RCC PORCUPINES AN EFFECTIVE RIVER BANK PROTECTION MEASURE – A CASE STUDY OF PROTECTION OF MAJULI ISLAND

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Synopsis

The Majuli Island is the largest inhabited riverine island in the world and seat of 15th century Vaisnavite culture and religious traditions. The island is located in the upper reaches of the river Brahmaputra between intake point of Kherkatia-Suti in East and outfall of Subansiri river in the West in Jorhat district of Assam. The island extends for a length of about 80 km along the East West and about 10 to 15 km wide along North South direction. The most important problem that threatens the very existence of this island and the life and property of its inhabitants is the constant and extensive erosion of land by mighty Brahmaputra, the Subansiri and Kherkatia-Suti. The island is reported to be under severe erosion since 1950, when a major earthquake occurred in the region. It has lost about 370 sqkm of its area due to flood and erosion since then.

Protection of river banks is a part and parcel of river training works. Permeable structures in the form of RCC porcupine screens/spurs/dampeners are a cost effective alternative to the impermeable bank protection works for the rivers carrying considerable amount of silt. RCC porcupine is a prismatic type permeable structure, comprises of six members of made of RCC, which are joined with the help of iron nuts and bolts.

Permeable screens, spurs, dampeners are the main type of permeable structures in vogue. Prima facie, the purpose, overall behavior and layout of the above mentioned structures can be compared to those of submersible bunds, groynes and revetment respectively. The permeable structures can be used either independently or with a support of other impermeable boulder structures or river training and bank protection measures. Depending upon the purpose, the permeable structures (RCC porcupines) may be constructed in transverse or parallel to direction of flow.

The paper gives an overview of the Permeable structures in the form of RCC porcupines for bank protection measures and their successful application at Majuli Island.
Keywords: Porcupine, riverine island, river training, permeable screens.

1.0 INTRODUCTION

The world's largest riverine island, "Majuli" is located in the central region of the Brahmaputra Basin and is bounded by river Brahmaputra, river Subansiri and river Kherkutia Suti. The Majuli lies in the upper reaches of the river Brahmaputra to the north of Jorhat town, Assam at a distance of about 20 km and lies between latitudes $26^0 45'$N to $27^0 10'$N and longitudes $93^0 40'$E to $94^0 35'$E.

The island extends for a length of about 80 km along the east west and is about 10 to 15 km wide along north-south direction. The population of Majuli Island is approx 1.50 lakh. As per the study conducted by the Brahmaputra Board, the area of island has been reduced from 733.79 sqkm (in year 1914) to 506.37 sqkm (in year 2008) due to erosion. It was the nerve center of Vaishnavite culture development during the unique Vaishnava Satra system founded by the great saint Sri Sri Sanhardeva in the 15th century. It is still the centre of Vaishnavite culture. The island is an administrative sub-division of Jorhat district. About 70% of its population belongs to tribal communities such as Mishing, Deuri, Kachari and Koch-Rajbongsi.

Majuli being a river island, flood is a regular phenomenon in every monsoon. Flood inundation and constant bank erosion threatens the existence of this island. Flood protection measures in the form of embankments, spurs, studs sal balli permeable spurs, bamboo porcupines and cribs, etc. have been used to protect the island in the past.

Recently, RCC porcupines in the form of studs, spurs & revetment have been successfully used to control bank erosion. These are innovative in nature particularly with respect to their low cost, ease in construction and implementation, long sustainability and least adverse effects on river regime and adjoining areas.

2.0 PROBLEM

Majuli island has two problems, namely, flood inundation and bank erosion.

Floods are commonly occurring annual feature of the Majuli Island. During the Monsoon period a large part of Island is inundated by the spill waters of the Subansiri and the Brahmaputra rivers when they are in high spate. After the great earthquake of 1950, river Brahmaputra has caused tremendous damages in the upper reaches of the island due to flood and erosion.

