

JICA THE PROJECT FOR CAPACITY DEVELOPMENT OF EFFECTIVE RIVER DIKES MANAGEMENT RESPONSE TO 2022 FLOOD

SEMINAR ON ISSUES AND CHALLENGES ON DESIGN, CONSTRUCTION, AND O&M OF BUNDS

Comparative Analysis of Design Manuals of Bunds in Sindh and Punjab Province
June 2024

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1 INTRODUCTION

2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

- 2.1 Extraction of Item to be Analyzed
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1. INTRODUNCTION

1.1 General

Table Project Outcomes and Activities	
Project Outcome	Activity for Outcome
1. The reproducibility of the 2022 flood considering climate change impact is assessed.	1-1: Analysis of the Reproducibility of the 2022 Flood in Consideration of Climate Change (already implemented by JICA)
2. A mechanism to perform inspection and diagnosis of existing river dikes is established.	2-1: Implementation of a comparative analysis of technical manuals on bund by Pakistani provinces → Presentation on THIS ACTIVITY 2-2: Implementation of an inventory survey of the present status of the main Indus River bund 2-3: Study on the maintenance and management method of the main Indus River bund suitable for Government of Pakistan system 2-4: Implementation of maintenance demonstrations in vulnerable areas of the Indus River Main River bund
3. The dike operation management plan including short to midterm action plan for the Indus River downstream of Tarbela dam is formulated.	3-1: Analysis of existing plans and projects related to the Indus River Main River bund 3-2: Preparation of supplementary materials to existing Pakistani technical manuals on bund management → The result will be reflected to this activity. 3-3: Arrangement and formulation of short- and medium-term action plans for the bund management
4. The prioritized projects based on the dike operation management plan are identified.	4-1: Extraction and arrangement of priority activities in the short to medium term action plan formulated in Output 3. 4-2: Identification of priority projects to be implemented as soon as possible.
5. The necessary pre-feasibility studies among the prioritized projects are performed.	5-1: Implementation of pre-F/S of priority projects identified in Output 4. 5-2: Implementation of capacity-building seminars on bund development and management → Part of THIS ACTIVITY

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1. INTRODUNCTION

1.2 Objectives

- ✓ Comparing the technical manuals of each province, lacking items or contents mentioned in only one of the manuals will be picked up and necessity for the addition will be analyzed.
- ✓ Extracting the issues on the existing manual considering the gap between the manuals and actual practice.
- ✓ Analysis of contents contributing to improve the technical manuals in each province by referring to technical standards in Japan..
- ✓ Based on the analysis result, measures to improve the existing technical manual will be recommended.

Table Standards Related to Bunds in Pakistan

Name of a Standard	Publisher	Year of Publication	Remarks
Manual of Irrigation Practice	Punjab Provincial Irrigation Department	2017	Including River Structure Other Than a Bund, Including Irrigation Facilities
Bund Manual (4th edition)	Sindh Provincial Irrigation Department	2008	Mainly About a Bund
National Flood Protection Plan (NFPP)-IV	Federal Flood Commission (FFC)	2018	Including River Structure Other Than Bund budget Not Approved

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1. INTRODUNCTION

1.2 Objectives

Table Major Standards Related to Bund in Japan (1. Laws and Government Orders)

Name of a Standard	Publisher	Year of Publication	Outline
River Law	Government of Japan	Revision in 2022	It covers the management and conservation of rivers, regulations on utilization, roles of river administrators, improvement and flood control measures, conservation of the river environment, management of water rights, regulations on river utilization, and supervision and penalties.
Enforcement Order for River Law	Government of Japan	Revision in 2022	Government ordinance (administrative order) that specifies the detailed operational methods and provisions for the implementation of the River Law. It complements the River Law by providing necessary procedures, criteria, and specific regulations for practical implementation.
Cabinet Order Concerning Structural Standards for River Administration Facilities, etc.	Government of Japan	Revision in 2013	It covers basic design standards, provisions for maintenance and management, regulations for the installation of river structures, seismic resilience requirements, and the responsibilities of administrators. The river structure includes dams, dikes, sluiceways&floodgates, weirs, bridges, pumping stations and inverted siphons.

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1. INTRODUNCTION

1.2 Objectives

Table Major Standards Related to Bund in Japan (2. National Standard)

Name of a Standard	Publisher	Year of Publication	Outline
Technical Criteria for River Works: Practical Guide for Designing [I]	Ministry of Land, Infrastructure, Transport and Tourism, Japan	Revision in 2019	It includes criteria for planning, survey&investigation, design, and operation&maintenance of river structures. These criteria cover design details of river structure such as dikes, revetments, spurs, weirs, sluiceways, floodgates, tunnel river, pumping station, inverted siphons.
Standard for Extra Embankment	Ministry of Land, Infrastructure, Transport and Tourism, Japan	1969	This standard specifies the standard height of extra embankment considering the settlement and compression depending on the type of earth material.
Performance Based Seismic Design Criteria for River Structures	Ministry of Land, Infrastructure, Transport and Tourism, Japan	2001	This specifies the methods, items, setting of external force and required function of river structure facilities after the earthquake. It considers Level 1 and Level 2 seismic conditions.
Inspection and Evaluation Guidelines for River Management Facilities such as Dikes and River Channels	Ministry of Land, Infrastructure, Transport and Tourism, Japan	Revision in 2023	A regulation that establishes provisions for the inspection and evaluation procedures of embankments, as well as other river management facilities and channels. It covers the purpose and scope of inspection, procedures and frequency, methods and techniques, evaluation and reporting of inspection results.

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1. INTRODUNCTION

1.2 Objectives

Table Major Standards Related to Bund in Japan (3. Guidelines)

Name of a Standard	Publisher	Year of Publication	Outline
Guideline for Structural Analysis of River Embankment	Japan Institute of Country-ology and Engineering	Revision in 2012	This guideline consists of inspection&investigation, safety analysis and reinforcement of the river dike especially against seepage, erosion and earthquake. In addition, inspection and reinforcement of the dike adjacent to the structure installed in the dike.
River Earthwork Manual	Japan Institute of Country-ology and Engineering	Revision in 2009	This is a supplement to the "Technical Criteria for River Works.", focusing on the design theory of embankments and complementing the section on river engineering. The manual covers topics, including surveys, design, construction, project management, and planning from start to completion of river engineering projects.
River Earthwork Manual	Japan Institute of Country-ology and Engineering	Revision in 2009	This is a supplement to the "Technical Criteria for River Works.", focusing on the design theory of embankments and complementing the section on river engineering. The manual covers topics, including surveys, design, construction, project management, and planning from start to completion of river engineering projects.

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1 INTRODUCTION

2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.1 Extraction of Item to be Analyzed

- 2.2 Comparison of the Manuals between Sindh and Punjab
- 2.3 Comparison of the Manuals with Japanese Standards

3 RECOMMENDATION TO THE MANUALS IN SINDH AND PUNJAB



2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.1 Extraction of Item to be Analyzed

✓ There are some **major issues which have been already recognized**. Based on these major issues, the relating items in the technical manuals of bunds to be analyzed are selected.

Table Major Issues and Relating Items to Be Analyzed

Major Issue	Item to be Analyzed
✓ There are a lot of damage caused by seepage flow and erosion .	<ul style="list-style-type: none"> ➢ Methods of Patrol and Inspection ➢ Methods of Safety Verification Analysis ➢ Countermeasures and the design methods of them
✓ Due to the long stretch and lack of labors and budget, it is necessary to improve the efficiency of maintenance and management activities.	<ul style="list-style-type: none"> ➢ Maintenance & management plan and its concept ➢ Organization of Data on Rivers and Bunds ➢ Accessibility to the Site
✓ It is necessary to consider the conditions of river channels , etc. for the planning and designing the countermeasures against erosion.	<ul style="list-style-type: none"> ➢ Design Methods of Revetments and Spurs ➢ Survey & Inspection for Setting the Design Condition
✓ Improvement of quality control (improvement of insufficient quality, construction defects)	<ul style="list-style-type: none"> ➢ Regulation on Construction Supervision
✓ Promotion of Information Sharing on Inspection Reports and Records on Bunds	<ul style="list-style-type: none"> ➢ Methods of Sharing and Storing the Reports and Record

2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.1 Extraction of Item to be Analyzed

✓ Considering the current major issues, the items are specifically broken down to the followings for the comparative analysis.

Table Extracted Items for the Comparison Analysis

No.	Item	Sub Item	No.	Item	Sub Item
1	Definition of a Bund	Definition	9	Construct-ion Works	Permission, Construction
2	Standard Shape of a Bund	Crest Width, Side Slope, Berm, Freeboard, Extra Embankment	10	Management Plan	Management Plan, Management Cycle
3	Quality Control	Material, Construction Method, Degree of Compact-ion	11	Monitoring of River Conditions	General, Patrol/Physical Inspection
4	Service Road/ Maintenance Road				Inspection with Equipment / Investigation / Exploration, River Profile / Inspection Report / Damage Record
5	Safety Evaluation	General, Slope Stability/Slip Circle, Erosion, Seepage Control			Analysis and Evaluation
6	Improvement of a Bund	Slope Stability/slip Circle, Erosion, Seepage Control	12	Inspection and Ledger	General, Bund, River Channel, Storage
7	Revetment	General, Material and Structure, Safety Verification, Structural Design	13	River Ledger	General, Contents, Storage
8	Spur (Stone Groyne)	Site Condition, Basic Shape, Material, Design Method	14	Bund Breach	Cause of Breach, Artificial Breach
					Immediate Action, Closure of Breach

1 INTRODUCTION

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

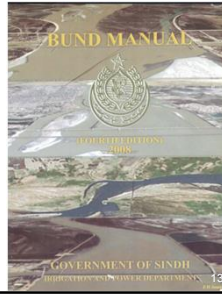
2.2 Comparison of the Manuals between Sindh and Punjab Manual in Sindh

General

- ✓ Bund Manual includes description of the basic shape, design, construction, surveys and repairs during a single year, and response to breaches of the bunds.
- ✓ **Mainly provides an overview of the basic principles and matters to be considered.**
- ✓ There is **little specific information on design criteria, design methods, and construction management standards.**

Table Table of Contents of the Bund Manual in Sindh Province

Chapter	Title
Chapter I	Glossary of terms used in connection with River Bunds in Sindh.
Chapter II	Constitution and Functions of the Indus River Commission.
Chapter III	Classification of expenditure on Bund Works and powers of Officers Subordinate to Government to accord Administrative.
Chapter IV	Proposal for new Bunds, Loops and Bund Sluices.
Chapter V	Design of new Bunds and Loop Bunds.
Chapter VI	Construction of new Bunds or Loops.
Chapter VII	Design and construction of Sand Cores and Diaphragm Walls.
Chapter VIII	Design and construction of Bund Sluices.
Chapter IX	Article Pre-Abkalani Maintenance.
Chapter X	Ordinary Maintenance during Abkalani.
Chapter XI	Emergent Measures or Causes of Failures of Bunds and Methods used to Combat Them.
Chapter XII	Breaches in River Bunds and how to Close them.
Chapter XIII	Periodical Reports and Returns.
Chapter XIV	Flood Management Practices on Mississippi River USA.
Chapter XV	Design of Stone Spurs or Stone Apron and Stone Pitching on Front Bunds as Protection against erosion.



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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

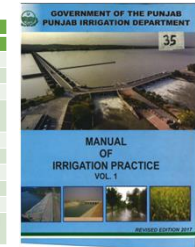
2.2 Comparison of the Manuals between Sindh and Punjab Manual in Punjab

General

- ✓ The structure of the bunds is mainly described in Chapter 5.16 & 5.20 of volume 1 and Chapter 2 of volume 2 and the maintenance is mainly described in Chapter 9 and 10 of volume 2. Due to the **scattering of the contents, it is sometimes hard to find the contents** which a reader wants to find.
- ✓ **More concrete description such as dimensions, methods for planning and design and analysis methods** are included comparing to the manual in Sindh. However, **the contents are still insufficient in some parts.**
- ✓ There are **little mentions of the construction such as quality control, inspections, documentations, etc.**

Table Table of Contents of the Manual of Irrigation Practice in Punjab Province

Vol.1		Vol.2	
Chapter	Title	Chapter	Title
Chapter 1	Definitions	Chapter 1	Small Dams
Chapter 2	History of Irrigation Development in Punjab	Chapter 2	River Training & Flood Management
Chapter 3	Punjab's Irrigation Infrastructure	Chapter 3	Hill Torrents Management
Chapter 4	Administrative Setup of Punjab Irrigation Department	Chapter 4	Groundwater – Optimal Use & Management
Chapter 5	Barrages	Chapter 5	Drainage & Salinity Control
Chapter 6	Design of Unlined Canals	Chapter 6	Mechanical, Electrical Works & SCADA
Chapter 8	Maintenance of Canals	Chapter 8	Hydraulic Modelling
Chapter 9	Outlets	Chapter 9	Asset Management Plan
Chapter 10	Computerized Monitoring System for Canal Operation	Chapter 10	Preparation of Annual O&M Budget
		Chapter 11	Preparing Annual M&R Work Plans and their Implementation



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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(1) Definition of a Bund / (2) Standard Shape of a Bund Manual in Sindh

- ✓ An **earthen embankment parallel to the riverbanks**
- ✓ **To protect the country from inundation by the river spill, during floods**

Source: JICA Project Team quoted from the Bund Manual in Sindh

Table Summary of Basic Shape of a Bund Specified in Bund Manual

Item	Type	Description
Crest Width	Main Bund	20 ft(=6.1m)
	Trench Bund	10 ft(=3.05m)
Side Slope (River Side)	Bund(8 feet and less)	3:1
	Medium Bund (Upto and including 12 feet.) High Bund (Exceeding 12 feet)	3:1(8ft to 12ft in Height) to 4:1(12ft to 13ft in Height) 3:1(12ft to 13ft in Height)to 4:1(Over 13ft in Height)
Side Slope (Land Side)	Bund	3:1 without Berm
	Medium Bund High Bund	3:1 without Berm 2:1 (Top to Back Berm), 6:1(Berm to Ground)
Berm	River Side	-
	Land Side	5 ft(=1.53m)
Freeboard	Main Bund	4 ft(=1.22m)
	Trench Bund	2 ft(=0.61m)
Extra Embankment	Normal	12 1/2 % of Deign Height
	With Scrapers/Foot Roller	6 1/4 % of Deign Height

Source: JICA Project Team summarized from Bund Manual

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(1) Definition of a Bund / (2) Standard Shape of a Bund Manual in Punjab

- ✓ An **earthen man-made embankment**
- ✓ **To provide protection from inundation and act as a barrier between flood water and protected area.**

Source: JICA Project Team quoted from the Manual of Irrigation Practice in Punjab

Table Summary of Basic Shape of a Bund Specified in Manual of Irrigation Practice

Item	Type	Description
Crest Width	Marginal Bunds	Minimum: 25 ft(=7.6m) Desirable: 30 ft(=9.1m)
	Bunds Protecting Strategic locations Bunds along open reaches of the rivers	Same as the Marginal Bunds Minimum: 20 ft(=6.1m) Desirable: 25 ft(=7.6m)
Side Slope (River Side)	Marginal Bunds(earthen)	Minimum: 3:1, Desirable: 4:1
	Marginal Bunds(protected)	Minimum: 2:1, Desirable: 3:1
	Bunds Protecting Strategic locations(earthen)	Minimum: 3:1, Desirable: 4:1
	Bunds Protecting Strategic locations(protected)	Minimum: 2:1, Desirable: 3:1
	Bunds along open reaches of the rivers(earthen)	Minimum: 3:1, Desirable: 3:1
	Bunds along open reaches of the rivers(protected)	Minimum: 2:1, Desirable: 2:1

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(1) Definition of a Bund / (2) Standard Shape of a Bund Manual in Punjab

Table Summary of Basic Shape of a Bund Specified in Manual of Irrigation Practice

Item	Type	Description
Side Slope (Land Side)	Marginal Bunds	Minimum: 2:1, Desirable: 3:1
	Bunds Protecting Strategic locations	Minimum: 2:1, Desirable: 3:1
	Bunds along open reaches of the rivers	Minimum: -, Desirable: 2:1
Berm	River Side	-
	Land Side	Slope 6:1 Width Set so that sufficient cover is provided above hydraulic grade line
Freeboard	Marginal Bunds	Minimum: 6 ft (=1.8m) Desirable: 7.0 ft (=2.1m) or as determined by analytical analysis whichever is greater
	Bunds Protecting Strategic locations	Same as the Marginal Bunds
	Bunds along open reaches of the rivers	Minimum: 6 ft (=1.8m) Desirable: 6 ft (=1.8m) or as determined by analytical analysis whichever is greater
Extra Embankment	Not mentioned	-

Source: JICA Project Team summarized from the Manual of Irrigation Practice.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(1) Definition of a Bund / (2) Standard Shape of a Bund Comparison

SUMMARY

Sindh ✓ In most of items, the specified values in the manual in Punjab is taking safety side (higher or larger). This is because the last update of the manual in Sindh was 2008 (Before the 20210 Flood).

