

The 6<sup>th</sup> International Conference on Vetiver (ICV-6) 5-8 May 2015, Da Nang, Vietnam

## Application of Vetiver (Vetiveria Zizaniodes) as a Bio-technical Slope Protection Measure —Some Success Stories in Bangladesh

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BUET



- Population Density: 1203 pop/square km
- ❑ Located between 20° to 26° North and 88° to 92° East
- About 50% of the land is within 6-7m of MSL
- Average temperature ranges from 17°C to 20.6°C during winter and 26.9°C to 31.1°C during summer; Annual Rainfall: Maxm. 5690 mm (northeast); Minm. 1110 mm (west)

## **Common Disasters in Bangladesh: Flood and Cyclone**







### **Common Disasters in Bangladesh: Arsenic Contamination and Salinity**







### **Common Disasters in Bangladesh: River Bank Erosion & Seismicity**







Bangladesh is frequented by natural disasters due to its unique geological formation. The most common disasters are:

- Cyclone
- Heavy Rainfall and Flood
- Earthquake
- Arsenic contamination, Salinity intrusion
- Contaminated Water (heavy metal, arsenic, industrial waste, etc.)

## How can we help the Disaster Affected People?



# **Roads and Embankments**



- 1/3 of the country was affected by the cyclone
- Wind speed: 250 km/hr
- Economic loss: 3.1 billion dollars
- Occurred in 2007

SOURCE: DMB (2008)





Survey after Cyclone SIDR 2007

### Flood Embankment No vegetation





### Bangladesh has many rivers.

Although Bangladesh is a small country, it has very long coast (750 km).

More than 4000 km coastal embankment has been constructed.







Sometimes tress alone are not effective

— After failure

Before failure

### **REASONS FOR EMBANKMENT FAILURE**

Poor construction practices and improper design of road and embankments without compaction make the embankments easily erodible to rain and wave action.

Rain-cut erosion/Rainfall impact:

Bangladesh is a low lying delta formed by recent deposits. Embankments are mostly constructed using dredged material from nearby river bed which are silty sand.

 Wave action/turbulent water currents cause erosion of embankments.

In some locations soft-soil also cause failure of embankments.

 Human activities (travel paths for men and cattle, cattle grazing, unplanned forestation of embankment slopes).





### **Usual Practices of Topsoil Erosion Control of Roadside Slopes**





Slope protection work with CC slab on slope and palasiding work at toe

#### SOURCE: ROAD DESIGN STANDARDS- RURAL ROAD of LGED (2005)

Slope protection work by brick block and geo-textile



# **River Bank Erosion**



মমুনার পানি বাড়ার করেশে জীপ্র স্তোতে গতকাল নিরাজগঞ্জ শহরবক্ষা বাঁধের গয়লা মসজিদ ও শ্রাপানঘাট এলাজায় বড় ধরনের ধল দেখা দেয়। এতে হমকির মুদ্রে পায়ে দাঁধটি ও হবি : এদামুল হক

### **River Bank Erosion**













Daily Prothom Alo, dt: 04.04.2011



### Geo-textile taken ou from River Bank site

The common practices are expensive and in many cases these are not effective during their design life.

# **Hill Slope**

### Top Soil Erosion due to Rain-cut at Hilly Regions of Bangladesh





### All these slopes are either uncovered or denuded

# Landslides a growing concern In Bangladesh

#### FARMON HUS.

W 1015N the harmony of nature is disturbed, it takes recently seen this deemstating side of nature, when soil of Chittagong 1001 Tract collapsed, rausing death to somarry people.

In Chittagong many plants and regetations have developed on the full slopes. These plants have been grown for millions of years. The full tracts are naturally laid on a slope as 1.2 or 1.3, which indicates the proportion of sectical to bortaintal distance. In this slope, suil remains safe and comparatively stable.

In Bangladesh the rainy season, the rainfall is hovey and frequently ranges between 1,300 – 2,300 mew per year. This rainfall has a sormal tendency to alido down the hill slope. When the hill is covered with plants and huge vegetations, the risk of sliding is loss. The beney taindrops first hit the plants before the slope that reduces their energy. This sloved down raindrop cannot ender the top suit early.

