Design Concept of the Bridge for managing the river

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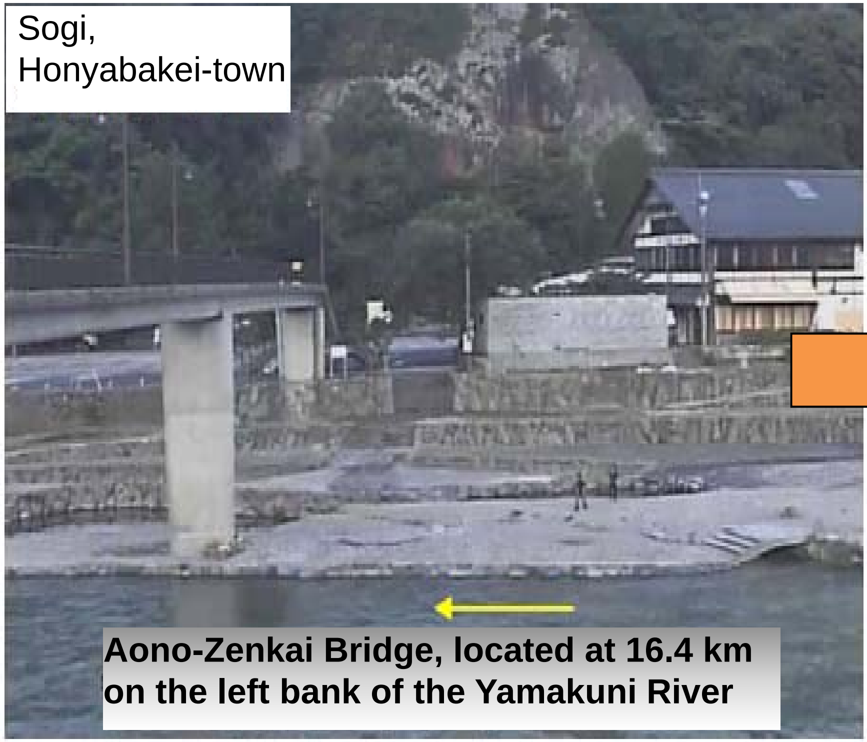
Contents of this PPT (53 slides)

Unique features of Japan's rivers

When it rains, water flows into rivers, resulting in rapid elevation in water level.

Kyushu Regional Bureau, MLIT

Flooding (July 3, Yamakuni River, Yamakunigawa waterway)



Normal water level near the Aono-Zenkai Bridge

Photo 1-1 Normal

Swollen stream near the Aono-Zenkai Bridge
(July 3 10:40AM)

Photo 1-2 Flooded

Bridge Piers/Trestles within river area hinders water movement during flooding.

Ikarashi R. after 2011 Flood

Photo 2-1 dam up the water level and detour /circuit stream by bridge pier
（example at Agaga River)

Photo 2-2 Complex stream around bridge pier
（example at Kokai river)

Photo 2-3 Collapse of bridge by score of abutment
(example of Yosasa river)

Photo 2-4 Collapse of bridge by local scour of surrounding pier（example at Fuji river)

Photo 1-5 Local scour of surrounding pier（example at Sakawa river)

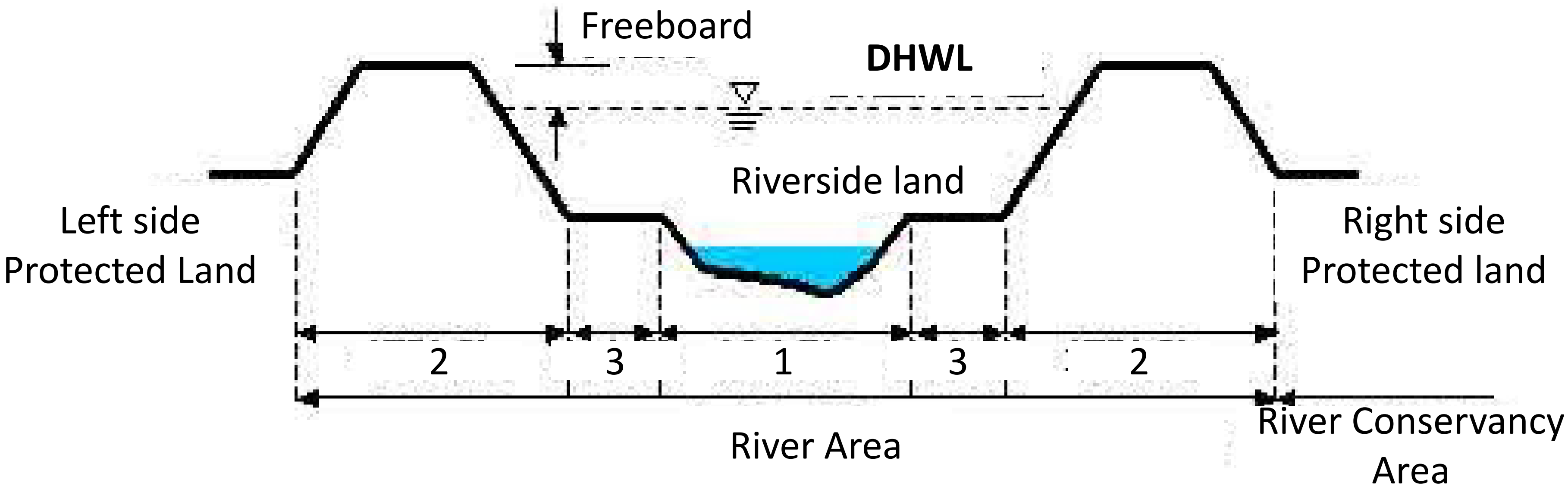
Source of photos : Manual for planning river-crossing bridge constructions (preliminary version; published in July 2009 by the Japan Institute of Construction Engineering; JICE publication No. 109001)

Brake 1

サツキ（皐月）

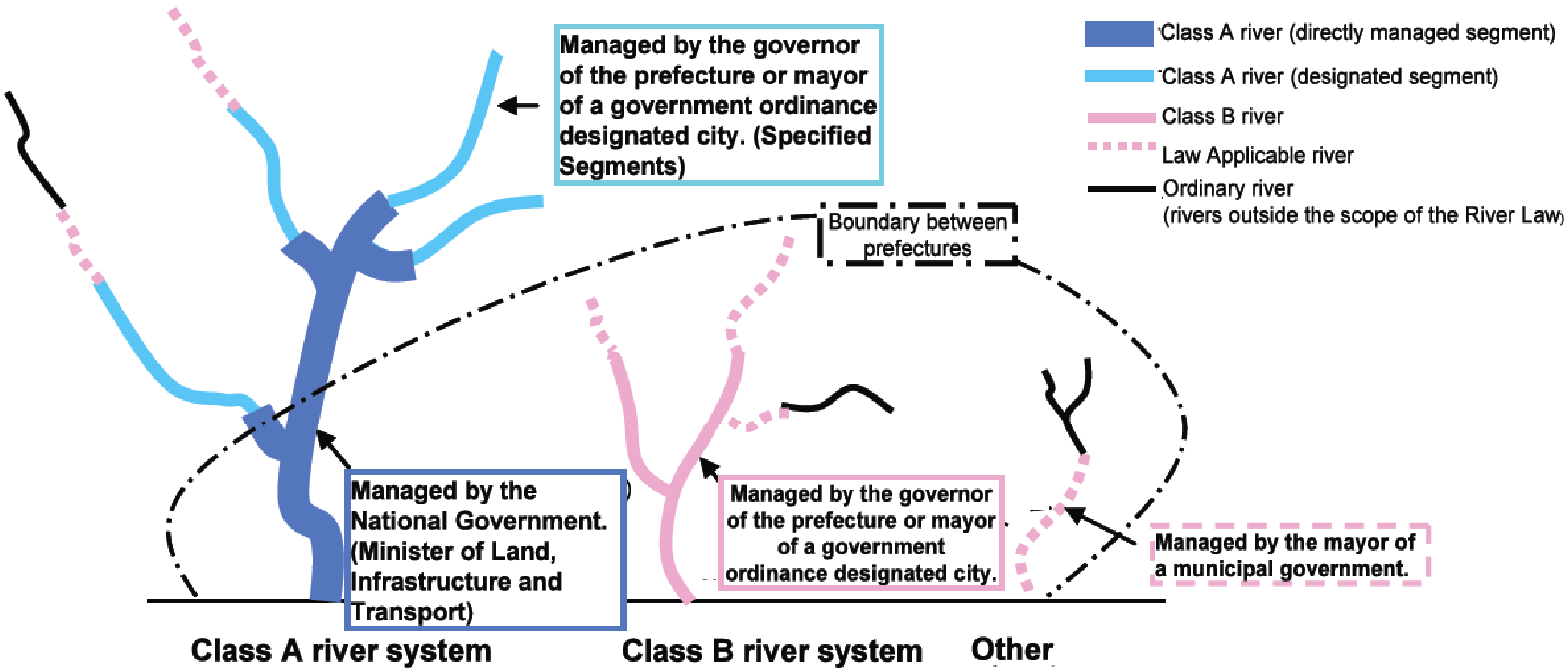
ツツジ（躑躅）: azalea

Names of the river



1	**Low water bed, Low-flow Channel**
2	Base of Dike
3	High water bed, River terrace

Classification of River Administrators



Specific Discharge Method

The specific discharge is the flood peak discharge per unit catchment area. Generally, the specific discharge for small rivers is comparatively larger than that of the bigger rivers.

