দপ্রধান প্রকৌশলীর দপ্তর
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Memo no- 733-CE,D/-

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Working Paper for Design Guidelines for Protective Work

1. Study DPP provision and guideline.
2. Study Feasibility Study or Technical Committee Report provision.
3. Identify the alignment and length on Google Map. Check it with field Data.
   Length : Sustainable Length shall be selected.
   a. Braided River : Minimum Length shall be extended up to which erosion is ceased.
   b. Meandering River : Length shall be extended up to that point where Thalweg shifted to other bank.

   If the length submitted by Field office are insufficient, then give a 'Note' in the design by mentioned that "for sustainability of work, minimum …….m protection is needed. Requested to send the rest data for design and included it in DPP".

4. Design Data
   a. Discharge : Yearly Maximum
      i. Major River 1:100 or 1:50 years
      ii. Medium River 1:20 years
      iii. Minor River 1:20 years or Bankfull Discharge
      iv. In case of no Discharge Data : survey the cross-section, measure the velocity. Q = A V
      v. Velocity may be measure by float method, if current meter is not available.
      vi. If it is not possible to measure the Velocity, then 3.00m/s may be assumed.
      vii. In Coastal Area, data may be collected from the Model output from IWM.

   b. High Water level : Yearly Maximum
      i. Major River 1:100 or 1:50 years
      ii. Medium River 1:20 years
      iii. Minor River 1:20 years or Bankfull Level
      iv. In case of no Water level Data : May be collected site survey & asking local people.
      v. Data May be collected from BIWTA.

   c. Low Water level
      i. Average water level in the dry months i,e average water level from December to April.

   d. <u>Frequency Analysis</u>
      i. Gumbel's Distribution
      ii. Log Normal Distribution

iii. Log-Pearson Type III (LP3) Distribution

e. Normally for Frequency Analysis Gumbel's Distribution is used.

f. Velocity, Wind Speed, Wind Duration, Wave period, Wave Height, Fetch Length etc.
g. D_{50} of river bed material
h. Cross Section of river
i. Index map, Site Plan
j. Soil Bore log
   i. Two Bore log in a section, one on the bank, other in river bed
   ii. Determine Depth of Bore log from Scour Depth.

5. Some Observed Data

Velocity (m/s)			
	Bahadurabad	Baruria Transit	Mawa
June to September	Max =3.68 Min =3.00	Max =4.23 Min =3.00	Max =4.35 Min =3.02
Average =	3.28	3.37	3.45

Maximum Velocity : (from FAP 24)	
Jamuna	Kamarjani = 3.2 m/s Bahadurabad = 3.7 m/s
Ganges	Gorai oftake = 4.0 m/s

Design Velocity used in Padma Bridge, Mawa is 4.60 m/s

JMREMP Mannual	Wind Speed	
(As per Halcrow)	m/s	km/h
Faridpur	18.00	64.80
Sirajgonj	18.00	64.80
Bogra	15.40	55.44
Mymensingh	15.40	55.44

Max Wave Height is 1.0 m
Wave Period is 3.00 sec (Halcrow-1994)

Location	River	Observed Scour Level (m PWD)	Design Scour Depth (m)
Sirajgonj	Jamuna	-33	
		-44	
Sailabari	Jamuna	-40	
Mawa	Padma	-50	
Noria	Padma	-65	
Hakimuddin, Bhola	Meghna	-65	
Ilisha, Bhola	Meghna	-32	
Monpura	Meghna	-37.96	
Jamuna Bridge guide bundh			40 to 45

Record of Scour in Jamuna :		
Location	Scour Depth (m)	Time (day)
Bahadurabad	6.0	10
	8.0	24
	12.0	30
Sirajgonj	5.3	1
	20.0	24
Kalitala	5.0	3
Mathurapara	12.0	10

6. Two issues in Design of Protective Work
    a. Hydraulic Issues
    b. Geotechnical Issues

7. Stability of Protection Material

    Besides other, Force acting on Protection Material
    a. Wave attack
    b. Current attack

    All these forces are encountered by self-weight of Protection Material.

8. Size of Protection Material : above LWL
    a. Stability Under Wave attack
    b. Stability Under Current attack

9. Size of Protection Material : below LWL
    a. Stability Under Current attack

10. Stability Under Wave attack

a. Pilarczyk (1990)

$$D_n \geq \frac{H_s \cdot \xi_z^b}{\Delta_m \cdot \Psi_u \cdot \phi_{sw} \cdot \cos\alpha}$$

Where

Dn	[m]	characteristic size of the revetment cover layer (single unit size for loose elements, thickness for mattress systems)
Hs	[m]	significant wave height
Δ_m	[-]	relative density of submerged material = $(\rho_s-\rho_w)/\rho_w$
g	(m/s^2)	acceleration due to gravity (= 9.81)
$\varnothing_{sw}$	[-]	stability factor for wave loads
Ψ_u	[-]	system specific stability upgrading factor
α	[°]	bank normal slope angle
ξz	[-]	wave breaker similarity parameter= $\tan\alpha \cdot \frac{1.25 \cdot T_m}{\sqrt{H_s}}$
T_m	[s]	mean wave period
b	[-]	wave structure interaction coefficient, dependent on roughness and porosity of protective material

	Padma Bridge	Halcrow for Jamuna	Jamuna, JMREMP	
			1:100	1:25
Hs (m) =	1.40	1.00	1.30	1.00
Tm (sce)=	3.40	3.00		

BWDB Manual	minimum	maximum
Wave Height (m)	0.70	2.00
Wave Period (sec)	2.80	5.00

The formula is restricted to values ξz <3 and cotα ≥ 2, i.e. to plunging breakers, which generate high local pressure heads. Otherwise overestimation of the unit size is likely, because dynamics of the breaking process are diminishing.

