Government of West Bengal
Irrigation & Waterways Department
Jalasampad Bhavan, 3rd Floor, Western Block
Bidhannagar, Salt Lake City, Kolkata 700 091

Memo No. 36/8- IFC
IW/0/IFC-4M-30/2014

Dated, 15.02.2024

From: The Joint Secretary
to the Govt. of West Bengal

1. The Chief Engineer (South)
Irrigation & Waterways Directorate

2. The Chief Engineer (South-West)
Irrigation & Waterways Directorate

3. The Chief Engineer (North)
Irrigation & Waterways Directorate

4. The Chief Engineer (West)
Irrigation &Waterways Directorate

5. The Chief Engineer (Design & Research)
Irrigation & Waterways Directorate

6. The Chief Engineer (North-East)
Irrigation & Waterways Directorate

7. The Chief Engineer & Project Director (WBMIFMP)
Irrigation & Waterways Directorate

8. The Chief Engineer (Teesta Barrage Project)
Irrigation &Waterways Directorate

Sub: Making provision of use of brick block pitching/interlocked brick block pitching/dry brick pitching instead of Concrete block pitching/brick block pitching/dry brick pitching for protection of the severely eroding Sundarban Embankments as embodied in the Departmental "Guidelines on Riverbank Protection & Anti sea erosion works in West Bengal (2nd Revision)" under para 6.5.1& 6.5.2

Ref: 1 Memo No. 7M-1/19, dated 04.01.2024 of the Director, Central Design Office

2. Memo No. 7M-1/103, dated 31.01.2024 of the Director, Central Design Office

With reference to the above-mentioned subject, the undersigned is directed to enclose herewith the suggestion of the Central Design Office communicated vide memo under reference -1 &2 ,on use of brick block pitching/interlocked brick block pitching/dry brick pitching, instead of Concrete block pitching/brick block pitching/dry brick pitching for river embankments and sea dykes of Sundarban areas in North & South 24pgs and Purba Medinipur as provisioned at para 6.5.1 & 6.5.2 of the

Departmental "Guidelines on Riverbank Protection & Anti sea erosion works in West Bengal (2nd Revision)".

The undersigned is also directed to state that, henceforth for preparation of all design, drawing and framing of estimates and execution of works, the said suggestion of the Central Design Office should be followed in lieu of that mentioned at para 6.5.1. & 6.5.2 of the Departmental "Guidelines on Riverbank Protection & Anti sea erosion works in West Bengal (2nd Revision). For already submitted schemes to DLTC or Committee of CE's, the schemes may be returned back and resubmitted after incorporating the necessary changes as suggested of the Central Design Office stated above.

The Departmental guidelines will be amended accordingly and published shortly.

This will have effect from 16.02.2024. All concerned may be informed accordingly.

This issues with the approval of the Principal Secretary of this Department.

Enclo: As stated

Sd/-
(B. Mukhopadhyay)
Joint Secretary to the
Government of West Bengal

Memo No. 36 /1(3)–IFC Dated: 15.02.2024

Copy forwarded for information to:

1. P.S. to Hon'ble Minister-In-Charge
   Irrigation & Waterways Department

2. Sr. P.A. to Principal Secretary
   Irrigation & Waterways Department

3. Financial Advisor
   Irrigation & Waterways Department

Sd/-
(B. Mukhopadhyay)
Joint Secretary to the
Government of West Bengal

Memo No. 36 /2(1)–IFC Dated: 15.02.2024

Copy forwarded for information to:

1. The Executive Engineer
   DVC Study Cell & Nodal Officer, I & W Dte

He is requested to upload the order in the Departmental Website with subject as Guidelines on Riverbank Protection & Anti sea erosion works in West Bengal (2nd Revision)

(B. Mukhopadhyay)
Joint Secretary to the
Government of West Bengal

Office of the Director of Designs
CENTRAL DESIGN OFFICE
(An ISO: 9001 – 2015 Organisation)
Irrigation & Waterways Directorate
Government of West Bengal
JalasampadBhawan (1st Floor), Kolkata-700 091
e-Mail: cdoiwdwb@gmail.com

Memo No. 7M-1 /103 Dated, Kolkata, the 31st January, 2024

From: - Director of Designs.
Central Design Office, I & W Dte,
Salt Lake, Kolkata – 700091.

To: - The Secretary,
Irrigation and Waterways Dept.,
Salt Lake, Kolkata – 700091,
Govt. Of West Bengal.

Sub.: Modifications of River protection manual of I&WD related to protection of banks and Embankments in Sunderban.

Ref.: This office memo no. 7M-1/19 dated 04-01-2024.

.Sir,

In continuation of the above cited memo we are enclosing a revised draft proposal in 8 pages on coastal protection zone Sundarbans to replace the related pages of the manual (Page No. 41 to Page No. 49 copies also attached herewith) for your approval. Further revisions are made as suggested by the C.E. (South) and S.E. (Eastern Circle).

Thanking you,

Enclo: 1) Draft copy of the revised proposal in 9 pages.
2) Copy of the relevant replaceable pages of the existing River Protection Manual in 5 pages.

Your's faithfully,

(G. C. SADHU)
Director of Designs
Central Design office

Memo No: 7M - 1 / 103/1 Dated, Kolkata, the 31st January, 2024

Copy with copy of above stated enclosures submitted to The C.E. (D&R) for his kind information.