Apart from inundation of area due to flood water, bank erosion is another major problem faced by the island. Bank erosion, in particular has caused a considerable damage to the Island. According to the census of 1971, the geographical area of the island (including some chars or chaporis) was 924.60 sqkm as against its earlier extent of 1246 sqkm during 1950 reported in the records of revenue. Prior to the great earthquake of 1950, erosion problem at Majuli was reportedly not so acute. It has become more serious after the flood of 1954 and since then erosion has become a common feature on both sides of the island. Bank erosion at Majuli Island is mainly due to the instability of the river behaviour in this region. Changes in river channel taking place in the river Brahmaputra and its tributaries are quite dynamic. It has been noticed that bank erosion occurs during the receding stage of the floods when excess sediments are deposited as sand bars with the channel causing the change of flow direction.

The Summoimari spill channel originating from the Brahmaputra River from Bessamora to Dakhinpat and then up to Kamlabari is causing serious bank erosion on the southern side of the Brahmaputra dyke since 1990. In August, 93, the channel breached the dyke at 5^{th} km for a length of 2.6 km. The channel then shifted towards Tuni river and joined it in 1994 and flooded area around Kamlabari township. During the floods of 1997, 1998 and in 2003 the erosion continued in the Kamalabari Kaniajan reach. The Water Resources Department, Government of Assam has taken flood control and Anti-Erosion measures from time to time, however the problem continued.

3.0 EXISTING WORKS

To contain the floods, construction of embankment was introduced in the island during 1952-53. Embankments were constructed on the island with the available hydrological data and the topographical surveys. The embankments constructed earlier were breached on number of occasions. A total of 155 km of embankments were constructed, however, at present only approximately 90 km of embankments exist.

4.0 MASTER PLAN FOR MAJULI ISLAND

Brahmaputra Board: The Government of India has set up an autonomous body namely Brahmaputra Board under the Brahmaputra Board Act, 1980 to carry out mainly Surveys and investigations in the Brahmaputra valley and prepare a Master Plan for the control of floods and bank erosion in the Brahmaputra valley.

The Brahmaputra Board had prepared a Master Plan for development of Majuli Island which inter-alia included measures for flood control, erosion control & drainage improvement. This Master Plan was approved by the Government of India in Feb 2004.

5.0 RCC PORCUPINES AS EROSION CONTROL/PRO-SILTATION MEASURES

Concept: Protection of banks is a part and parcel of river training works. This protection comes under Anti Erosion works. Permeable structures envisaging construction of RCC porcupine screens/spurs/ dampeners are a cost effective alternative to the impermeable bank protection works for the rivers carrying considerable amount of silt. RCC porcupine is a prismatic type permeable structure, comprises of six members of made of RCC, which are joined with the help of iron nuts and bolts.

Permeable screens, spurs, dampeners are the main type of permeable structures in vogue. Prima facie, the purpose, overall behavior and layout of the above mentioned structures can be compared to those of submersible bunds, groynes and revetment respectively. The permeable structures can be used either independently or with a support of other impermeable boulder structures or river training and bank protection measures. Depending upon the purpose, the permeable structures (RCC porcupines) may be constructed in transverse or parallel to direction of flow. Typical sketch of a RCC porcupine is as given at Fig.-1.

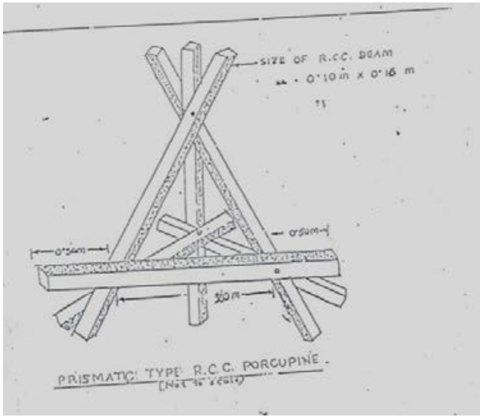

Fig. 1: Typical sketch of RCC porcupine

Dampening of velocity is achieved by using the permeable structures. If the flow is sediment laden, siltation is induced in the slack flow region and the channel is shifted away from the protected reach.If the flow is not carrying the sufficient sediments, only dampening of velocity can result. Sedimentation may not be achieved near the protected reach.