But when people cause definestation to the hilly region, this situation alters completely. People living in hilly sense practice 'Josen' cultivarior. They burn plants on hills to create land. As a result, hill supbecomer bare and exprosed. The rais drops falling on this bare soil causes significant errotion resulting.



its contilinumum washing of topsell.

Further living at the front of the fulls in Chittagong malertain a vulnerable entatorice. They often can down the soil of hills to construct their bourses. In this way, the normal comfort level of this hilly come is being disturbed bogoly. The natural slope of the hill is also altered by making it 1:0, instead of 1:2 or 1:3.

Because of this imbalance is slope as well as deforestation, frequent landalide occurs in the ChittagoingHillTjact. Is three any way to arrest such emotion of hill slopes?

Dy. Mohammad Shariful Islam, Associate Professor, Banglailesh University of Engineering and Technology (Baet) accounts:

There are different solutions. To restore a slope to its harmer candition, illing of that particular section might be needed. But this may not be possible. An oct- friendly long-term solution to this problem is plantstion of long control vegetation.

If we saw wede on a slope, then a specific period will be needed to

grew these plants. During this period, we can use 'genjuta' on the shipe surface. Geojute is an open medi type gentectile. It is biodegratable, eccedriendly and cost effection. Momenet, projute can absorb water of about 4-5 times in dry weight. The rough surface of jute makes the passing of rainwater difficult on the topsoil by reducing its venicity. This helps to reducing its venicity. This helps to reduce soil ensuin. The plastation along with vegetation can higely reduce landslide on bills.

From our experience in various. graduate.

projects, we have seen that some small bushy type plants possess a long and very strong root system. One example is 'Vetiver', which can go up to 5 feet, but its root system can go up to 14 feet below the ground. This strong root system protects the aid from crossion, and thus prevents landslide. At last, we all must remember that we should live in nature by respecting it.

The writer is a cluit engineering preduces.

#### Daily Star: A daily Newspaper in Bangladesh

# **Haor Area**



North eastern part of Bangladesh

Haor islands are continuously eroded by wind induced wave action







Photo: Prof. M. Shamsul Hoque, BUET

### **Protection System:**

Soft Vegetative Protection Measure -Using Dholkolmi -Using Bamboo/Murta/'Binna grass -Using Hizol/Koros Trees -Bamboo with Chailya Grass

#### **Semi-Hard Protection Measures**

-Using Boulders -Using Sand Cement Mixture -Using Cement Concrete Blocks

#### **Retaining Wall Based Hard Measures**

Ref. Hoque (2013)

Some of these methods are not effective, some take long time, and hard solutions are very expensive.







### Dhaka, the capital city of Bangladesh



### **Heavy Metals Contamination to**

wate

পানিত প্রহমন ১ হাজার প্রতিপঞ্জ নাটনের চঠাগ্রহে জনামুল্টী এবং পুলনার প্রৈরত ও পঞ্চর নাটিছে এগতে এলায়ের যিরিয় জলালারে অভারতিক মারার মুলনার্জী আরি প্রবাহনি মারিয়া গান্ধার লোকে বেরি প্রতিপ্র পদেশ ছয়েছে জনায়ের জনামের প্রি কির্মেন ও কাল প্রাণ্ট মিন্দেল মারায়ের জরিবার ও মহারি মার্চারিক এক প্রাণায় ইয়েলে কার মারায়ে এলা কালেকার নাট ও জলামেরে প্রতিরে ভয়ানে মারায়ে এলার কালেকার নাট ও জলামেরে প্রাণায়ে ইয়েলে মারায়ে এলার কালকার নাট ও জলামেরে