Enclo: 1) Draft copy of the revised proposal in 9 pages.
2) Copy of the relevant replaceable pages of the existing River Protection Manual in 5 pages.

(G. C. SADHU)
Director of Designs
Central Design office

6.5. Zone E: Sundarban areas in North & South 24-Parganas and Sea dykes in Purba Medinipur away from coastline

6.5.1. District covered: Parts of North & South 24-Parganas and Purba Medinipur

Embankments

Protection: Type E1

Description: Brick block pitching (530mm thick) / interlocked brick block pitching (250 thick) /dry brick pitching on river or seaside slope over conventional filter with toe walls as per Fig. 33 with dimensions as per Table 11.0.

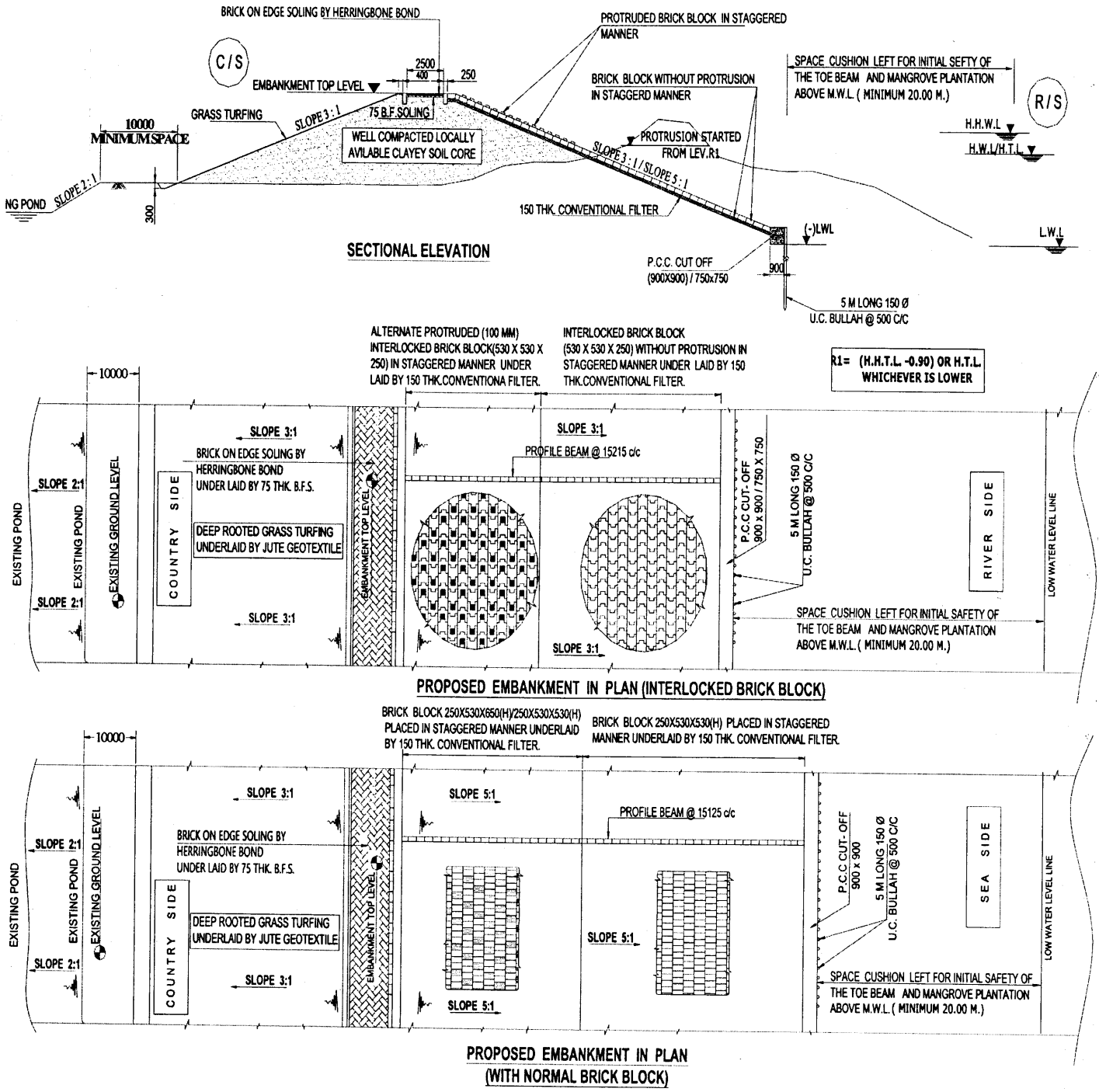


Fig. 33: Bank Protection Type-E1 (*For zone* E)

