Development of Technology for Waterfront Creation and Case Study of Continuous Block System

2011. 11. 11

Sukhwan JANG,

Daejin University

ARRN FORUM 2011

KRRN Korea River Restoration Network

Contents

ARRN FORUM 2011

KRRN Korea River Restoration Network

1. Introduction

■ Current Status of Urban Streams

For the last decades before 21st century, stream management based on government-led planning had been mainly considered with the use of water and flood-control in urban areas. As results, the ecology of urban streams was more deteriorated due to

-. Drying of stream
-. Straightening of stream channel
-. Concrete covering and bank protection
-. Artificial riverbed
-. Water pollution
-. Covering and pavement of stream
-. Crossing obstacle in stream
-. Parking lot construction in stream

Damaged aquatic ecosystem in stream

1. Introduction

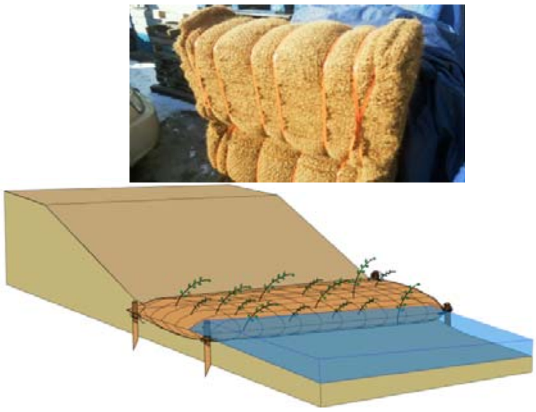
Research Team Objectives

- Development of nature friendly waterfront technology to improve ecological function as well as hydraulic safety between river and bank
- Restoration of aquatic ecosystem and improvement of diversity in waterfront
- Improvement of aesthetic function nearby waterfront and securing nature-friendly leisure and resting places for the residents

1. Introduction

Development of Technology for Creation of Waterfront

Mattress groyne system composed of natural materials in streams



Soft-bag system for the creation of natural water front

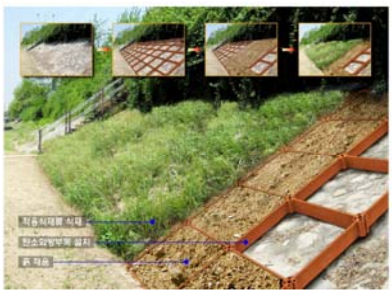
1. Introduction

Development of Technology for Replacement of Concrete Covering in Waterfront

Geo-green Loess Fiber Block

Grass-con system of continuous block system

Soil-layered system reinforced with fibers for vegetation



Frame system composed of burned woods

2. Case Study of Continuous Block System

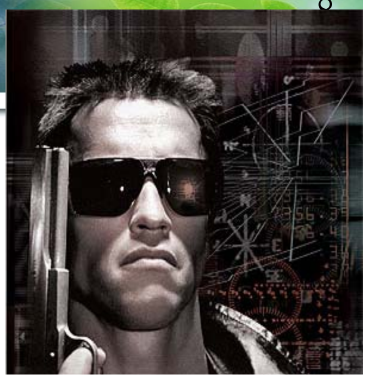
- Background of Continuous Block System Development
  - ☞ Propelled River Restoration and Rehabilitation after 90's
  - ☞ Hydraulic Safety Problems of Existing Slope Protection Methods for Close-to-Nature Application
  - ☞ Sustainable Urban Drainage System
    - Pervious Area Reduction
  - ☞ New Method for Safe and Environmental Slope Protection and Urban Drainage

- Approaches
  - ☞ Review of Existing Block Application System for Slope Protection in River Banks
  - ☞ Hydraulic Analysis for GRASSCON
    - ▸ Physical Model Test ▸ Numerical Analysis