Wave Type after Pilarczyk				
	ξz <	0.5	Spilling	ছলকানো
0.5	< ξz <	2.5	Plunging	ঝাপাইয়া পড়া
2.5	< ξz <	3.5	Collapsing	
	ξz >=	3.5	Surging	

In the formula 'b' is the exponent related to the interaction between waves and revetments (0.5 ≤ b ≤ 1.0). For rough and permeable revetments, b = 0.5, for smooth and less permeable placed-block revetments it is close to unity. For other systems b = 0.67 may be applied. Ψ_u is the system specific stability upgrading factor.

Table : Coefficients for design of various cover materials against wave attack

Revetment type	Stability factor for incipient motion φ[-]	Stability upgrading factor, Ψ_u [-]	Interaction coefficient, b [-]
Randomly placed, broken riprap and boulders	2.25-3.00	1.00-1.33	0.50
CC blocks, cubical shape, randomly placed in multi-layer	2.25-3.00	1.33-1.50	0.50
CC blocks, cubical shape, hand placed ,single layer (geotextile filter)	2.25	2.00	0.67 - 1.00
CC blocks, cubical shape, hand placed in single layer, chess pattern (geotextile on sand)	2.25	1.50	0.67 - 1.00
CC blocks cable connected	2.25	1.80	0.67
Wire mesh mattress	2.25	2.50	0.50
Gabions/mattress filling by stone	2.25	2.50	0.50

(2) Hudson

$$W = \frac{H_S^{\,3} \cdot \rho \cdot \tan\alpha}{k \cdot \Delta_m^{\,3}}$$

(3) Iribarren

$$W = \frac{f \cdot H_S^{\,3} \cdot \rho}{\Delta_m^{\,3} (\cos\alpha - \sin\alpha)^3}$$

Where

W	(kg)	weight of revetment material
H_s	(m)	significant wave height
α	(°)	bank slope angle
f	(-)	coefficient related to the amplitude of the wave and slope angle
Δ_m	(-)	relative density of submerged material = $(\rho_s - \rho_w)/\rho_w$
ρ_s	(kg/m^3)	density of protection material
ρ_w	(kg/m^3)	density of water
k	(-)	coefficient varying from 3.2 for smooth quarry stone to 10 for tetrapods

Values of Stability Coefficient K_D		K_D	
Rock :	Breaking Wave	2.00	
	Non Breaking Wave	4.00	
Cube :	Breaking / non breaking wave	6.50	7.50
Tetrapods :		7.00	8.00
Dolosse :		15.80	31.80
JMREMP Manual		3.20	10.00

(4) California State Highways: (in FPS unit)

$$W = \frac{2.31 \times 10^{-3} \cdot S_s \cdot Hs^3}{(S_s - 1)^3 \cdot \sin^3(70 - \alpha)}$$

11. Stability Under Current attack

(1) Pilarczyk

$$D_n \geq \frac{0.035 \cdot \overline{u}^2}{\Delta_m \cdot 2g} \cdot \frac{\phi_{sc} K_\tau K_h}{K_s \cdot \Psi_{cr}}$$

Where,

D_n	(m)	Equivalent diameter (cover layer)
Δ_m	(-)	$(\rho_s-\rho_w)/\rho_w$ = relative density of submerged material
ρ_s	(kg/m^3)	density of protection material
ρ_w	(kg/m^3)	density of water
$\bar{u}$	(m/s)	depth averaged mean flow velocity;
g	(m/s^2)	acceleration due to gravity
φ_{sc}	(-)	stability factor for current
K_τ	(-)	turbulence factor
K_h	(-)	depth factor, dependent on the assumed velocity profile and water depth (h) to equivalent roughness height ratio.
K_s	(-)	Slope parameter
Ψ_{cr}	(-)	critical Shield`s parameter,
α	(°)	slope angle of bank or structure
θ	(°)	angle of repose considering the material specific internal friction

The stability of revetment elements also depends on the slope gradient under which the revetment is applied in relations to the angle of internal friction of the revetment. This effect on the stability is taken into account with the slope parameter K_s, which is defined as

$$K_s = \sqrt{1 - \left(\frac{\sin\alpha}{\sin\theta}\right)^2} \quad \text{where } \theta > \alpha$$

or, $K_s = \cos\alpha_b$

α_b = slope angle of the river bottom (parallel to the flow)

Type of Protection Material used	Shields parameter	Angle of repose (°)		Bed roughness factor, Kr
	ψ_{cr}	Geotextile filter	Granular filter	
CC Block, hand place,single layer	0.05	20	25	0.1
CC Block, multi layer	0.035	30	35	1
Stone Boulders/Rock	0.035	40	40	2
Geobag (filled with dry sand)	0.05	35	35	1
CC Block, Cable connected	0.06	20	25	
Gabion / Mattress filled with stones	0.09	45	45	
Wire Mesh Mattress filled with brick	0.07	20	25	

Table : Values of stability factor (Pilarczyk 1998)

Revetment Type	Stability factor φ_{sc}	
Cover layer	Continuous protection [-]	Exposed edges transitions [-]
Randomly placed, broken riprap and boulders	0.75	1.5
CC blocks, cubical shape, randomly placed in multi layer	0.80	1.50
CC blocks, cubical shape hand placed in single layer chess pattern	0.65	1.25
Riprap and placed blocks; Sand fill units	1.0	1.50
Block mats, gabions, washed-in blocks, geo-bags, concrete filled geo-bags and geo-mattresses, wire-mesh mattress	0.5	1.00
Gabions/ mattress filling by stones	0.75	1.5

