorable to the landscape or coastal utilization but costs more. On the other hand, if the height of the dam crest of a dike or revetment is made larger, the coastal use or environment in the landside area may deteriorate. Additionally, changing the height of a series of dikes or revetments because of the construction of wave-dissipation facilities etc. is not psychologically desirable for the community. Thus, a certain dam crest height of a series of dikes along the same beach should be determined after a comprehensive consideration of the regional situation.

When the dam crest height needed for the dike or revetment to protect the beach is not socially and economically favorable, the parameters of the design coastal profile and the presence of wave-dissipation facilities or works must be reexamined.

3.4 Wave-dissipation facilities

3.4.1 Types of wave-dissipation facilities

The type of wave-dissipation facilities should be selected based on the necessary wave-dissipation effects, their effects on the coastal environment (including the landscape) and its utilization, economic efficiency, constraints of construction, etc.

Explanation

The wave-dissipation facilities include wave-dissipation works, detached breakwaters, and artificial reefs.

The wave-dissipation works exert their wave-dissipation effects by wave reflection at the front of the slope, the attenuation of wave energy due to turbulence that occurs as the waves pass through the inside of the dike, or the decrease in wave runup height due to the roughness of the slope.

Since part of the incident waves are reflected or the wave energy is decreased as the waves are passing through the dam site, detached breakwaters can exert wave-dissipation effects. A wave that flows in from the opening is dispersed by diffraction, and thus the wave height is lowered.

On artificial reefs, the wave height is lowered because the waves are breaking on a slope at the offshore side or on the crest; it is also lowered by the dispersion of wave energy that occurs as the broken waves pass over the shallow-water dam crest.

The wave-dissipation effects of the wave-dissipation facilities are represented by the permeability rate—that is, the ratio of the height of the wave that has passed over the crest to the height of the wave that was in front of it. The wave runup height can be calculated by converting the height of the wave after it has passed, back into the deepwater wave height.

When the scale of a facility is made larger, the load on a dike or revetment is relatively reduced and its effect on the inland area or access to it is also decreased. At the same time, however, the load on the coastal environment and utility can be also increased, which is considered unprofitable from a cost standpoint in many cases. Thus, the question of whether the scale of a facility should be enlarged must be comprehensively considered.

On the other hand, when the sea floor on which the foundation of a wave-dissipation facility is established is lowered by erosion, the wave-dissipation effect is also lowered and the purpose of disaster prevention cannot be accomplished. Thus, the presence or absence of erosion must be confirmed as well.

Meanwhile, artificial reefs do not spoil the landscape, because they are submerged facilities. However, with wave-dissipation works and detached breakwaters, especially of the block type, in which the dam crest is constantly above the water, the deterioration of landscape is more likely to come into question. Thus, a new type of detached breakwater that has a foot and performs better in the landscape than the conventional types has been developed.

In terms of coastal environments, artificial reefs create shallow areas in the sea, which, in turn, produce undersea forests or habitats for natural life forms. Additionally, detached breakwaters sometimes offer habitats for living things that dwell around rocks. Because most of the effects of seacoast preservation facilities on ecosystems remain unknown, it is necessary to properly monitor and understand the changes that occur in the coastal environment after their construction.

In terms of coastal utilization, since an artificial reef with a wide and shallow dam site is likely to obstruct traffic and have detrimental effects on the fishery, careful monitoring is required. Detached breakwaters restrain the utilization of the sea surface. Wave-dissipation works obstruct access to beaches.

In terms of cost-effectiveness, evaluated from only the initial construction cost, detached breakwaters are generally the most profitable. The cost-effectiveness of each facility should be examined not only in terms of the structure, each of which should have the same functionality in terms of coastal protection, environmental conservation, or utilization, but also the lifecycle cost. Thus, it is not appropriate to evaluate facilities only by the initial construction cost.

The constraints of construction depend on the conditions of the ground or waves. For example, on poor ground or homogeneous fine sandy ground, it is necessary to build foundations when a detached breakwater, whose dam site weighs a greater amount, is selected.

3.4.2 Detached breakwaters

The plane configuration, dam crest height, and structure of a detached breakwater should be specified such that the necessary wave-dissipation effect can be ensured when the design tidal level and the design wave work on a beach that has the parameters of the design beach profile.

The detached breakwater planning should consider the effects on the shoreline, flow conditions, and coastal environment and utilization.

Explanation

Detached breakwaters are divided into continuous and discontinuous levees by landform, and into permeable and impermeable levees by wave permeability. In many cases, permeable and discontinuous levees, whose constraints of construction are commonly less, are used in anticipation that a tombolo can be formed behind them. With continuous levees, it is necessary to take care of water pollution caused by water level rises or seawater retention at the shore side. Impermeable levees are used when a wave-dissipation effect higher than that provided by permeable levees is required.