ARRN FORUM 2011

KRRN Korea River Restoration Network

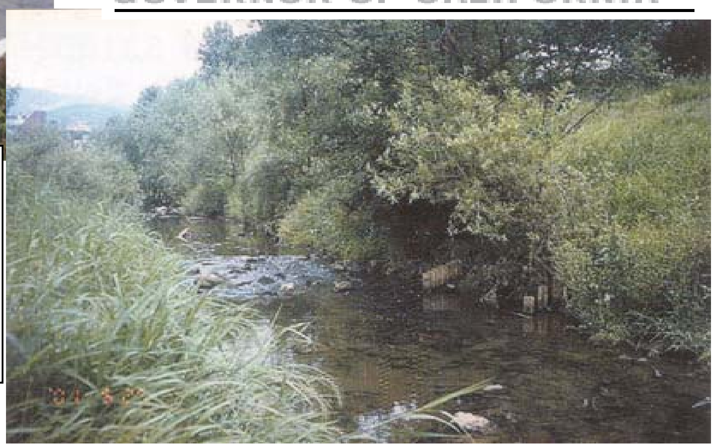
Not Available of Co-existence between Hydraulic Safety and Vegetation ?



"I SAY THE DEBATE IS OVER — WE KNOW THE SCIENCE, WE SEE THE THREAT, & THE TIME FOR ACTION IS NOW"
ARNOLD SCHWARZENEGGER, GOVERNOR OF CALIFORNIA

-Resistance against High Velocity Flood in River Bank Block System

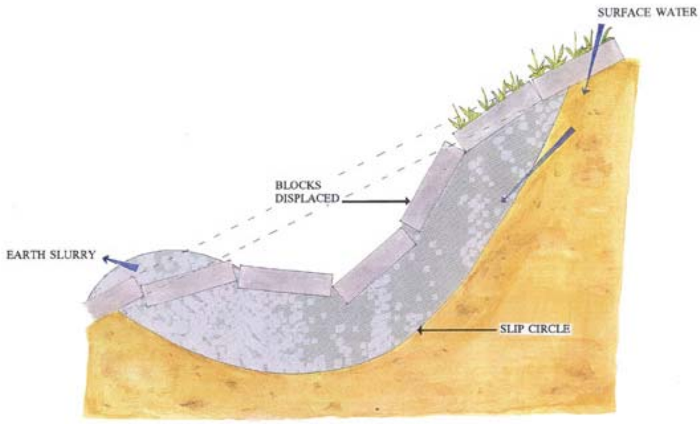
- Any Problem of Existing Precast Block System?