Punjab ✓ It is recommended to incorporate the description about extra embankment.

Item	Sub Item	Sub-sub Item	Comments
Definition of a Bund Standard Shape of a Bund	Definition		<ul style="list-style-type: none"> Both manuals define a bund as an earthen embankment to protect the land from inundation during flood. Manual in Punjab specified a wider width.
	Side Slope	River side	<ul style="list-style-type: none"> Manual in Sindh specifies different slopes depending on height of a bund for each type. The range of slope in the earthen type is 3:1 to 4:1 in both.
		Land side	<ul style="list-style-type: none"> The slope of berm is same in both. The slop without berm is 3:1 in Sindh and 2:1 to 3:1 in Punjab.
	Berm		<ul style="list-style-type: none"> The width is 5ft in Sindh and is set to cover the hydraulic gradient line in Punjab.
	Freeboard		<ul style="list-style-type: none"> Punjab specified a higher freeboard. The reason for this seems to be that the Bund Manual in Sindh was published in 2008 which was before the 2010 flood.
	Extra Embankment		<ul style="list-style-type: none"> It is recommended for the Manual of Irrigation Practice in Punjab to describe this item based on the description of the manual in Sindh.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(3) Quality Control Manual in Sindh

1) Embankment Material

✓ The bund is built, as a rule, of earth obtainable along the line of the bund or from the borrowpits on the river side immediately in front of the bund.

✓ Sand mixed with a fair proportion (30 to 40%) of clay is desirable. (The sand in the clay will prevent shrinkage and cracks without destroying the watertightness and toughness of the clay.)

Source: JICA Project Team quoted from the Bund Manual in Sindh

- About the embankment material, the importance of the fine particle contents is recognized.
- It must be difficult to obtain such a desirable material along Indus River in Sindh Province.
- Available materials based on the past cases are also introduced as below.

Table Available Materials Based on the Past Cases Introduced in Bund Manual

Item	Description	Verification/ Remarks
Sand with 6 inches thickness clay cover	85% of Sand, 10% of Silt, and 5% of Clay.	Without Clay Cover, due to the flat saturation, large Section is Required.
Sand Mixed with Clay	50-70% of Sand, 30-50 of clay	Optimum admixture
Loam with 6 inches Thickness Clay Cover	30-50% of Sand, 30-50% of silt, and Less than 20% of Clay.	Little stability when saturated.
Clay with Sand Core	5% of Sand, 40% of Silt, and 55% of Clay.	Bunds should not be constructed of such soils unless absolutely unavoidable

Source: JICA Project Team summarized from Bund Manual.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(3) Quality Control Manual in Sindh Manual in Punjab

2) Construction Method Manual in Sindh(Bund Manual)

✓ All earth laid in the embankment shall be free from all roots, grass, sticks or other foreign matter.
 ✓ The earth shall be deposited and spread in horizontal layers, 6 inches thick, for the full width of the bank.
 ✓ All clods, and lumps of earth shall be broken up in the borrow pits to a diameter of not more than 2 inches.
 ✓ To facilitate rolling, the bank shall be carried up in uniform layers of not more than 6 inches in thickness
 ✓ No fresh layer shall be put on until the previous one has been thoroughly consolidated to the satisfaction of the Executive Engineer or subordinate.

Source: JICA Project Team quoted from the Bund Manual in Sindh

- The manual is describing the importance of embankment with a uniformed material without contamination of foreign mattes
- Equipment to be used for the embankment work is not mentioned clearly in this manual, and the description for it is necessary
- No description of the degree of compaction (Required value, what to do in case it cannot be satisfied).
- Also, Standard specification is not opened to the public.

Manual in Punjab (Manual of Irrigation Practice) → Quality control is not mentioned.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(3) Quality Control
Comparison

SUMMARY

General ✓ Even though it is usually stated in the technical specification, both manuals are recommended to describe the required degree of compaction and the options to be taken when it is difficult to satisfy the requirement.

Punjab ✓ It is recommended to incorporate the entire contents of quality control during Construction.

Item	Sub Item	Sub-sub Item	Comments
Quality Control	Material	Desirable Material	It is recommended for the Manual of Irrigation Practice in Punjab to include this item based on the description of the manual in Sindh.
		Available Material	Same as the above
	Construction Method	Degree of Compaction	
			Both manuals are recommended to describe this item based on o manuals in other countries. Also, it is recommended to add the options to be taken when it is difficult to satisfy the requirement as the references.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab


(4) Service Road/ Maintenance Road
Manual in Sindh
Manual in Punjab

Manual in Sindh(Bund Manual)

✓ Public traffic is not permissible on bunds and, therefore, cross fencing is necessary at road crossing and longitudinal and cross fenceings near villages.

Source: JICA Project Team quoted from the Bund Manual in Sindh

- The road on the top of the bunds is exclusively used for the PIDs or concerned public agencies.
- Ordinary private vehicles are seldom traveling or parking on the top of the bunds. Hence, no major issue has occurred in practice.



Typical Situation of the Top of the Bund

Manual in Punjab(Manual of Irrigation Practice)

- Service road and maintenance road are not mentioned.
- Due to holes and unevenness, it takes time for vehicles to travel on it.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(4) Service Road/ Maintenance Road
Comparison

SUMMARY

Common ✓ Manuals in both Sindh and Punjab are recommended to describe this item
 ✓ it is recommended to add a description about pavement on the top of bunds to improve access for the sooth access by the maintenance vehicles.
 ✓ It seems necessary to add the standard pavement composition (minimum sample assuming.

Item	Comments
Service Road/ Maintenance Road	Both manuals are recommended to describe this item based on o manuals in other countries.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(5) Safety Evaluation
Manual in Sindh

1) Slope Stability(Slip Circle)

✓ The cross-section is fixed from experience, on consideration of stability under all conditions

Source: JICA Project Team quoted from the Bund Manual in Sindh

- Only mentions that the bund shape is determined based on experience, taking into account the effects of seepage, etc.
- There is no mention that the bund shape needs to be determined based on stability analysis using numerical analyzes such as slip circle and seepage flow analysis.

2) Erosion

	Where distance between Bund and pucca edge is	Distance between two consecutive ordinates
Above Sukkur	2 to 3 miles 1 to 2 miles Less than a mile	1 mile apart Half a mile part One furlong apart
Below Sukkur	2 to 3 miles 1 to 2 miles Less than a mile	No ordinates Half a mile apart One furlong apart

Source: JICA Project Team quoted from the Bund Manual in Sindh

- The distance where the erosion ordinates and the distance apart to be kept between the two consecutive ordinates are introduced
- The development of the bank erosion is being monitored by checking the distance from the riverbank to the bund.

3) Seepage Flow →Any concrete methods and conditions are not mentioned.

4) Seismic Condition →No description.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(5) Safety Evaluation
Manual in Punjab

1) Slope Stability(Slip Circle)

- Concrete methods and factor of safety on the slope stability analysis are described.

Table Summary of Stability Analysis Method Specified in Manual of Irrigation Practice

Item	Description																	
Analysis method	Method of Slices, using Simplified Bishop Method Location of the phreatic line is determined by using Casagrande's solution.																	
Items to be Considered	Geometry of embankment, Soil Properties, Design Flood Level, Low Water Level, Seismic Force, Phreatic line and pore water pressure, Surcharge on the embankment																	
Loading Condition	"Gravity", "Seepage, and "Earthquake"																	
Calculation Case	i) End of construction, ii) Design flood level with steady seepage, iii) Flood draw-down, and iv) Assuming fully launched stone apron																	
Minimum Safety Factor	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th rowspan="2">Condition</th> <th colspan="2">Minimum safety factor</th> </tr> <tr> <th>Without earthquake</th> <th>With earthquake</th> </tr> </thead> <tbody> <tr> <td>During and end of construction</td> <td style="text-align: center;">1.4</td> <td style="text-align: center;">1.2</td> </tr> <tr> <td>Rapid river draw-down</td> <td style="text-align: center;">1.3</td> <td style="text-align: center;">1.1</td> </tr> <tr> <td>River low flow level</td> <td style="text-align: center;">1.2</td> <td style="text-align: center;">1.0</td> </tr> <tr> <td>Design flood</td> <td style="text-align: center;">1.5</td> <td style="text-align: center;">1.2</td> </tr> </tbody> </table>	Condition	Minimum safety factor		Without earthquake	With earthquake	During and end of construction	1.4	1.2	Rapid river draw-down	1.3	1.1	River low flow level	1.2	1.0	Design flood	1.5	1.2
	Condition		Minimum safety factor															
		Without earthquake	With earthquake															
	During and end of construction	1.4	1.2															
	Rapid river draw-down	1.3	1.1															
River low flow level	1.2	1.0																
Design flood	1.5	1.2																

Source: JICA Project Team summarized from Manual for Irrigation Practice. 25

2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(5) Safety Evaluation
Manual in Punjab

2) Erosion

- The methods to evaluate the safety is **not** described. However, the estimate methods for scour depth are mentioned

✓ It is recommended to calculate the depth of local scour, constriction scour, bend scour, and confluence scour by several available methods and then use engineering judgment to select the preferred results.

✓ The recommended local scour depth methods for various river gradient are listed .

River gradient	Material	Recommended method
Very mild	Sand and silt	-Lacey method (1930)
		-Ingils method (1940)
		- Lacey's equation (Expanded by USBR, 1984)
Mild (incised)	Gravel, sand and silt	-Blench equation (USBR,1969)
		-Molesworth and Yanidunia equation
		-Lacey method (1930)
Steep	Gravel and coarse sand	-Ingils method (1940)
		- Lacey's equation (Expanded by USBR, 1984)
		- Blench equation (USBR,1969)
		- Neill equation (USBR,1973)
		-Molesworth and Yanidunia equation
Very steep	Gravel and boulders	- Blench equation (USBR,1969)
		- Farraday and Charlton equation
		- Brown formula

Source: JICA Project Team summarized from Manual for Irrigation Practice. 26

2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(5) Safety Evaluation
Manual in Punjab

3) Seepage Flow

For seepage in the bund body:

- Hydraulic Gradient should be at least 2 ft below natural surface level at the toe of the bund.
- Minimum cover of 4 ft provided above hydraulic grade line if it exits on the landside in made up soils.

For seepage in the foundation:

- Detailed subsurface investigations needed for proper foundation evaluation.
- Investigation will provide information such as material type and zoning, permeability of riverbed material, in-situ density, hardness of cobbles and boulders, and bearing pressure capacity.

Source: JICA Project Team summarized from Manual for Irrigation Practice.

- Concrete method for evaluating the safety for bund body is described. However, for seepage in the foundation, only the survey items are listed.

4) Seismic Condition

- Acceleration due to earthquake is selected on the basis of 50% reduction for horizontal and vertical component.
- These earthquake forces act at the center of gravity of the slice.
- The acceleration due to Open Basis Earthquake values is adopted on the basis of specific related earthquake zone criterion.

Source: JICA Project Team summarized from Manual for Irrigation Practice.

- Seismic condition is considered as the loading condition in slope stability analysis.
- The method for determining the load is also described.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(5) Safety Evaluation
Comparison

SUMMARY

Punjab

- About erosion, it is recommended to incorporate the method for safety evaluation like the manual in Sindh.

Sindh

- It is recommended to add the items on slope stability and seepage control.
- About erosion, describing the concrete methods of scour depth calculation is recommended.

Item	Sub Item	Comments
Safety Evaluation	General	-
	Slope Stability/ Slip Circle	It is recommended for the manual in Sindh to include this item based on the description of the manual in Punjab.
	Erosion	It is recommended for the Bund Manual in Sindh to describe the concrete methods of scour depth calculation based on the Manual of Irrigation Practice in Punjab The manual in Punjab is recommended to include the method for safety evaluation like the manual in Sindh.
	Seepage Control	It is recommended for the Bund Manual in Sindh to describe this item based on the Manual of Irrigation Practice in Punjab.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

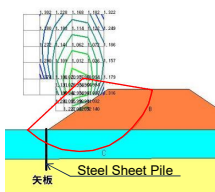
(6) Improvement of a Bund
Manual in Sindh

1) Slope Stability(Slip Circle)

a. Expansion of the Rear Section to cover the saturation line.
b. Mangli or a ring bund around the slip
c. Installation of drainage material at the land side toe

Source: JICA Project Team quoted from the Bund Manual in Sindh

- Mainly focusing on reducing the water level around the slip surface comparatively.
- A wall with steel sheet piles to stop the slip circle can be an option.