Table – 11.0

Sl. No.	River / Sea	Type of pitching	Thick-ness of pitching (m)	Pitch-ing Slope H:V	H_s (m) and T (Sec)	Design crest level of embankment (DCL)					Toe wall descript-tion
						HWL /HTL Z_0 (m)	Wave run up $Z_{2\%}$ (m)	Settle-ment S (m)	Free board f (m)	Total Z (m)	
1.	Sea facing dykes (Extent of this type sea facing protection work to be decided by Engineer-in-charge)	0.25m x 0.53m x 0.53m brick blocks pitching over 150 mm conventional filter. **(Read note 8)**	0.53	5:1	1.871m and 5.019 sec	Note-1	2.13	0.30	0.5	2.93 + Z_0	1:1.5:3 PCC toe wall (0.0.90m x 0.90m), of cast in situ with bullah at vertical outer face 5m @ 0.5m c/c.
2.	River embankment facing or near sea within 7 km upstream of confluence of river with sea	0.53m x 0.53m x 0.25m interlocked brick blocks pitching over 150 mm conventional filter. **(Read note 9)**	0.25	5:1	1.298m and 4.073 sec	Note-1	1.38	0.30	0.5	2.18 + Z_0	– do –
3.	River embankment beyond 7 km from sea and aligned more or less in north-south direction	0.53m x .53m x 0.25m interlocked brick blocks pitching over 150 mm conventional filter. **(Read note 10)**	0.25	3:1	1.075m and 3.746 sec	Note-1	1.85	0.30	0.3	2.35 + Z_0	1:1.5:3 PCC toe wall (0.75m x 0.75m), of cast in situ with bullah at vertical outer face 5m @0.5m c/c.
4.	River embankment beyond 7 km from sea and aligned more or less along east-west & minor creeks / channels.	Dry brick pitching over 100mm thick filter cum leveling course. **(Read note 11)**	0.20/ 0.325	3:1	0.885m and 3.342 sec	Note-1	1.44	0.30	0.2	1.94 + Z_0	PCC toe wall (0.60m x 0.60m), of cast in situ.

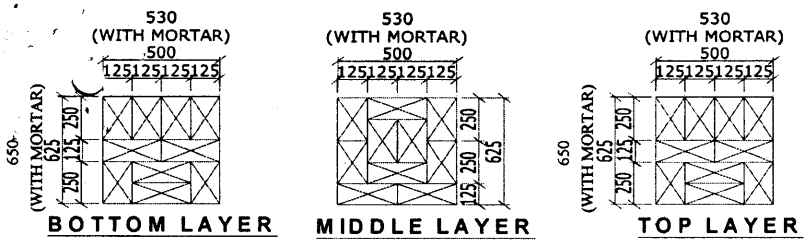
Note: A. Interlocking / normal brick block may be provided on slope for Sundarban regions. Shape as decided and shown. Bricks shall be of 1st class kiln burnt bricks having crushing strength not less than 10.5Mpa, should absorb water greater than 20% of its dry weight when immersed in water for 24 hrs, metallic sound come out when stuck together, shall develop no impression when scratched with fingernails. They must be prepared having cement: sand mortar in proportion of cement: sand 1:4.

B. Herring bone bond may be allowed in embankment top under laid by BFS for Sundarban regions.

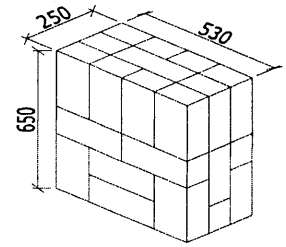
C. Depending on the design, the embankment top level may be lower than the design level with a maximum rate of overtopping **1 l/m/s.** Accordingly, the countryside shall be protected by good grass cover under laid by Jute Geotextile.

D. Profile beam or separator beam shall be provided not less than @15.125m c/c for sl. no 1 and 4 and not less than @15.215 m c/c for sl. no. 2 and 3 respectively.

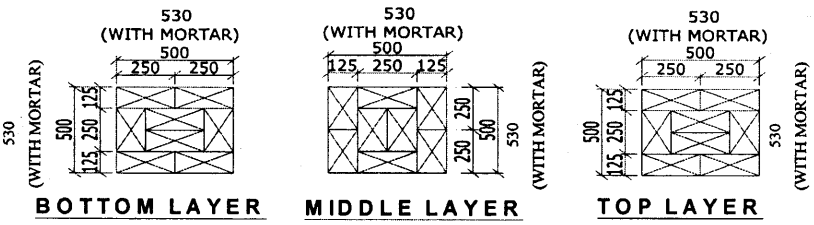
E. Where, there is a pond in the countryside minimum space of 10m shall be left from country side toe of the embankment at the average country side GL and accordingly pond need to be filled up.



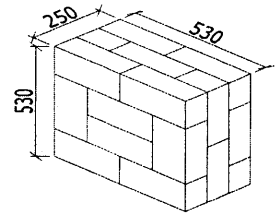
DETAILS OF BRICK BLOCK (530x250x650(H)) (3 LAYERS IN PLAN)



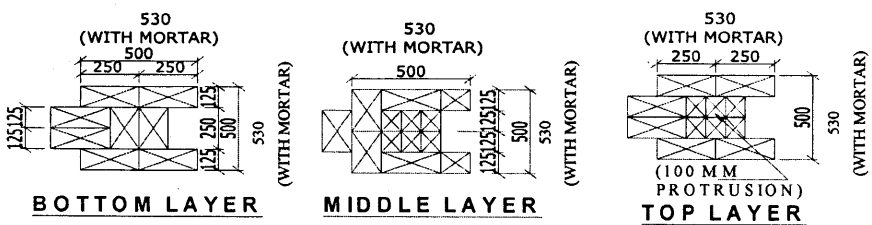
BRICK LAYERS IN BRICK BLOCK 530x250x650(H) (SINGLE UNIT BY 30 NOS. BRICKS)



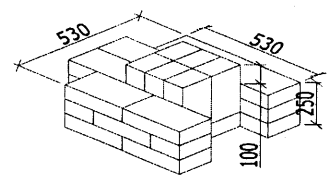
DETAILS OF BRICK BLOCK [530x250x530(H)] (3 LAYERS IN PLAN)