2. Case Study of Continuous Block System

Existing Block System

CAUSES OF PRE-CAST BLOCK FAILURES

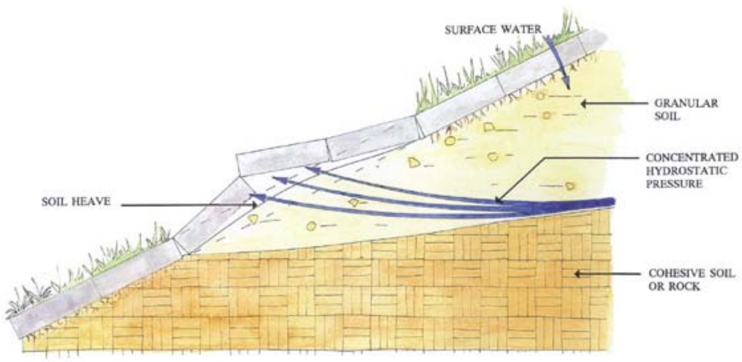


ROTATIONAL SLIP CIRCLE

Caused by Water Intrusion at the Top of the Slope

2. Case Study of Continuous Block System

CAUSES OF PRE-CAST FAILURES



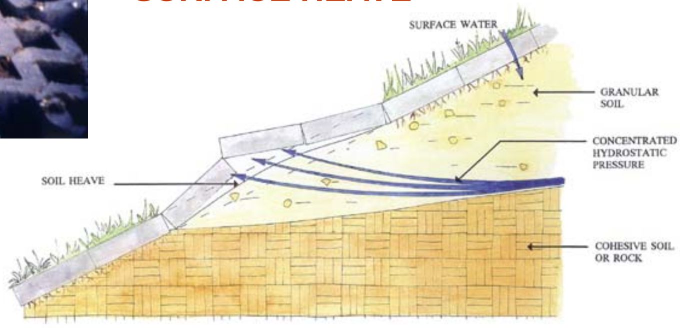
SURFACE HEAVE

Caused by Static Pressure between Two Impervious Layers

2. Case Study of Continuous Block System

Review of Some Problems

SURFACE HEAVE



2. Case Study of Continuous Block System