রপার, জিন্দ, নেতা, রেচনিয়াম, উটায়েনিয়াম, মাজনিয়া, নোগলেই, মায়েনা ও জারিকর কামারের উপাদন এবা হরমেয়েনার করি হয় এমন গর পদার্গের মারিত্ব রচেয়ে। সালীয় মায়ার রেয়ে মাপিক মারার এমন পারুর মারিত্ব পারার লেছে প্রালপায়।

জনম্বান্থ্যের ভয়ঙ্কর হুমকি

भावात (मार) भाषिक स्वाह आप र पहुल सहित्र भावता (मार) भाषिक स्वाह आप र पहुल सहित्र भाषपाल भाष रहा, सिनिध भिन्न शहिरेल क सार्थनाह (मार काल स्वाह एमप क आप नहीं क समाप : (सार महात प्रमान क सार नहीं क समाप : (सार महात प्रमान क सार नहीं क समाप : (सार महात प्रमान क सार नहीं क समाप : (सार महात प्रमान क

पुराष्ट्रमित महज पार्वाहरण वायरण मांगरमाहाल फवि गराम । हामांग 'पहणांगि राग्रज कम वहर मीनोपवियरन नवे गराम तुनिज भागित मातरभ । भरताभाव राभारण ग्राहा, अळ्यात गरि अ कलभरावर गांधे वरित्र प्रकारण माराम । मिंगर भागा विश्वामा नाजव गराम । मारान कामारच महत भारत । विश्वित राग्राल कामक रामी अ मीनदावित कामारच महत । विश्वित राग्राल कामक रामी अ मीनदावित किन्द्र राज्य नगराम । विश्वित राग्राल कामक रामी अ मीनदावित विश्व राज्य नगराम । विश्वित राग्राल कामक रामी अ मीनदावित विश्व राज्य नगराम । विश्वित राग्राल कामक रामी अ मीनदावित विश्व राज्य नगराम । विश्वित राग्राल कामक रामी अ मीनदावित विश्व राग्र नगराम । विश्व राग्राल वालाक राज्य नगराम नगराम, - अवाझ राग्रालगरा वाणावाडि ज प्राहानित राग्राहत कावरण नामात्राण, किन्द्री, प्रार्थ, मान्य अपनि, स्वरूप्तव स्वाराज्य नगि हायम । यज्ञ नगरा माराम वाणिजना माज्याम हात्र नगराम स्वाराहराण ।

প্রতিদিন ২৩ লাম মনমিটার দূযিত বর্জা নদীতে ফেলা হচ্ছে

প্রতিপার করিছে প্রতিদিন এজনেই লোগে হাজ কেরিবারপের ব্রুজ। ৯ জনে বিভিন্ন করিন ৬ জনে নহার্য দেশির প্রতিদ হাজে, 💷 পরিবা ব্যবহা

मनामा सीमीफीटराट (तेनगरे प्रान्तुल निशित कहटक तथा गंडीपल क वेशिएक कर्मटाडीटल विश्वकरण गानि प्राटम्ब डाव रन्द्राव कुछ हामटक त्रमार्थे गल्द्राम् मार्ट्राम् लाहल प्राटम् सानिहाटान निर्माणकराः मन्द्रांड इडिहाम् निर्माणनटात् वेननिर्देडिव ne cello recen acu fir-cleu (netaxanan), frifi tilifualiti ne non a nesfiture nonaratifi fegleune clivare ann annae rifi rifiu nee alle fono-rupie irclufe riti i at nereti nere manu acese মারিমায়ের মান্য ও বৃথি মহে (এফএর), রোজন এনারারেন্দ্রেন্দ্রেল মেনিনিটি (জিরিকা) ও মে কর বেজন নার্জ মের্ডিন ইর্নোনিয়েন্দ্রিম প্রথম ২০০৫ মারেনে নারেম্বর মেরে ২০০৫ মারেন্দ্র নারেম্ব নারেম্ব এলাকা সেরে মহুলা (২ প্রায় ২ বহু লেন্দ্র)

Heavy metal in Rivers; everyday 13,00,000 ton waste are disposed to rivers -Daily Janakantha. Bandladesh

## BACKGROUND

- Failure of embankment and riverbank erosion are common problems in Bangladesh. Devastating flood, excessive rainfall and tidal surge accelerates the failure process.
- Unfortunately our State budget is never sufficient which confines rigid structural protection measures to the most acute sections, never to the full length of the river bank or coastline and embankment.
- This hard engineering structures makes the scenic environment unpleasant and helps only to transfer the problem from one place to another place, to the opposite site, or downstream.
- Establishment of vegetation as a soft bioengineering technique to rigid or hard structures accepted all over the world due to its low cost, longevity and environment friendliness.