Table : Turbulence Intensity Factor K_τ (current) (FAP 21/22)

Turbulence Intensity	K_τ (-) Gabions, Mattresses	K_τ (-) Others
Normal turbulence in rivers	1.0	1.0
Non-uniform flow with increased turbulence, mild outer bends	1.0	1.5
High turbulence, local disturbances, sharp outer bends	1.0	2.0
Jet impact, screw race velocity, hydraulic jump	3.0 - 4.0	3.0 - 4.0

With the depth parameter K_h, the water depth is taken into account, which is necessary to translate the depth averaged flow velocity into the flow velocity just above the revetment. The depth parameter also depends on the measure of development of the flow profile and the roughness of the revetment. Logarithmic velocity profiles exist for long stretches with constant bed roughness. For most engineering works as bottom protection or slope protection, the non developed velocity profile is usually present. K_h is the coefficient due to conversion from the local mean bottom velocity to mean velocity $\bar{u}$.

The following formulas for K_h are recommended (Pilarczyk 2008):

Fully developed profile: $K_h = 2 \cdot \left[\log\left(1 + \frac{12h}{k_s}\right)\right]^{-2}$

Non-developed profile: $K_h = \left(1 + \frac{h}{k_s}\right)^{-0.2}$

Very rough flow ($h/k_s < 5$): $K_h = 1$

Where, h is the water depth (m), in the case of dimensioning the revetments on a slope, the water level at the toe of the slope must be used for h.

k_s is the bed roughness (m) given approximately by:
$k_s = 0.1D$ for smooth units (i.e. pitched concrete blocks),
$k_s = D$ for block mats, and
$k_s = (1 \text{ to } 3)D_n$ (rough units, i.e. rock).

For riprap, k_s is equal usually to twice the nominal diameter of the stones ($k_s \approx 2D_n$), for bags it is usually equal to the thickness (d), for mattresses it depends on the type of mattress: k_s of about 0.05 m for smooth types and about the height of the rib for articulating mats.

Note: usually $12h/k_s$ is applied, however, by using $(1+12h/k_s)$ the discontinuity at small values of h can be avoided; the same adjustment is also applied for other velocity distributions. The effect of this additional (imaginary) depth practically vanishes for $h/k_s>2$ (after Pilarczyk 2008).

(2) Isbash

$$W = \frac{4.1 \times 10^{-5} \cdot S_s . V^5}{(S_s - 1)^3 \cdot \cos^3 \alpha}$$

(3) California State Highways:

$$W = \frac{2 \times 10^{-5} \cdot S_s \cdot V^6}{(S_s - 1)^3 \cdot \sin^3(70 - \alpha)}$$

(4) PIANC

$$D_n = \frac{0.70\, V^2}{g(S_s - 1) \cdot \cos\alpha \left[1 - (\tan^2\alpha / \tan^2\theta)\right]^{0.5}}$$

(5) JMBA

$$D_n = \frac{0.7 V^2}{2 \cdot (S_s - 1) \cdot g} \cdot \frac{2}{\log(6h/D)^2} \cdot \frac{1}{\left[1 - (\sin\alpha / \sin\theta)^2\right]^{0.5}}$$

(fps or metric unit) (the equation has been developed for cc blocks)

In these equations:

W	(kg or lb)	weight of Individual stone
D	(ft or m)	diameter of stone
Dn	(ft or m)	dimension of cube
V	(ft/s or m/s)	mean velocity at the adjacent channel
h	(ft or m)	depth of water
S_s	(-)	specific gravity of stone
α	(°)	slope of bank
θ	(°)	angle of repose of revetment material
Ψ	(-)	Shield's parameter
g	(m/s^2 or ft/s^2)	gravitational acceleration

Note : PIANC gives excessive large size. Not recommended.

12. Thickness of Riprap for Pitching Work

Opinion of different authorities and professionals regarding the thickness of slope pitching are given below.

a) U.S. Army Corps of Engineers (1991), recommends that thickness of protection should not be less than the spherical diameter of the upper limit W_{100} (percent finer by weight) stone or less than 1.5 times the spherical diameter of the upper limit W_{50} stone, whichever results in greater thickness.

Used to determined thickness US Army Corps				
	From Table 10.3, Page 208, Neil			
Velocity	W_{100} %		W_{50} %	
m/s	mm	kg	mm	kg
upto 3.05	0.450	136.08	0.300	36.29
upto 3.96	0.750	680.40	0.500	181.44
upto 4.57	1.200	2268.00	0.750	680.40
	1 lb =	0.4536	kg	

b) California Highway Division (1991) recommended that there should be at least two layers of overlapping stones so that slight loss of materials does not cause massive failure.

c) ESCAP (1973) recommends that thickness of protection should be at least 1.5D, where D is the diameter of the normal size rock specified.

d) Inglis (1949) recommended following formula to compute thickness of protection required on the slope of revetment,

$$t = 0.06\ Q^{1/3}$$

Where,

t	(m)	thickness of stone riprap
Q	(m^3/s)	discharge

The Inglis formula apparently gives excessive thickness for higher discharge.

e) The thickness of stone pitching and soling for permanent slopes required at head, body and tail of guide bank for river flowing in alluvial plains as recommended by Gales (1938).