$Q = A\,q$ $(q = Q/A)$ *Equation (a)*

Where :

q : specific discharge ($m^3/s/km^2$)

Q : *design discharge* (m^3/s)

A : *catchment area* (km^2)

$$q = c \cdot A^{(A^{-0.048}-1)}$$

Equation (b)

Where:

c : constant (Table 5.2a)

A : catchment area (km^2).

Table : Constant (*c*) for Regional Specific Discharge Curve in Philippines

Region	Return Period					
	2-year	5-year	10-year	25-year	50-year	100-year
	15.66	17.48	18.91	21.51	23.83	25.37
Visayas	6.12	7.77	9.36	11.81	14.52	17.47
	8.02	9.15	10.06	11.60	12.80	14.00

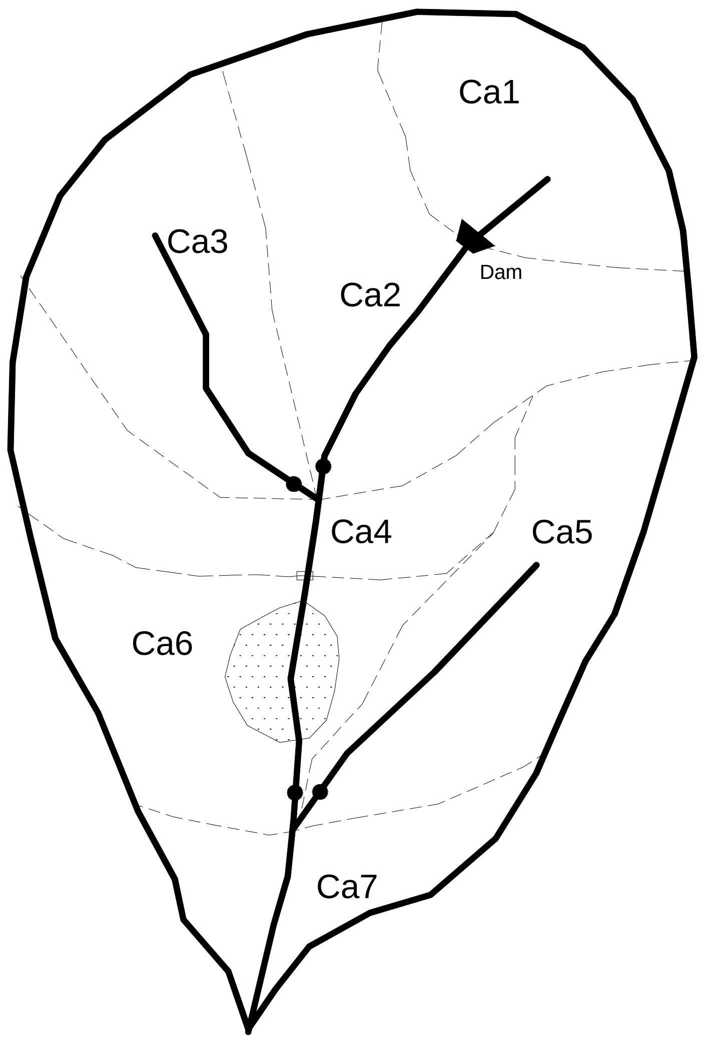
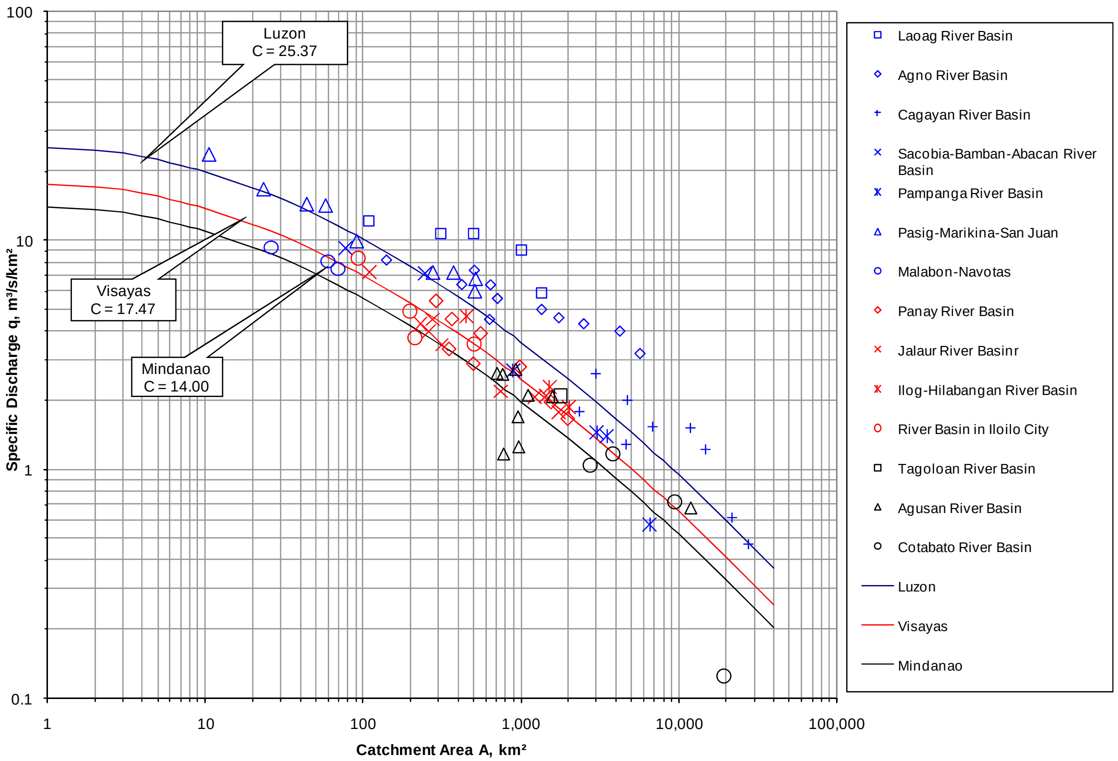


Image of Catchment
Area of the river

Generally, the specific discharge for small rivers is comparatively larger than that of the bigger rivers. The specific discharge curve explains this. From this curve, design discharge is roughly calculated even without any runoff analysis. The reliability of the design discharge estimated by runoff methods can be easily assessed by comparing it with specific discharge method.



Philippines case

LUZON	c (constant)	Specific Discharge (q) ($m^3/s/km^2$)			
		20 km^2	100 km^2	1,000 km^2	10,000 km^2
2-year	15.66	10.484	6.283	2.229	0.583
5-year	17.48	11.703	7.013	2.488	0.651
10-year	18.91	12.660	7.587	2.692	0.704
25-year	21.51	14.401	8.630	3.062	0.801
50-year	23.83	15.954	9.560	3.392	0.887
100-year	25.37	16.985	10.178	3.612	0.944
VISAYAS	c (constant)	Specific Discharge (q) ($m^3/s/km^2$)			
		20 km^2	100 km^2	1,000 km^2	10,000 km^2
2-year	6.12	4.097	2.455	0.871	0.228
5-year	7.77	5.202	3.117	1.106	0.289
10-year	9.36	6.266	3.755	1.332	0.348
25-year	11.81	7.907	4.738	1.681	0.440
50-year	14.52	9.721	5.825	2.067	0.540
100-year	17.47	11.696	7.009	2.487	0.650
Minadanao	c (constant)	Specific Discharge (q) ($m^3/s/km^2$)			
		20 km^2	100 km^2	1,000 km^2	10,000 km^2
2-year	8.02	5.369	3.218	1.142	0.298
5-year	9.15	6.126	3.671	1.303	0.341
10-year	10.06	6.735	.036	1.432	0.374
25-year	11.60	7.766	4.654	1.651	0.432
50-year	12.80	8.570	5.135	1.822	0.476
100-year	14.00	9.373	5.617	1.993	0.521

Peak discharge (1/50) in Philippines by specific discharge method

	20 km^2	100 km^2	1000 km^2	10000 km^2
Luzon	319 m^3/s	956 m^3/s	3392 m^3/s	8870 m^3/s
VISAYAS	194.4 m^3/s	582.5 m^3/s	2067 m^3/s	5400 m^3/s
Mindanao	171.4 m^3/s	513.5 m^3/s	1822 m^3/s	4760 m^3/s

Manning’s Equation

$$V = \frac{1}{n} R^{2/3} \cdot S^{1/2} \quad (m/s)$$

Where:

V : Average river velocity (m/s)

R : Hydraulic radius (m)