The sediment transport control effect of a detached breakwater depends on parameters such as the height and width of the dam crest, the depth at which the breakwater is established, the dam length, opening width, distance from the shore, etc.

For the actual examination, see the *Design Manual for Seacoast Preservation Facilities*.

3.4.3 Artificial reefs

The plane configuration and the dam crest height of an artificial reef should be specified such that the necessary wave-dissipation effect can be ensured when the design tidal level and the design wave work on a beach that has the parameters of the design beach profile.

The artificial reef planning process should consider the effect of the reef on the shoreline, the flow conditions, and the coastal environment and utilization.

Explanation

The wave-dissipation effect of an artificial reef is controlled by parameters such as the depth and width of the dam crest, the depth of the dam foot, the width of the opening, etc.

The mean water level rises on the artificial reef, where incident waves are forcibly broken. As the depth of the dam crest becomes shallower compared with the height of the incident wave, the percentage rise also becomes higher, with the mean water level rising by 10% to 20% of the height of the incident wave on the shore side of the artificial reef. Thus, in the actual planning of wave runup height, it is necessary to consider the percentage rise in water level on the shore side.

In the process of configuration of the plane of an artificial reef, although it is desirable to make the dam site continuous so that wave height distribution cannot occur in a coastal direction, the percentage rise in mean water level can be more efficiently controlled by establishing an opening. The width of the opening needs to be specified so that the wave height behind the dam site cannot exceed that of the dam site.

When the basic type of artificial reef is selected, the interaction among those parameters should be considered carefully so that the reef's required function of wave dissipation can be fulfilled most efficiently as a whole. For the actual examination, see the *Design Manual for Artificial Reefs*.

3.4.4 Wave-dissipation works

The cross-section of wave-dissipation works should be specified in such a way that the required wave-dissipation effect can be ensured when the design tidal level and the design wave work on a beach that has the parameters of the design beach profile.

Planning for the wave-dissipation works should consider their effects on the coastal environment and its utilization.

Explanation

The wave-dissipation effects of wave-dissipation works are determined by parameters such as the width of the dam crest, the height above the water surface, the depth of establishment, etc.

However, wave-dissipation works should not be applied, if possible, since they not only obstruct access to the beach but also spoil the landscape and environment. When it is economically or socially difficult to have any other option, however, there is no choice but to apply these works for the purpose of lowering the height of the dam site.

To specify the parameters of the wave-dissipation works, see the *Design Manual for Seacoast Preservation Facilities*.

Section 4 Tsunami Control Facilities

4.1 Overview

The plan for the installation of tsunami control facilities should not only decide the allocation among dikes or revetments and tsunami breakwaters but also develop the basic conditions for getting the required protection performance out of dikes or revetments or tsunami breakwaters while considering the coastal environment and its utilization.

Explanation

This section aims to select the most suitable combination from the multiple allocation options of dikes or revetments and wave-dissipation facilities.

For these structures to perform their required functions, the structural conditions must be properly developed.

The conditions related to the stability of the facilities etc. are established according to the *Manual for River Works in Japan (Draft)*.

4.2 Allocation among dikes or revetments and wave-dissipation works

The allocation among dikes or revetments and tsunami breakwaters should be decided in consideration of parameters such as their stability, cost-effectiveness, constraints on construction, effects on hinterlands, sea areas, and beaches, and the status of their neighboring beaches.

Explanation

It is necessary to determine the tsunami runup height, while at the same time comprehensively considering the attenuation of the tsunami that occurs when it runs up on the slope of a dike or revetment, as well as the attenuation by a tsunami breakwater.

Since the tsunami that has reached the highest-ever water level is set as the design tsunami in many cases, one that has a very high water level can be also targeted, depending on the landform. Therefore, to protect this by a dike alone, the dam crest inevitably becomes very high, possibly obstructing access to the beach or spoiling the environment. Thus, the height of the dam crest can be lowered by using a combination of a dike with a wave-dissipation facility such as a tsunami breakwater, etc.

When revetment improvement is expensive because the bay mouth is small or the coastline long, the introduction of a tsunami breakwater is worth considering. Since this breakwater would prevent the seawater from exchanging within the bay, however, it is necessary to address water quality deterioration.

The combination of dikes or revetments and wave-dissipation facilities can provide a number of ideas for disaster prevention. It is necessary to choose the most suitable prevention idea from among these, while comparing them from the perspectives of cost-effectiveness, coastal environment and utilization, and social effects.