## **SLOPE PROTECTION: WHY VETIVER?**

- Vetiver grass is an "ecological-climax" species. It outlasts its neighbors and seems to survive for decades showing no aggressiveness or colonization ability. It withstands drought and high levels of flooding.
- It is tolerant to high levels of pesticides and herbicides and also to a wide range of toxic and heavy metals. Temperature variation from -14° C to 55 ° C, Soil pH from 3.0 to 10.5, High level of tolerance to soil salinity, sodicity and acid sulphate.
- When vetiver roots interact with the soil in which it is grown, a new composite material comprising roots with high tensile strength and adhesion embedded in a matrix of lower tensile strength is formed.
- Vetiver roots reinforce a soil by transfer of shear stress in the soil matrix to tensile inclusions. The roots of the grass have an average tensile strength of MPa 75 and improve the shear strength of soil by between 30% and 40%. Engineers liken them to a "Living Soil Nail".
- Vetiver grass is an economic attractive solution. In most countries in South-East Asia Vetiver grass can be planted for less than \$ 3 per meter, which is 60-70% less relative to hard engineering practice.

All the attribute show that Vetiver grass will be very suitable for slope protection in Bangladesh context.

### **MAJOR CATEGORIES OF RAINCUT EROSION**

Raincut Erosion	Factors for Raincut Erosion		
-Top soil erosion -Block slide -Manmade unstable slopes	Soil -Texture -Particle Size -Moisture Content -Surface roughness	Vegetation -Type -Height -Density of Cover -Seasonal distribution	Climate -Temperature -Rainfall distribution -Rainfall intensity

## Mechanism of top soil erosion

Two fold mechanisms may be involved with top soil erosion



### **BIO-ENGINEERING SOLUTION AIDED BY GEOJUTE**



WOVEN TYPE JGT (OPEN MESH)





- 500 gsm-750 gsm
- Opening area about 50%
- Moisture absorption is about
  500% its dry weight
- Cost: Tk. 1.60 per sft for 500 gsm
- Durability: 2 years

SOURCE: Bangladesh Jute Mill Corporation (BJMC) and PRIVATE JUTE MILLS

### How JGT and Vegetation Act together ?



### SCIENCE BEHIND ACTION

•Geojute absorbs water required for vegetation growth and acts as mulch on its biodegradation. As the Geojute degrades with time, grasses and trees grow up and take over the job of Geojute.

## **OBJECTIVES**

- Exploration of vetiver availability and their growth characteristics in Bangladesh. Identification of properties of local vetiver (leaf, shoot and root).
- Determination of slope stability of vetiver grass protected slope. Field trials for determining the efficacy under different soil (saline, non-saline, contaminated soil) and geographic condition (flood plain and coastal zone) in Bangladesh.
- Heavy metal extraction from industrial waste contaminated soil. Salinity tolerance of vetiver and salinity removal using vetiver.
- Dissemination of the technology to local people, academia, engineers, NGOs, government agencies and policymakers.