Where: R = A/P

P *:* wetted perimeter (m)

A *:* Average river cross-sectional area (m^2)

R *: h, if the river width is extremely larger than depth*

h *: flow depth*

S : Riverbed gradient

n :Manning’s coefficient of roughness

Uniform Flow is described by the formula :

Qc = A V Equation (c)

$$Q_C = \frac{1}{n} \cdot A \cdot R^{2/3} \cdot S^{1/2} \quad (m^3/s)$$ Equation (d)

Where:

Q_C : Existing discharge capacity (m³/s)

A : Average river cross-sectional area (m²)

Using those equations, we can estimate river width and depth at peek discharge period

Brake 2

あやめ : iris

菖蒲

River Law : Article 24. (Permission for Land Occupancy)

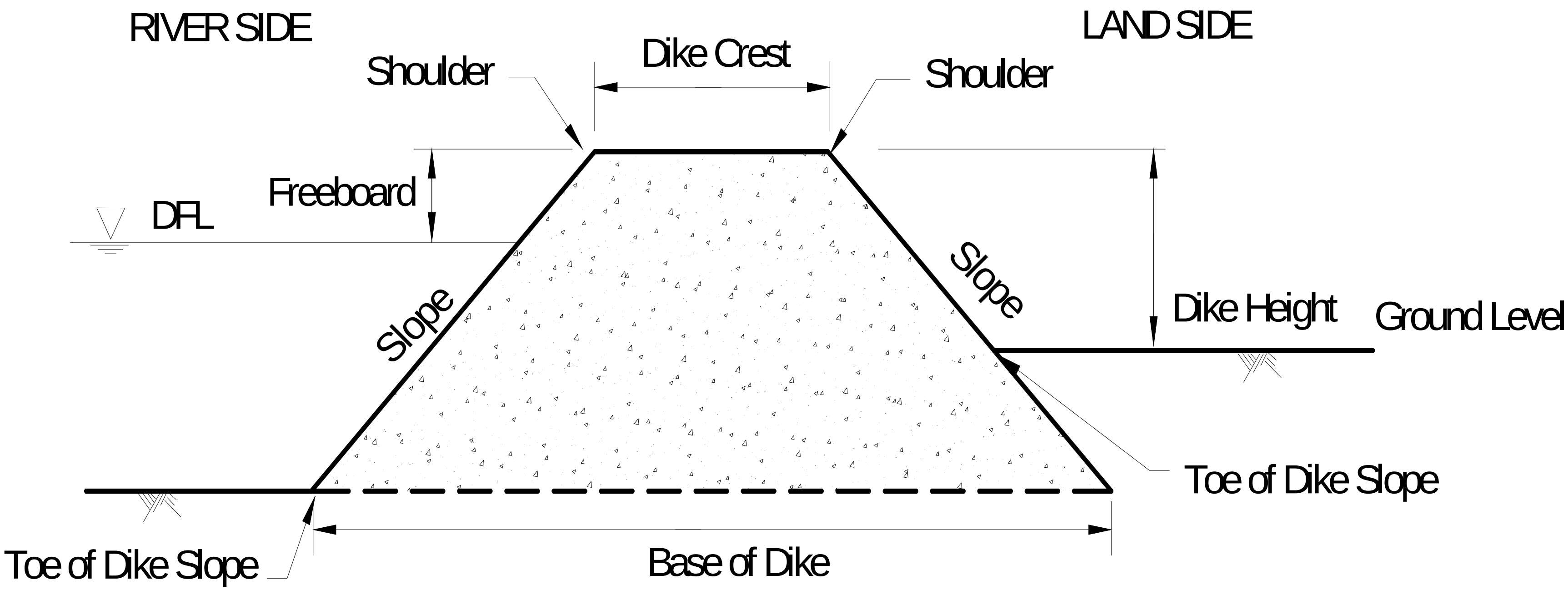
- Any person who intends to occupy land within a *river zone* (excluding land administered by a person other than the *river administrator* on the basis of his title; hereinafter the same in the following article) shall obtain the permission of the *river administrator as may* be provided for in detail by Ministry of Land Infrastructure Transport and Tourism Ordinance .

River Law : Article 26.
(Permission for Construction of Structures)

- Any person who intends to construct, reconstruct or remove a structure on the land within a *river zone* shall obtain the permission of the *river administrator* as may be provided for in detail by Ministry of Land Infrastructure Transport and Tourism Ordinance. The same shall apply to any person who intends to construct, reconstruct or remove a structure for storing or making stagnate the water of a river in the sea near the estuary .

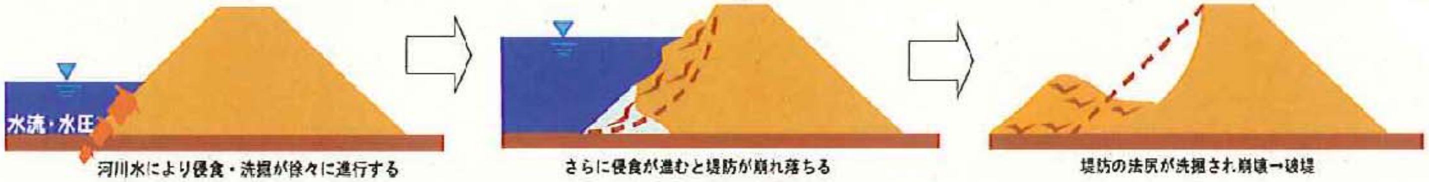
Dike

- A dike is an embankment or levee constructed along the banks of a stream, river, lake or other body of water for the purpose of protecting from overflowing floodwater by confining the stream flow in the regular channel. River improvement should be planned with non-diked river if possible to have efficient drainage conveyance.



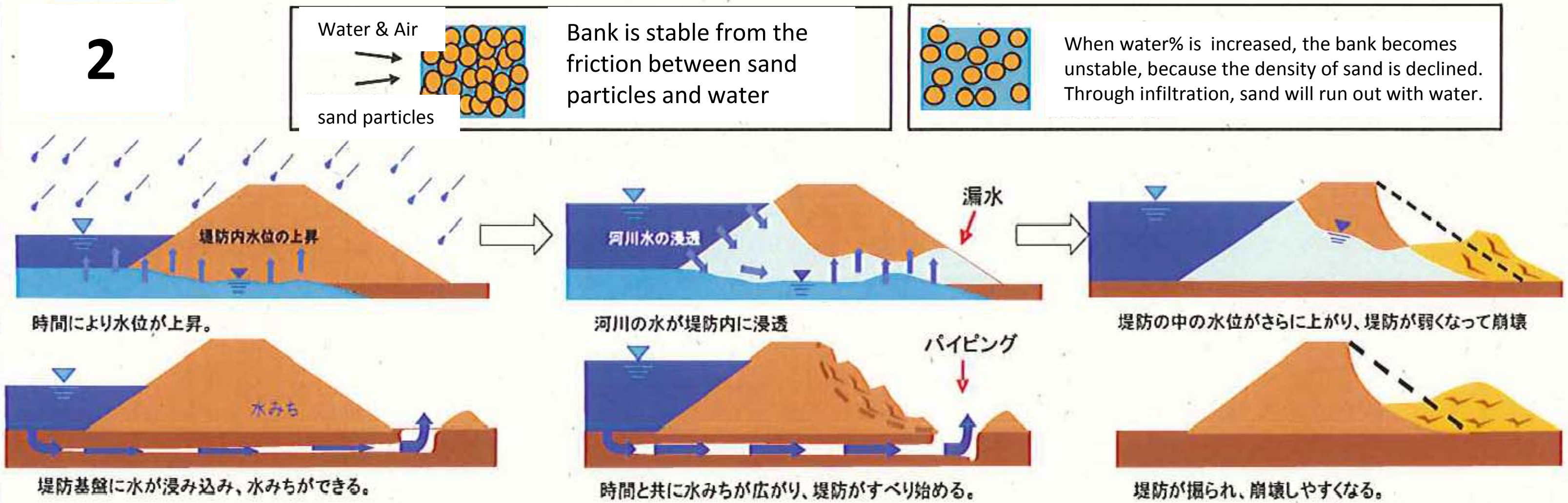
Parts of Dike

1



There is a possibility that, by the force of stream during flood, the bank and river front will be scrapped and those will be collapsed.