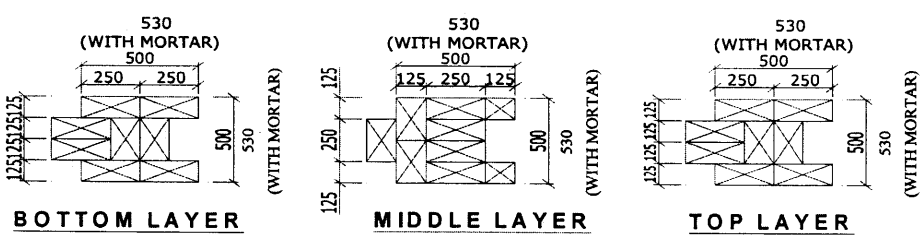
BRICK LAYERS IN BRICK BLOCK 530x250x530(H) (SINGLE UNIT BY 24 NOS. BRICKS)



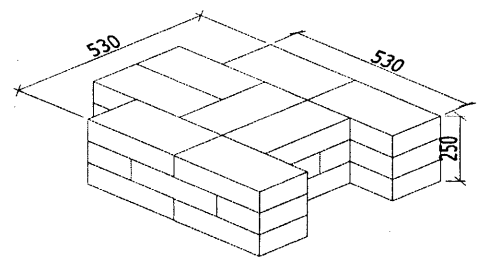
BRICK BLOCK WITH 100 MM PROTRUSION (3 LAYERS IN PLAN)



BRICK LAYERS IN INTERLOCKING BRICKS BLOCKS WITH 100 MM PROTRUSION. [530x530x250(H)] (SINGLE UNIT BY 26 NOS. BRICKS)



BRICK BLOCK WITHOUT PROTRUSION (3 LAYERS IN PLAN)



BRICK LAYERS IN INTERLOCKING BRICK BLOCK [530x530x250(H)] (SINGLE UNIT BY 24 NOS. BRICKS)

Fig. 34: Normal and interlocking Brick Block (*For zone* E)

Note: 1. HWL / HTL value to be considered at a particular location as per available data.

HTL / HWL and LTL / LWL may be obtained by observing water levels for every one hour for 24hours at full moon day, 8th day after full moon day, new moon day, and 8th day after new moon day. This observation shall be carried out for two seasons (summer and monsoon) at all intervention sites. The highest water levels among the all levels shall be taken up as HWL / HTL.

2. The value of wave run up, '$Z_{2\%}$', calculated (sl. No. 1, table 11) conforming dyke and revetment manuals Netherlands as follows. **The significant wave height, wave period, and wave run-up may be determined from table 11.0 if fetch length and design wind speed data are not available.** Settlement and free board shall be followed from table 11.0 as per the guidelines of Netherland and Euro top manual.

Calculation of Breaker Index on Slope

$\xi_0 = tan\alpha/sqrt(s_0)$, (For wave hitting the revetment perpendicularly) ..... eq. (1)

Where, ξ_0 = Breakwater parameter = 0.91696

α = Angle of slope = 1(v):5(h) = $tan\ \alpha$ = 0.20

s_o = wave steepness = $2.\pi.H_s/(g.t^2_{m-1,0})$= 0.04757

$t_{m-1,\,0}$ = Spectral wave period = T 5.019 sec

L = wave length = $(g.\ t^2_{m-1,0})/(2.\ \pi)$ *or* $H_s/\ s_o$ = 40 meter (Approx.)

H_{m0} *or* H_s= Design significant wave height = 1.871 m
g = Acceleration of gravity = 9.81 m/s^2
Calculation of significant wave height / design wave height and time period from the following formulae:

$$\frac{gH_s}{u^2} = 0.283 \tanh\left[0.530\left(\frac{gd}{u^2}\right)^{0.750}\right] \tanh \frac{0.0125\left(\frac{gF}{u^2}\right)^{0.42}}{\tanh\left[0.530\left(\frac{gd}{u^2}\right)^{0.750}\right]} \quad \text{eq. (2)}$$

$$\frac{gT}{u} = 2\pi .1.2 \tanh\left[0.833\left(\frac{gd}{u^2}\right)^{0.375}\right] \tanh \frac{0.077\left(\frac{gF}{u^2}\right)^{0.25}}{\tanh\left[0.833\left(\frac{gd}{u^2}\right)^{0.375}\right]} \quad \text{eq. (3)}$$