River	Rivers with discharge 0.25 to 0.75 million cusec		Rivers with discharge 0.75 to 1.50 million cusec		Rivers with discharge 1.50 to 2.50 million cusec	
Parts of guide bundh	Head	Body and Tail	Head	Body and Tail	Head	Body and Tail
Pitching stone	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"	3'-6"
	1.07 m	1.07 m	1.07 m	1.07 m	1.07 m	1.07 m
Thickness of soling ballast	7"	7"	8"	8"	9"	9"
Total thickness	4'-1"	4'-1"	4'-2"	4'-2"	4'-3"	4'-3"

Thickness suggested by Gales is 1.07m. This Thickness suggested by Gales is valid for discharge from 7086 cumec to 70860 cumec.

f) Thickness of Stones on Slope as per Spring

River bed materials as classified by Springs	Thickness in inches for river slopes in inches per mile					Remarks
	3	9	12	18	24	
Very Coarse	16	19	22	25	28	The stone pitch prevents sand underneath from being sucked out by high velocity. More rationally stone pitch thickness should be based on velocities.
Coarse	22	25	28	31	34	
Medium	28	31	34	37	40	
Fine	34	37	40	43	46	
Very Fine	40	43	46	49	52	

(Thickness suggested by Spring varies from 0.40m to 1.30m)

The thickness suggested above, should be increased by 50% when the riprap is placed under water to provide for uncertainties associated with the type of placement (US Army Corps of Engineers).

Note : ***The above recommendations are for boulder. Due to resemblance of cubical shape CC Block with boulder, the above recommendations are adopted for CC Block.***

USACE, ESCAP, California Highway Division recommended thickness equal to larger Size, 1.5 layer & 2 layers for boulder.

For Pitching, 1 layer of CC Block, is used. Size of CC Block is determined in such a way that it is not washed out by wave & current attack. 3 types of filter are used so that soil beneath the Pitching Block are not comes out.

13. Scour Depth:

Lacey's regime formula is used to find out scour depth. This empirical regime formula is:

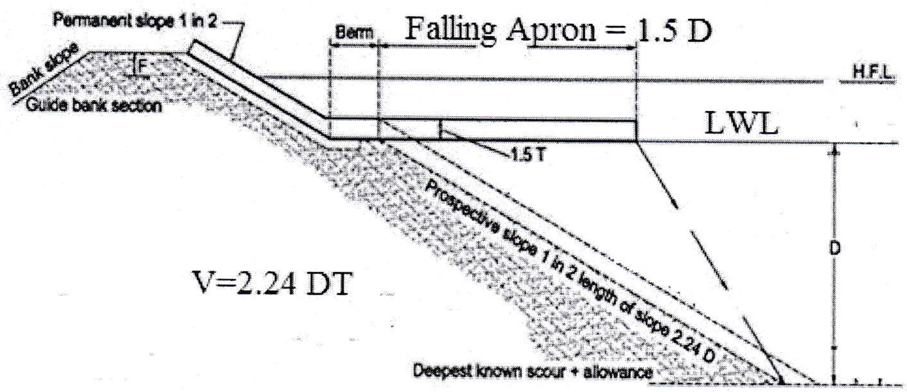
$$R = 0.47\ (Q/f)^{1/3}$$
$$D_s = XR - h$$

Where, D_s	(m)	Scour depth at design discharge
Q	(m^3/s)	Design discharge
f	(-)	Lacey's silt factor = $1.76\ (d_{50})^{1/2}$
d_{50}	(mm)	Median diameter of sediment particle
X	(-)	Multiplying factor for design scour depth
h	(m)	Depth of flow, may be calculated as (HFL-LWL)

Table : Multiplying Factors for Maximum Scour Depth by Lacey's approach

		Size of bed material	
Nature of location	Factor (X)	Silt factor, f	D_{50} (mm)
Straight reach of channel	1.25		
Moderate bend	1.50	0.4	0.052
Severe bend	1.75	0.5	0.081
Right angle abrupt turn	2.00	0.6	0.116
Noses of piers	2.00	0.7	0.158
Alongside cliffs and walls	2.25	0.8	0.207
Noses of guide banks	2.75	1.0	0.323

14. Dumping Volume



D = Scour Depth
T = Thickness of Prospective protection

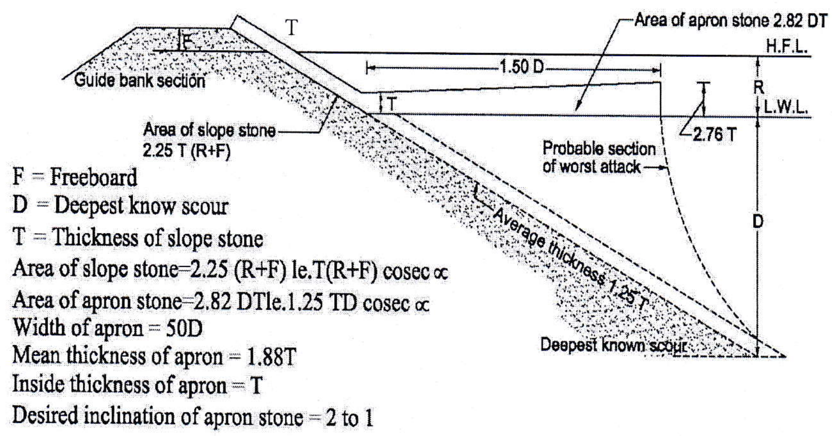
Dumping Volume, V = 2.24 DT, assuming that material will be launch in 2:1 slope.

Among the various methods, launching apron or falling apron has been considered to be most economic and common method of toe protection of revetment. Falling aprons are generally laid horizontally on flood plain/river bed at the foot of the revetment, so that when scour occurs, the material will launch and will cover the surface of the scour hole in a natural slope.