Review of Some Problems

Tractive Forces and Erosion against High Velocity

2. Case Study of Continuous Block System

Review of Some Problems

Interlocking
between Units

3. Application of Continuous Block System

THE GRASSCON SYSTEM

PERFORMANCE OF REINFORCED MATERIAL with GRASS

In-Situ Applicable Continuous Structure

NO PRE-CASTi

Filler

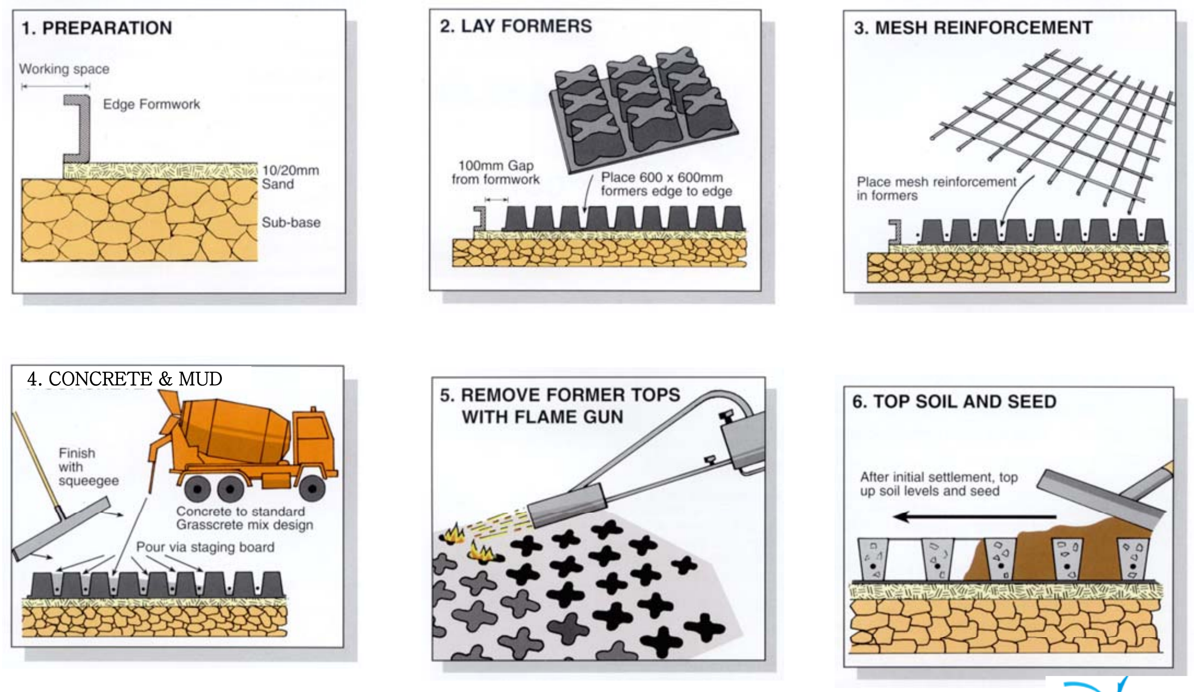
Reinforcement

Former

ARRN FORUM 2011

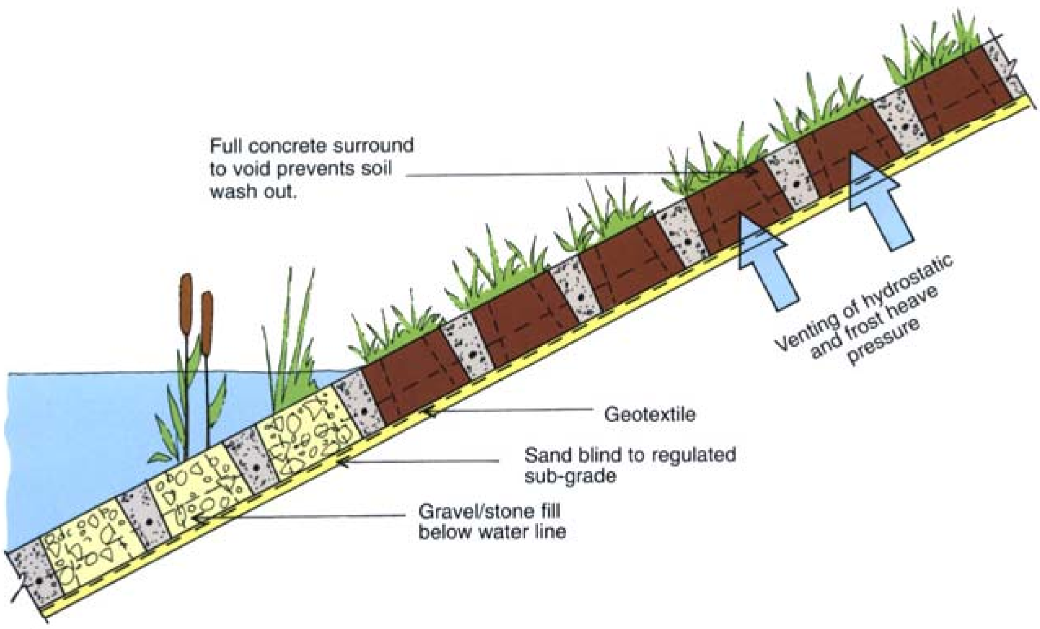
3. Application of Continuous Block System