Here, u = Design maximum wind speed (** refer note) 33m/s
F = Fetch length, generally it is taken 10km 10000m
d = Depth of water near toe from HTL 8m (maximum)
H_s = Significant wave height in meter
T = Spectral wave period in sec = $t_{m-1,0}$
Note: ** Last storm event happened in West Bengal Amphan over Sundarban was about 150 KM/Hr we take 80% of this wind speed i.e. 120 km/hr or 33.33m per sec.
From Eq (2), gH_s / u^2 = 0.017
H_s = 1.871 m
From Eq (3), gT / u = 1.492
T = 5.019 sec
For calculating the wave run up $z_{2\%}/H_s = 1.65 \times \gamma_b \times \gamma_t \times \gamma_\beta \times \xi_0$ eq. (4)
with a maximum value of $z_{2\%}/H_s = \gamma_t \times \gamma_\beta \times (4\text{-}1.5/\text{sqrt}(\xi_0))$ eq. (5)
Where, $z_2\%$ = 2% wave run up above still water line.
γ_b = Influence factor for a berm (Here, no berm) so, $\gamma_b = 1$
$\gamma_\beta = (1\text{-}0.0022 \times \beta)$ for $\beta < 80^\circ$
$\gamma_\beta = (1\text{-}0.0022 \times 80)$ for $\beta > 80^\circ$
$\gamma_\beta = (1\text{-}0.0022 \times 80) = 0.824$ (influence factor for angled wave attack), as ($\beta > 80^\circ$)
(The angle of wave attack is defined as the angle between the direction of propagation of waves and the perpendicular to the axis of the dyke, here $\beta^\circ = 87.5^\circ$, however it may be changed as per site condition)
γ_t or γ_f= Influence factor for roughness elements on slope (As protrusion is there so we may take it as per the following formulae as per the Euro top manual)
Height of protrusion, f_h = 120mm
Our case we provide 530 x 250 protrusions 1 after 3rd block (i.e. 25% area) over 530 thick brick block pitching in sea facing embankment.
Now, γ_t or $\gamma_f = 1 - (1-\gamma_{f,min}) \times f_h / (0.15 \times H_s)$, *for,* $f_h / H_s < 0.15$ .....eq. (6)
Protrusion size = 530 x 250 = 0.1325 m^2
Original block size = 530 x 250 = 0.1325 m^2
Protruded block / total surface area = (0.1325) / (0.1325x4) = 0.11792
$\gamma_{f,min}$ = (from EurOtop manual pg 120) 0.80
From Eq (6), γ_t or γ_f = 0.914
Hence, $z_{2\%}$ = 2% wave run up above still water line = 2.13m
(Calculated from equation 4)
$z_{2\%\ max}$ = (refer eq. 5) 3.42m
In order to fixing the design crest level, the wave run up should be added to the highest still water level i.e. HWL/HTL along with free board and settlement. Depending on site requirements, the design level may be lower than the above standard if overtopping and appropriate country-side protections are considered.

3. The rate of overtopping calculated as per the following procedure conforming dyke and revetment manuals Netherlands.

$$\frac{q}{\sqrt{gH_s^3}} = \frac{0.067}{\sqrt{\tan\alpha}}\gamma_b\xi_0 . \exp\left(-4.3\frac{R_c}{H_s}\frac{1}{\xi_0\gamma_b\gamma_f\gamma_\beta\gamma_v}\right) \quad \text{.....eq. (7)}$$

$$\frac{q}{\sqrt{gH_s^3}} = 0.2.\exp\left(-2.3\frac{R_c}{H_s}\frac{1}{\gamma_f\gamma_\beta}\right) \quad \text{.....eq. (8)}$$

R_c = Difference between embankment top and Maximum still water level

Proposed embankment top = 7.2m

HTL = (Actual HWL for each site shall be obtained as per the methodology mentioned in the Note 1) = (here assumed) 4.2m

Hence, $R_c = 7.2 - 4.2$ = 3.0m

Hence, $q = a.exp\ (b.R_c)$ = (Ref eq. (7)) 0.01 l/s/m

Where, a = 1.097, b = -3.74

(The factors $\gamma_b, \gamma_b, \gamma_f, \gamma_\beta$ shall be taken from the same calculation mentioned in wave run up)

For calculating maximum limit, $q = a.exp\ (b.R_c)$ as in Eq. (8)

Where, a = 1.603, b = -1.828 and q = 6.7 l/s/m

γ_β = (1-0.0033 x β) for $\beta<80^\circ$, the value β varying from site to site, here, 87.5°

γ_β = (1-0.0033 x 80) for $\beta>80^\circ$ here, $\gamma_\beta = 0.736$

As per the Dutch guidelines

1. Overtopping rate equals or less than 0.1 l/s per m requires sandy soil with poor grass cover.
2. Overtopping rate equals or less than 1 l/s per m require clayey soil with good grass cover.
3. Overtopping rate equals or less than 10 l/s per m requires armored inner slope.

.Thickness of revetment by (Pilarzyke method)

In order to avoid uplift of revetment thickness of revetment, $H_s/(\Delta\ X\ D) \leq F\ X\ Cos\alpha/\xi^b$

H_s = significant wave height at the toe of the revetment

Δ = Relative mass density of the pitching

D= Thickness of cover layer (Interlocked or normal Brick Block revetment)

F = Factor for various types of revetments = $\psi_u\ x\ \phi$ =2 x 2.25

b = Exponential to breaker parameter = 0.67 assumed value

4. If designed Crest Level (DCL) cannot be attained due to space constraint, rate of overtopping shall be calculated and accordingly countryside protection shall be provided.

5. In case of protection work in Sundarban, if the foreshore berm length less than 50metres double layer of tied (two rows at bottom layer and one row at top layer) porcupine cluster along the bank line are to be placed along the entire length of zone of protection (except for the work under serial no 4 of the table 11.0, where porcupines are not required). Each cluster having a length of 25metre (vertically two layers) and @ 32 cages. Spacing of the adjoining cluster being 7.5m centre to centre. Assessment of length of zone of use of porcupine cages is to be made from the available survey data. The area to be covered by porcupine shall be decided as per survey data. However, provision of porcupine may be decided by the Engineer-in-charge as per site vulnerability.