Source: <https://isabou.net/Convenience/Tool/morido/morido.asp>

2) Erosion

No.	Item	Remarks
1	Stone Spurs and Stone Aprons	<ul style="list-style-type: none"> Calculation of expected deepest scouring based on the historical highest discharge. Calculation of length and thickness of stone apron by it.
2	Revetment	As a feasible options in Sindh, it is introduced without concrete design method.
3	Cemented Stabilized Soil Revetment	Same as above
4	Tree Groyne	Same as above
5	Bandelling	Same as above

Source: JICA project Team extracted from Bund Manual

- Stone spurs and stone aprons are introduced with the design method is also described in detail.
- Information about others such as design methods and requirements on each type is not clearly mentioned.**

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

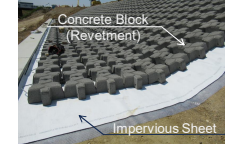
(6) Improvement of a Bund
Manual in Sindh

3) Seepage Flow

No.	New or Existing	Item	Remarks
1	New	Proper Choice of Earth Fill	
2	New and Existing	Apply the Standard Section in Sindh	Bund Manual mentions "Experience has shown that with the standard sections adopted in Sindh the base width is wide enough to prevent piping."
3	New and Existing	Installation of Drainage material at the Land Side Toe	This is not introduced as a countermeasure for seepage control but is effective.
4	Existing	Expansion of the Rear Section to Cover the Saturation Line	Not clearly mentioned on seepage control for the existing bund.

Source: JICA project Team summarized from Bund Manual

- Basically, any other countermeasures for seepage control aside from the expansion of the cross-sectional shape are not introduced.
- There are other countermeasures which can be adopted in Sindh **such as covering with impervious sheet, seepage cut-off wall(SSP).**



https://www.daika.co.jp/products_search/list2005/item_2069

This may increase the initial cost, but the **total cost(including O&M and Rehabilitation) will be expected to be reduced.**

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(6) Improvement of a Bund
Manual in Punjab

1) Slope Stability(Slip Circle)

- Countermeasures for slope stability are **not mentioned** and are necessary to be added.

2) Erosion

No.	Item	Remarks
1	Stone Apron	The concrete design methods based on scour depth, flow velocity, and wave-height are introduced.
2	Slope Protection	<ul style="list-style-type: none"> Various protection types are described. For only stone pitching, the concrete design methods based on scour depth, flow velocity, and wave-height are introduced.
3	Spur	<ul style="list-style-type: none"> Basic Shape is described. For determining the length and angle, the physical model studies are recommended.
4	Studs	<ul style="list-style-type: none"> Basic shape is mentioned. The concrete method for determining the length is not mentioned.
5	Gabion	Geometry and stability are checked by the design criteria of Barrage.

Source: JICA Project Team summarized from Manual for Irrigation Practice.

- Spurs, stone pitching, and stone apron are introduced with the detailed design method.
- Except for stone pitching, **description of the slope protections such design methods and requirements on each type is not clearly mentioned.**

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(6) Improvement of a Bund
Manual in Punjab

3) Seepage Flow

No.	Purpose (Foundation or Bund)	Item	Remarks
1	Foundation	Cut off trench	It is introduced without concrete design method.
2	Foundation	River side impervious blankets	Same as the above
3	Foundation	Pervious toe trenches	Same as the above
4	Foundation	Pressure relief wells	Same as the above
5	Both	Land side seepage berms	The concrete method to determine shape is describe
6	Bund	Drainage Material	<ul style="list-style-type: none"> 3type, Landside Toe, Horizontal, and Inclined, are described. Only the materials for landside toe is mentioned.

Source: JICA Project Team summarized from Manual for Irrigation Practice.

- There are other countermeasures which can be adopted in Punjab **such as covering with impervious sheet, seepage cut-off wall with sheet piles.**
- The descriptions of measures No. 1~5 seem to be excerpts from the U.S. manual, but. **concrete design methods are missing**
- The descriptions of the measures are scattered in various chapters in the manual,** and there are some inconsistencies between chapter titles and content.

This may increase the initial cost, but the **total cost(including O&M and Rehabilitation) will be expected to be reduced.**

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(6) Improvement of a Bund
Comparison

SUMMARY

Common ✓ Countermeasures that are described only in one of the manuals needs to be incorporated also in the other.

✓ **About the Erosion and Seepage Control, the manuals in both Sindh and Punjab are recommended to incorporate the concrete design methods with reference to the manuals form the other countries.**

Item	Sub Item	Comments
Improve ment of a Bund	Slope Stability/slip Circle	• The Manual of Irrigation Practice in Punjab is strongly recommended additionally introduce the improvement method as well as the Bund Manual in Sindh.
	Erosion	• In order to cover a wide range of countermeasures, countermeasures that are unique to one side should be added to each other. • It is recommended for both manuals to add concrete design methods with reference to manuals from other countries so that the design methods can be described for all countermeasures.
	Seepage Control	• Countermeasures for a bund body are generally the same in both manuals. • The Bund Manual in Sindh is recommended to additionally include countermeasures relating to a foundation based on the Manual of Irrigation Practice in Punjab, . • Both manuals have to additionally describe design methods with reference to guidelines from other countries.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(7) Revetment
Manual in Sindh

1) Material and Structure

- a. Stone Masonry Pitching
- b. Burnt Brick Masonry Pitching
- c. Brushwood Pitching Including Alternate Layers of Earth
- d. Muharis, Single or Double
- e. Lai Groynes (single)
- f. Lai Mats Including Fixing
- g. Date Mats Including Fixing
- h. Cemented Stabilized Soil Revetment

Source: JICA Project Team quoted from the Bund Manual in Sindh

- Revetment is defined as “a pitching protection of stone, or brick or sand bags containing a certain proportion of cement or similar materials.”
- Several types are introduced.

2) Safety Verification

- There is **no mention of the specification and design method** for each type,
- Also, **no contents about safety verification** of the revetments are not included.
- It must be **difficult for the engineer at practical level to design** revetments.

3) Structural Design

- **No description regarding the design of foundations considering seepage control and scouring.**
- **Stone aprons on front bund with the detailed design calculation method is** introduced as a foot protection work.
- There are **few descriptions of foot protection other than stone aprons.**

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(7) Revetment
Manual in Punjab

1) Material and Structure

- There is no definition of revetment and few descriptions of revetment, however some types of slope protections are introduced.

No.	Permanent or Temporary	Type	Remarks
1	Temporary	Khaji Mats	• No concrete design methods
2	Temporary	Fascine Covering	Same as the above
3	Temporary	Pilch Rolls,	Same as the above
4	Temporary	Longitudinal Stakes and Bushing Protection	Same as the above
5	Temporary	Pilch Pitching	Same as the above
6	Permanent	Brick Pitching	Same as the above
7	Permanent	Dumped Stone Rip-Rap	• With Concrete Design Method
8	Permanent	Stone Pitching	• With Concrete Design Method
9	Permanent	Soil Cement Cover	• No concrete design methods
10	Permanent	Cement Concrete Paving	Same as the above
11	Permanent	Asphaltic Concrete	Same as the above
12	Permanent	Porous Concrete Slab	Same as the above
13	Permanent	Gabions	Same as the above
14	Permanent	Geotextile Filter	• With Concrete Design Method

Source: JICA Project Team summarized from Manual for Irrigation Practice.

2) Safety Verification

- There is **no mention of the specification and design method** except for some types.
- Also, **no contents about safety verification** of the revetments are not included.
- It must be **difficult for the engineer at practical level to design** revetments.

3) Structural Design

- **No description regarding the design of foundations** considering seepage control and scouring.
- **Stone aprons on front bund with the detailed design calculation method is** introduced as a foot protection work.
- There are **few descriptions of foot protection other than stone aprons.**

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(7) Revetment
Comparison

SUMMARY

Common ✓ **About the Safety Evaluation and Design Method, the manuals in both Sindh and Punjab are recommended to add the descriptions.**

Sindh ✓ **Since only the manual in Panjab introduces the standard cross section of gabions and the concrete design method for stone pitching, the manual in Sindh is recommended to incorporate the description.**

Item	Sub Item	Sub-sub Item	Comments
Revetment	Material and Structure		• The main difference between them is that the only Panjab manual states the introduction and the standard cross section of gabions and the concrete design method for stone pitching. • It is desirable for the Bund Manual in Sindh to additionally describe the above items. • Both are recommended to describe this item in reference to manuals in other countries.
		Safety Verification	• The contents in both are almost the same.
	Structural Design	Slope	
	Foundation		
	Foot Protection		


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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(8) Spur (Stone Groyne)
Manual in Sindh

Item	Description	
1) Site Condition	a. A location where loop bund is needed, but no available land. b. (a location which needs a loop bund) Where the edge of the pucca bank is less than 3,000 ft. proposals for loop bund should be sent in at once.	
2) Basic Shape	• Cross sectional shape is not mentioned	
3) Material	• The used material is stone.	
4) Design Method	• The concrete design method is not stated .	Sample Photo of a Spur used in Sindh Province. 

Source: JICA Project Team summarized from the Bund Manual in Sindh

- It might be difficult for the engineer at practical level to design spurs.
- Eventually, spurs with the same specification have been installed.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(8) Spur (Stone Groyne)
Manual in Punjab

- Basic approach to determine the dimensions are introduced.
- Basically, design of a spur is often conducted based on the consideration of past cases or the hydraulic model study.

Item	Description
1) Site Condition	A spur is installed where the followings are required. a. Creating slack flow with an objective of silting up the area in the vicinity. b. Protecting the riverbank by keeping the flow away from it.
2) Basic Shape	• Crest width = 30 ft, Side slopes - Shank = 3H:1 V, Side slopes - Head = 2H:1V • About planner shape, 10 types of spurs are introduced.
3) Material	• The used material is stone.
4) Design Method	• Recommended Space: <ul style="list-style-type: none"> ➢ Straight reach; Less than (5) to six (6) times the length of spur ➢ Convex bends; 2.5 to 3.0 times the length of spur ➢ Concave bends; equal to the length of spur • The position, length, angle, and shape of spurs at any site should be determined by physical model studies.

Source: JICA Project Team summarized from Manual for Irrigation Practice.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(8) Spur (Stone Groyne)
Comparison

SUMMARY

Sindh ✓ Since the manual in Punjab is describing more detailed and concrete contents on spurs, it is recommended to **incorporate the contents with reference to the one in Punjab**.

Item	Sub Item	Comments
Spur (Stone Groyne)	Site Condition	• The Bund Manual in Sindh mentions that a spur is installed when the available land is limited.
	Basic Shape	• It is recommended for the Bund Manual in Sindh to incorporate this item based on the Manual of Irrigation Practice in Punjab.
	Material	• The contents in both are almost the same.
	Design Method	• It is recommended for the Bund Manual in Sindh to incorporate this item based on the Manual of Irrigation Practice in Punjab.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(9) Construction Works
Manual in Sindh
Manual in Punjab

Manual in Sindh (Bund Manual)	2) Procedure
<div style="background-color: #D3D3D3; padding: 5px; margin-bottom: 5px;">1) Permission</div> <p>✓ The contractor shall not enter upon or commence any portion of the work, except with the written authority and instruction of the Executive Engineer or his subordinate in charge of the work.</p> <p style="font-size: x-small;">Source: JICA Project Team quoted from the Bund Manual in Sindh</p> <p>✓ Considering the latest construction method, the statement on the equipment shall be updated.</p> <p>✓ No mention or guide for technical specification regarding 3) Site Inspection, 4) Quality Inspection, 5) Acceptable Criteria.</p>	<div style="background-color: #D3D3D3; padding: 5px; margin-bottom: 5px;">1) Site Preparation: 2. Lining Out and Profiles: 3. Borrow Pits: 4. Key Trench and Sand Core: 5. Construction of Embankment: the height shall be greater than designed to allow for settlement. The earth shall be deposited and spread in horizontal layers, 6 inches thick, for the full width of the bank. 6. Consolidation: Each layer shall be thoroughly consolidated either by ramming, rolling, or by weighted bullock carts as directed by the Executive Engineer. 7. Measurements:</div> <p style="font-size: x-small;">Source: JICA Project Team quoted from the Bund Manual in Sindh</p>
<div style="background-color: #D3D3D3; padding: 5px; margin-bottom: 5px;">Manual in Punjab (Manual of Irrigation Practice)</div> <p>✓ Construction works is not mentioned.</p>	<div style="background-color: #FFDAB9; padding: 5px;"> <p>✓ The durability and strength of an embankment varies depending on its structure, materials, and construction.</p> <p>✓ Standards for constructing embankments with a certain level of strength are necessary.</p> </div>

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(9) Construction Works
Comparison

SUMMARY

Common ✓ The manuals in **both Sindh and Punjab** are recommended to incorporate the description on **Site Inspection for Work Accomplishment (Shape inspection)**.

Punjab ✓ Since the manual in Sindh has the descriptions on permission, it is recommended for **the manual in Punjab to incorporate the contents with reference to the one in Sindh**.

Item	Sub Item	Sub-sub Item	Comments
Construction Works	Permission		<ul style="list-style-type: none"> It is recommended for the Manual of Irrigation Practice in Punjab to add this item based on the Bund Manual in Sindh.
	Construction	Procedure	Same as the above
		Site Inspection for Work Accomplishment (Shape inspection)	<ul style="list-style-type: none"> Both are recommended to describe this item in reference to manuals in other countries.
		Quality Inspection Acceptability Criteria	Same as the above

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(10) Management Plan

Manual in Sindh
Manual in Punjab

Manual in Sindh(Bund Manual)

- ✓ "Pre-abrakani Maintenance" and ordinary maintenance is stated
- ✓ **No mention on middle and long term management plan.**
- ✓ The maintenance stated in the manual **seems to focus on a single year activity.**

Manual in Punjab(Manual of Irrigation Practice)

- ✓ *Flood protection embankments and spurs are inspected before the advent of flood season every year for assessing their reliability to withstand flood onslaught.*
- ✓ *Their deficiencies are removed prior to flood season.*
- ✓ *As such in ideal conditions there should not exist any deferred maintenance requiring rehabilitation of this type of the infrastructure.*
- ✓ *Normally in the Punjab, banks require to be strengthened periodically after about five years.*

Source : JICA Project Team quoted from the Manual of Irrigation Practice

- ✓ The introduction of **Asset Management Plan (AMP)** into all facilities controlled is described in the manual. This AMP assumes **the long-term plan** which includes long term investment **covering a 20-year** planning and **short-term program** of expenditure for **5-10 years**
- ✓ However, the **maintenance for flood embankments and spurs** seems to focus on **a single year activity.**
- ✓ **The bund shall be strengthened periodically.**

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(10) Management Plan
Comparison

SUMMARY

Common ✓ The manuals in **both Sindh and Punjab** are recommended to incorporate the description on **management plan and management cycle considering the multiple years**. The case of **Japan would be a good sample to be referred**.

Punjab ✓ Only the manual in **Punjab** describes long-term maintenance plan of structures as **Asset Management Plan**.

Item	Sub Item	Comments
Management Plan	Management Plan	<ul style="list-style-type: none"> Long-term maintenance plan is introduced only in the Punjab manual, but it is still difficult to develop the plan based on it. it is recommended for the both manuals to additionally describe the concrete methods for management plan with reference to other countries guidelines.
	Management Cycle	<ul style="list-style-type: none"> Both manuals are recommended to describe this item with reference to manuals in other countries.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(11) Monitoring of River Conditions
Manual in Sindh

1) Patrol/Physical Inspection

<Inspection Items after a Flood>

i. Top Levels	v. Runnel
ii. Unwanted Vegetation and Debris	vi. Settlement
iii. Encroachments	vii. Land Subsidence
iv. Slope/Section Stability	viii. Damaged Armour
	ix. Flood Wall Damage

Source : SAFETY EVALUATION OF FLOOD BUND

<Bund Manual>

- ✓ Patrol during a high flood is mentioned in detail.