4.3 Design tsunami runup height

The design tsunami runup height should be properly determined by considering the effect of a tsunami breakwater when the design tidal level and the design wave work on a beach that has the parameters of the design beach profile.

Explanation

The types of dikes or revetments, alignment, and freeboard; the heights of dikes or revetments; and the gradient of the foreshore should follow the description in 3.3.

If the maximum water level at the position of a revetment can be estimated on the basis of the height of a past tsunami mark, which would have been affected by complex ground landforms and constructions such as houses, their hydraulic effects should be sufficiently considered. In conducting numerical simulations of tsunamis, the validity of the calculations must not be confirmed without comparing the results with the heights of the past tsunami marks.

4.4 Tsunami breakwaters

Tsunami breakwaters should be planned properly and individually.

Explanation

Tsunami breakwaters cannot be generalized, since they are large-scale facilities. If anything, they should be planned separately by using the latest technology.

References

1) National Association of Sea Coast. *Design Manual for Artificial Reefs.* Supervised by Seacoast Division, River Bureau, Ministry of Construction, 1992:92.
2) Japan Society of Civil Engineers. *Design Manual for Seacoast Preservation Facilities*. Editorial Subcommittee of Coastal Engineering Committee, 2000:582
3) Seacoast Division, River Bureau, Ministry of Construction. *Design Manual for Detached Breakwaters*, 1986

Chapter 5 Planning for the Installation of Information Facilities

Section 1 General Information

Planning for the installation of information facilities should be conducive to the implementation of river, sediment and erosion, and seacoast projects and the sophistication of river administration systems etc. It should include the development of a system for efficiently gathering, managing, and commoditizing hydrological information such as present and past rainfall, water level, and water quality; disaster prevention information in the form of images etc. and other disaster information; basin information related to river utilization etc.; and general public opinions.

Planning should ensure the certainty, reliability, rapidity, and interactivity of information facilities used to issue evacuation warnings so that these warning facilities can be properly arranged by proper methods. Notably, for information related to landslide disasters, a system that allows interactive messages between community members and administrative organizations should be developed.

Explanation

In the preparation of projects for rivers, sediment and erosion control, and seacoasts, hydrological observation data of past floods and droughts and environment data are necessary as basic sources. It is necessary to accumulate time data for each flood, annual day-unit data, short-time rainfall data every 10 minutes, etc. as hydrological observation data, and to maintain their quality. Additionally, the data should be basically developed as GIS systems that allow multiple indications to be connected by maps, in order to conduct runoff analyses or flood simulations with typographical or construction data or to facilitate indication-processing descriptions. The data management method must then be specially determined and the performance of information-gathering instruments improved, for example, by introducing an automatic updating system.

On the other hand, from the viewpoint of management of rivers etc., it is especially important to gather information on both the present situation and future predictions to determine what countermeasures should be taken in a time of disaster. Thus, to gather, develop and provide river information, the system needs to be formed to meet a need from the viewpoints of the relevant organizations and bodies and to share necessary information provided by them.

Above all, in the case of landslide disasters, which are likely to involve human lives, because the discovery of premonitory signs and communication are the keys to reducing damage, it is necessary to construct a system that allows community members and administrative organs to interactively communicate.

Section 2 Collecting Information and Ordering, Provisioning, and Commoditizing the System

In the preparation of systems for collection and ordering by the offering and sharing of information about rivers, sediments and erosion, seacoasts, etc., the following items should be examined:

- Development of a system for gathering information, data, etc.
- Development of a database whose quality is ensured
- Construction of a network for sharing information and data.

Explanation

Information- or data-gathering instruments, such as CCTV, have been introduced in recent years to gather image information. Information outlets and backslope sliding and debris detectors that work with flood protection and evacuation on warning, as well as hydrological information equipment (water gauges, rainfall recorders, radar rain gauges), have conventionally been used for river management. It is necessary to effectively arrange these items depending on the purpose and to then gather information.

For the information to be offered to and shared with the general public, it is important that the quality of the data be maintained. Thus, the information acquired must be examined on the assumption that it will be available to the general public and its quality must be maintained. In order to share information with the general public, it is necessary to develop the system into something more available to the public by computerizing the collected information or data. Furthermore, it is also important to foster an environment in which opinions are exchanged more actively, by sharing information with the general public.

In addition to conventional general public lines and dedicated wireless services, dedicated fiber-optic cables and satellite connections are useful as methods of communicating and sharing information and data. It is important to construct an effective information-sharing system by forming a network for any purpose between the relevant organizations and bodies.