6. In case of historically subsidence prone areas where brick blocks are being lifted due to wave action, placement of double row of bullah filled with locally available bush needs to be considered as the wave breaker in the sea / riverside of the protection work as shown below. Plantation of mangrove shall also be started in staggered manner with proper protection of propagules at the foreshore for considerable reduction of the wave action.

7. In case of river or sea where sufficient foreshore are available and considerable

erosion has been observed for last few years, silt trapping unit using bamboo or bullah (where wave thrust is high, say in sea dyke bullah shall be considered and where wave thrust is less, say in river dyke bamboo shall be considered) need to be made as shown in the following fig 36.

8. For sea facing dyke (sl. no 1 of table 11) pitching will be done by 0.25 m x 0.53 m brick block of thickness 0.53 m. Protrusion of 120mm should be provided above HTL covering maximum 25% surface area of the pitching. Country side should have a slope of 1(V):3(H) covered by good grass turfing along with plantation of Acacia nilotica (gum arabic/desi babla/babul) like trees. Foreshore protection work by mangrove plantation, STU, or permeable spurs shall be undertaken as per site suitability.

9. For Sl. No. 2 of table 11 pitching will be done by 0.53 m x 0.53 m interlocked brick block of thickness 0.25 m protrusion of 100mm should be provided above HTL covering maximum 12.5% surface area of the pitching.

10. For Sl. No. 3 of table 11 pitching will be done by 0.53 m x 0.53 m interlocked brick block of thickness 0.25 m protrusion of 100mm may be provided above HTL covering maximum 12.5% surface area of the pitching. The requirement of protrusion may be decided by The Engineer-in-charge.

11. For Sl. No. 4 of table 11 pitching will be done dry brick pitching without protrusion.

12. For all the cases mentioned from sl. no. 7 to 11, countryside should have a slope of 1(V):3(H) covered by good grass turfing with plantation of Acacia nilotica-like trees under laid by jute-geotextile, if necessary. Foreshore protection work by mangrove plantation (mangroves like Avicennia or Baen, Rhizophora or Goran), STU (Silt trapping unit), or permeable spurs shall be undertaken as per site suitability for all embankment constructions.

6.5.2. Embankment Protection: Type E2 (Supplementary to or rehabilitation of Type E1, Foreshore Protection by Nature based solutions).

Description: A foreshore is the section in front of embankment and can be horizontal or up to a maximum slope of 1(V):10(H) and having a minimum length of one wavelength. Where foreshore berm length is less than the wave length under storm (50metres) porcupine cages may be dumped as per site suitability (except for the work under serial no 4 of the table 11.0, where porcupines are not required). Mangrove (Avizinia, rizhopora) plantation along with suitable protection of propagules above the MWL i.e. mean water level (average of HTL and LTL) shall be carried out in staggered manner while the permeable spurs are to be made in the soil level below the mean water level and may be extended up to the LWL as per site condition. Below LWL porcupine may be dumped if required. Details survey is required for each of this case. Spacing and length of the spurs depend upon the vulnerability of the foreshore and may be consulted with CDO if required. Generally spacing is equal to 1.5xL is recommended where; L is the length of permeable spurs. Permeable T spurs shall be made with two layers of bamboo or bullah pins (generally 2/3 embedded

and 1/3 length exposed) filled with locally available bush or locally available invasive species. If the foreshore berm level is less than MWL then double rows of bullah and bamboo may be driven at the foreshore as per Fig. 36 as a silt trapping unit. Terracotta rings can also be used as silt trapping unit as shown. The bamboo spurs shall be used in the less vulnerable area i.e. for river foreshore whereas bullah spurs shall be used where wave attack is high i.e. near sea. Country side slope (3(H):1(V) slope) shall be protected by good grass cover under laid by jute geotextile along with plantation of Acacia nilotica like trees.

Note: The Nature Based anti erosion/ silt arresting Solution like porcupines, silt trapping unit (STU) made of bamboo, bullah, brush wood etc. need to be maintained/nourished for a period of about 5 years after their original construction, and status of those is to be monitored periodically. Suitable provision in the DPR may be made for this purpose.