Only partial obstruction to the flow of about 15 to 20% only is envisaged in the design. Higher obstruction causes more diversion of flow resulting in undesired scouring around the proposed structures, particularly at the nose portion. Additional protection to the nose and flanks is required to avoid such scour. Therefore, obstruction more than 20% is avoided. Submergence of RCC porcupine screens/spurs/ dampeners is kept upto 50% of depth of flow. For example, single layer of RCC porcupines is sufficient for depth of water till 6 m.

Functions: Permeable structures in form of RCC porcupines serve one or more of the following functions:

(a) Training the river along the desired course.
(b) Reducing the intensity of flow at the point of river attack.
(c) Creating a slack flow to induce siltation in the vicinity of the permeable structures and in the d/s reach.
(d) Providing protection to the bank by dampening the velocity of flow along the bank.

Structural elements of RCC porcupines: The elements used in the RCC porcupine screens/spurs are as under:

(a) Members/Elements: The porcupines are made of RCC members/elements. These members are casted in-situ at the site or location near the site. Generally, six members are used to construct one porcupine. The size of one member is kept as 3m x 0.1m x 0.1m or 2m x 0.1m x 0.1m. These members are joined with the help of Nails.
(b) Nails: Standard commercially available nails of length 100 mm to 150 mm are used to join the porcupine members. Double nailing at critical joints may be provided.
(c) GI Wire: 4 to 5 strands of 4 mm GI wire should be sued for inter-connecting the porcupines and may be anchored with the ground. Alternatively, 12 mm 3-4 strands wire ropes should be used for the interconnecting the porcupines.

Use of nylon ropes instead of GI wires may also be tried. But these are susceptible to disintegration in presence of UV rays. In view of this, UV stabilized nylon ropes may be tried instead of GI wires due to their better usability and flexibility and non-corrosive behavior.

Protection to the permeable structures: As it is evident that members of the RCC porcupines may be tied using the preferably GI wires to withstand the high velocity and other materials like broken tree planks etc. Following points may be kept in the mind while providing the RCC porcupines.

(a) The elements ie. RCC porcupine members may be tied with each other by GI wire or Nylon ropes (UV stabilized). The tie ropes may be duly anchored to the bank and at the nose with the help of suitable anchor. Depending upon the length of the screen/spur/dampeners, intermediate anchors may be provided at an interval of 15 m to 20 m along the length of structure on u/s side.
(b) No bed protection is needed for the RCC porcupine structures. Sinking of these structures in riverbed is a welcome feature, which adds up to the stability during floods resulting in better performance.
(c) In order to divert the flow and reduce pressure on the RCC porcupine works, wherever feasible, pilot channels should be provided in additional to the river training works.

Economic cost of the RCC porcupines: The cost of bank protection against erosion using the RCC porcupine is very less as compared to the other structures like solid spurs or bank revetment. Generally, construction cost per km length of the bank using the RCC porcupine is 1/3rd of the cost of bank revetment. But cost of protection works may be increased later due to strengthening of the works by provision of extra RCC porcupines in coming one or two years.

Limitation of RCC porcupines: Following are the limitation using the RCC porcupines as river bank protection.

(a) In case of high velocity flows, implementation of only RCC porcupine works is not favored. However, use of RCC porcupine works in between the reach of two solid boulder spurs is more effective.
(b) Generally additional quantities of RCC porcupines is kept for placing the RCC porcupines in 2nd year or consequent years at locations where partial silting has taken place after implementation of RCC porcupines in 1st year. In the absence of placing additional porcupine the silted region near the bank may not be made firm.

6.0 MEASURES TAKEN FOR PROTECTION OF THE ISLAND

Brahmaputra Board prepared a scheme for “Protection of Majuli island from flood and erosion” envisaging works in three phases as detailed below:

Phase-I
- Construction of nose of the existing land spurs.
- Permeable screens in the form of RCC porcupines (1390 no.).
- Improvement of road cum embankment (50 km).
- Construction of new embankment (18 km).
- Bank revetment work (1.5 km).

Phase-II
- Permeable spurs to be constructed in specific locations in the above reaches (21 no.).

Phase-III
- Land spurs (10 no.) along with bank Revetment.

Brahmaputra Board initiated works as listed under phase-I in 2005. Suitable modifications were incorporated based on the recommendations of various experts who visited the site from time to time. Prior to the above mentioned works, some immediate measures, as listed below, were also taken up in 2004-05.