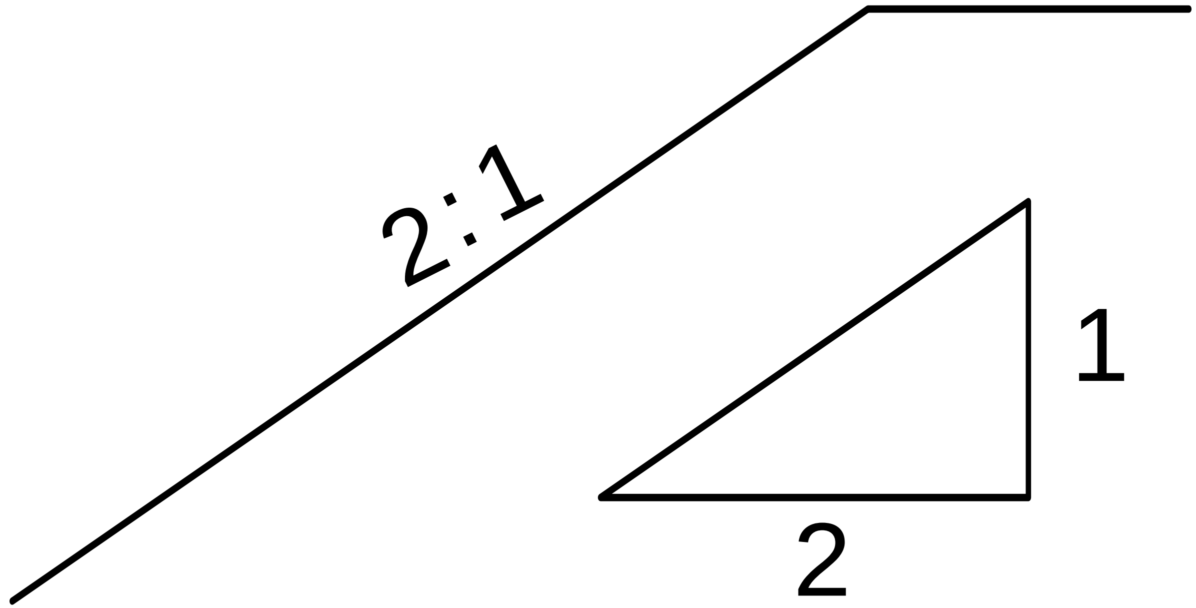
2



During the flood, even if the water level is bellow the bank top, there is a possibility that, owing to the infiltration of river water into the bank and weakening it, then the bank will be collapsed.

3

Because a bank is made by earth, there is a possibility that once river flow over topped from the bank, it will scrape against the earth, then the bank will be collapsed.



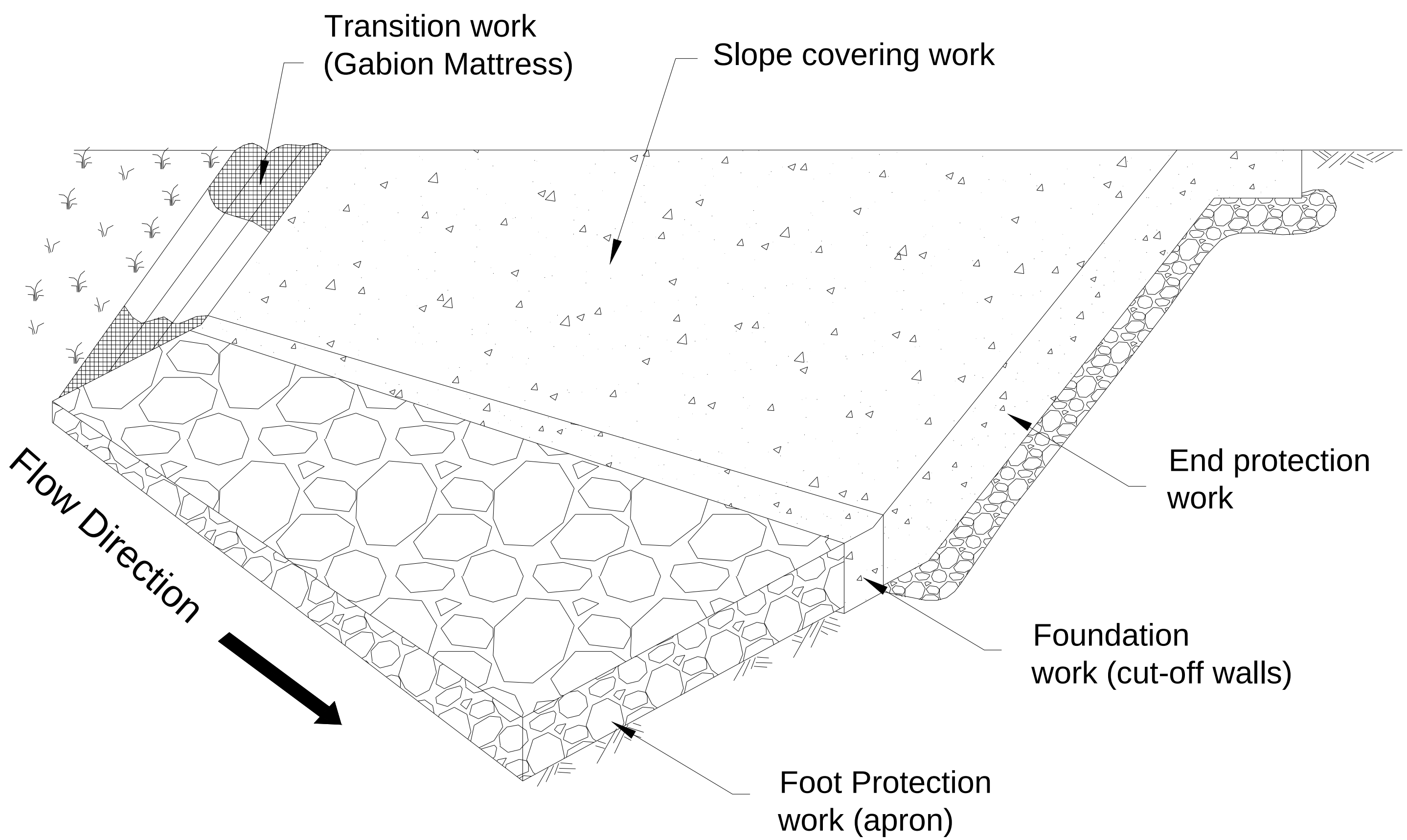
Minimum Slope of Dike

Design flood discharge Q (m^3/s)	**Freeboard (m)**
Less than 200	0.6
200 and up to 500	0.8
500 and up to 2,000	1.0
2,000 and up to 5,000	1.2
5,000 and up to 10,000	1.5
10,000 and over	2.0

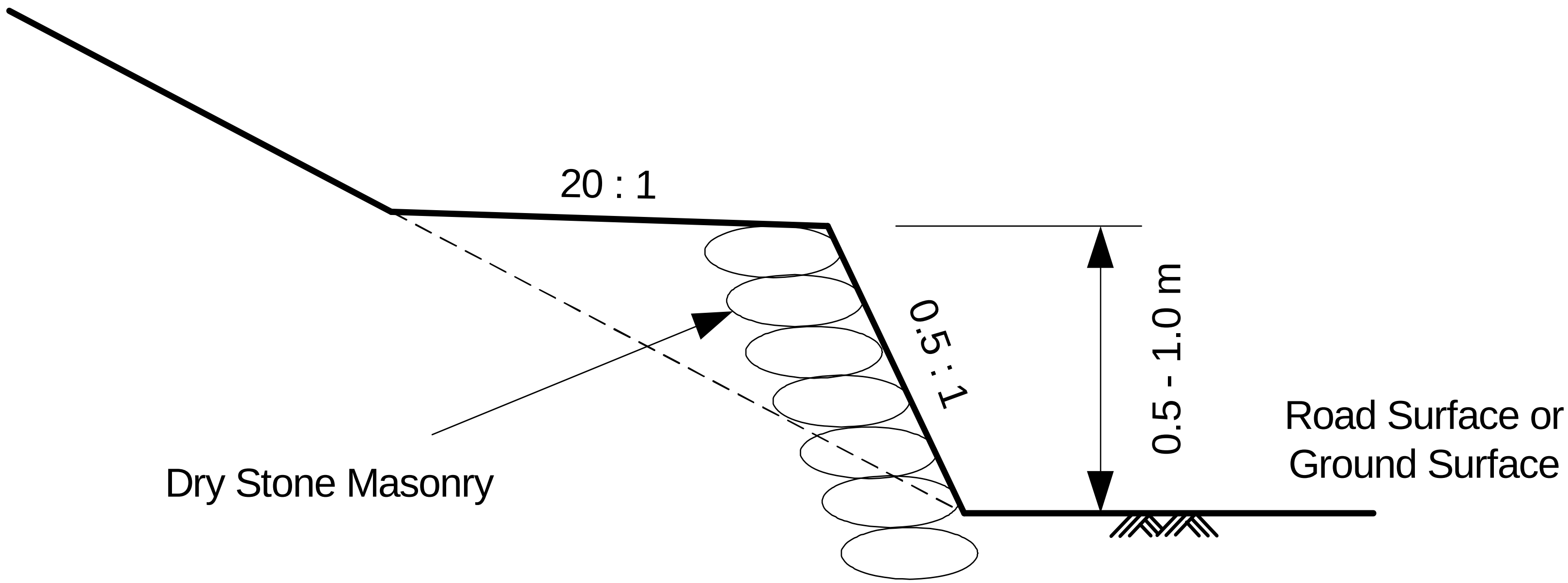
Design flood discharge, Q (m^3/sec)	Crest Width (m)
Less than 500	3
500 and up to 2,000	4
2,000 and up to 5,000	5
5,000 and up to 10,000	6
10,000 and over	7