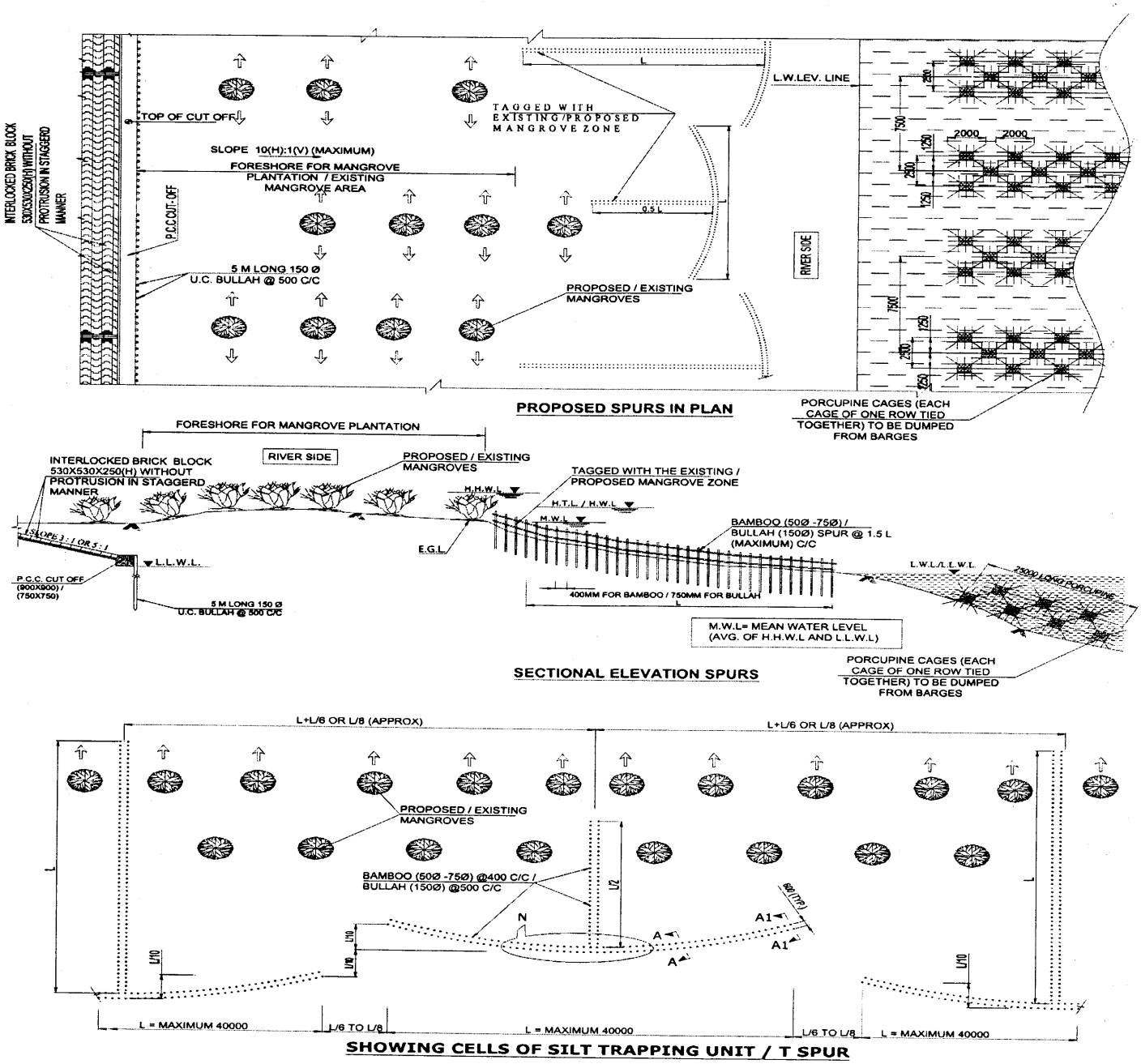


Fig. 35: Foreshore protections with curved T Spurs and Mangroves (*For zone* E)