GRASSCON – APPLICATIONSEQUENCE

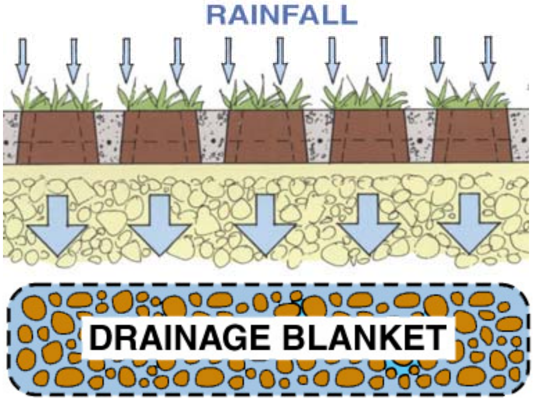


3. Application of Continuous Block System

Grasscon



3. Application of Continuous Block System



- PREVENTION OF LOCAL FLOODS
- RETENTION OF SURFACE WATER
- INCREASED DRAINAGE LAG TIME
- REDUCED DOWNSTREAM FLOODING

3. Application of Continuous Block System

RESERVOIRS
AND
SPILLWAYS

3. Application of Continuous Block System

REPAIRED RIVER EMBANKMENTS FROM FLOOD

KRRN Korea River Restoration Network

3. Application of Continuous Block System

SUPPORTING A WIDE RANGE OF VEGETATION IN FLOOD STORAGE

RESIST EROSION UNDERNEATH

KRRN Korea River Restoration Network

3. Application of Continuous Block System

TESTED VELOCITY RESISTANCE AGAINST FAILURE TO OVER 8METRES/SECOND

CONTINUOUS REINFORCED STURCTURE

KRRN Korea River Restoration Network

3. Application of Continuous Block System

Samples of GrassCon

KRRN Korea River Restoration Network

4. Hydraulic Analysis and Physical Model Test

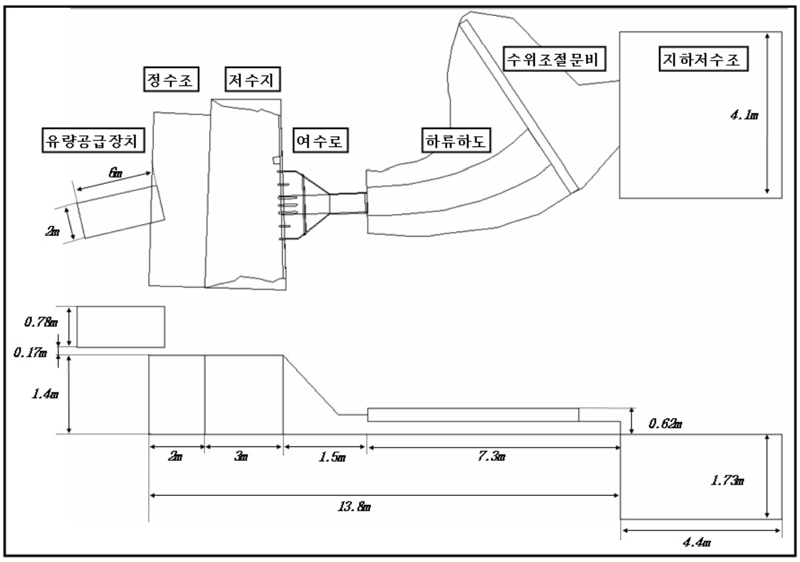
Physical Model Test

- Scale
  - Froude Similarity 1/50
- Prototype
  - Length 212m,
  - Width 35m
  - Bed Slope 1.6%
  - Bank Slope : L(1:2.0), R(1:3.0)
- Discharge Condition (Bohyun River) :
  - 200m^3/sec (100yr Design Flood)
  - 400m^3/sec
  - 600m^3/sec (PMF)

4. Hydraulic Analysis and Physical Model Test

HYDRAULIC Model Test

- Facilities



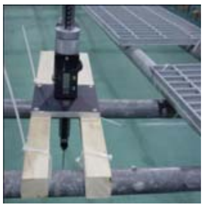
4. Hydraulic Analysis and Physical Model Test

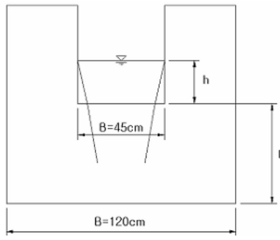
● Hydraulic Model Test

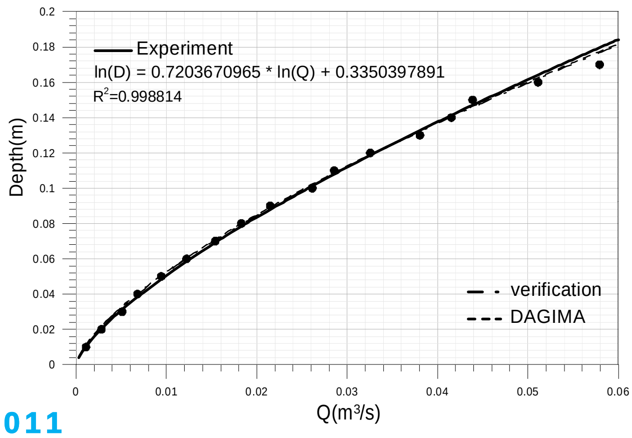
☞ Measurement
- ▸ Water Level : Digital Point Gauge
- ▸ Velocity : 1 D Current Meter

☞ Supply Discharge Verification
- ▸ Idea-Dejima Eq.

  ln(h) = 0.72xln(Q) + 0.335





ARRN FORUM 2011

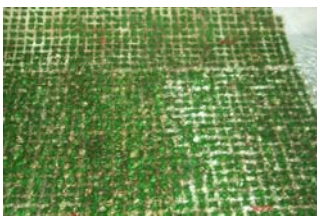
KRRN Korea River Restoration Network

4. Hydraulic Analysis and Physical Model Test

● Hydraulic Model Test

☞ Experiments Performed
- ▸ GrassCon Application
  for with/without Vegetation Condition
- ▸ Q = 200, 400, 600m³/sec
- ▸ Measurement for Water Levels, Velocities