<SAFETY EVALUATION OF FLOOD BUND >

- ✓ Inspection after a flood is stated in "SAFETY EVALUATION OF FLOOD BUND"(Not the Bund Manual).
- ✓ Inspection items are listed with **deformations to be focused on with the solution**. However, **No concrete considerations for the planning and design** are stated.

b) Carryout physical inspection of the bund and look for:

(i) Top Levels
If lower than designed may result in overtopping.
Solution: Redesign the bund raising the top to safe elevation.

(ii) Unwanted Vegetation and Debris
Vegetation roots can trigger and allow undue and damaging seepage. Vegetation and debris also retard the process of identifying problems like leakages, covered damages and implementation of their remedial measures.
Solution: The unwanted vegetation and debris should be removed and not allowed to reappear.

No Mention of ...

- Inspection with Equipment/investigation/exploration
- River Profile / Inspection Report / Damage Record
- Analysis and Evaluation

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab Manual in Punjab

(11) Monitoring of River Conditions

1) Patrol/Physical Inspection

- ✓ Routine Inspections
- ✓ Flood Preparedness Inspection Report before Flood
- ✓ Flood inspections during the Flood
- ✓ Flood Damage Report after the Floods
- ✓ Identification and Prioritization of critical damages

Source: JICA Project Team quoted from the Manual of Irrigation Practice

- ✓ "Flood Preparedness Inspection Report before Flood" and "Flood Damage Report after the Floods" seem to be related to the **inspection of river training work**.
- ✓ "Routine Inspections" and "Flood Inspections during the Flood" seems to be related to a **patrol**.
- ✓ **The inspection of river training work is introduced with the detailed information.**
- ✓ From the composition of survey team members, it seems that this inspection is intended to be conducted by HSSEU

Table Summary of Inspection mentioned in the manual in Punjab

Item	Contents									
Timing	Before and after flood									
Responsibility Person	Sub-engineers and sub-divisional officers see that the actual section is not very much below the standard laid down in the type cross section.									
Survey Team Member	A three-person inspection team should be comprised, a leader, hydraulic engineer, geotechnical engineer.									
Inspection Item	<table style="width: 100%; border: none;"> <tr> <td style="width: 33%;">i. Top Levels</td> <td style="width: 33%;">iv. Slope/Section Stability</td> <td style="width: 33%;">vii. Damaged Armour</td> </tr> <tr> <td>ii. Unwanted Vegetation and Debris</td> <td>v. Settlement</td> <td>viii. Flood Wall Damage</td> </tr> <tr> <td>iii. Encroachments</td> <td>vi. Land Subsidence</td> <td>ix. Runnels Caused by:</td> </tr> </table>	i. Top Levels	iv. Slope/Section Stability	vii. Damaged Armour	ii. Unwanted Vegetation and Debris	v. Settlement	viii. Flood Wall Damage	iii. Encroachments	vi. Land Subsidence	ix. Runnels Caused by:
i. Top Levels	iv. Slope/Section Stability	vii. Damaged Armour								
ii. Unwanted Vegetation and Debris	v. Settlement	viii. Flood Wall Damage								
iii. Encroachments	vi. Land Subsidence	ix. Runnels Caused by:								

Source: JICA project Team summarized from the Manual of Irrigation Practice 45

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab Manual in Punjab

(11) Monitoring of River Conditions

2) Inspection with equipment/investigation/exploration

- ✓ *Geophysical investigations: Electrical resistivity/ Cavities, weak soil strata and buried objects through Ground penetrating radar*

Source: JICA Project Team quoted from the Manual of Irrigation Practice

3) River Profile / Inspection Report / Damage Record

- ✓ *The reports normally comprise an introduction, location of the training works, analysis for design parameters, physical inspection results.*
- ✓ *The committee will formulate its inspection/evaluation report and submit it to the owner/requesting authority within 15 days of the inspection.*

Source: JICA Project Team quoted from the Manual of Irrigation Practice

✓ It is not intended for monitoring, but **geophysical investigation is introduced for planning the bund.**

✓ **There is not mention of the river profile.**

✓ However, **the inspection report which include damage record is described.**

4) Analysis and Evaluation

- ✓ *Review the design according to the state-of-the-art design methods/procedures, point out any deficiencies to be corrected and suggest suitable action to withstand the accepted Probable Maximum Flood.*

Source: JICA Project Team quoted from the Manual of Irrigation Practice 46

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab Comparison

(11) Monitoring of River Conditions

SUMMARY

Common

- ✓ There are descriptions to be complemented from the contents in each manual.
- ✓ The manuals in **both Sindh and Punjab are recommended additionally to incorporate the description on Inspection with Equipment / Investigation / Exploration.**

Sindh

- ✓ It is recommended to incorporate the **description of Inspection Report / Damage Record.**

Item	Sub Item	Comments
Monitoring of River Conditions	Patrol/Physical Inspection	About Patrol <ul style="list-style-type: none"> • The manual in Punjab is recommended to describe the patrol structure with reference to on the Bund Manual in Sindh • Both manuals need to introduce the patrol items in detail. About Physical Inspection <ul style="list-style-type: none"> • The Bund Manual in Sindh is recommended to add the missing items such as responsible person and survey team composition with reference to the Manual in Punjab.
	Inspection with Equipment / Investigation / Exploration	<ul style="list-style-type: none"> • It is desirable for both manuals to additionally introduce this item with reference to guidelines in other countries.
	River Profile / Inspection Report / Damage Record	<ul style="list-style-type: none"> • It is recommended for the Bund Manual in Sindh to incorporate the description of Inspection Report / Damage Record based on the Manual of Irrigation Practice in Punjab.
	Analysis and Evaluation	Same as the above

Source: JICA Project Team summarized from the Manual of Irrigation Practice 47

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab Manual in Sindh

(12) Inspection and Ledger

1) Bund

Table Forms of Ledgers and Repots Introduced in Bund Manual in Sindh

No.	Item	Interval
1	Erosion Statement	Weekly
2	Abkalani Report(Bund)	Weekly
3	Reports on the State of Bund Sluices and Regulators.	Yearly
4	Statement of High Flood Levels on Bund Mile Gauges and Free Board Available During the Abkalani	Yearly
5	Position in Line of Defense(Bund Register)	Yearly
6	Register Showing Incidence of Leaks	When an Incident Occurs.
7	Report of Leveling on Bunds	Yearly

Source: JICA Project Team summarized from the Bund Manual in Sindh 48

- ✓ All the inspection ledger/reports are efficient for the bund management. On the other hand, **there is no mention of the organization of these documents.**
- ✓ it is **difficult to immediately grasp the contents** of each document from the engineer in the main office of each PID
- ✓ **It is necessary to create records early, to organize and to store them so that they can be easily searched.**
- ✓ There are **no regulations for the storage of the ledgers, and the documents are scattered in various divisions and office.**

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

Manual in Sindh

(12) Inspection and Ledger

Table Description of Forms of Ledgers and Repots Introduced in Bund Manual in Sindh

No.	Item	Interval	Description
1	Erosion Statement	Weekly	The form to report the weekly development of erosion of the riverbank from Subdivision Engineer.
2	Abkalani Report(Bund)	Weekly	As soon as there is water against a bund line, the Sub-Divisional Officer will submit every week.
3	Reports on the State of Bund Sluices and Regulators.	Yearly	A yearly report which contains the state of bund sluices and regulators specially. This is showing the defects noticed and the steps taken to remedy them.
4	Statement of High Flood Levels on Bund Mile Gauges and Free Board Available During the Abkalani	Yearly	This is to compare the H.F.Ls. obtained each year with the previous maximum and to verify if the freeboard is sufficient or not.
5	Position in Line of Defense(Bund Register)	Yearly	Bund Register is to present at a glance the various details of the bund line at every mile. It forms a comprehensive record for reference purposes.
6	Register Showing Incidence of Leaks	When an Incident Occurs.	A register, showing the position of leaks and the immediate action taken at the for plugging or closing the leak and the action subsequently taken for opening out and refilling the entire course of the leak in the full width of the embankment.
7	Report of Leveling on Bunds	Yearly	A yearly report to check the formation levels and slopes of all river bunds (including trench bunds) and the actual position in regard to available freeboard.

Source: JICA Project Team summarized from the Bund Manual in Sindh 49

2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

Manual in Sindh

(12) Inspection and Ledger

2) River Channel

- ✓ The Executive Engineers in charge of bund lines should inspect the river course in their charge immediately after the abkalani.
- ✓ Inspections should also be made, during the abkalani, if there are reports of an adverse change in course.
- ✓ A full report, together with any proposals considered necessary, should be forwarded to the Superintending Engineer, if an unfavorable river course or river set is indicated.

Source: JICA Project Team quoted from the Bund Manual in Sindh

- ✓ No specific ledger or form is described and introduced.
- ✓ Concrete methodology for the inspection is not introduced.
- ✓ An inspection shall be conducted at least once a year. And, in case an unfavorable river course or river set is indicated, it must be informed with a full report.

3) Storage

- ✓ No mention of the method to store the ledger sheet and report.
- ✓ It is necessary to specify the regulation about the storage.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

Manual in Punjab

(12) Inspection and Ledger

1) Bund

SAMPLE CHECKLIST FOR BUND SITE INSPECTION

Name of the Bund: _____

Design Section: _____

Date of Inspection: _____

Inspector: _____

Remarks: _____

Evidence of piping

Evidence of heavy seepage, springs and boils on the land side

Erosion by flow

Is the bund prone to wave action

Erosion by wave action

What to input is not clearly guided.

- ✓ One check list which include all inspection items is introduced.
- ✓ It includes 1)Basic Information of the Bund, 2)Situation of Flow, Seepage, Erosion etc., 3) Arrangement of watching, fighting, waring system etc.
- ✓ Since there is little explanation of the necessary information for each item, the input information may varies depending on the individual knowledge and experience.

Source: Manual of Irrigation Practice 51

2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

Manual in Punjab

(12) Inspection and Ledger

2) River Channel

Table Survey and Investigation Item for River Channel in Punjab

No.	Item	Interval	Description
1	Topo Survey	Yearly	Survey area is extending to 15000 x afflux feet on the upstream and 25000 ft on the downstream of the barrage.
2	Bathymetric Survey	Yearly	This survey shows the areal placement of river channels, their variations, erosions and shoals and changes in the meanders of the river channels.

Source: JICA project Team summarized from the Manual of Irrigation Practice

- ✓ Any ledger or form is not described and introduced, but item for the survey and investigation is described.
- ✓ The objectives of bathymetric survey is not mentioned clearly, but this survey seems to be carried out near the barrage to assess the condition

3) Storage

- ✓ The sub-divisional officer in charge of the barrage has the responsibility of checking and initiating all the data record regularly at prescribed intervals.
- ✓ There is no clear provision for the storage of inspection ledgers.
- ✓ it is stated that the sub-divisional officer in charge of the barrage is responsible for keeping all documents.
- ✓ It is preferable to improve this regulation because he or she has little relevance to the bunds.

Source: JICA Project Team quoted from the Manual of Irrigation Practice 52

2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(12) Inspection and Ledger Comparison

SUMMARY

Common ✓ About Storage, the manuals in both Sindh and Punjab need to be improved

Punjab ✓ About the Bund, it is recommended to **add ledgers such as those listed in the Bund Manual in Sindh.**
 ✓ **Describing more detailed instruction for each inspection item** is recommended.

Sindh ✓ **About River Channel, Describing inspection and survey items is recommended.**

Item	Sub Item	Comments
Inspection and Ledger	Bund	• The manual in Punjab is recommended to add ledgers such as those listed in the Bund Manual in Sindh to clarify what needs to be checked.
	River Channel	• It is recommended for the Bund Manual in Sindh to add the inspection and survey items of erosion and bathymetry. • Both manuals need to describe concrete methodology for inspection with reference to other countries guideline. • The manual in Punjab is recommended to expand the area of river course inspection and erosion not to limit the area around the barrages, as they are basic information for maintaining the bund.
	Storage	• The Bund Manual in Sindh needs to state the methodology for storage. • Both manuals have to clearly describe the type of reports to be stored.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

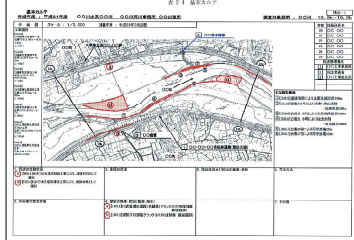
2.2 Comparison of the Manuals between Sindh and Punjab

(13) River Ledger Manual in Sindh Manual in Punjab


Bund Manual in Sindh **Manual of Irrigation Practice in Punjab**

✓ **No specific ledger or form as a River Ledger.**
 ✓ For a bund, similar type of ledger is introduced in the manual.

✓ **No specific ledger or form as a River Ledger.**
 ✓ There is no mention of the method to store the ledger sheet and report.



Basic Ledger



Monitoring Ledger

Figure Sample River Ledger

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(13) River Ledger Comparison

SUMMARY

Common ✓ About Storage, the manuals in both Sindh and Punjab need to be incorporate the description.

Punjab ✓ It is recommended to **include the ledger which shows the characteristics of the bund** with reference to the Bund Manual in Sindh.

Item	Sub Item	Comments
Inspection and Ledger	Contents	• The Manual of Irrigation Practice in Punjab is recommended to include the ledger which shows the characteristics of the bund with reference to the Bund Manual in Sindh.
	Storage	• Both manuals are recommended to describe this item with reference to manuals in other countries.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(14) Bund Breach Manual in Sindh Manual in Punjab

1) Cause of Breach

a. Erosion of the Bund by the River Itself
 b. Failure of Masonry Works, Such as Sluices and Regulators
 c. An Uncontrolled Leak Developing into a Breach
 d. Overtopping or Severe Scour of the Bund

✓ The most frequent cause of a breach is the development of a leak

Source: JICA Project Team summarized from the Bund Manual in Sindh and from the Manual of Irrigation Practice

✓ Contents in the manuals of Sindh and Punjab is the same.

✓ **Development of a leak is considered as the most major factor.**

2) Artificial Breach

Manual in Sindh(Bund Manual)

✓ Artificial bund breach is **not described.**

Manual in Punjab(Manual of Irrigation Practice)

Conditions

a. The location is approved by a committee.
 b. The pre-requisite site conditions are following.
 ➢ Inflow >Discharging capacity of the structures.
 ➢ The critical / emergency gauge at a fixed location has exceeded the limiting value and the river discharge still rising.

Methodology

✓ The breaching section can be activated through, Mechanical means or Blowing up the body of the bund through use of explosives
 ✓ Mechanical means is desirable. The success rate of blowing up is less than 50%.

Source: JICA Project Team quoted from the Manual of Irrigation Practice

✓ Conditions and Methodology on the artificial breach is described.