## **Vetiver (Vetiveria Zizanoides)**



Vitiver: The root system goes up to 14 ft deep in 6 to 8 months time

## **Past Researches on Vetiver in Bangladesh**

Author(s)	Objectives
Rahman et al. (1996), Uddin (2000), Islam (2000), Thomas et al. (2002), Huq (2006), Islam et al. (2008), Bhuiyan et al. (2008)	Mainly studied the vetiver availability and potential uses of vetiver in Bangladesh.
Moula and Rahman (2008)	Investigated the optimum number of tillers per clump for the proper propagation of vetiver grass.
Moula and Rahman (2009)	Investigated seed germination potential of vetiver grass.
Thomas et al. (2002)	Presented the trials of vetiver grass in 28 km of embankment project built on the Kangsha River in Netrokona District under Dampara Water Management Project (DWMP) in 2000. DWMP demonstration sites proved that the vetiver grass provides outstanding protection against erosion while also being a sustainable supply of fodder and thatch.
Islam (2003)	Presented the use of vetiver in controlling water borne erosion with particular reference to Bangladesh coastal region through Coastal Embankment Rehabilitation Project (CERP). Vetiver was introduced in 18 coastal polders and 87 km of earthen embankments where half a million vetiver tillers were planted from 1999 to 2003.

### **Availability of Vetiver in Bangladesh**



## **Availability of Vetiver in Bangladesh**





and	
	re.
Protection by LGED, Sirajganj	

### **Observations**

Vetiver grows both in the clay and sandy soil in the climatic condition of Bangladesh.

✤The available type is Vetiveria Zizanioides.

✤People already use it for different purposes. As it is a labour intensive technique it will be a well accepted in Bangladesh.

VS is not the only solution, but it will be very good for Bangladesh, particularly with sea level rise and increased coastal and flooding damage. VS should also be used for waste water treatment in Bangladesh.
## **Vetiver Availability in Bangladesh**





Reproduced from Thomas et al. 2002

# In-situ Test: Determination of Shear Strength of Rooted Soil





Test Set-up for In-situ Shear Strength Determination



## **Reasons for Embankment Failure**



#### Un-rooted block sample



Rooted block sample









Pubail: Flood prone area Kuakata: Coastal Zone

Both strength and deformation capacity of vetiver rooted soil matrix are higher than those of the bared soil







Strength of vetiver rooted soil matrix is 2.1 times higher than that of the bared soil

# **Laboratory Test**

## **Reconstituted Sample Preparation**









## **Strength of Reconstituted Samples**



Strength and ductility of rooted soil samples are higher than those of the unrooted soil samples.

Islam, M.S., Arifuzzaman, Hossain, M.S. and Nasrin, S. (2013), "Effectiveness of vetiver root in embankment slope protection: Bangladesh perspective", *Intl. J. of Geotechnical Eng.*, **7**(2), 136-148.

# **Growth Study**











Local vetiver grow better than other collected from other countries.

Vetiver grew even on concrete dump.





#### **Study on Growth of Vetiver**



# **Training Local People for Vetiver Nursery**











# Field Trial- Road Slope Protection Rain-cut Erosion

#### Keraniganj-Kholamura-Hazratpur-Itavara-Hemayetpur Road Zilla Road (District Road)





AADT: 73.18; Temperature: 14-34°C Humidity: 45-79%; Annual Rainfall: 1875 mm

# Grain Size Distribution of the Top-soil of the Road Side



A stretch of mild sloped roadside was selected for protection with geo-jute and vegetation Slope soil is susceptible to erosion

## **Design of Slope Protection Scheme**



Vetiver plantation: 20 cm x 20 cm in square grid pattern



#### **Implementation of the Proposed Erosion Control System**

#### Work Started on 25/10/2011 (Winter)







Unit Mass: 700 gsm, Opening: 31 x 33 mm2 Tensile strength: 21092 N/m (x); 5886 N/m (y) Absorption capacity: 2.75

#### **Implementation of the proposed Erosion Control System**

#### Work Started on 25/10/2011







#### Implementation of the proposed bio-technology

#### Work Started on 25/10/2011



#### A)Slope preparation

#### **Implementation of the Proposed Bio-technology**

#### Work Started on 28/10/2011





Fixation of geo-jute by steel clip (10 x 24 cm) 107 cm apart along the slope 60 cm along the road length