〉 without Vegetation




〉 with Vegetation

ARRN FORUM 2011

KRRN Korea River Restoration Network

4. Hydraulic Analysis and Physical Model Test

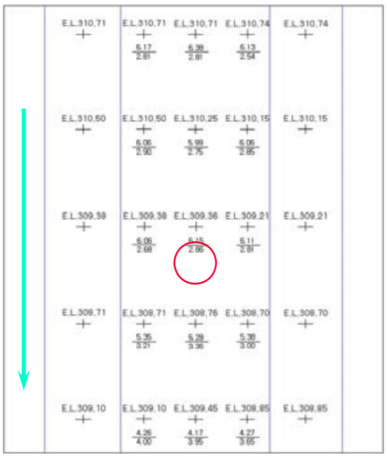
● Results of Physical Model Test

☞ Q=200m³/sec Condition

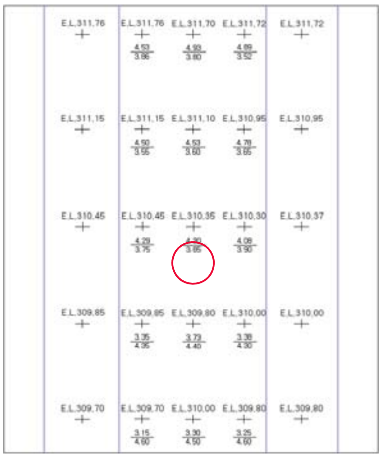
▸ Velocities : 6.15 → 4.30m/sec(3.5%~19% decrease)

▸ Water Level : 2.86 → 3.85m (1.4%~28% increase)

Reduce Delivery Time of Flood



without Veg.



With Veg.

4. Hydraulic Analysis and Physical Model Test

● Numerical Analysis

☞ Simulation

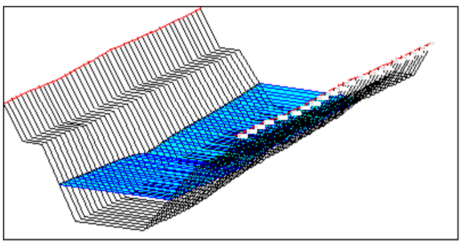
▸ 1-D Model : HEC-RAS(45 section structure)

▸ 2-D Model : SMS(1141 nodes structure)

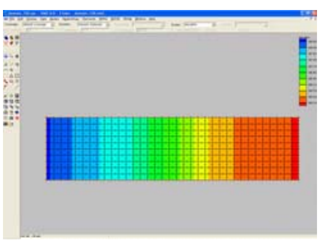
☞ Model Calibration

▸ Parameter (Roughness Coefficient) : 1-D Model

- without Vegetation : 0.017~0.035
- with Vegetation : 0.040~0.060



1-D Model



2-D Model

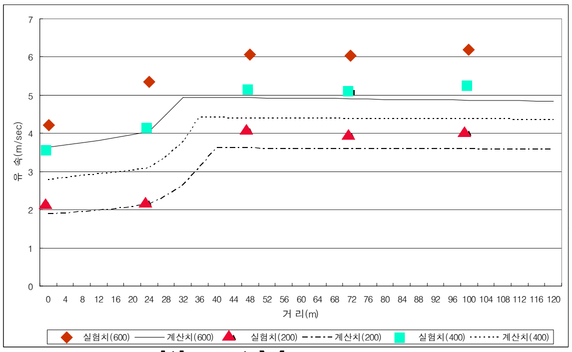
4. Hydraulic Analysis and Physical Model Test

Numerical Analysis

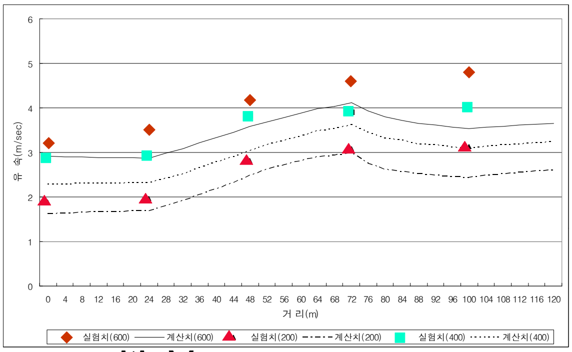
☞ Results of 1-D

▸ Difference Comparison with Physical Model

- Q=200m³/sec without Veg 4.93~11.74%
  with Veg. 2.02~13.00%
- Q=600m³/sec without Veg. 18.87~26.50%
  with Veg. 7.34~16.62%



without Veg.



with Veg.