Revetment

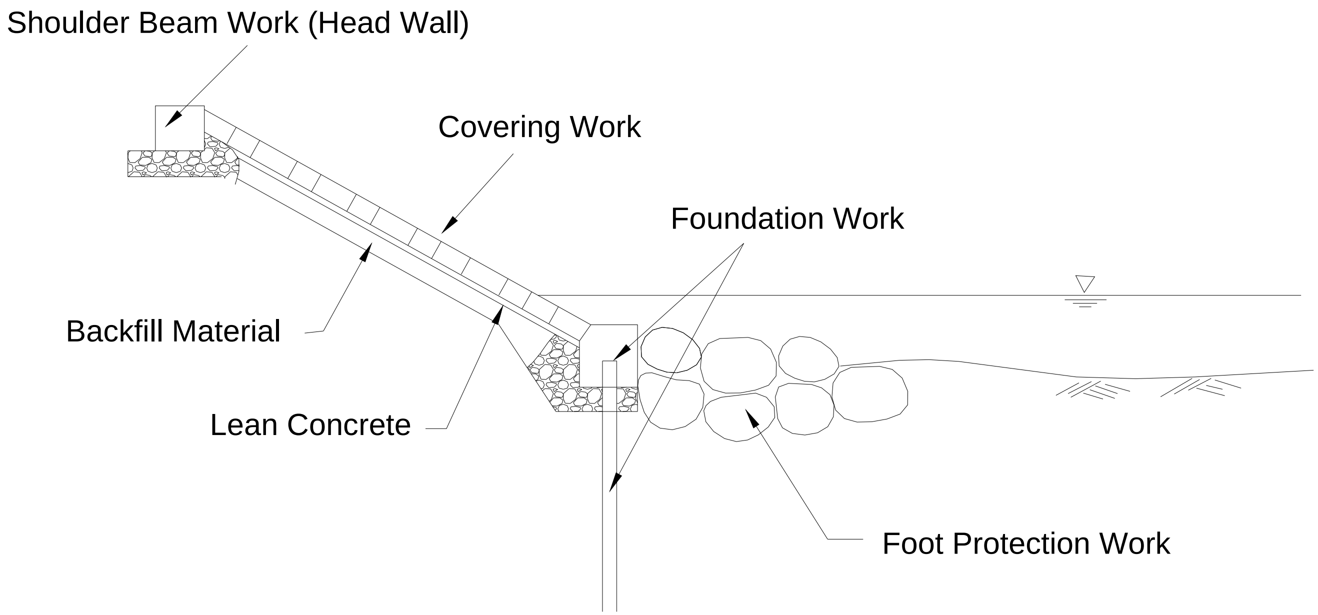
- Function of revetment is to protect the collapse of riverbank due to erosion, scouring and/or riverbed degradation.

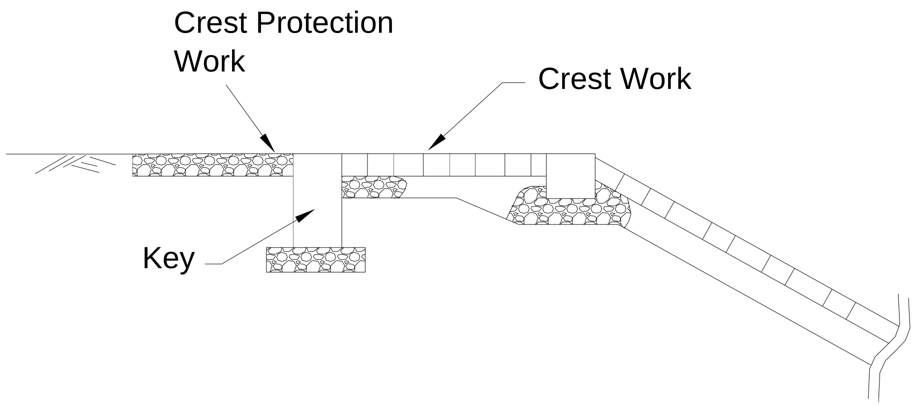


Components of Revetment



Toe Protection work





Crest Protection Work

Components of Revetment

- **Gabions** (from Italian *gabbione* meaning "big cage"; from Italian *gabbia* and Latin *cavea* meaning "cage") are cages, cylinders, or boxes filled with rocks, concrete or sometimes sand and soil that are used in civil engineering, road building, and military applications. For erosion control caged riprap is used. For dams or foundation construction, cylindrical metal structures are used. In a military context, earth or sand-filled gabions are used to protect artillery crews from enemy fire.
- (From Wikipedia, the free encyclopedia)

- **Riprap**—also known as **rip rap**, **rubble**, **shot rock**, **rock armour** or **Rip-rap**—is rock or other material used to armor shorelines, streambeds, bridge abutments, pilings and other shoreline structures against scour, water or ice erosion.
- It is made from a variety of rock types, commonly granite or limestone, and occasionally concrete rubble from building and paving demolition. It can be used on any waterway or water containment where there is potential for water erosion.
- From Wikipedia, the free encyclopedia


6月15日 起点側

さるすべり(百日紅):
Monkey Slipping, Crape,
Myrtle

藤 : wisteria

Brake 3

The following are possible impacts resulting from the construction of a bridge:

1. Water level increase upstream of the bridge due to heading-up for the bridge piers
2. Flow velocity increase due to the bridge piers and impacts of drift currents on levees
3. Impacts of changes in flow shear force due to the bridge piers on river-bed fluctuations
4. Local scouring in bridge piers and river banks due to flow velocity increase and turbulence caused by the bridge piers

Restrictions concerning river management for bridge construction

[Mandatory restrictions]

-The bridge clearance must exceed the total height of the design flood level and the design freeboard.

-The bridge must not interrupt the continuity of river management roads.

[Recommendations]

-The bridge construction should avoid river sections in which the flow regime changes, such as narrow sections, water-colliding fronts, confluences, bends, etc.

-The bridge construction should avoid river sections with frequent river-bed fluctuation (points of bed-slop change).

-The bridge should be built perpendicular to the flow direction during flooding.

-The bridge should not be built too close to other existing river-crossing structures (e.g., bridges, weirs, inverted siphons, ground sills).

-The bridge construction should avoid past breach points and old river channels.

[Considerations]

-The bridge construction should be coordinated with surrounding land-use conditions in terms of landscapes and natural and social environments.(* this consideration can be considered as specific to some local areas)

-The bridge construction should be consistent with the basic plan for river environment management.

-The bridge should not have adverse impacts on other existing structures excluding river-crossing structures.

The construction of river-crossing bridges must follow the above restrictions.

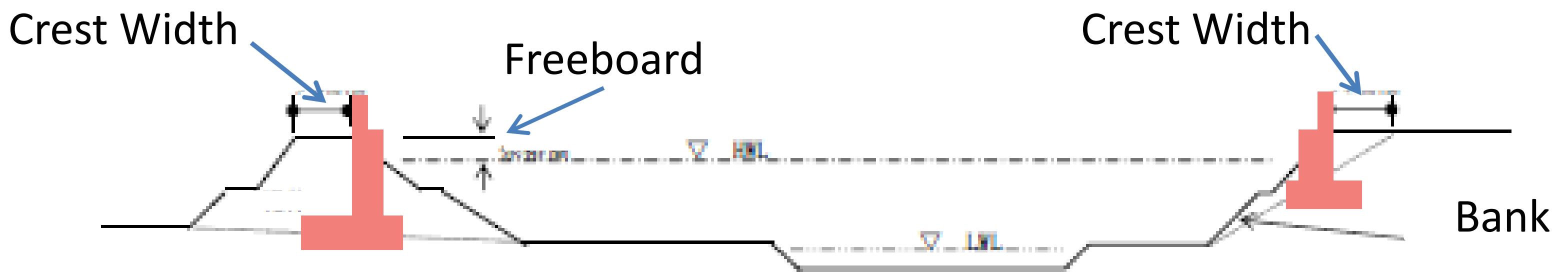
Source: Manual for planning river-crossing bridge constructions (preliminary version; published in July 2009 by the Japan Institute of Construction Engineering; JICE publication No. 109001)

Bridge

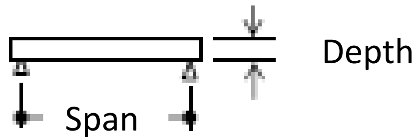
- A structure built to span a river for the purpose of providing passage over it.
- (1) Abutment and pier to be built within the river area shall be a structure which will be safe against the action of river flow at a water level equal to or lower than the design water level (or the design high tide level in a high tide section).
- (2) Abutment and pier shall not disturb the flood flow at a water level equal to or lower than the design high water level.
- (3) They shall not severely hinder the structure of adjacent river banks and facilities.
- (4) And they shall be designed in consideration of prevention of scour in river bed adjoining the abutment or the pier.