✓ **Setting of the critical gauge values to be referred is not clearly described.**

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(14) Bund Breach

Manual in Sindh Manual in Punjab

3) Immediate Action

- ✓ Contents in the manuals of Sindh and Punjab is the same.
- ✓ Update the mention of communication tool is recommended.
- ✓ About the report, the items are introduced precisely, but introducing the form to be filled is recommended. So that, the accumulation and extraction of the information becomes easier.
- ✓ Also, considering the digitalization which will come in near future, using the fixed format is preferable.

a. If a breach occurs or is threatened, the overseer should immediately send a telegram, and later send in a report.
b. The report should include the basic information of the bund, the outline of the breach and site conditions such as the water level & nature of soil etc.
c. Ask to supply labor immediately.
d. The detailed report indicates the measures taken and the steps proposed to be taken for protecting the ends, closing the breach, and diverting the water where it would do the least damage.
e. The probable route of the river water shall be reported.
f. Immediate intimation of any breach to the Railway, Highway, Gas Transmission authorities
g. When a breach occurs, the first step to be taken is to prevent the breach from widening.

Source: JICA Project Team summarized from the Bund Manual in Sindh and from the Manual of Irrigation Practice

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(14) Bund Breach

Manual in Sindh Manual in Punjab

4) Closure of Breach

- ✓ Contents in the manuals of Sindh and Punjab is the same.
- ✓ Introducing the past cases will be good reference for the engineers who are going to work on the closure.
- ✓ In the Bund Manual in Sindh, a closing of 1942 breach in Sukkur Begari Bund is also presented. Since the time has passed and technology has been developing, additional latest cases are also recommended to introduced for the future reference.
- ✓ in order to introduce as the sample case, it is important to accumulate the records of the actual closure.

1. Measurements taken underwater to determine ring bund placement.
2. Juckwork location chosen based on shallow water depth and erosion-resistant soil.
3. Time schedule created to close breach at favorable river condition.
4. Materials and labor estimated and arranged.
5. Final closure gap determined after detailed inspection.
6. Flow through breach will be adjusted
7. Stakes driven to determine placement of mangui.
8. In deep watercourse, sandbags used if flow too fast.
9. Lining with mats, compartments packed with brushwood. Careful soil placement in deep sections.
10. Edges joined with props, supports, and gunny bags to prevent collapse.
11. Gap paved with gunny bags to prevent soil digging.
12. If leakage occurs, small ring bund constructed around downstream end of leak, protected by gunny bags

Source: JICA Project Team summarized from the Bund Manual in Sindh

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(14) Bund Breach

Comparison

SUMMARY

Common ✓ The descriptions stated in each manual are basically the same

- ✓ Artificial Breach is only listed in the Manual of Irrigation Practice in Punjab. The reason for that seems that there is no designated breach point or officially announced breach point in the province of Sindh.

Item	Sub Item	Comments
Bund Breach	Cause of Breach	• The same cause of breach is listed on both Sindh and Manual in Punjab.
	Artificial Breach	• This item is only listed in the Manual of Irrigation Practice in Punjab. The reason for that seems that there is no designated breach point or officially announced breach point in the province of Sindh.
	Immediate Action	• The contents are almost same in both manuals
	Closure of Breach	• The contents are completely same in both manuals

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.2 Comparison of the Manuals between Sindh and Punjab

(15) Gap between the Manual and Actual Practice

SUMMARY

- ✓ The documents are not properly stored.
- ✓ It is difficult to grasp the needed information immediately.
- ✓ Some regulations in the manual may not be properly reflected to the technical specifications or not be complied in the actual practice.

Major Findings

1. It seems that the details of the work (progress and components) have not been grasped in the main office. Also, information is not shared properly because the responsibility system is not clear.
2. In some part, the regulation stated in the manual might not be sufficiently reflected in the technical specifications of the construction work.
3. The description in the manual is a recommendation for quality and construction management, and on-site judgment may take precedence (For example, the embankment material to be used).
4. Inspection documents related to construction management are not stored properly, or they are stored but are not known where they are.
5. In particular, it is assumed that construction managements by contractors in the repair and reinforcement works tend to be simplified and may not conform to the manual.
6. Since the relating documents of the construction project such as technical specification, the reports on the quality inspections, the shape inspections have not been obtained, it is not verified if the implementations of the construction works are in accordance with bund reinforcement specified in the manual or not.

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- 1 INTRODUCTION
- 2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND
 - 2.1 Extraction of Item to be Analyzed
 - 2.2 Comparison of the Manuals between Sindh and Punjab
 - 2.3 Comparison of the Manuals with Japanese Standards**
- 3 RECOMMENDATION TO THE MANUALS IN SINDH AND PUNJAB



2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(1) Definition of a Bund

Japanese Standard

- ✓ **Earthen embankment** designed and constructed to prevent water from flowing out of the river.
- ✓ It is **safe against water levels below the target water level**(high water level(HWL) based on a design discharge calculated from probabilistic analysis).

Source: JICA Project Team translated from Cabinet Order Concerning Structural Standards for River Administration Facilities, etc., Japan.

- About the target water level which shall be protected by a bund, **high water level(HWL) based on a probabilistic analysis** is used.
- Basically, material for bands is **SOIL**.

Table Design Scale Depending on the Importance of a River

Importance	Design Scale (yr) (Probability year to exceed the rainfall of target rainfall)	Remarks
A	More Than 200	Major Stretch along 1 st Class River
B	100 to 200	Same as Above
C	50 to 100	Urban Area along other 1 st Class or 2 nd Class River
D	10 to 50	Other 1 st Class or 2 nd Class River
E	Less Than 10	Same as Above

Source: Technical Criteria for River Works: Planning

- Advantage**
- ✓ Low Cost, Easy Procurement
 - ✓ Easy Rehabilitation/Upgrade/Change in the future
 - ✓ Less Deterioration
 - ✓ Able to follow the deformation of the foundation ground.
- Disadvantage**
- ✓ Inhomogeneous Material
 - ✓ Stability decreases due to the saturation.
 - ✓ Easily Eroded/scoured by the water flow
 - ✓ Weakness against overflowing

2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(1) Definition of a Bund

Comparison

SUMMARY

- Common**
- ✓ Among the manuals in Sindh, Punjab and Japan, the contents are almost the same.
 - A bund is basically **an earthen structure**.
 - **Containing foreign matters in the bund body is not deemed preferable** by them.
 - ✓ About a bund height, it is determined based on probability in Japan, but it is determined based on experiences in Sindh and Punjab.

Item	Sindh	Punjab
Definition of a Bund	<ul style="list-style-type: none"> • Contents are almost same in both manuals. • Once the highest water level due to a flood is updated, the target water level for the bund design will increase. 	Same as the left

2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(2) Standard Shape of a Bund

Japanese Standard

- ✓ **Crown Width** : Depending on the design discharge as shown in the following Table.
- ✓ **Side Slope** : Gentler than 2:1 except for the bund with a height of 2.0 ft (=0.6 m)
- ✓ **Berm Width** : Larger than 3 m
- ✓ **Freeboard** : Depending on the design discharge as shown in the following Table
- ✓ **Extra Embankment** : 20 cm to 50 cm or more, depending on the soil type and bund height.

Source: JICA Project Team summarized from Cabinet Order Concerning Structural Standards for River Administration Facilities, etc., Japan.

Table Crown Width		Table Freeboard	
Discharge	Width	Discharge	Freeboard
Under 17,657 cusec (=500 m ³)	9.8 ft (= 3 m)	Under 7,062 cusec (=200 m ³)	2.0 ft (= 0.6 m)
17,657 to 70,629 cusec (=500 to 2,000 m ³)	13.1 ft (= 4 m)	7,062 to 17,657 cusec (=200 to 500 m ³)	2.6 ft (= 0.8 m)
70,629 to 176,573 cusec (=2,000 to 5,000 m ³)	16.4 ft (= 5 m)	17,657 to 70,629 cusec (=500 to 2,000 m ³)	3.3 ft (= 1.0 m)
176,573 to 353,146 cusec (=5,000 to 10,000 m ³)	19.7 ft (= 6 m)	70,629 to 176,573 cusec (=2,000 to 5,000 m ³)	3.9 ft (= 1.2 m)
Over 353,146 cusec (=10,000 m ³)	23.0 ft (= 7 m)	176,573 to 353,146 cusec (=5,000 to 10,000 m ³)	4.9 ft (= 1.5 m)
		Over 353,146 cusec (=10,000 m ³)	6.6 ft (= 2.0 m)

Source: JICA Project Team translated from Cabinet Order Concerning Structural Standards for River Administration Facilities, etc., Japan.

Source: JICA Project Team translated from Cabinet Order Concerning Structural Standards for River Administration Facilities, etc., Japan.

- **These values are minimum requirement** and larger value is often applied especially in urban area. Such values are specified by the local river offices.
- Extra embankment is set also considering the result of 1D settlement analysis, if necessary.

2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(2) Standard Shape of a Bund
Comparison

SUMMARY

Sindh ✓ Higher values in the Crest Width, Berm Freeboard are preferable.

Punjab ✓ Description of the Extra embankment is necessary.

Item	Sub-item	Sub-sub-Item	Sindh	Punjab
Standard Shape of a Bund	Crest Width		Considering the discharge during floods, duration of high water level and the available earthen material around Indus River, higher value is preferable.	The design value is almost the same as the rivers which has over 353,146 cusec(=10,000 m ³ /s) in the Japanese standard.
	Side Slope	River side, Land side	The value is milder than it in Japan. It is preferable when considering a high water level with long duration in Indus River.	Same as the left
	Berm		Considering the discharge during floods, duration of high water level and the available earthen material around Indus River, higher value is preferable.	The design concept differ from the Japanese standard.
	Freeboard		Same as Above	The design value is almost the same as the rivers which has over 353,146 cusec (=10,000 m ³ /s) in the Japanese standard.
	Extra Embankment	Levelling of Top of Bunds after Construct-ion.	This is almost the same value between Sindh Province and Japan.	It is recommended to describe this item with reference to the Japanese guideline.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(3) Quality Control
Japanese Standard

1) Material

- ✓ Fine particle contents is important.
- ✓ 15% to 50% of fine particles (Not larger than 0.075mm in the size) is desirable.
- ✓ Maximum particle size is not larger than 10 to 15 cm.
- ✓ A soil which has wide distribution in particle size, and not so many contents of silt.

Source: JICA Project Team summarized from River Earthwork Manual, Japan.

- In addition to the specified condition, the area of particle size distribution considering the cracks generating due to the drying and permeability of the bund body is recommended.
- Furthermore, measures to be taken at the case when the specified material cannot be obtained are introduced.
1) Soil Mix, 2)Lowering Moisture Content, 3)Stabilization

Limit of Particle Size Distribution for Embankment

Passing Rate (%)

Particle size (mm)

Area with High Risk of Cracks Generation

Source: JICA Project Team summarized from River Earthwork Manual, Japan and an Acceptance Standard for the Construction Soil .

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(3) Quality Control
Japanese Standard

2) Construction Method

✓ The thickness of 1 layer of a embankment is 11.8 inches(=30cm).

✓ The required and recommended equipment to be used for each earth work item is listed, and 5 major equipment such as bulldozer, tire roller, vibrating roller, vibrating compactor, and tamping machine is introduced with the applicable types of embankment materials.

✓ Inspection & investigation to verify the applicability for the embankment material, methodology of quality control, countermeasures for soft ground and environmental aspects are also introduced.

Source: JICA Project Team summarized from River Earthwork Manual, Japan.

- About embankment works, applicable combination of equipment and soil type is introduced.
- Thickness of 1 layer is bigger than it in Sindh.

Table General Adaptation of Soil Types and Equipment for Compaction

Type of Soil	Equipment					Remarks
	Normal Bulldozer	Wheel Roller	Vibrating Roller	Vibrating compactor	Tamping Machine	
Sand	○	○	○	△	△	Single-grained sand, incised gravel without fine grains, sand from dunes etc.
Sand with Gravel	○	○	○	△	△	Good particle size mixed soil that contains moderate fine particles, decomposed granite soil, mountain gravel, etc.
Sand	◎	◎	○	△	△	Sensitive Soil with a little fine particle, loam with low moisture content, easy-to-crush mud rock, etc.
Sandy Soil	○	○	○	×	△	Soil which is difficult to adjust the water content and to secure sufficient trafficability, silty soil, etc.
Sandy Soil with High Water Content	○	×	×	×	×	
Clay	○	○	○	×	△	
Clay with Gravel	○	○	○	×	△	
Sandy Soil with High Water Content	○	×	×	×	×	
Clayey Soil with High Water Content	○	×	×	×	×	

Legend: ◎ Applicable, ○ Usable
△ Usable but it is used depending on the site condition such as the area limitation, × Not Usable

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(3) Quality Control
Japanese Standard

3) Degree of Compaction

✓ The average value is larger than 90% of the maximum laboratory dry density.

✓ The minimum value is larger than 80% of the maximum laboratory dry density.

✓ When it may not be possible to ensure these criteria, it is necessary to confirm the degree of compaction by trial embankment and set compaction management standards suitable for the soil material used.

Source: JICA Project Team summarized from River Earthwork Manual, Japan.

Table Two Types of Specification for Compaction

Type	Description
Specifying Quality	The required quality is specified in the technical specification and the contractor can propose the method. The quality of embankment shall be the target for the inspection.
Specifying Method	Equipment to be used and numbers of compactions are specified in the technical specification. In case of the complicated soil condition or the experience of the contractor is insufficient, this type might be better.

- Due to the variety of the soil material, setting with average value is considered practical.
- In order to maintain the quality more than a certain level, the minimum limit is also set.
- There are 2 types of specification for compaction. In case of river bunds, specifying the quality is usually used.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(3) Quality Control Comparison

SUMMARY

Sindh ✓ Adding the descriptions of particle size distribution, construction equipment, embankment material survey etc. is recommended.
 ✓ The revision of current rule for the source of the embankment material is recommended.

Punjab ✓ Entire Description of the Quality Control is recommended to added.

Item	Sub-Item	Sub-sub-Item	Sindh	Punjab
Quality Control	Material	Desirable Material, Available Material	Recommend to state the maximum particle size and allowable range of the particle size distribution. The rule for the source of the embankment material is necessity be revised.	No Description
	Construction Method		It is necessary to add the description of... ✓ the construction equipment and the feature of materials that is applicable. ✓ the method of embankment material survey and quality control. ✓ the countermeasures for soft ground.	Same as Above
	Degree of Compaction		It is recommended to add the description of... ✓ the case in which the required degree cannot be satisfied. ✓ setting a compaction criteria by a trial embankment.	Same as Above

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(4) Service Road/ Maintenance Road Japanese Standard

✓ The minimum width of the maintenance road is set to 3m considering purposes of patrols, rehabilitation and flood fighting during floods.
 ✓ Easy access and use by the residents nearby is considered.
 ✓ Due to these purposes, a paved road is recommended.
 ✓ Structure gauge is as follows.