ARRN FORUM 2011

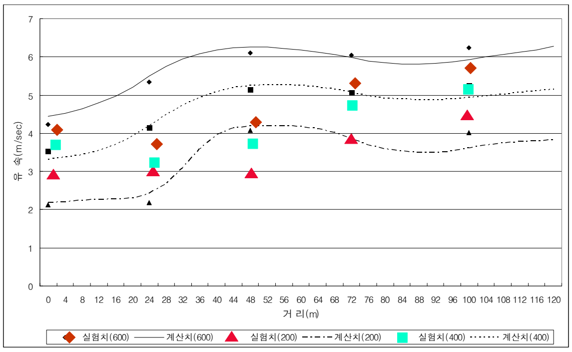
4. Hydraulic Analysis and Physical Model Test

Numerical Models

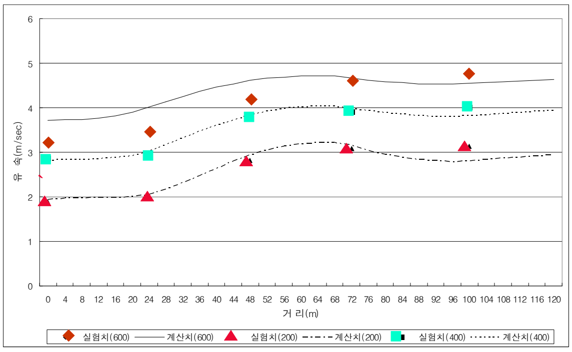
☞ 2-D Results

▸ Difference Comparison with Physical Model

- Q=200m³/sec without 1.21~10.22%
  with 2.50~10.54%
- Q=600m³/sec without 0.12~5.20%
  with 2.34~10.86%



without Veg

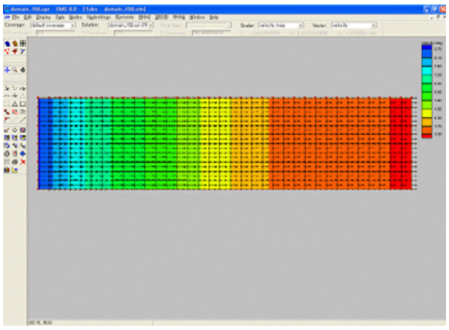


with Veg.

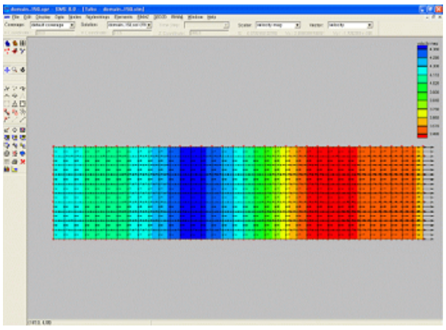
ARRN FORUM 2011

4. Hydraulic Analysis and Physical Model Test

- **Numerical Analysis**
  - ☞ 2-D Simulation Results
    - ▸ Closer Results to Physical Model Results than 1-D
    - ▸ 2-D Simulation is more Rational



Velocity Vectors without Veg.



Velocity Vectors with Veg.

5. Summary and Conclusion

- Review Characteristics between Existing Pre-cast Block System and Continuous Block System in Terms of Hydraulic Safety and Environment
  - → Application Feasibility for Close-to-Nature Stream River Works and Sustainable Urban Drainage
- Verification through Hydraulic Model Test for CBS
  - → Velocities Decrease, Water Level Increase
- Numerical Analysis Application
  - → 1-D, 2-D Simulation : Roughness Coefficient Verification
  - → 2-D Simulation Analysis is More Rational

Further Study Goes :

→Flow Resistance and Maximum Allowable Velocities

Thank you

ARRN FORUM 2011

Korea River Restoration Network