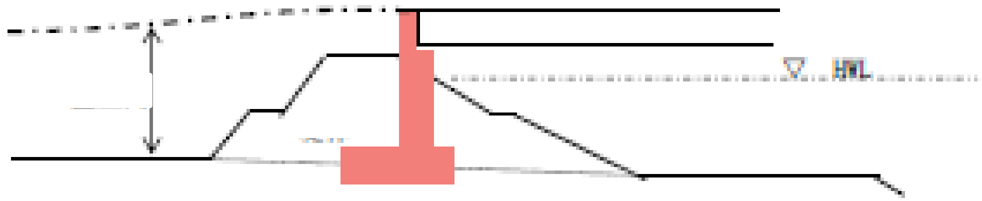
Source: Ordinance for Structural Standards of River Administration Facilities (STRUCTURAL RULES), Japan

Abutment



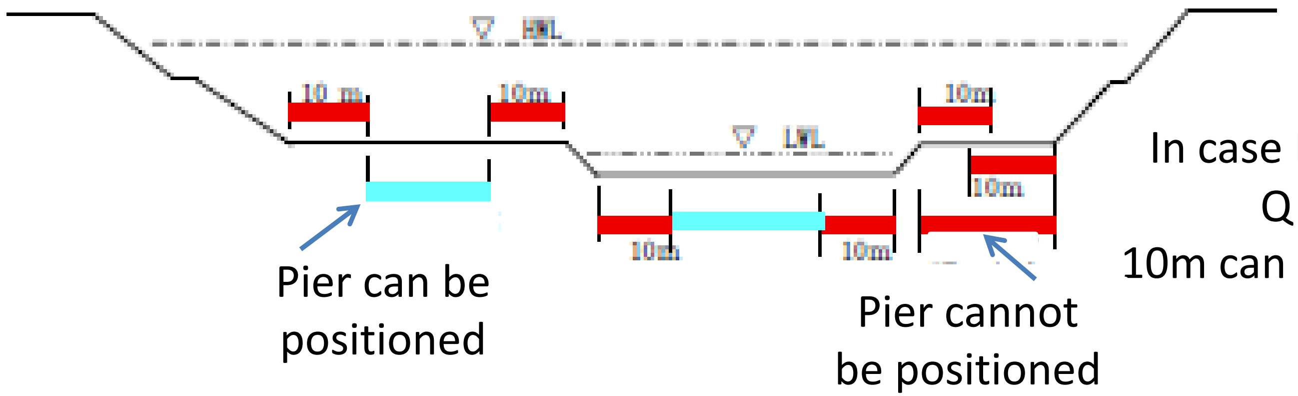
Usually, depth ratio is 1/(18-20).
Be careful for high banking in soft ground





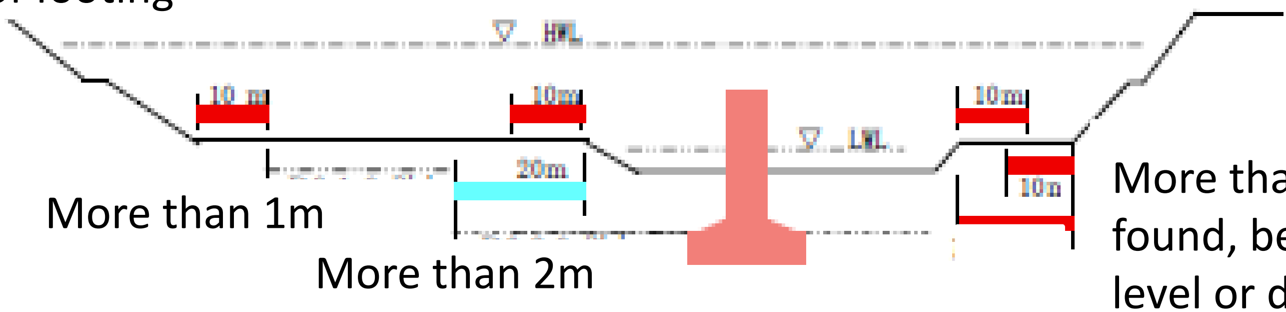
Pier

Position of Piers



In case Design Discharge
Q≦500 m^3/s
10m can be reduced to 5 m

Depth of footing

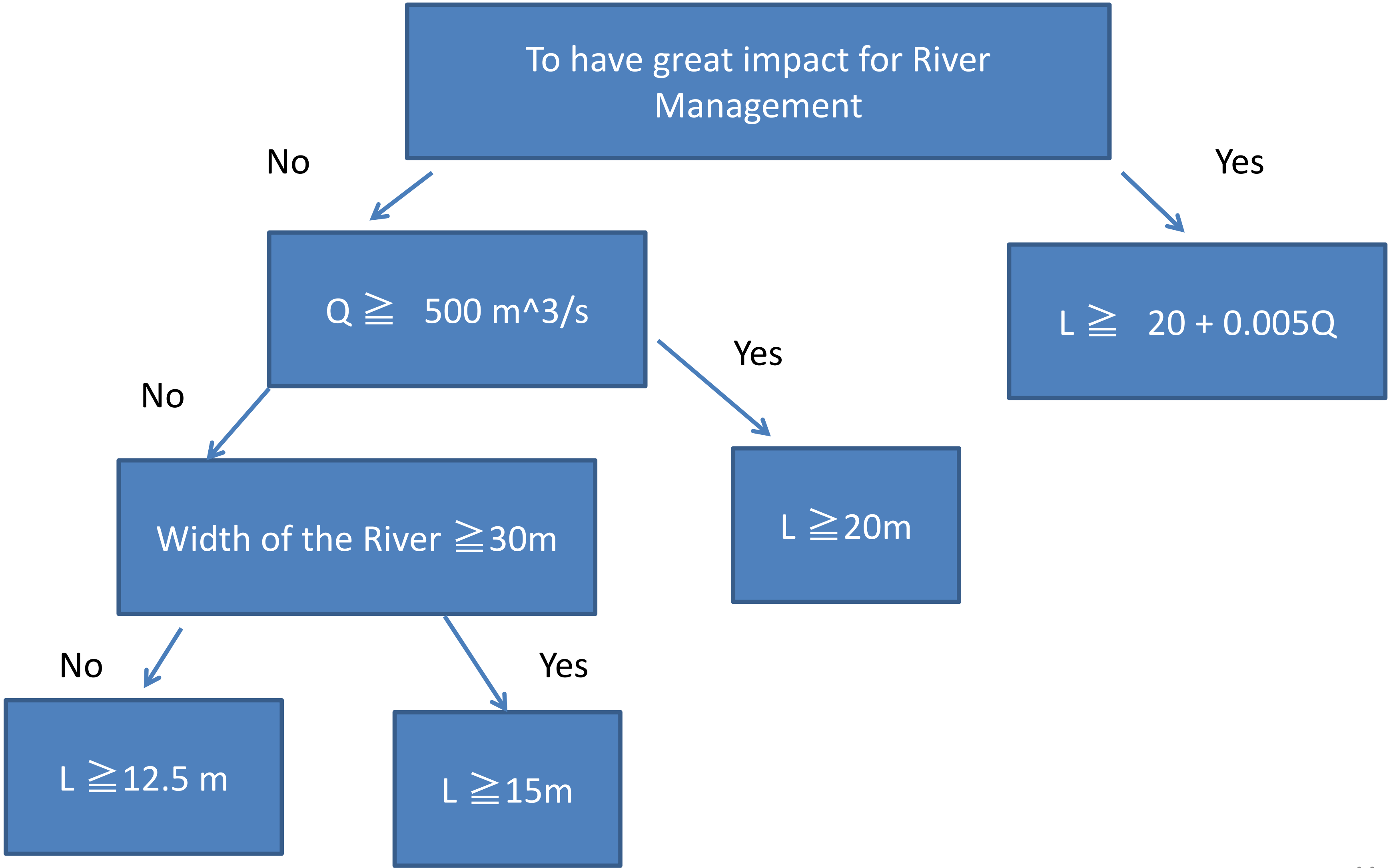


More than 2m score is found, below the planned level or deepest score level

Disturbance Ratio of the piers of Bridge:
The ratio of total width of the piers to the width of the river. In order to minimize the disturbance of the flow discharge, in general, the ratio should be less than 5%.