Length of Falling Apron = 1.5 D
Thickness of Falling Apron = 1.5 T

15. Distribution of Dumping Material

a. Shape of apron suggested by Spring (1903)

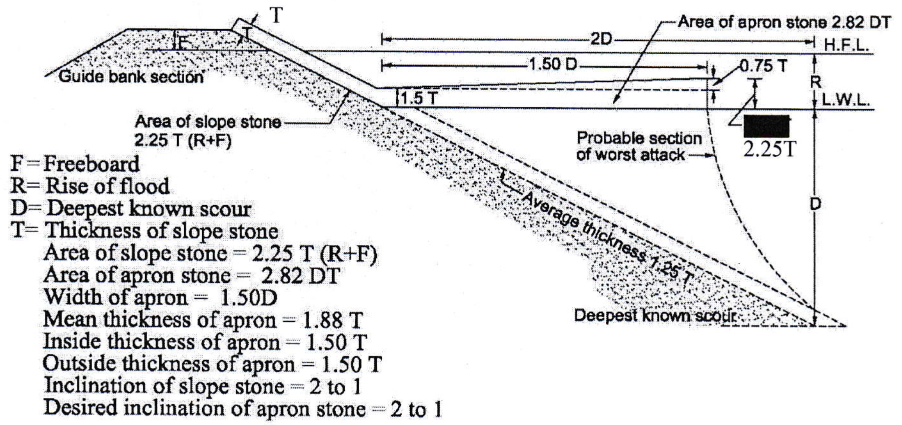


Spring recommended a minimum thickness of underwater protection equal to 1.25 times the thickness of stone riprap of the slope of revetment.

If the thickness of slope protection is T, then thickness of protection after launching will be 1.25T.

So, here Dumping Volume, V = 2.24 * D * (1.25T) = 2.82 DT

b. Shape of apron suggested by Rao (1946)



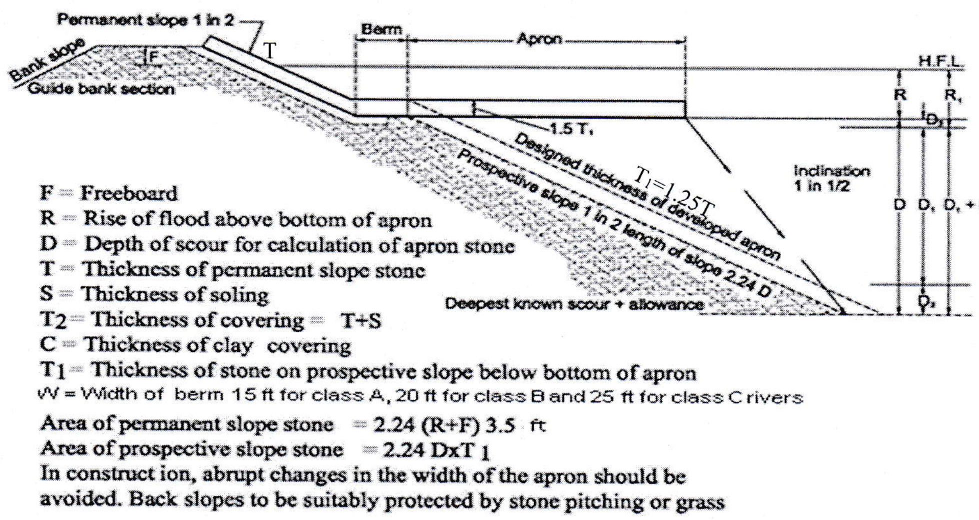
Since Apron stone has to be dumped under water and cannot be hand placed, thickness of apron at junction should be 1.5 times thickness of slope protection T.

Thickness of pitching work is T

Dumping Volume, $V = \frac{1}{2}(1.5 + 2.25)\, T * (1.5D) = 2.82\, DT$

Thickness of protection after launching is 1.25 T.

c. Shape of apron suggested by Gales (1938)



Thickness of Pitching Stone = T

Thickness of Stone on Prospective Slope, $T_1 = 1.25\, T$

Width of Falling Apron = 1.5 D

So, Dumping Volume, $V = 2.25DT_1 = 2.25\, D * (1.25T) = 2.82\, DT$

16. Prospective Thickness for Dumping Material (Boulder & Block)

a. Spring, Rao & Gales recommends Prospective Thickness for under water slope protection is 1.25 times the thickness of Pitching Stone.

b. Dumping Volume is same in all the three distribution.

Thickness of Pitching work = T
Thickness on Prospective Slope after launching, $T_1 = 1.25$ T
Thickness of Falling Apron = 1.5 T_1
Width of Falling Apron = 1.5 D
Dumping Volume : $V = 2.25DT_1 = 2.25D * (1.25T) = 2.82\ DT$
Or, $V = (1.5D) * (1.5T_1) = 2.25DT_1$
$= 2.25D * (1.25T) = 2.82\ DT$

17. Thickness for Geobag (from JMREMP Guidelines) :
    a. Systematic coverage of the bank slope by minimum three layers of geobag from the deepest part to the Low Water Line may provide a dependable protection;
    b. To ensure minimum two-layer coverage at least four layers of geobags need to be placed systematically.
    c. A 15 m wide falling apron at the end of Arial Coverage (average 45 m wide) towards the deeper section of the river shall be built to attain a sustainable protection. The thickness of falling apron shall be at least 0.50 m or 3 layers of geobag.

18. Thickness of Geobag coverage in Areal Coverage

From the Recommendation of JMREMP Guidelines

3 layer Geobag provides a dependable protection.