• Considering the use during the normal time, the space for fire vehicle and drainage pump vehicle, more than 4m width is recommended in the urban area.
 • Type of pavement is usually gravel(aggregate base course) or asphalt.

1) Gravel

2) Asphalt

Source: Cabinet Order Concerning Structural Standards for River Administration Facilities, etc.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(4) Service Road/ Maintenance Road

SUMMARY

Common ✓ For the smooth passage of maintenance vehicles, it is recommended to add a description about the pavement on the top.

Item	Sindh	Punjab
Service Road/ Maintenance Road	No Description	No Description

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(5) Safety Evaluation Japanese Standard

Table Methods for Safety Evaluations

Item	Description
Slope Failure	<ul style="list-style-type: none"> Verify the stability against slip circle by a numerical analysis with a software. Modified Fellenius Method is specified for slip circle analysis.
Erosion	<ul style="list-style-type: none"> Secure the distance from the riverbank to the bund, which varies depending on the feature of the river(called a "segment" in Japan) Verify the stability of slope protection material against the design flow velocity.
Seepage Flow	<ul style="list-style-type: none"> Numerical analysis with a software Verify the stability against slip circle and local hydraulic gradient at the toe of a bund considering the movement of the water level during floods Unsteady flow calculations considering rainfall and river level changes.
Earthquake	<ul style="list-style-type: none"> Numerical analysis with a software Verify if the top elevation of a bund after an earthquake is higher than the specific water level.

The following safety conditions are verified by setting an appropriate river level as a verification condition.

- Normal Time
 - Slope Stability Against Slip
 - Settlement
 - Erosion Caused by Rainwater Drainage
- During Flood
 - Direct Erosion and Lateral Erosion
 - Seepage (Slope Stability Against Slip and Piping)
- Earthquake
 - Settlement Due to Liquefaction
- During Storm Surges
 - Erosion
 - Wave Overtopping

Source: Technical Criteria for River Works: Practical Guide for Designing, etc.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(5) Safety Evaluation
Comparison

SUMMARY

Common ✓ Necessary to conduct studies and evaluations based on numerical analysis or simple calculations, considering river and geological conditions

Sindh ✓ Entire Description of the Seepage Control is recommended to added.

Punjab ✓ Detailed description of seepage analysis method are needed.

Item	Sub-item	Sindh	Punjab
Safety Evaluation	General	It is necessary to conduct studies and evaluations based on numerical analysis, considering river and geological conditions.	Same as the Left
	Slope Stability/ Slip Circle	Same as above	Almost the same in both Punjab's and Japanese manuals.
	Erosion	Verification of the stability against the target flow velocity is recommended.	Same as the Left
	Seepage Control	No Description	A numerical analysis for seepage analysis is introduced in the Japanese standard, while only the simple relational equation is listed in the manual in Punjab.
	Seismic Condition	It is desirable to study for adding the description of stability against earthquakes considering the future condition.	Same as the Left

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(6) Improvement of a Bund
Japanese Standard

Table Major Bund Improvement Methods

Item	Description	Item	Description
Slope Failure	<ul style="list-style-type: none"> Milder Slope Counterweight Embankment The Measures for Seepage Flow to Reduce the Water Level in the Bund Body Sheet Pile to Stop the Slip Circle 	Seepage Flow	<ul style="list-style-type: none"> <For a Bund Body> <ul style="list-style-type: none"> Expansion of Bund Body Installation of Drain(Gabion) Covering Riverside Slope(Impervious Sheet) Covering All the Surface <For Foundation Ground> <ul style="list-style-type: none"> Seepage Cut-off in front of a Bund Blanket Method Well Method
	<ul style="list-style-type: none"> <Without Revetment> <ul style="list-style-type: none"> Revetment(for a Bund/low Water Channel) Erosion Control Mat Control the Vegetation on the Bund Realignment Spur <With Revetment> <ul style="list-style-type: none"> Strengthening the Revetment Extension of Bottom of the Revetment Making a Dry Masonry to a Wet Masonry Foot Protection Work Realignment Spur 		Earthquake

Source: Technical Criteria for River Works: Practical Guide for Designing, etc.

- There are some countermeasures which have high applicability to Pakistan such as impervious sheet and seepage cut-off wall in the Japanese standard.
- In case of Japan, several countermeasures against each phenomena are introduced with the concrete design method(most of the caser, specification design).

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(6) Improvement of a Bund
Comparison

SUMMARY

Common ✓ It is recommended to include improvement methods and foot protection works that can be applied in Pakistan(seepage cut-off walls and impervious sheets as seepage control works and concrete blocks and net gabion as foot protection works).

Punjab ✓ Entire Description of the improvement method for Slope Stability is recommended to added.

Item	Sub-item	Sindh	Punjab
Improvement of a Bund	Slope Stability/ Slip Circle	✓ Similar types of methods to Japan are introduced.	No Description
	Erosion	<ul style="list-style-type: none"> ✓ As a foot protection work, it is recommended to introduce concrete blocks and net gabion. ✓ In the future, application of erosion control mat or a vegetation which can resist such severe climate in Pakistan with inexpensive cost is desirable. 	Same as the Left
	Seepage Control	✓ It is recommended to include improvement methods that can be applied in Pakistan, such as seepage cut-off walls and impervious sheets, as seepage control works.	Same as the Left
	Seismic Condition	✓ It is desirable to add countermeasures against earthquakes.	Same as the Left

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(7) Revetment
Japanese Standard

1) Material

Purpose: To protect the bunds from the action of flowing water.

A Revetment consists of the following components.

- Slope Protection Work:** Direct contact between the embankment surface and flowing water to prevent scouring.
- Foundation Work:** Supports the Slope Protection.
- Foot Protection Work:** Prevents scouring of the riverbed in front of the foundation during floods and stabilizes the foundation work.

Source: JICA Project Team summarized from Cabinet Order Concerning Structural Standards for River Administration Facilities, etc.

Material	Slope : Not milder than 1.5:1	Slope : Milder than 1.5:1
Stone	<ul style="list-style-type: none"> Wet Stone Masonry Dry Natural Stone Masonry 	<ul style="list-style-type: none"> Wet Stone Masonry Dry Natural Stone Masonry
Wood	<ul style="list-style-type: none"> Wooden Lattice, Block, Picket Fence 	<ul style="list-style-type: none"> Wooden Lattice, Block, Fascine Mattress
Gabion	<ul style="list-style-type: none"> Gabion(Step Type) 	<ul style="list-style-type: none"> Gabion(Mattress, Net Gabion)
Mat, Sheet, Cement, Concrete	<ul style="list-style-type: none"> Concrete Block Retaining Wall Reinforced Concrete Retaining Wall 	<ul style="list-style-type: none"> Geotextile Mattress Block Mattress Concrete Block (Lining, Connecting)
Others	<ul style="list-style-type: none"> Steel Sheet Pile Wall 	<ul style="list-style-type: none"> Vegetation(Not Revetment)

Source: JICA Project Team extracted from Basic Disaster Recovery Policy to Protect Beautiful Mountains and Rivers in Japan

- In Japan, concrete blocks, gabion and vegetation are widely used to protect slopes.
- Geotextile mattress is placed under the revetments in a lot of cases to prevent the soil particles from draining out from the bund body.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(7) Revetment Japanese Standard

2) Safety Verification

✓ For the assessment, it needs setting the required conditions and acts depending on each installation location, type of work, and structural form of each component according to the table. Based on this, the assessment items shall be set.

Source: JICA Project Team summarized from Technical Criteria for River Works: Practical Guide for Designing.

Condition	Act
Normal	Dead Weight, Earth Pressure, Water Pressure
Flood	Acting Force generated by the flowing water which has the water level below HWL, Dead Weight, Earth Pressure, Water Pressure
Seismic	Dead Weight, Earth Pressure, Water Pressure, Influence of Earthquake

3) Structural Design –Slope Protection-

- ✓ Slope : Not milder than 1.5:1 → Piled up Type
- ✓ Slope : Milder than 1.5:1 → Lining Type
- ✓ In case of the stability analysis for the lining type, situations such as sliding, overturning, traction are considered.

Source: JICA Project Team summarized from Technical Criteria for River Works: Practical Guide for Designing

- In Japan, mainly stability against design velocity is verified.
- About Piled up Type, stability during normal and seismic condition shall be verified.
- The design velocity is determined based on the average flow velocity considering curves, cross-sectional shapes, riverbed profiles.
- The average flow velocity is usually calculated from uniformed flow or 1-D non-uniformed flow calculation.

2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(7) Revetment Japanese Standard

3) Structural Design –Foundation-

✓ The foundation work of revetments is designed as a safe structure that can support the slope protection work, taking into consideration factors such as scouring caused by floods.

Source: JICA Project Team summarized from Technical Criteria for River Works: Practical Guide for Designing

- There are four basic approaches to determine the elevation of the foundation work considering the expected bed elevation at maximum scouring (Expected Deepest Riverbed Nearby).
- Expected Deepest Riverbed Nearby shall be determined from the monitoring record of riverbed or riverbed fluctuation (numerical) analysis.

Monitoring is important!!

Source: TECHNICAL STANDARDS AND GUIDELINES FOR DESIGN OF FLOOD CONTROL STRUCTURES, Project for the Strengthening of Flood Management Function of the DPWH, Philippines (Same Contents as Japan)

2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(7) Revetment Japanese Standard

3) Structural Design –Foot Protection-

✓ The purpose of a foot protection work is to design a safe structure for the foundation by considering the fluctuation of the riverbed and other factors related to fluid forces.

Source: JICA Project Team summarized from Technical Criteria for River Works: Practical Guide for Designing

- In Japan, mainly stability against design velocity is verified.
- The width of a foot protection is set considering Deepest Riverbed Nearby.

Source: TECHNICAL STANDARDS AND GUIDELINES FOR DESIGN OF FLOOD CONTROL STRUCTURES, Project for the Strengthening of Flood Management Function of the DPWH, Philippines (Same Contents as Japan)

2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(7) Revetment Comparison

SUMMARY

Common

- ✓ It is recommended to add the description of a concrete design method that allows practitioners to perform the design and safety verification.
- ✓ To include following types of material as the options is recommended.
 - Slope Protection : Gabion, Concrete Block (connected type, articulated type) and Filter Cloth
 - Foot Protection : Concrete Blocks

Item	Sub-item	Sub-sub-item	Sindh	Punjab
Revetment	General		✓ There is no mention of the parts such as a slope, foundation and foot protection.	Same as the Left
	Material and Structure		<ul style="list-style-type: none"> ✓ It is recommended to include Gabion, Concrete Block (connected type, articulated type) and Filter Cloth. ✓ In addition to recommending the development of an inexpensive surface covering material, using stone pitching on the landside slope is recommended. 	Same as the Left
	Safety Verification		No description	Same as the Left
	Structural Design	Slope	✓ Due to the mild slope of bunds, only lining type revetment is considered in the manual.	Same as the Left
		Foundation	No description	Same as the Left
		Foot Protection	✓ Concrete Blocks can be considered in Pakistan.	Same as the Left

2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(8) Spur (Stone Groyne)
Japanese Standard

Table. Types of a Spur and its Purpose

	Type I	Type II
Purpose	Reducing the Flow Velocity Nearby	Controlling the Flow Direction
Feature	a. The height of the spur is low. b. A Spur with low permeability considering the water depth or permeable. c. Mainly light structure such as piling work. d. Several to dozens of lines are installed in parallel and act as a whole.	a. The height of the spur is high. b. Semi-permeable or Impermeable. c. Heavy and large structures made of earth, stone, concrete, etc. d. Single or in small numbers in parallel.
Dimensions (Reference)	Length : Less than 10% of the river width. Height : Approximately 0.2 to 0.3 times the HWL. Spacing : Often 2 to 4 times the length and 10 to 30 times the height.	Height at the connection point of the spur : Approximately the HWL. Spacing : Usually, 1/2 to 1/3 of the length of the sandbar formed in the respective section. Direction : Mostly perpendicular to the riverbank or slightly downward.

Source: Technical Criteria for River Works: Practical Guide for Designing

- In Japan, Piled up Concrete Blocks, Piled up Natural Stones and Wooden Type are used.
- For designing spurs, [past experiences, records from similar rivers, and the results of trial construction, model experiments, and research surveys for new construction methods](#) are utilized with consideration for construction feasibility, cost-effectiveness, maintenance management, and the safety of river users.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(8) Spur (Stone Groyne)
Comparison

SUMMARY

Common ✓ Concrete Brocks are recommended to include as an options.

Sindh ✓ It is recommended to **add the descriptions on the concrete design method.**

Punjab ✓ Installation interval and basic shape is mentioned in the manual.
 ✓ Adding descriptions of the other items such as length, height, etc.is recommended.

Item	Sub-item	Sindh	Punjab
Spur (Stone Groyne)	Site Condition	✓ It is recommended to include such a detailed information relating with the practical design method.	✓ It is recommended to add specific design items other than the installation interval.
	Basic Shape	No description	✓ Detailed dimensions are specified in the manual of Punjab.
	Material	Concrete Blocks can be considered.	Same as the Left
	Design Method	✓ It is recommended to include such a detailed information relating with the practical design method.	✓ It is recommended to add specific design items other than the installation interval.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(9) Construction
Japanese Standard

1) Permission

✓ *Somebody other than river administrators may implement river works or maintenance of rivers with the approval of the river administrator as prescribed by the cabinet order. However, for those considered to be of a minor nature as determined by the cabinet order, approval from the river administrator is not required.*

Source: JICA Project Team summarized from River Law Article 16(3) ~ Article 21, Japan

- In Japan, somebody who have a permission from the river administrator can implement works or conduct maintenance in a river area.

2) Procedure

- The process of construction inspections can vary depending on the type of construction, the inspector, and the conditions at the time of inspection.
- As a general example, the following flowchart illustrates the typical order of the document preparation.

Inspection with Documents	1. Bid Document 2. Contract Document 3. Construction Plan 4. Work Schedule 5. Documents on Meeting for Construction 6. Documents on Quality Control 7. Documents on Shape Control 8. Site Photos 9. As-built Drawings and others
Inspection at Site	Shape Inspection Check of Quality and Finished Shape with Drawings, Quality Calculations and Measurement Record

Source: River Earthwork Manual, Japan

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(9) Construction
Japanese Standard

3) Site Inspection for Work Accomplishment (Shape inspection)

Table. Site Inspection(Measurement) for Work Accomplishment

Item of Works	Description
Embankment Work	Longitudinal Inspection : Stations are often placed every 20 meters to measure the length of embankment work . Benchmark elevation is typically measured at a location per 100 meters. Cross-sectional Inspection : Using a level and scale , measurement is conducted using the stations placed every 20 meters .
	Excavation Work
Dredging Work	Bathymetry survey is conducted at the dredging site. Measurement points are selected at a location per 20 m² . Cross-sectional surveys are conducted to calculate the volume of soil, and this is compared with the acceptance criteria.