(i) Construction of permeable screens of standard RCC porcupines of length 25 m and at interval of 50 m for a length of 9200 m.
(ii) Construction of bamboo crib screens.

(iii) Construction of RCC porcupine spurs.
(iv) Restoration of retirement bund.
(v) Closing of breaches.

It was interesting to note that RCC permeable screens at most vulnerable reaches at Sonowal Kachari, Salmara, Kaniajan & Kamalabari, Bhakat Chapori, Birinabari, Malual & Ukhalchuk and at Jengrai showed substantial reduction of erosion with increased siltation.

Still after carrying out measures listed above by 2008, it was analysed during field visits that there are some reaches which are highly vulnerable and accordingly following works involving RCC porcupine were undertaken:

1. Construction of 10 no. of dampeners at Bessamara and at Dakhinpat reach (5 no. at each reach)
2. Construction of 3 no. tie bund by earth filled cement bags, one at bank channel and one at Tuni channel at Bengenaati area and one at Tuni chammel at d/s of Kamalabari.
3. Construction of 6 no. of RCC porcupine screen downstream of Potia channel and downstream of Kharkharijan and at Bhakat chapori.
4. Construction of 10 no. of dampaners down stream of Potia channel and up stream of Kharkharijan. and at up stream of Kamalabari.
5. Repairing of existing 6 no. of dampaners at Kamalabari reach.
6. Construction of 5 no. of RCC porcupine spurs at up stream of Kamalabari.

The works of phase-I were completed by the Brahmaputra Board during 2010-11. Thereafter works envisaged for Phase-II & III were taken up with suitable modifications as per the changed ground situation. A schematic map of the works is shown in Fig.-2.