Section 3 System for Gathering Information, Data, etc.

In addition to the system for gathering hydrological information such as rainfall and water levels, image information and information on construction-operating conditions etc. are useful as countermeasures in times of disaster. Thus, it is necessary to examine the development of the disaster-information gathering system, including CCTV, sensors, information outlets, etc. Moreover, in terms of landslide disasters, it is also necessary to examine the development of mudflow detecting sensors and landslide monitoring instruments, which are required to construct a system for prompt evacuation on warning.

Explanation

In areas that have been frequently hit by flood damages in recent years or to which flood protection will have to be selectively applied, the establishment of CCTV, water level sensors, etc., needs to be examined.

To confirm the safety within a river course at the time of dam discharging, the establishment of CCTV should be considered in places where there may be considerable delay between the warning point and the hazard location, such as in the basins of mountain streams or in places that are likely to have blind spots.

Meanwhile, it is important to develop slope-sliding detection sensors that can be interlocked with flood-fighting works, information outlets by which information can be sent from disaster sites, and optic-fiber networks.

In particular, in cases where a secondary disaster may be caused by slope collapse etc., it is necessary not only to construct a warning and evacuation system but also to establish debris flow sensors or landslide monitors that can assess sediment movement.

Section 4 Development of a Quality-assured Database

It is necessary to formulate a system for dividing the basic data required by the general public into real time data (quick estimation) and accumulated data (established estimation) and to then develop the data and offer them in the form of a database. Since a system for gathering and providing real-time data is important for mitigating disasters in time of flood, it is necessary to take the speed and certainty of the system into consideration. In terms of accumulated data, quality maintenance and availability to the general public should be considered.

Explanation

In setting up river, sediment and erosion, and seacoast projects, data on the hydrological observation of previous floods, droughts, landslide damage, environments, etc. are basic necessities. Also, the planning should provide for accumulation of time-stamped data for each flood and annual day-unit data, maintaining their high quality. To reduce damage in times of flood, it is important to promptly provide the general public with both situation reports of hydrological observation data (such as rainfall rate, water level, etc.) and information on forecasts. In this way, because some items of hydrological information that are offered take priority over others, depending on their purpose, it is necessary to construct a database from the different viewpoints of real-time data (quick estimation) and accumulated data (established estimation).

In gathering and developing the real-time data, it is especially important to gain data on the present situation and for the future, in order to determine which countermeasures should be taken in times of disaster. In gathering and providing the real-time data, it is necessary not only to satisfy needs from this viewpoint but also to have a system by which information can be shared with medical agencies.

In terms of accumulated data (e.g. hydrological observation data), it is necessary to accumulate time data on each flood and annual day-unit data, while ensuring their quality. In terms of availability to the general public, the data must be basically developed as a GIS system. It should allow runoff analysis or flood simulation interlocked with typographic or construction data, or multiple indications interlocked with maps to make indication-processing easy to explain. Then, attempts should be made to improve the performance of information-gathering instruments; for example, the introduction of an automatic updating system should be attempted and a specialized data management method should be devised.

The basic approaches to the development of a river GIS are given below.

a. Basin and river base maps

The development of basin and river basement maps of 1/25,000 and 1/2,500 is attempted so as to gather on GIS the data needed for flood simulation, runoff calculation, and analysis of hydrological observations or environmental information. To transform the basement maps into 3D imaging, the following procedures are followed: 1) feed in the 50-m mesh elevation data that have been developed to make hazard maps; 2) in mapping inundation risk area of different return periods by using a laser profiler, feed in the finer mesh elevation data; and 3) in an area where micro-landform elevation data are to be gathered by laser profiler (e.g. a low-lying area within a city that requires coercive drainage by pumps and extremely precise simulation of flooding with or without a dike), feed in the micro-landform elevation data gathered by laser profiler.

b. Data on the present status of the river

In terms of river longitudinal/cross section, construction parameters and drawings, disaster situation, etc., construction diagrams updated during the building, maintenance or repair of a structure, and diagrams of permitted structures, should be developed in such a way that they can be computerized as CAD data and managed on GIS connected to CALS/EC.

c. Hydrological and water quality data

The real-time data (quick estimation) or accumulated data (established estimation) related to hydrological and water quality data should be developed in such a way that they can be shown in comparison with the past data on GIS.