Source: JICA Project Team summarized from River Earthwork Manual, Japan

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(9) Construction

Japanese Standard

4) Quality Inspection

- Quality inspections are basically conducted by the client based on the document submitted by the contractor,

Table Quality Inspection

Item of Works	Description
Embankment Martial Quality	<ul style="list-style-type: none"> If specified in the contract, the client will inspect the records of the material tests. They will also verify if the material is sourced from the designated borrow pit if specified.
Thickness of a Layer:	<ul style="list-style-type: none"> The client primarily verifies if the embankment has been constructed to the thickness as specified in the contract or based on the results of trial embankment, often using photographs as evidence. For general soil, the typical thickness of a layer is 35 to 45 cm.
Compaction:	<ul style="list-style-type: none"> If compaction degree inspections are required after the completion of embankment work, the client will confirm the results through the quality control records approved by the supervisor or through the supervisor's confirmation. During constructions, compaction degree tests for quality control can be conducted using methods such as dry density, saturation degree or void ratio, strength characteristics, or based on the type of compaction equipment and number of passes.

Source: JICA Project Team summarized from River Earthwork Manual, Japan

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(9) Construction

Japanese Standard

5) Acceptability Criteria

- The criteria for determining acceptance is specified in the specifications or contract conditions. There are two common methods for determining acceptance.

Table Types of Quality Inspections

Item of Works	Description
Specification Value Method	<ul style="list-style-type: none"> 100% Inspection →All measured values during the inspection must meet the specified values (allowable tolerances) as indicated in the design drawings or specifications. This method is commonly used for inspections of structural dimensions, among other things.
Acceptance Criteria Method	<ul style="list-style-type: none"> Sampling Inspections →The size of the lot and the number of samples per lot are determined, and measurements are taken. The results are considered acceptable if they satisfy the following criteria: Upper acceptance criteria value \geq Average of measured values Lower acceptance criteria value \geq Lower acceptance criteria value. This method is commonly used for quality inspections and other types of inspections.

Source: JICA Project Team summarized from River Earthwork Manual, Japan

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(9) Construction

Comparison

SUMMARY

- Sindh**
- ✓ The description on the permission for the construction activities by other agencies or individuals is recommended to be added.
 - ✓ Adding the description of inspection for work accomplishment is recommended.
- Punjab**
- ✓ Entire descriptions of Construction Works are needed.

Item	Sub-item	Sub-sub-item	Sindh	Punjab
Construction Works	Permission		<ul style="list-style-type: none"> ✓ In Sindh, implementation of works by the other public or private sector in the river area is not clearly mentioned and there is no mention of the permission for it. 	No description
	Construction	Procedure	<ul style="list-style-type: none"> ✓ In case of Pakistan, such instruction is seemed to be included in technical specification in each contract. 	Same as the Left
		Site Inspection for Work Accomplishment (shape Inspection)	<ul style="list-style-type: none"> Not clearly mentioned. *However, permission by the Executive Engineer is needed to proceed to the next layer of embankment 	No description
		Quality Inspection	No description	Same as the Left
	Acceptability Criteria	Same as above	Same as the Left	

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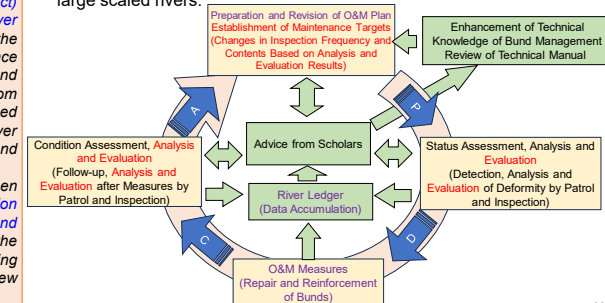
2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(10) Management Plan

Japanese Standard

- ✓ About the river maintenance management, the basic principle is to establish a PDCA (Plan-Do-Check-Act) cycle. This involves 1)conducting river patrols and inspections to assess the condition, 2)implementing maintenance measures, and 3)analyzing and evaluating the knowledge gained from these activities. The insights obtained are then 4)reflected in the river maintenance management plan and implementation.
- ✓ In river management, safety has been adaptively ensured through the repetition of dealing with river abnormalities and their responses, as well as the occurrence of disasters due to flooding and countermeasures, and new developments.



Source: JICA Project Team summarized from Technical Criteria for River Works: Practical Guide for O&M(For River), Japan

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(10) Management Plan Comparison

SUMMARY

Common

- ✓ Repetition of inspections and repairs within a single year is NOT efficient and need to change it.
- ✓ It is necessary to create a multiple year plan that improves the durability and strength of the bunds by repair and reinforcement considering the PDCA cycle.

Item	Sub-item	Sindh and Punjab
Management Plan	Management Plan	✓ Current description is like an emergency annual plan. It is necessary to create a plan that improves the durability and strength of the bunds by repair and reinforcement.
	Management Cycle	✓ Instead of inspections and repairs within a single year, it is necessary to introduce PDCA cycle maintenance and management in multiple years.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(11) Monitoring of River Conditions Japanese Standard

1) Patrols/ Physical Inspection

Item of Patrols	Table Types of Patrols
	Description
Regular River Patrol	1) General Patrol : Inspections based on predetermined patrol items. 2) Purpose-specific Patrol : Select the inspection items, objectives, and locations to gain a more detailed understanding of the situation.
River Channel and River Management Facility Patrol	Visually identify relatively significant changes or abnormalities that can be observed in the river channel or facilities.
Illegal Activity Detection Patrol	Check for any illegal occupancy of land or unauthorized installation of structures.
River Use Monitoring Patrol	Monitor the use of the river and assess its utilization.
Natural Environment Assessment Patrol	Assess the condition of the natural environment in and around the river.
Patrol During Floods	During flood events to quickly and comprehensively assess the situation, including the condition of bunds, flood flows, trees within the river channel, river management facilities, and the extent of inundation in the surrounding areas. It also involves monitoring the progress of flood control operations and water drainage.

Source: JICA Project Team summarized from Technical Criteria for River Works: Practical Guide for O&M(For River) Japan

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(11) Monitoring of River Conditions Japanese Standard

2) Inspection with Equipment / Investigation / Exploration

Inspection before Rainy Seasons and During Typhoons

- Technologies such as MMS (Mobile Mapping System) are used to assess the condition of long and extensive structures.
- Radar void exploration is employed for non-destructive investigation of the rear side of revetment.
- For the inspections of river channels and bunds, new technologies such as airborne laser-based river topography monitoring and UAV (Unmanned Aerial Vehicle) terrain surveying are being developed and utilized.

Source: Case Series of the Utilization of MMS in River Management, Japan

Source: Utilization of Drone by River Manager

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(11) Monitoring of River Conditions Japanese Standard

3) River Profile / Inspection Report / Damage Record

4) Analysis and Evaluation

- ✓ In large scaled rivers, the history of river maintenance management is preserved and documented as a river ledger, serving as a fundamental resource for river management.
- ✓ The river ledger includes implemented measures such as inspections and repairs, as well as records of river construction work projects, disasters, and corresponding countermeasures.
- ✓ To ensure efficient data management, the river ledger is stored in a database, enabling efficient recording and accumulation of information relevant to river management history.

Source: JICA Project Team summarized from Technical Criteria for River Works: Practical Guide for O&M(For River) Japan

- ✓ To enhance the implementation of specific maintenance management for each river based on the river maintenance management plan, it is important to clearly identify the challenges that need to be addressed according to the situation of each river.
- ✓ It is also crucial to analyze these challenges progressively as they are being addressed and implemented.

Source: JICA Project Team summarized from Technical Criteria for River Works: Practical Guide for O&M(For River) Japan

- Importance of record and proper accumulation of them is clearly mentioned.
- Also, identification of issues and challenges with monitoring the progress is important.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(11) Monitoring of River Conditions
Comparison

SUMMARY

Common ✓ To carry out **inspections and exploration with equipment as needed** and to **collect basic data such as hydrological data and topographic surveys** are needed.
 ✓ For the fundamental information for the analysis and evaluation, **enhancing data sharing from the other authority such as WAPDA and PMD and periodical survey work by PID** is recommended.

Item	Sub-item	Sindh	Punjab
Monitoring of River Conditions	General	✓ It is necessary to verify that the inspection sheet format, storage, and viewing system are functioning properly.	Same as the Left
	Patrol/ Physical Inspection	✓ It is necessary to include the description not only to conduct visual inspections, but also to carry out inspections and exploration with equipment as needed and to collect basic data such as hydrological data and topographic surveys.	Same as the Left
	Inspection with Equipment / Investigation, etc.	Same as Above	Same as the Left
	River Profile / Inspection Report / Damage Record	Same as Above	Same as the Left
	Analysis and Evaluation	✓ In the Japanese standard, the several items such as hydraulic and hydrological observation, topographic survey, inspection after earthquake and inspection for mechanical equipment, and river ledger are described for monitoring of river conditions.	Same as the Left

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(12) Inspection and Ledger
Japanese Standard

1) General

✓ The inspections are conducted to ensure the following two functions related to flood control in rivers:
 1. Confirming that **the river channel maintains the required flow capacity.**
 2. Ensuring that **the river management facilities, such as bunds, maintain the necessary functions.**

Table General of Inspection

Item	Description
Inspection Target	Bund(including Earthen Bunds, Revetments, Foot Protection Works, Spurs, etc.) River Structure(including Facilities equipped with sluice gates, culverts, water gates, weirs, etc.)
Inspection Timing	1) Prior to Rainy Season, 2) During Typhoon Seasons, 3) After Flooding Events.
Inspection Methods	Visual observation and other appropriate methods.
Evaluation Methods:	Focus on visible "deformation" that could impact the functionality of the facilities. Evaluations for each identified deformation and a comprehensive evaluation based on these factors.
Recording and Utilization	<ul style="list-style-type: none"> Recorded in a database. Utilized for comprehensive evaluations and consideration of countermeasures. Factor analysis to assess the need for fundamental repairs or updates to the structures.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(12) Inspection and Ledger
Japanese Standard

1) General ✓ Each deformation will be evaluated with the levels presented in a to d.
 ✓ Considering the evaluation for each inspection item and numbers of deformations in a certain stretch, the condition of the bund will be **comprehensively evaluated**

Table Criteria for Comprehensive Evaluation

Evaluation	Status	Deformation	Malfunction
a No Problem	✓ There is no visible deformation, or there is some visible light deformation. ✓ But the river is in a healthy condition with no malfunction of river management facilities such as bunds.	NO	NO
b Needs Monitoring	✓ The function of river management facilities such as bunds is not lost. ✓ But development of the deformation has been confirmed , and the progress needs to be monitored (including cases where minor repairs are required).	OBSERVED	NO
c Needs Preventive Maintenance	✓ Although the functions of river management facilities such as bunds is not lost, the problem is progressive and it is desirable to take measures from a preventive maintenance perspective. ✓ A situation in which it is necessary to reevaluate the state of decrease in the function of river management facilities such as bunds through detailed inspections (including surveys).	OBSERVED	NO
d Needs Taking Measures	✓ The functioning of river management facilities such as bunds is affected and measures such as repair or renewal are required. ✓ Detailed inspection (including investigation) has evaluated that there is a problem with functionality, and countermeasures are required.	OBSERVED	OBSERVED

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(12) Inspection and Ledger
Japanese Standard

2) Bund ✓ Inspection items are indicated **depending on the portions of a bund.**
 ✓ Each item is presented as a **Q&A style**. So that **the answer does not easily vary by the inspector.**

Table inspection Items on Bunds Listed in the Japanese Guideline

Structure	Portion	Inspection Item
Earthen Bund	Slope, Berm	✓ Are there any cracks, holes, protrusions, collapses or deformation of slope, erosion, etc. (or are they more developed than the previous inspection)?
		✓ Are there any abnormalities in the condition of the vegetation and topsoil, such as peeling of the sodding (or are they more developed than the previous inspection)? etc....
	Top of the Bund	✓ Are there any deformations such as cracks, cave-ins, unevenness, or subsidence at the top of the bund and the shoulder of the bund (or are they more developed than the previous inspection)?
		✓ Is there any erosion at the shoulder (or are they more developed than the previous inspection)? etc....
Land Side Toe of the Bund	✓ Is there any infiltration due to poor drainage near the bund?	
	✓ Is there a risk of the fluidization of the embankment soil due to the soil near the toe becoming soft? etc....	
Bund Foot Drainage	✓ Is there any leakage or boiling sand from the joint of the drainage channel? etc....	

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(12) Inspection and Ledger
Japanese Standard

3) River Channel

- ✓ These Items are to be checked by topographic survey results and satellite images etc. and are concrete and practical.
- ✓ Each item is presented as a Q&A style. So that the answer does not easily vary by the inspector.

Table inspection Items on River Channel Listed in the Japanese Guideline

Inspection Items	
Flow Capacity	<ul style="list-style-type: none"> ✓ Is there any sediment accumulation such as riverbed rise that obstructs the flow of the river? ✓ Is there any shrinkage in the river width due to redeposition in the section where low water channel expansion has been carried out? etc....
Riverbed Decline	<ul style="list-style-type: none"> ✓ Is there any deformation (subsidence, etc.) of the structure as a sign of riverbed decline or local scouring?
Riverbank Erosion	<ul style="list-style-type: none"> ✓ Are there any collapses or erosion occurring on the natural riverbank? Does the riverbank normal line cross the bund protection line/low channel riverbank management line and approach the bund side? etc....
Estuary Closing	<ul style="list-style-type: none"> ✓ Are there any signs of estuary closing or increase in estuary sand bar height?

Source: JICA Project Team Summarized from Inspection and Evaluation Guidelines for River Management Facilities such as Dikes and River Channels Japan

4) Storage

- ✓ The method of the storage is specified in the Ordinance for Enforcement of the River Law.
- ✓ The storage and accumulation of the record is recognized important.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(12) Inspection and Ledger
Comparison

SUMMARY

Common

- ✓ It is recommended to perform a graded evaluation based on the observed deformations to score the degree of soundness, and then use it as an index of priority for repair and improvement.
- ✓ About storage, specifying the method and responsibilities is recommended like the case of Japan.

Item	Sub-item	Sindh	Punjab
Inspection and Ledger	General	<ul style="list-style-type: none"> ✓ In addition to preparing inspection ledgers for each site, it is recommended to perform a graded evaluation based on the observed deformations to score the degree of soundness. 	Same as the Left
	Bund	<ul style="list-style-type: none"> ✓ It is recommended to inspect and record the deformation of each part of the embankment. 	Same as the Left
	River Channel	<ul style="list-style-type: none"> ✓ Ledger or form is not described. ✓ At the vulnerable points against erosion, it is necessary to analyze and evaluate the transition of river channels using surveys and satellite images. 	Same as the Left
	Storage	No description	<ul style="list-style-type: none"> ✓ it is recommended to specify the method and responsibilities for storing the inspection ledgers and report like the case of Japan.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(13) River Ledger
Japanese Standard

- ✓ The river administrator shall prepare and maintain a ledger for the rivers under their management.
- ✓ The contents of the river ledger and other necessary matters regarding its preparation and storage shall be prescribed by the cabinet order.
- ✓ When requested to view the river ledger, the river administrator shall not refuse unless there is a legitimate reason to do so.
- ✓ The river ledger shall be stored at the offices of the relevant regional development bureaus and at the offices of the relevant prefecture as prescribed by the MLIT.