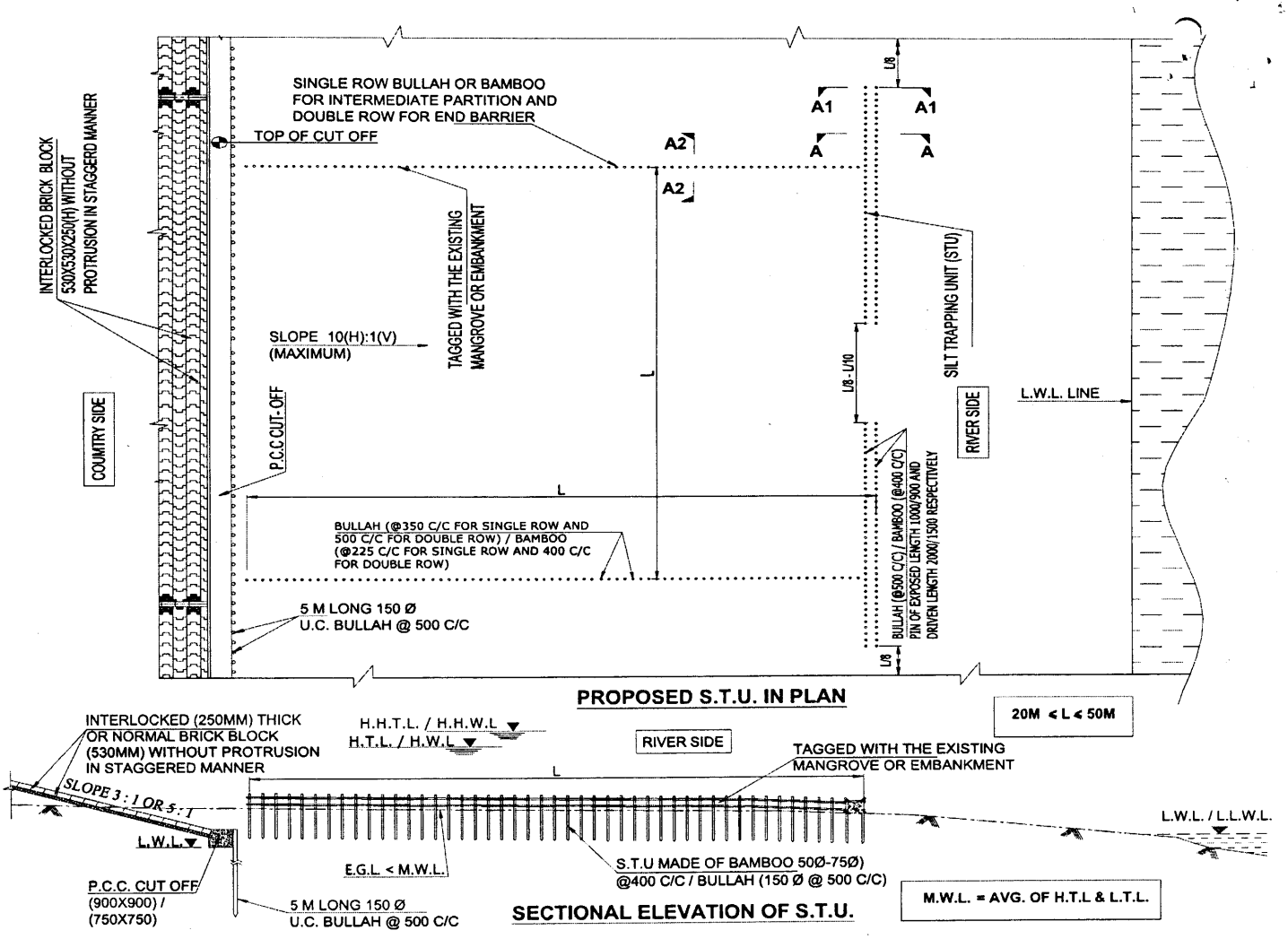


Fig. 36: Foreshore protections with silt trapping unit (*For zone* E)

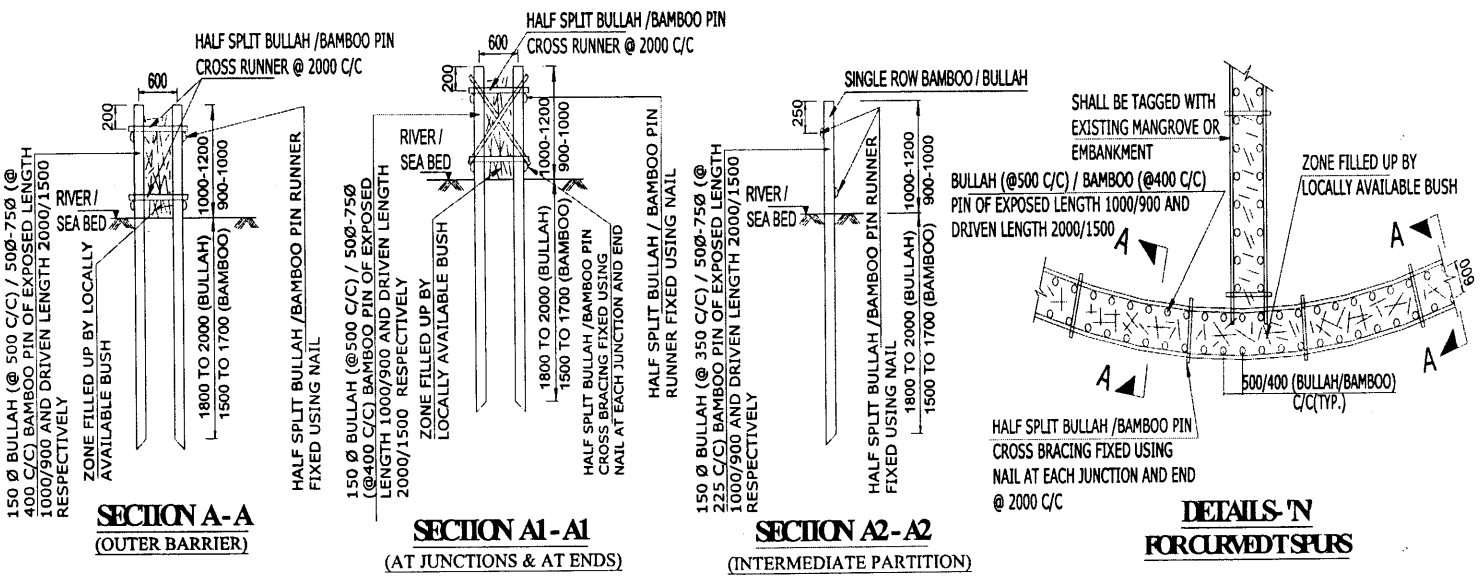
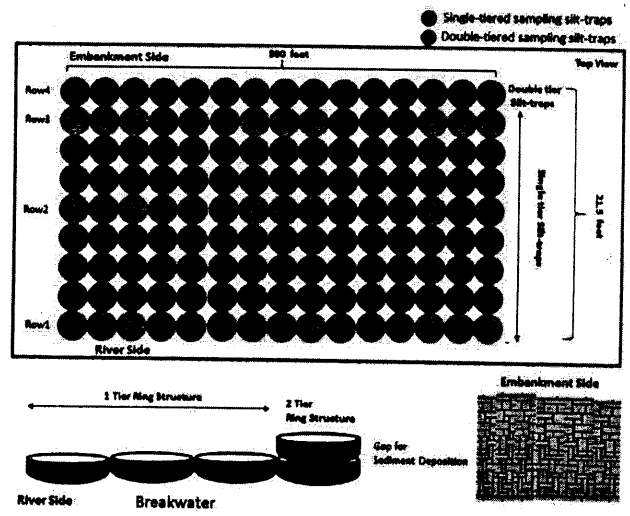


Fig. 37: Section details of silt trapping unit / curved T spurs (*For zone* E)



Teracotta rings may be used as silt trapping unit