B) Laying and fixing of geo-jute

#### **Implementation of the Proposed Bio-technology**

#### 28-30/10/2011





C) Vetiver plantation

#### Work Finished on 30/10/2011



### **E)** Monitoring







After 1 month: Root length: 10 cm Shoot length: 30 cm

#### **E)Monitoring**

#### 13/07/2012 More than 8 Months



# Visit of RHD, LGED, JDPC Officials to the Site 21/09/2012









# Field Trial- Pond Slope Protection Wind Induced Erosion

## **Pond Slope Protection in Rajshahi**





#### **Grown Vetiver**





Vetiver clumps were collected from Tarash

# Field Trial- Saline Zone Dyke Protection

Dykes for shrimp production





## No vegetation is seen on the dykes



Saline Zone	Salinity (ds/m)
Kaliganj	1.57
Baliapur	3.93
Nildumur	4.19
Bashkhali	12.37

http://maps-of-bangladesh.blogspot.com/

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Bangladesh

- Satkhira Saline Zone Study Area

Vetiver Study Area

#### Kaliganj: EC= 1.5 ds/m







This initiative was taken to demonstrate to the local people & to plant to other places

Shrimp cultivation in dykes, but generally vegetation do not grow













#### **Root and Shoot Growth with Time**

# **Model Test for Erosion**







#### Slope with VS

#### Coastal Climate Resilient Infrastructure (CCRIP)



A project of Local Government Engineering Department (LGED). Funded by IFAD, UN

12 districts in the coastal zone of Bangladesh:
-Raincut erosion
-Wave action
-Soft soil problem
-Salinity

# Heavy Metal Removal from Contaminated Soil
# **Cleaning Contaminated land and water**

Collecting soil from *Buriganga* river bed





Soil Properties: Silt= 91.5% Clay= 8.5%





# Salinity Tolerance and Salinity Removal

# Salinity Tolerance/Salinity Removal



Alluvia Soil Sand= 84% Silt= 4% Clay= 12%

EC= 4.8 to 12.5 ds/m

### Vetiver clump



Soil



Vetiver grass survived in saline soil and also found effective in salinity removal.

Vetiver planted in saline soil

# **Earthen Block Stabilization**



People started to make CGI sheet houses as they found difficult to make earthen house due to shortage of water.



### **Drought prone area**





### **Earthen House**



## Discussion with community people



Soil Vetiver straw Training local people

Completed earthen house

# Analyses

Method Name	Bishop's Method	Coppin and Richards Method	Remarks
Equation	$Fs = \frac{\sum \frac{1}{m_{\alpha}} [c'b + (W - ub) \tan \phi']}{W \sin \alpha}$	$Fs = \frac{c' + (\gamma z - \gamma_w h_w) cos^2 \beta \tan \phi'}{\gamma z sin \beta cos \beta}$	
Description	c'= cohesion of soil b =width of slice W= weight of slice u= pore water pressure $\phi$ '= angle of internal friction of soil. $m_{\alpha}$ = (1+tanǿ tan $\alpha$ /F <sub>s</sub> )cos $\alpha$	c' = Effective soil cohesion $\gamma$ = Unit weight of soil, Vertical height of soil z = Above slip plane $\beta$ = Slope angle $\gamma_w$ = Unit weight of water $h_w$ = Vertical height of GWT above slip plane $\phi'$ = Effective angle of internal friction of the soil	FS safety estimated for bared slope by these two methods are same
Values used	c'= 20 kN/m2; b= 2m; φ'= 230	c' = 10 kN/m2; $\gamma$ = 18 kN/m3; z = 1.0 m; $\beta$ = 350; $\gamma_w$ = 9.8 kN/m3; h <sub>w</sub> = 0.5 m; $\phi$ ' = 350	

 $\frac{(c'+c'_R)+[\{(\gamma z-\gamma_w h_v)+W\}\cos^2\beta+T\sin\theta]\tan\phi'+T\cos\theta}{[(\gamma z+W)sin\beta+D]\cos\beta}$ 