On the other hand, since the use of weather radar data plays an important role in real-time emergency management (for example, in flood forecasting), the quality of the data should be unified nationwide. A system should be developed so that weather data that is revised by the analysis of ground rainfall gauge data can be offered in real time. The accumulation and development of past weather radar data are conducted according to the plan.

d. Data related to river environment information

Data should be developed in such a way that the variation with time of information related to important habitats and growing environments of plants and animals can be described on GIS. This makes it possible to grasp the overall environmental characteristics of the target river, its particular attributes, and its important habitats, all of which are conducive to river improvement and environmental management. (Such management includes the preparation of plans, the construction process, maintenance and management, conservation of habitat, permission for occupancy, etc.) It is necessary to support the activities of community members in river environmental conservation.

e. Dam data, hydrological observation data related to dams, environmental information related to dams, etc.

Dam data such as storage capacity and outflow discharge, hydrological data related to dams, and environmental information are developed in such a way that they can be indicated in comparison with past data on GIS.

f. Data related to water cycle information

To create a register of water utilization, the data should be developed in such a way that they can be represented on GIS.

In basins where, despite particularly high levels of water utilization, some problems with the construction of a sound water cycle remain unsolved, information related to the water cycle (such as the type of system and the amount of intake and drainage), as well as the data mentioned above, should be developed. For that purpose, it is necessary to standardize the data structure and to construct a framework for sharing the information among relevant organizations and bodies.

g. Information related to areas prone to landslide disaster

Information about debris-flow-prone torrents, landslide-prone places, and places prone to steep slope failure should be developed.

At the same time, it is desirable to develop data on the peripheral topography, geology, and natural conditions such as vegetation; social conditions such as housing and public facilities; past disaster occurrence situations; erosion control design areas; erosion control facilities, etc.

Section 5 Construction of a Network for Sharing Information and Data

The construction of high-speed networks such as ultrafast large-capacity fiber-optic networks should be examined among the relevant organizations and bodies for disaster prevention. Commoditization of disaster-prevention information and the mutual exploitation of the latest data need to be attempted using high-speed networks. It is also necessary to construct a system by which the relevant organizations and bodies can promptly and effectively deal with disasters in a time of disaster. Additionally, the information should be widely provided to the general public over the Internet etc.

The provision of real-time data is important for the purpose of reducing damage in times of emergency. The system should be such that real-time data can be promptly, precisely, and clearly provided to the general public and the relevant organizations and bodies. Moreover, it is necessary to construct a system that can provide information from multiple media while working with the relevant organizations and bodies, on the assumption that communication may be blocked in time of disaster.

Accumulated data should be conveyed to members of the general public by providing them with maps of probable flood-prone areas or hazard maps so that they can prepare themselves for an emergency on a daily basis. At the same time, it is also important to provide both daily data on water levels and water quality, and on the status of the river environment and its utilization, and past data, so that the general public can take advantage of this when carrying out various activities. Thus, the information service needs to be conducted by a system that is available to them.

Explanation

(Emergency)

From the viewpoint of reducing damage in a time of disaster, it is particularly important to promptly and precisely determine the rainfall, water level, and other river information, such as the river course status, and to share future prediction information among the relevant organizations and bodies. In gathering, developing, and providing river information, it is necessary to satisfy needs from the viewpoints of the relevant organizations and bodies and to construct a system by which the information can be shared among these bodies.

Therefore, it is effective to construct a high-speed network such as an ultra large capacity optic-fiber network that can transmit image information and the results of flood simulations to the relevant disaster-prevention agencies.

Additionally, the high-speed network should be constructed in consideration of security against virus entry, backup, the effective arrangement of servers, etc.

Since a fast information service is important to prevent disasters and reduce the damage they cause, river administrators, erosion control implementation bodies, and seacoast administrators have to develop a real-time data information service system by which they can grasp the information and provide it to the general public.

For the information service, it is important to indicate the present situation and predicted values by processing them into what is easy for the general public to understand. Additionally, since this information needs to be provided by a variety of media, such as those in related municipalities, mass media, the Internet, information bulletin boards, recorded telephone messages, etc., the system must be prepared from various perspectives on a regular basis.

In terms of network construction, backup for emergencies is also considered.

(Ordinary times)
For smooth evacuation and flood protection in times of disaster, information on inundation-hazard areas, the behavior of flood flows, volcano hazard maps, etc. must be conveyed to the general public through the Internet.

On the other hand, there is a common view that rivers are habitats, places for walking and sport, and important factors in forming the cultural climates of communities, as beautiful natural environments that change from season to season. This common view is very important for conducting proper river administration. Additionally, to support these various public activities, it is necessary to develop a system to provide people with related information, considering the roles of rivers as areas for civil activities or events related to rivers and environmental education. Moreover, it is also necessary to supply the public with daily observation data on hydrology, water quality, and the environment; this will help the general public to monitor or participate in river administration and will encourage them to embrace research activities.