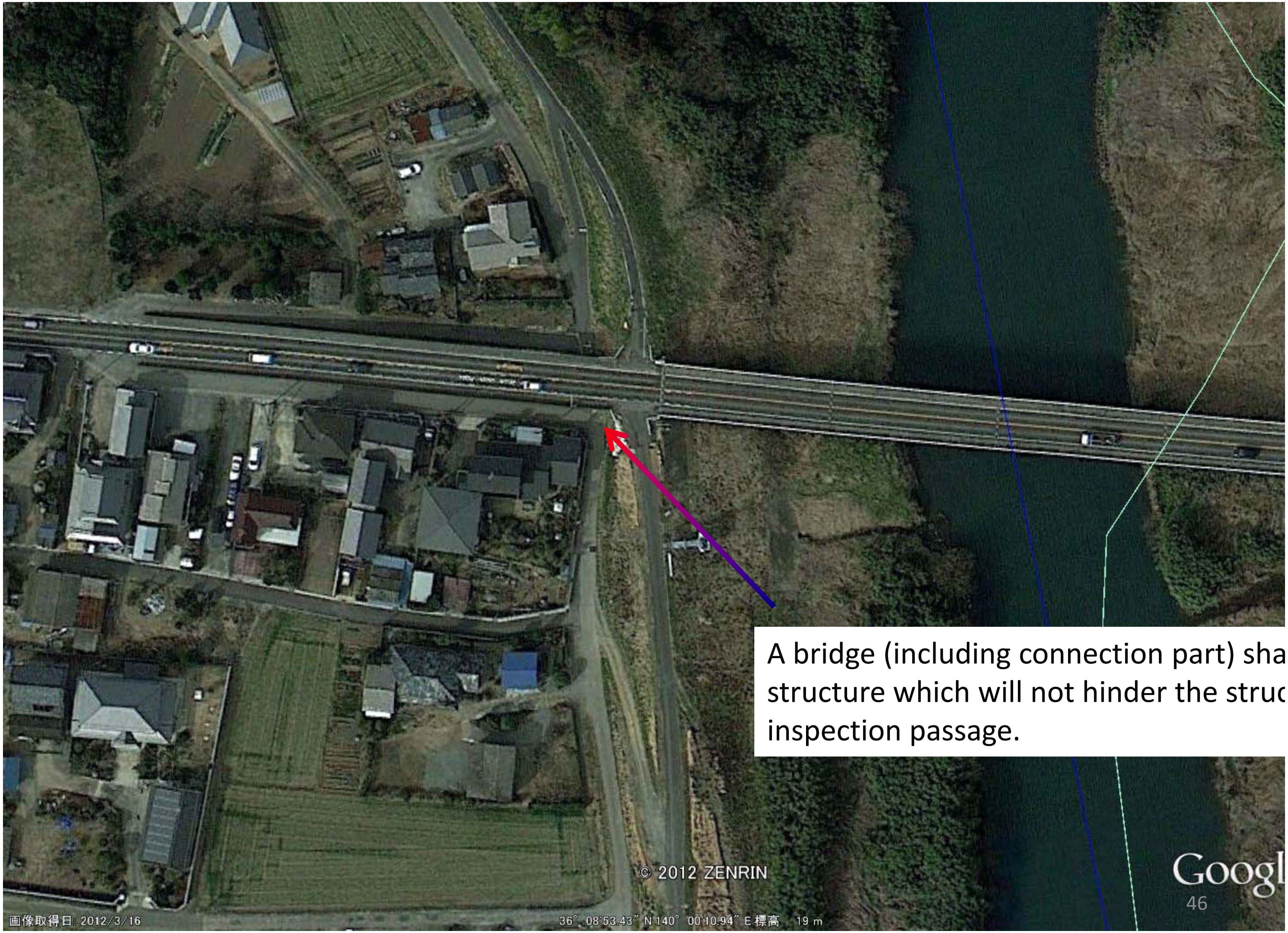
Width of the river is the length of design high water level (DHWL) at the right angle of the flow between the banks. Width of the pier is the pier width, which is right angle of the flow at the height of DHWL. In order to minimize the disturbance of the flow discharge, in general the ratio should be less than 5%. Even in the worst case, under the condition of the structural safety, the ratio should be less than 6% in general bridge and 8% in Shinkansen railway bridge and Highway Bridge.

L : Length between the piers or abutment
(Between front of the Abutment to middle of the pier
or between middle of the piers)



In the case of Weir

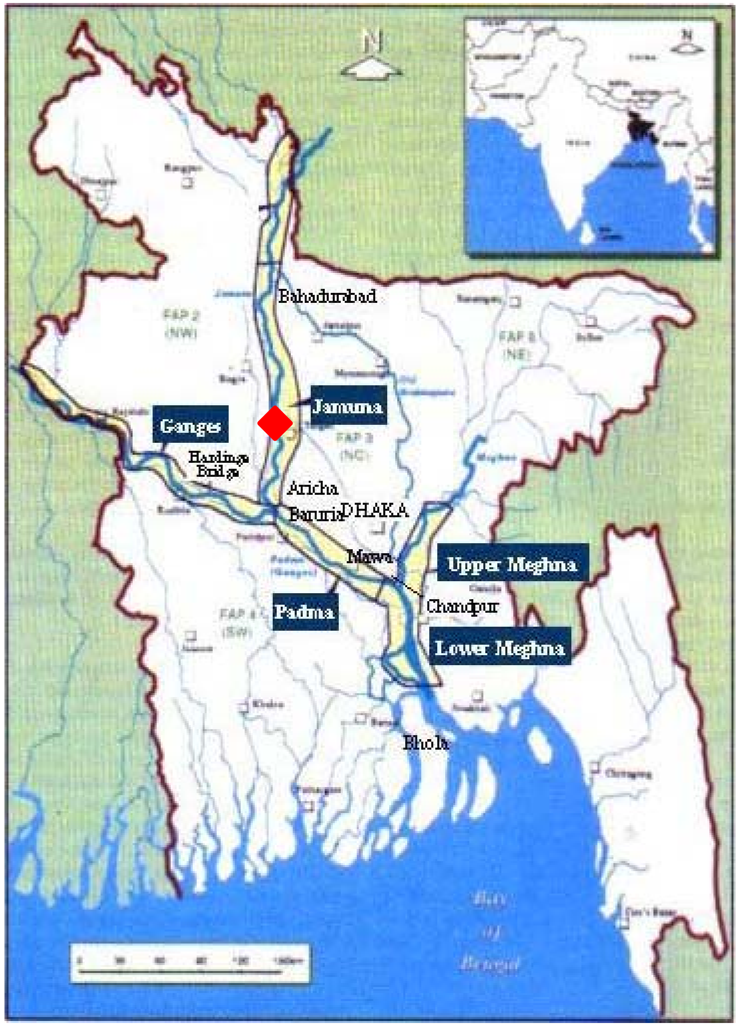
Design flood discharge (m^3/sec)	Span length (m)
Less than 500	15
500 and up to 2,000	20
2,000 and up to 4,000	30
4,000 and over	40


A bridge (including connection part) sha
structure which will not hinder the struc
inspection passage.
© 2012 ZENRIN
画像取得日: 2012/3/16
36° 08′53.43″ N 140° 00′10.94″ E 標高 19 m

ヒメジョオン（姫女菀、学名: Erigeron annuus）

田　(Paddy)