Note: River administrator is an authority which is in charge of the river management. MLIT is Ministry of Land, Infrastructure, Transport and Tourism, Japan

Source: JICA Project Team summarized from River Law and Enforcement Order for River Law, Japan

Table Items to be included in the River Ledger

For a Ledger	For a Figure
<ul style="list-style-type: none"> ✓ Name of River System ✓ River Name ✓ Length of the River ✓ River Area ✓ General Profile of Major River Management Facilities 	<ul style="list-style-type: none"> ✓ Boundaries of River Area ✓ Information of the Power of River Manager on the land within the river area ✓ Major River Management Facilities ✓ Major permitted structures

- ✓ Preparation, Maintenance and Storage of the river ledgers are instructed by the law and enforcement order of the law.
- ✓ Also, there is a specific ledger forms prepared by MLIT.

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2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND

2.3 Comparison of the Manuals with Japanese Standards

(13) River Ledger
Comparison

SUMMARY

Common

- ✓ It is recommended to prepare the river ledgers.
- ✓ The purpose is accumulating data aimed at improving the efficiency of bund management.
- ✓ About storage, specifying the method and responsibilities is recommended like the case of Japan.

Sindh

- ✓ "Position in Line of Defense (Bund Register)" seems to be containing the similar information as the river ledgers in Japan

Item	Sub-item	Sindh	Punjab
River Ledger	General	No Description	Same as the Left
	Contents	<ul style="list-style-type: none"> ✓ Among the reports and forms introduced in the manual, "Position in Line of Defense (Bund Register)" seems to be containing the similar information as the river ledgers in Japan, 	No Description
	Storage	<ul style="list-style-type: none"> ✓ It is recommended to specify the method and responsibilities for storing the inspection ledgers and report like the case of Japan. 	Same as the Left

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- 1 INTRODUCTION
- 2 COMPARATIVE ANALYSIS OF THE DESIGN MANUALS OF BUND
 - 2.1 Extraction of Item to be Analyzed
 - 2.2 Comparison of the Manuals between Sindh and Punjab
 - 2.3 Comparison of the Manuals with Japanese Standards

3 RECOMMENDATION TO THE MANUALS IN SINDH AND PUNJAB



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3 RECOMMENDATION TO THE MANUALS IN SINDH AND PUNJAB

3.1 General

POLICY

- ✓ The recommendations are prepared for each items indicated below, which are basically as same as the items used in Chapter 2 for the analysis.
- ✓ The recommendations are indicated with rank presented from A to C considering their priorities.

Target Item

1. Standard Shape of a Bund
2. Quality Control
3. Service Road/ Maintenance Road
4. Safety Evaluation
5. Improvement of a Bund
6. Revetment
7. Spur(Stone Groyne)
8. Construction Works
9. Management Plan
10. Monitoring of River Conditions
11. Inspection and Ledger
12. River Ledger
13. Bund Breach
14. Gap from the Actual Practice

Prioritization Criteria

A : 1st Priority, Necessary

It is relating with the current issues to be urgently dealt with and is deemed highly effective to improving bund management.

B : 2nd Priority, Recommended

It is relating with the issues which have not been recognized serious at present or which have been considered partially, but it is highly effective to improving bund management.

C : 3rd Priority, Desirable

It is relating with the issues which are not recognized fatal at present, but it is desirable to be dealt with considering the future.

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3 RECOMMENDATION TO THE MANUALS IN SINDH AND PUNJAB

3.2.1 Recommendation from the Analysis on the Manual Itself

	Common	Sindh	Punjab
Rank A : 1st Priority	2 ✓ Improve or add the description on Quality Control. ✓ Add the description on equipment and compaction.	2 ✓ Modify the description of the source of materials not to limit it along river channels.	1 ✓ Unify the presentation of types of embankments in Vol.1 and 2, or add explanations for each type.
	4 ✓ Add the description of a quantitative evaluation by numerical analysis or calculation, including the setting of analysis conditions (Especially on Seepage and Slope Stability).	5 ✓ Add the description of seepage control work that can be applied in Sindh Province, such as a impervious sheet.	5 ✓ Add the description of countermeasures against slip surface ✓ Add the description of concrete design methods for each countermeasures for seepage control.
	10 ✓ Specify the method and responsibilities for the storage of inspection results, and reports .	7 ✓ Additional descriptions are required so that practitioners can make design.	8 ✓ Add the entire contents on Construction Works.
	11 ✓ Description such as communication should be updated based on the latest technology.		10 ✓ Introduce the concept of AMP to the bund management with a multi-year outlook.
	14 ✓ Enhance the Storing and Sharing records and documents on construction works properly.		11 ✓ Expand the scope for monitoring river channel to the area around Vulnerable Points

Note: 1:Standard Shape of a Bund, 2:Quality Control, 3: Service Road/ Maintenance Road, 4: Safety Evaluation, 5: Improvement of a Bund, 6:Revetment, 7. Spur(Stone Groyne), 8: Construction Works, 9: Management Plan, 10: Monitoring of River Conditions, 11: Inspection and Ledger, 12: River Ledger, 13: Bund Breach, 14: Gap from the Actual Practice

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3 RECOMMENDATION TO THE MANUALS IN SINDH AND PUNJAB

3.2.1 Recommendation from the Analysis on the Manual Itself

	Common	Sindh	Punjab
Rank B:2nd Priority	3 ✓ Add a description about pavement on the top of bunds to improve access.	5 ✓ Add the description of the concrete design method of other types than Stone Apron.	5 ✓ Improve the organization of the contents not to scatter the descriptions in various sections.
	6 ✓ Add and improve the description on the foundation and foot protection.	8 ✓ Improve the quality control (inspection items and methods, inspection timing, quality control standards).	11 ✓ Improve the ledger to avoid the variety of input information by the inspectors.
	6 ✓ Add the description of the concrete design method for each type.	10 ✓ Describe the inspection with equipment such as surveying and underground exploration.	Note: 1:Standard Shape of a Bund, 2:Quality Control, 3: Service Road/ Maintenance Road, 4: Safety Evaluation, 5:Improvement of a Bund, 6:Revetment, 7. Spur(Stone Groyne), 8: Construction Works, 9: Management Plan, 10: Monitoring of River Conditions, 11: Inspection and Ledger, 12: River Ledger, 13: Bund Breach, 14: Gap from the Actual Practice
13 ✓ Reporting with unified forms and accumulate information.			
13 ✓ Include multiple examples of the closure of Bund Breach.	4 ✓ Consideration of Earthquake.		
Rank C: 3rd Priority	14 ✓ It may be necessary to create reference samples for collection and organization of documents.		

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3 RECOMMENDATION TO THE MANUALS IN SINDH AND PUNJAB

3.2.1 Recommendation from the Analysis on the Manual Itself

SUMMARY

- ✓ Improving or adding the following major contents is necessary.
 - Quality Control : compaction of embankment
 - Safety Verification : quantitative evaluation by numerical analysis or calculation, including the setting of analysis conditions
 - Management Plan : concept of Asset Management Plan(AMP), plan for multiple years
 - Monitoring of River Conditions : proper storage and sharing of the documents
- ✓ Adding the following major contents is recommended.
 - Improvement Method: description of the concrete design method of other types than Stone Apron
 - Monitoring of River Conditions : not only the visual inspection but also a inspection with equipment
 - Inspection and Ledger : Improvement of the ledgers form
- ✓ Adding the following major contents is desirable.
 - Bund Breach : more examples of the closure
 - Gap from the Actual Practice : proper storage and sharing of the documents

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3 RECOMMENDATION TO THE MANUALS IN SINDH AND PUNJAB

3.2.2 Recommendation from the Comparison Between Sindh and Punjab

	Sindh	Punjab
Rank A: 1st Priority	4 ✓ Add a description about slope stability analysis by slip circle and seepage analysis.	1 ✓ Add a description of the extra embankment
	4 ✓ Add the calculation method of the maximum scouring depth.	2 ✓ Add the entire contents of Quality Control.
	4 ✓ Add a description about slope stability considering earthquakes.	4 ✓ Add the description of the indicator on safety evaluation for erosion.
	5 ✓ Geotextile Filter, Gabion and Studs need to be added as countermeasures against erosion.	5 ✓ Add the description of the countermeasures against slip circle.
	5 ✓ About seepage flow, consider the measures for the foundation grounds.	8 ✓ Add the entire contents of Construction Works (Permission, Quality Control, Documents, etc)
	6 ✓ Gabion needs to be added.	Note: 1:Standard Shape of a Bund, 2:Quality Control, 3: Service Road/ Maintenance Road, 4: Safety Evaluation, 5: Improvement of a Bund, 6:Revetment, 7. Spur(Stone Groyne), 8: Construction Works, 9: Management Plan, 10: Monitoring of River Conditions, 11: Inspection and Ledger, 12: River Ledger, 13: Bund Breach, 14: Gap from the Actual Practice
	7 ✓ Description for how to determine the basic shape and the other dimensions.	
	9 ✓ Introduce the concept of AMP to the bund management	
	10 ✓ Add the description of Survey Team Member and Responsibility Person	
	10 ✓ Add the description of Inspection Report, Damage Record and Analysis/Evaluation	
10 ✓ Add the description of monitoring of river channels by ground and bathymetry surveys.		

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3 RECOMMENDATION TO THE MANUALS IN SINDH AND PUNJAB

3.2.2 Recommendation from the Comparison Between Sindh and Punjab

	Sindh	Punjab
Rank B: 2nd Priority	1 ✓ Needs to be updated in light of the 2010 flood.	12 ✓ Add ledgers other than the outline of the bunds.
		12 ✓ Improve the ledgers of the bunds to specify what to input.
Rank C: 3rd Priority	—	—

Note: 1:Standard Shape of a Bund, 2:Quality Control, 3: Service Road/ Maintenance Road, 4: Safety Evaluation, 5: Improvement of a Bund, 6:Revetment, 7. Spur(Stone Groyne), 8: Construction Works, 9: Management Plan, 10: Monitoring of River Conditions, 11: Inspection and Ledger, 12: River Ledger, 13: Bund Breach, 14: Gap from the Actual Practice

SUMMARY

- ✓ Basically, the items or descriptions which are mentioned only in one of the manuals of Sindh and Punjab is needed to be incorporated also in the other.
- ✓ The manual in Punjab is described comparatively in detail and practical in many portions.
- ✓ Since the Bund Manual in Sindh is issued before the 2010 Flood, it is recommended to update considering the major flood after 2008.

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3 RECOMMENDATION TO THE MANUALS IN SINDH AND PUNJAB

3.2.3 Recommendation from the Comparison with Japanese Standards

	Common	Sindh	Punjab
Rank A: 1st Priority	2 ✓ Add descriptions about the method of embankment material survey and quality control.	2 ✓ Describe what to do when there is no suitable embankment material nearby.	1 ✓ Add a description of the extra embankment.
	9 ✓ Instead of inspections and repairs within a single year, introduce PDCA cycle maintenance and management in multiple years.		2 ✓ Add the entire contents of Quality Control.
	10 ✓ Add the description to carry out inspections and exploration with equipment as needed and to collect basic data.		5 ✓ Add a description of the countermeasures against slip circle.
	11 ✓ About the vulnerable points for erosion, Analyze and evaluate the transition of river channels using surveys and satellite images.		

Note: 1:Standard Shape of a Bund, 2:Quality Control, 3: Service Road/ Maintenance Road, 4: Safety Evaluation, 5: Improvement of a Bund, 6:Revetment, 7. Spur(Stone Groyne), 8: Construction Works, 9: Management Plan, 10: Monitoring of River Conditions, 11: Inspection and Ledger, 12: River Ledger, 13: Bund Breach, 14: Gap from the Actual Practice

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3 RECOMMENDATION TO THE MANUALS IN SINDH AND PUNJAB			
3.2.3 Recommendation from the Comparison with Japanese Standards			
	Common	Sindh	Punjab
Rank B/2nd Priority	2 ✓ Adding a description about setting a compaction criterion by a trial embankment.	2 ✓ Describe the maximum particle size and the range of particle size distribution in the specification of the embankment material.	2 ✓ Add the specifications of the embankment material in detail as well as Japanese standard.
	3 ✓ Add a description about the pavement on the top.		
	4 ✓ Conduct studies and evaluations based on numerical analysis, considering river conditions and geological conditions.	11 ✓ Adding a description to inspect and record the deformation of each part of the embankment.	4 ✓ Add safety evaluation against settlement by earthquakes.
	5 ✓ As a foot protection work, concrete blocks and net gabion, can be considered.		7 ✓ Add specific design items other than the installation interval.
5	✓ Include improvement methods that can be applied in Pakistan, such as seepage cut-off walls and impervious sheets, as seepage control works.	Note: 1:Standard Shape of a Bund, 2:Quality Control, 3: Service Road/ Maintenance Road, 4: Safety Evaluation, 5: Improvement of a Bund, 6:Revetment, 7: Spur(Stone Groyne), 8: Construction Works, 9: Management Plan, 10: Monitoring of River Conditions, 11: Inspection and Ledger, 12: River Ledger, 13: Bund Breach, 14: Gap from the Actual Practice	
6	✓ Include Gabion, Concrete Block(connected type, articulated type) and Filter Cloth, as options		
6	✓ Development of inexpensive slope covering material. ✓ Use stone pitching on the land side slope.		

3 RECOMMENDATION TO THE MANUALS IN SINDH AND PUNJAB			
3.2.3 Recommendation from the Comparison with Japanese Standards			
	Common	Sindh	Punjab
Rank B/2nd Priority	10 ✓ Verify that the inspection sheet format, storage, and viewing system are functioning		Note: 1:Standard Shape of a Bund, 2:Quality Control, 3: Service Road/ Maintenance Road, 4: Safety Evaluation, 5: Improvement of a Bund, 6: Revetment, 7: Spur(Stone Groyne), 8: Construction Works, 9: Management Plan, 10: Monitoring of River Conditions, 11: Inspection and Ledger, 12: River Ledger, 13: Bund Breach, 14: Gap from the Actual Practice
	11 ✓ Perform a graded evaluation based on the observed deformations to score the degree of soundness. ✓ Then, use it for prioritization.		
	12 ✓ Prepare the river ledgers for the purpose of accumulating data aimed at improving the efficiency of bund management		
Rank C/3rd Priority	5 ✓ Study for adding the description of stability against earthquakes.		
	6 ✓ Add countermeasures against earthquakes.	—	—

SUMMARY

- ✓ Descriptions of **Quality Control, Management Plan and Monitoring of River Condition** are needed to be improved. And Japanese standard can be a reference for them.
- ✓ **Service Road/ Maintenance Road** is recommended to be described.
- ✓ **Concrete analysis, evaluation and design methods** are recommended to be added for the practical level with reference to the manuals of Japan or other countries.
- ✓ Consideration of earthquakes is desirable considering the future condition.