To attain 3-layer coverage, 5-layer Geobag shall be dumped systematically, considering different uncertainties such as velocity, depth of water, direction of flow, position of geobag after dumping etc.

Thickness of 5-layer Geobag = 5*0.167 = 0.835m.

19. Thickness of Geobag for Falling Apron

From the Recommendation of JMREMP Guidelines

3 layer Geobag provides a dependable protection i,e thickness of prospective slope coverage, T = 3 layer.

Thickness of Falling Apron = 1.5 T = 1.5 * 3 = 4.5 layer, say 5 layer
Thickness of 5-layer Geobag = 5*0.167 = 0.835m.

Width of Falling Apron = 1.5 D
Dumping Volume, V = (1.5D) * (***5-layer***) = (1.5D) * (***0.835***)

20. Thickness for Mixed Material

If CC Block and Geobag are mixed for under water protection, then ratio of mixture shall be 50:50.

Areal Coverage:
When Thickness of Protection, t = 1.00m
0.50m Geobag, 0.50m CC Block

CC Block					Remark
t = 0.50 m, Volume = 0.50 cum/sqm/m					
Size of Block	Calculated	Provided			
	nos./sqm	nos./sqm	Volume	Total Volume	
0.40 m 0.30 m	4.69 7.41	4.5 7.5	0.288 0.203	0.491	Roughly creates 2 layer coverage
0.45 m 0.35 m	3.29 4.66	3.5 4.5	0.319 0.193	0.512	
0.50 m 0.40 m	2.40 3.13	2.5 3	0.313 0.192	0.505	

Geobag					
t = 0.5m, Volume = 0.50 cum/sqm/m					
250kg (nos./sqm)		175kg (nos./sqm)		125kg (nos./sqm)	
Calculated	Provided	Calculated	Provided	Calculated	Provided
3.00	3	4.30	4.3	5.95	6

Falling Apron :
When Thickness of Protection, t = 1.50m
t = 1.50m, 0.75m Geobag, 0.75m CC Block

CC Block : t = 0.75 m, Volume = 0.75 cum/sqm/m					Remark
Size of Block	Calculated	Provided			
	nos./sqm	nos./sqm	Volume	Total Volume	
0.40 m 0.30 m	7.03 11.11	7 11	0.448 0.297	0.745	creates 2 layer coverage
0.45 m 0.35 m	4.94 7.00	5 7	0.456 0.300	0.756	
0.50 m 0.40 m	3.60 4.69	3.5 4.5	0.438 0.288	0.726	

Geobag					
t = 0.75 m, Volume = 0.75 cum/sqm/m					
250kg (nos./sqm)		175kg (nos./sqm)		125kg (nos./sqm)	
Calculated	Provided	Calculated	Provided	Calculated	Provided
4.51	4.5	6.44	6.5	8.93	9

21. Protection through Adaptation Approach

A) <u>FRERMIP Approach :</u>

Protection work is done in three stage. This approach was used in Jamuna & Padma at Kukuria (15km), Enyatpur (7km), Benotia (3.50km) & Horirampur (4km).

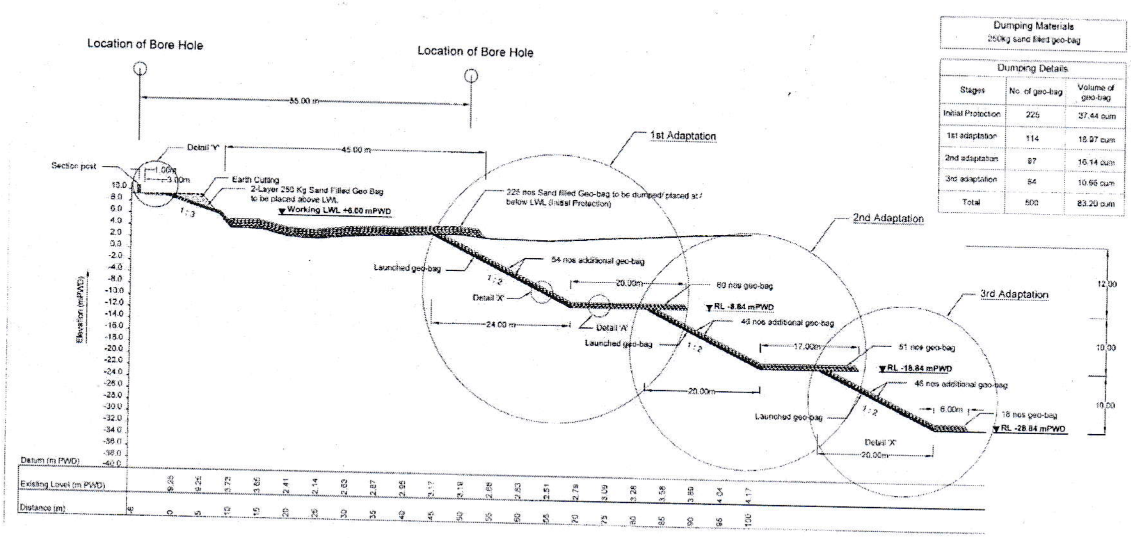
a) Initial Protection : On the basis of Calculated scour depth, quantity or amount of Initial protection work are determined. Initial Protection are done by Geobag.

b) Adaption Work : During design phase, on the basis of some assumption, quantity or amount of Adaption Work are determined. Adaption Work are done by Geobag.

From a study in JMREMP, it was found that the trends of scour of Jamuna are normally 10m in one year. Considering this phenomenon of 10m scour depth, an Adaptation plan was prepared for design Phase, for Jamuna. This approach may be followed for other rivers.