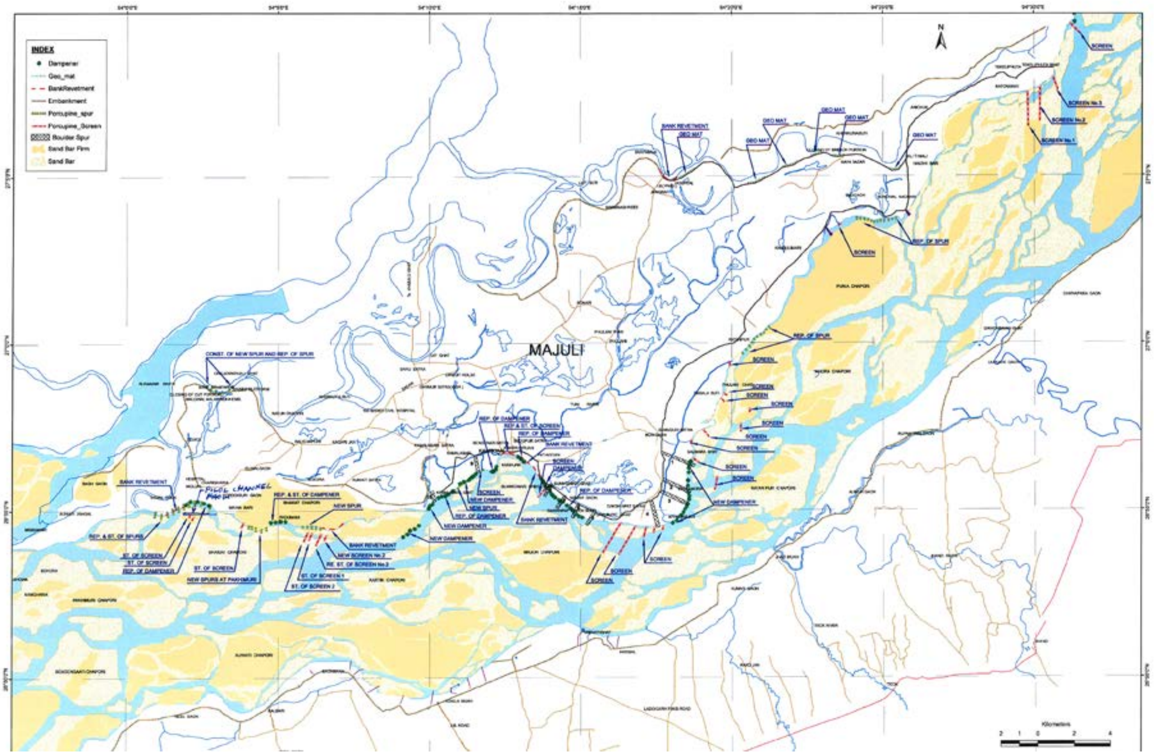

Fig.-2: Ongoing works of phase-II &III

A panel of Experts visited the island in Nov. 2010 and noticed significant improvement in the situation of Majuli area due to various measures taken up for protection of flood protection as well as erosion control. It was observed that since 2004-05, no embankment breached in south bank of Majuli island. It was also noticed that after a long gap of 20 years, harvesting of Sali paddy in Lower Majuli area has started and at several places large tracts of land have been reclaimed by inducing siltation near the bank as shown in Fig.-3.

Fig.-3: Reclamation of land due to porcupine screens

Fig.-4 shows the signs of siltation at various locations due to RCC porcupines as noticed by the panel of experts.

Fig.-4: Siltation induced due to RCC porcupines

7.0 STUDY CONDUCTED BY THE BRAHMAPUTRA BOARD

Brahmaputra Board analysed area of island using Survey of India toposheets taking area in year 1914 as base and subsequent years, whenever the surveys were carried till 2008. The findings are given in the table below:

Year	Area in sqkm	Area eroded in sqkm	Area reclaimed in sqkm
1914	733.79	-	-
1949	708.91	24.88	-
1963	588.79	120.12	-
1988	513.89	74.90	-
1998	510.79	3.10	-
2000	520.23	-	9.44
2003	511.89	8.34	-
2004	502.21	9.68	-
2008	506.37	-	4.16

From the above table, it is observed that the island has not lost much during last 20 years. In fact, from year 2004, there is some overall gain the in the area of the island due to anti erosion measures mainly in the form of RCC porcupines were undertaken.

8.0 CONCLUSIONS

Siltation measures in the form of R.C.C. porcupines have been found quite effective in reducing intensity of erosion of the river Brahmaputra at Majuli Island, Assam. The anti-erosion works for “Protection of Majuli Island” are still in progress. However, from the observations made by the panel of Experts in 2011, it can be concluded that the works in the form of RCC, porcupines which are cheap in cost, easy to construct, sustainable and without significant adverse effects in upstream or downstream or on opposite bank are a proven tool for checking erosion of river banks.

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BRIEF PROFILE OF THE AUTHORS

Ashok Kumar Kharya graduated in Civil Engineering from Government Engineering College, Rewa, Madhya Pradesh, India in 1984. He did his M.Tech. in Stress and Vibration Analysis from Maulana Azad College of Technology, Bhopal, Madhya Pradesh, India in 1987. He joined Central Water Engineering Service (CWES) in 1988 and been put to field assignment of hydrological data collection and flood forecasting for about three years in field office of Central Water Commission. As an Executive Engineer, he was involved in field investigations and preparation of Detailed Project Report of Pancheshwar Multipurpose Project – a joint project between India and Nepal for about four years. He was engaged in techno-economic examination of Major & Medium Irrigation and Multipurpose Projects as Deputy Director.

Mr. Kharya is presently looking after climate change issues pertaining to water resources in India. CWC published a document viz. "Preliminary Consolidated Report on Effect of Climate Change on Water Resources" which was prepared by him. He has co-authored "Water Resources Assessment – A National Perspective" – A technical guide to water resources engineers and planners published by NRSC, Hyderabad. He has worked for mathematical model development particularly for flood forecasting using MIKE 11 for about three years and river data management of the country for about one and half year as Director in CWC, New Delhi. He has been actively involved in the constitution of "North-East Water Resources Authority (NEWRA)". He spent around three years in Brahmaputra and Barak basins of North-east India collecting hydrological data and issuing flood forecasting as Superintending Engineer at Guwahati. He also coordinated with China, Bhutan and Bangladesh for data collection and transmission of flood warnings as per bilateral arrangements with these countries. He has represented CWC in various workshops, seminars etc. on the issues related to impacts of climate change on water resources. He is working in the field of water resources sector since last 24 years in various capacities.