### For Rooted soil (Coppin and Richards Method):

- $c'_{R}$  = Enhanced effective soil cohesion due to soil reinforcement by roots
- W = Surcharge due to weight of vegetation
- $h_v$  = Vertical height of GWT above the slip plane with the vegetation
- T = Tensile root force acting at the base of the slip plane
- $\theta$  = Angle between roots and slip plane
- D = Wind loading force parallel to the slope

Value used:

 $c'_{R} = 9.1 \text{ kN/m}^{3}$ ; W = 2.5 kN/m<sup>2</sup>; h<sub>v</sub> = 0.4 m; T  $= 5 \text{ kN/m}; \theta = 45^{\circ}; D = 0.1 \text{ kN/m}$ 

# **Comparison of Factor of Safety**



FS increased by 75%.

The Program of Prati Amati, Srl (2006) also showed that the installation of vetiver will increase slope stability by about 40%.

6<sup>th</sup> International Conference on Vetiver (ICV-6), 5-8 May 2015, Vietnam



Avg. dia of root= 0.75 mm Avg. root length= 2.5 m E= 2.65 GPa

Islam, M.S. and Hossain, M.S. (2013), "Reinforcing effect of vetiver (vetiveria zizanioides) root in geotechnical structures- experiments and analyses", Journal of Geomechanics and Engineering: An International Journal, 5(4), 313-329.

### **Observations**

From the analyses, it was revealed that reinforcement with vetiver roots causes a significant reinforcing effect in the Pubail and Kuakata ground.

The vetiver root enhances the bearing capacities of the grounds and stabilizes the embankment slope.



### **Transferring Technology to the People**



সমূহপৃষ্ঠ থেকে বাংগদেশের পত্র ভিদ্যা ১০০ ফুটেরও কম। বনা। वाहे निजाल्ली ( बाह का टोकाटक मनीत लाज 6 रहडिनेलर) मध्यभाषित त्याका । प्रवेशमें किंह उकडि मनुष्ट याम लागग कहा আরো পরিলোলী করা মায় এই ভাগ। রিয়া নামের এই যাস নিয়ে গদেষণা চলাম মুয়েটে। আলাগার জানাগেন ক্ষুবায়ের মোলন ও



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### Kaler Kantha: A daily Newspaper in Bengali



# **Summary & Recommendations**

Embankment failure due to erosion is a common problem in Bangladesh. Plantation of vetiver system along the slope of embankments, river banks and hill slope is an alternative green solution to the problem. Field and laboratory tests were conducted to determine the strength of vetiver rooted soil. Field trail has been conducted to investigate the suitability of vetiver with geo-jute for slope protection. The main findings of the study are as follows:

- In-situ shear tests conducted on vetiver rooted soil system showed that shear strength of vetiver rooted soil matrix is 2.0 times higher than that of the bared soil. Again, the effective cohesion of vetiver rooted soil matrix is 2.1 times higher than that of the bared soil. The vetiver rooted sample showed ductile behavior. Direct shear tests conducted on laboratory reconstituted unreinforced and reinforced samples showed similar trend as observed in in-situ tests.
- Field trials have been conducted in road embankment and slope protection with vetiver at different sites. It is found that the sub-tropical climate of Bangladesh is suitable for vetiver plantation. Plantation of vetiver along with the use of geo-jute(JGT) can be a cost-effective, sustainable, ecofriendly method for the erosion control of slopes in Bangladesh.

# **Summary & Recommendations**

- Slope stability analyses conducted for both bared and vegetated slopes. The factor of safety is about 1.66 for bared slope and 2.90 for rooted slope. Finite Element (FE) analyses revealed that reinforcement with vetiver roots causes a significant reinforcing effect in the Pubail and Kuakata ground.
- Vetiver plantation costs least compared to other common practices such as cement concrete block and clay claddings.
- Vetiver is also found to be effective in uptaking heavy metal and salinity removal.
- Vetiver is effective in stabilizing earthen block.
- Extensive field trails are being conducted with the cooperation of Government and NGOs.
- International collaboration is needed to establish vetiver network and accelerate the use of vetiver in Bangladesh.

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# **Thank You**



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