But actual Location, Quantity, Areal Coverage, Falling Apron will be finalized from field survey data when Adaptation will be needed. But it is a difficult job.

c) After completion of Adaption work,
   - 2 layer (or 0.50m) CC Block may be dumped, depending on site condition.
   - Pitching work by CC block above LWL shall be done.



Calculated Scour Depth = 35m from LWL

Scour Depth = 32m from existing bed level

Assume Scour in 3 stage, i,e 12 + 10 + 10 =32m

Stage 1 : Initial Protection :

D= Scour Depth from LWL

Width of Falling Apron = 1.5 D

T = Thickness, 5 layer Geobag

V = 1.5 D * (5 layer Geobag)

Stage 2 : 1st Adaptation :

D= 12m (assumed)
2-layer Areal Coverage over scoured slope = 2.24*12*2 layer
Assume Scour Depth for 2nd Adaption is 10m
Falling Apron = 1.5D = 15m + 2m (extra) =17m
Volume = 17*3 layer.

Stage 3 : 2nd Adaptation :

D= 10m
Areal Coverage over scoured slope, 2 layer = 2.24*10*2 layer
Assume Scour Depth for 3rd Adaption =10m
Falling Apron = 1.5D = 15m+ 2m (extra) =17m
Volume = 17*3 layer.

Stage 4 : 3rd Adaptation :

Assume, Calculated Scour Depth = 35m from LWL
Assume, Scour Depth = 32m from Present Bed Level

Depth needed to reach Final Scour Depth = 32 –(12+10) = 10m
Areal Coverage over scoured slope, 2 layer = 2.24*10*2 layer
provide additional Apron = 6m
Volume = 6*3 layer.

Note: ***Adaptation volume mentioned above are tentative one. Actual volume will be determined through field survey.***

Some important aspects Adaptation Work.

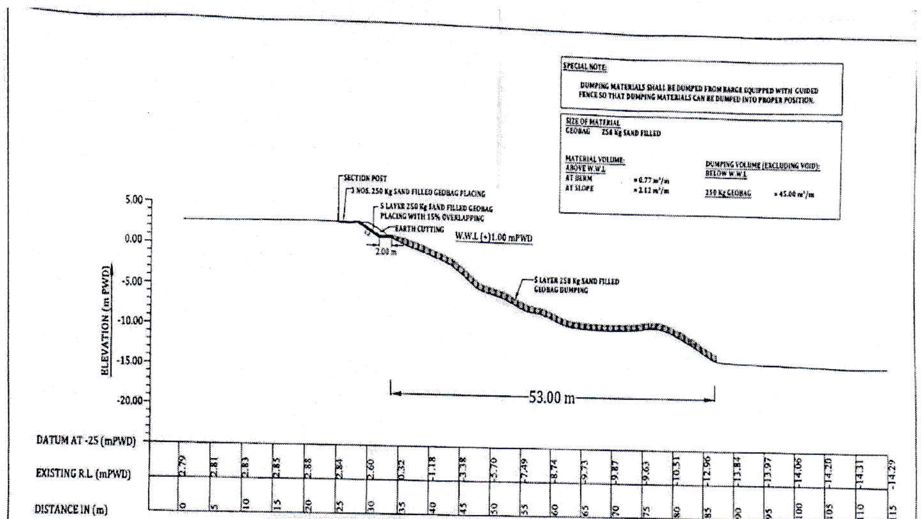
- Adaptation may be needed in second year or in third year and so on.
- In JMREMP, in Bera part (7km), which was completed on or before 2006, Adaptation not yet needed. This work still is in good condition.
- In JMREMP, in MDIP(11.40km), which was completed on or before 2006, Adaptation not yet needed. This work still is in good condition.
- In JMREMP, in Koijuri Part (10km), which was completed on or before 2006. Adaptation was needed, but could not be done, because of no project or no budget. The work is not in good condition.
- In FRERMIP, Trench 1, at Chouhali (5km), Horirampur (7km), Zafargonj (2km) Adaptation was needed, during first monsoon after completion and it was done. No remarkable damage observed during flood season of 2019 & 2020.

B) <u>River Stabilization Approach :</u>

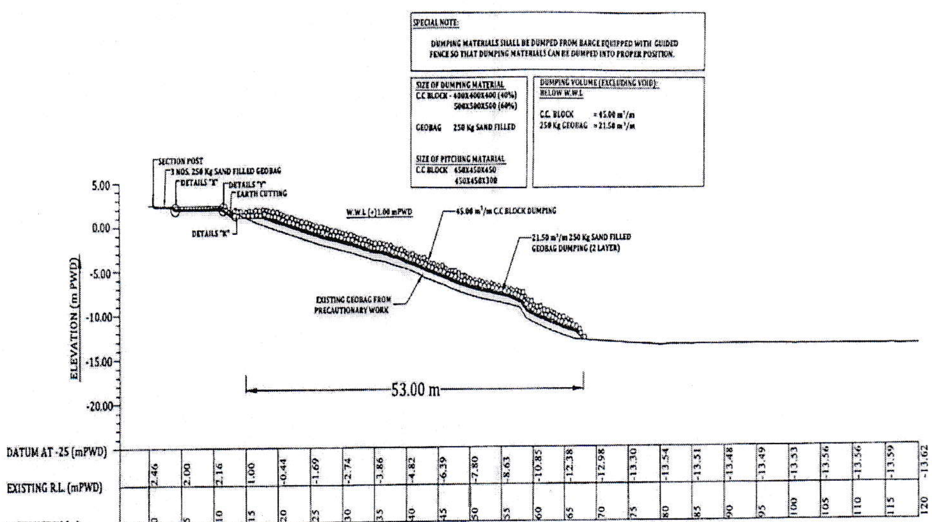
Protection work is done in two stage
To address the issue in a holistic approach.
When relatively a long reach is needed for Protection.
Time constraint for manufacturing of CC Blok is a major issue.
Fund or Budget constraint is also an issue.