Brake 4



Bridge in Bangladesh

The Impact of structures within the river on flood flow.2

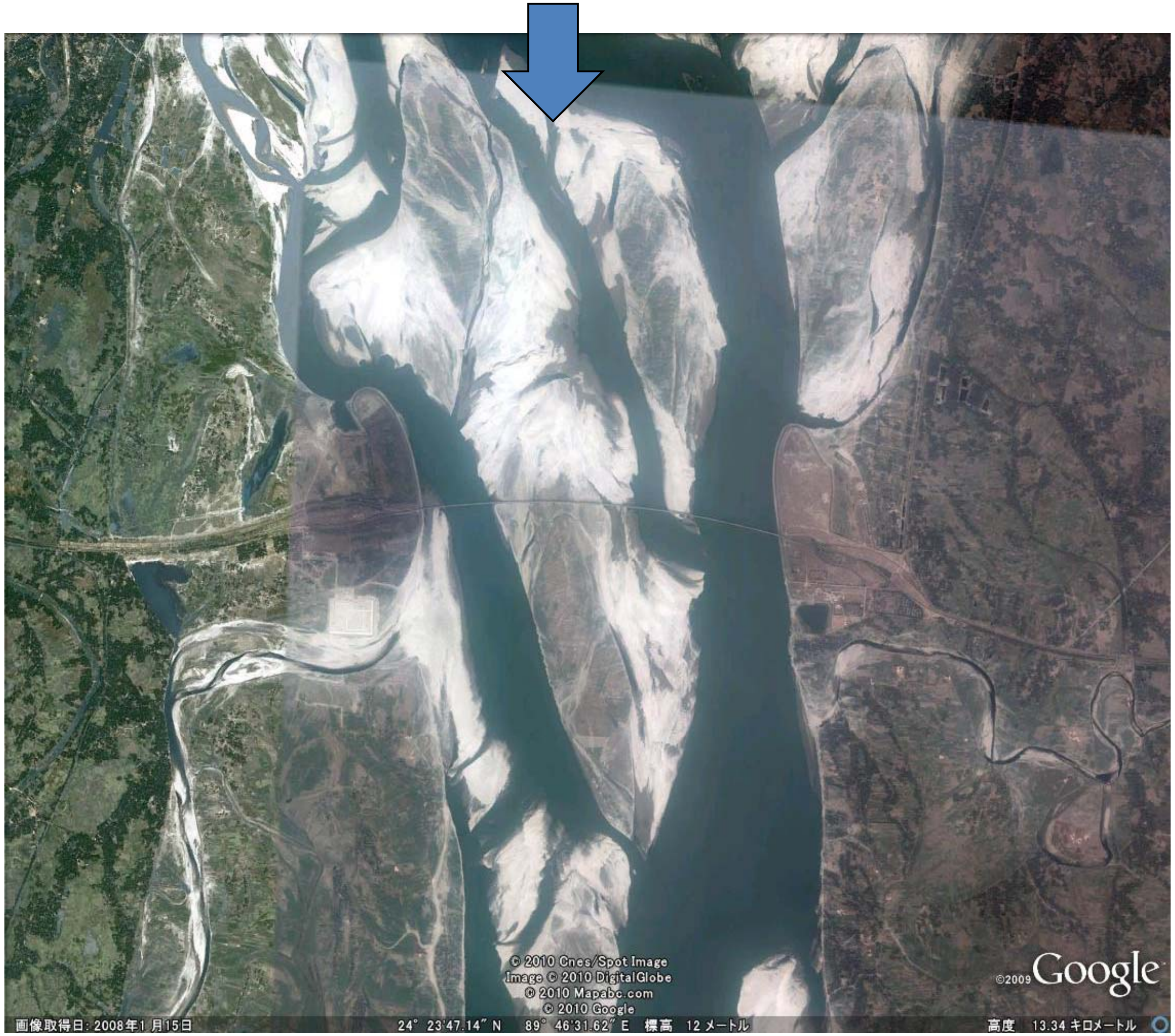
Jamuna Bridge in Bangladesh

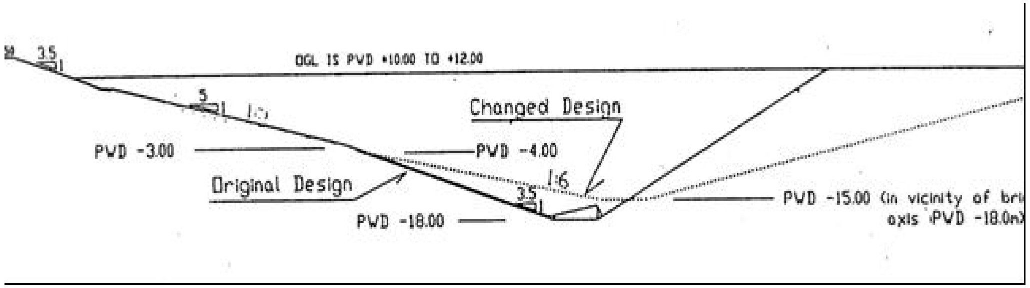
Opened in June 1998.

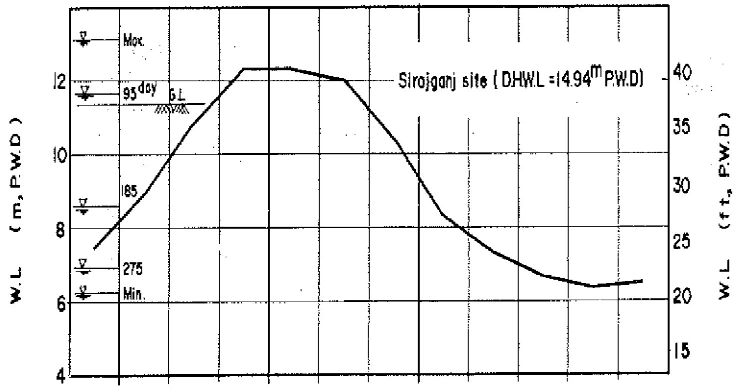
75 chars and 70,000 inhabitants within a span of 10kms of the Bridge site both up and down stream

40,000 m3/s : bankful
91,000 m3/s : 1 /1 O0

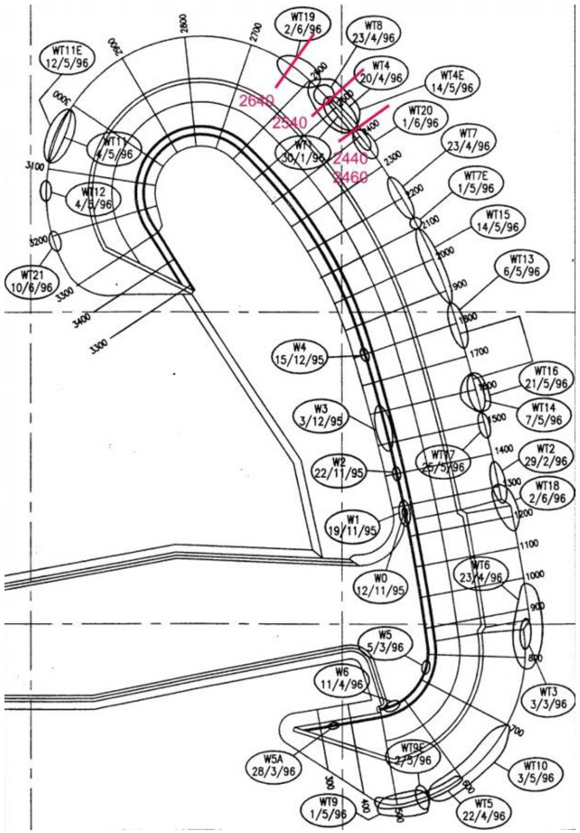
Main Bridge	4.8 km
East Guide Bund	3.07 km
West Guide Bund	3.26 km







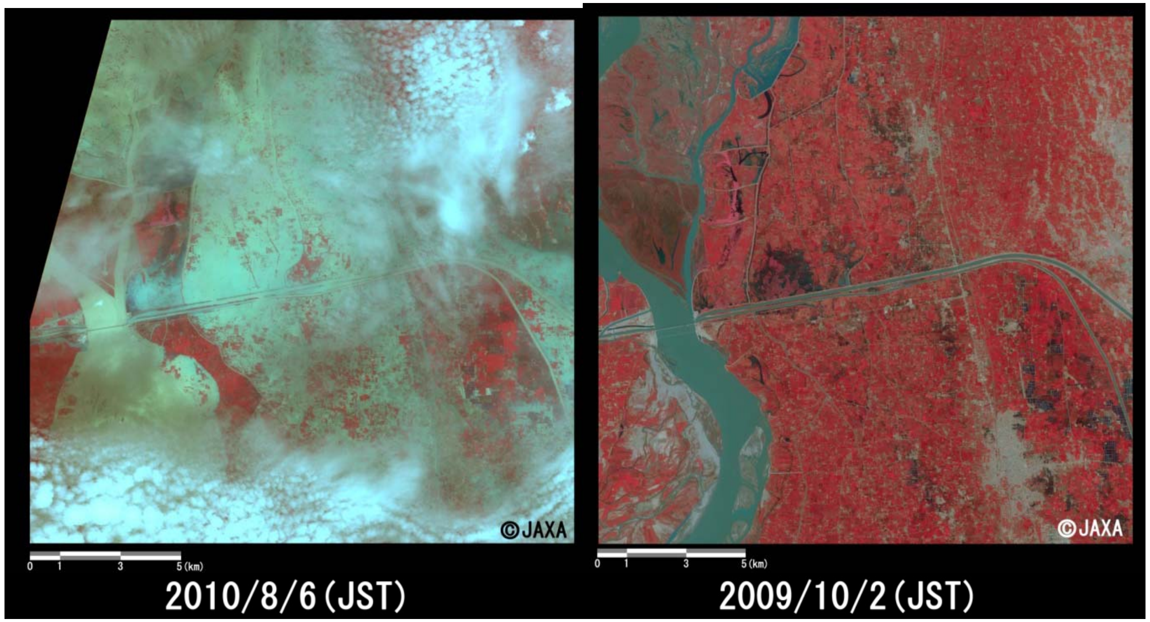
Monthly Mean Water Level



- Construction of slope protection in stagnant water
- Trench dredged to full depth
- Occurence of flow slides during construction
- Most slides on Eastern part of dredged trench
- Slope reduced to 1: 6 (initial design 1:3.5)
- Reduced the depth from -18m to -15m

From Dr. Gerrit J. Klaassen
and JICA study report.

The Impact of structures within the river on flood flow. 1



Taunsa Barrage in Pakistan

Completed in 1958, rehabilitation from 2003 to suply irrigation for 8000km^2. 65 Gates (including rocks) Width 1325m, Flood discharge: 30,000 m^3/s

1. Review the infrastructures within the river
2. Width of Natural river and flow discharge volume
3. The level of river water upstream and downstream of the structure.
4. Erosion and Accretion in the vicinity of the structure
5. Emergency discharge release

Identify the issues of designing structures within the river

from Pakistan Floods 2010 Preliminary Damage and Needs Assessment (ADB, WB)

Reference

- Ministry of Land Infrastructure Transport and Tourism Ordinance for Structural Standards of River Administration Facilities (STRUCTURAL RULES), Japan

- River and Dam Technical Standards, Japan

- Manual for planning river-crossing bridge constructions (preliminary version; published in July 2009 by the Japan Institute of Construction Engineering; JICE publication No. 109001)

Thank you for your attention

紫陽花 : hydrangea

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