This approach was used to address 26.40 km (in 5 spots) which will connect 60.44 km in the east coast of Bhola.

To encircle whole Manpura Island, for a length of 37.74km.



TYPICAL SECTION OF PRECAUTIONARY BANK PROTECTION WORK ALONG THE BANKLINE



CROSS SECTION AT Km. 74.790 (OLD Km. 77.100)
(LIMIT OF SECTION: FROM Km. 73.950 TO Km 75.500 IN BETWEEN EMBANKMENT= 1440m)

a) Initial Protection : On the basis of Calculated scour depth, quantity or amount of Initial protection work are determined. Initial Protection are done by Geobag.

   D= Scour Depth from LWL
   Width of Falling Apron = 1.5 D
   T = Thickness, 5 layer Geobag
   V = 1.5 D * (5 layer Geobag)

b) Adaption Work :

   - 2-layer Geobag, to address the anticipated damage of Geobag, if needed.
   - Under water dumping of 2 layers CC Block over Geobag.
   - Pitching work by CC block above LWL

22. Geotechnical Issues

a. Slope Stability Analysis : to determine stable slope above water & under water.

b. Above water : Normally used Slope is 1V : 2H
For Jamuna, Ganges & Meghna use 1V : 3H

i. If it is unavoidable to prepare the slope as stated above, then use bullah or other protection measure against slope failure.

ii. Always use Slope on Original Bank, by cutting earth.
iii. Avoid making slope on filled earth. If it is unavoidable, then use bullah or other protection measure against slope failure.

c. Under water : It is assumed that the material will launch on a Slope of 1V :2H

d. Provide Berm at LWL or 1.50 m below LWL. Width of Berm shall be at least 1.50m to 2.00m.

23. Seepage Issue

a. Fill up the diches on C/S with local earth at least for 50 to 100m, before ~~lope~~ start of pitching work.
b. Filter Gallery may be used.

24. Miscellaneous Issue

a. Compressive Strength of concrete of CC Block shall be 18 N/mm^2 for saline area and 12 N/mm^2 for Non-saline area.
b. Life Time of Geobag shall be minimum of 30/50/100 years.
c. Dumping shall be Complete by 30th April.
d. Dumping shall be done by Berge. A Dumping Plan shall be prepared.

e. 1 Layer Geobag with 15% overlapping on slope above WL as a precautionary measure to prevent Bank Line Shifting.
or, 1 Layer Geobag with geotextile on slope above WL as a precautionary measure to prevent Bank Line Shifting.

f. Top of pitching Block must match with GL. Top block shall not obstruct free drainage or shall not cause water logging.
g. 2 to 3 Geobag shall place at the Top end of Pitching Block, when Bank Line is subjected to submergence.

h. Excavated Earth of slope preparation shall not dump into river. It shall not be used to build key. Excavated Earth shall not heap along the Bankline. Key Shall not be constructed on Filled material.

i. Section post shall construct at each section at "Zero point of section or as shown in drawing". All Monitoring survey or survey for repairing or rehabilitation or adaptation, shall use this "Zero point".

j. Bathymetric survey shall be done from July to October at an interval of minimum 30days.

   Minimum 300m from bankline for Jamuna, Padma, Meghna, Teesta and coastal large river.

   Minimum upto thalweg, from bankline for other rivers.

k. No Dredging shall be done within 1.00km from the "End of Apron" and U/S & D/S End of Protective Work for Jamuna, Padma, Meghna, Teesta and coastal large river

   Location, length & alignment of dredging shall be selected carefully in consultation design office in the vicinity of Protective Work for other rivers.

l. Better to use the difference between the size of assorted dumping material is 100mm.

m. For pitching, 2 size CC block shall be used to act as wave breaker.

n. 1 layer Geobag with 15% overlapping or 1 layer Geobag over geotextile may be used above LWL for to prevent bank lline shifting, before manufacturing of pitching block or before completion of dumping.

o. Stockpile must be kept.

p. Work shall be started, preferably from U/S.
q. Khal Crossing or Armoring.
r. Recreational Area, Stair, Changing Room etc.
s. Harbor area and capstan.
t. Plantation.
u. KM Post, Section post, Sign Board etc.

25. Maintain a file for Hard Copy of design.
    Store all Soft copy. Create a Folder for individual "BWDB Division". Store all soft copy by creating a Sub-Folder under the name of each Project.

26. For Design, BWDB Design Manual, Text Book, Other manual etc. may also be followed.

(Md. Harun ur Rasheed)
Chief Engineer, Design
BWDB, Dhaka

Memo no-733/CE,D/-

Date : 09/11/2020

Copy forwarded for favour of kind information and necessary action to: -

1. ADG, Planning/East/West, BWDB, Dhaka.
2. SE, Design circle 1/2/4/5/6/7/8/9, BWDB, Dhaka. He is requested to circulate it among all EE, SDE, AE of his circle and attend the workshop/discussion on 10-11-2020 on conference Room, Level 5, Pani Bhaban.
3. CSO to DG, BWDB, Dhaka.

(Md. Harun ur Rasheed)
Chief Engineer, Design
BWDB, Dhaka