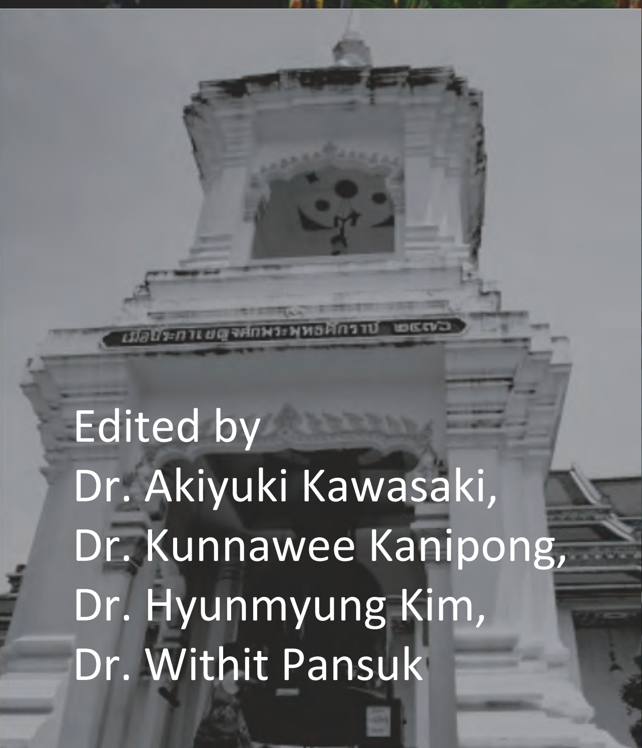
6th JOINT STUDENT SEMINAR On CIVIL INFRASTRUCTURE August 6-7, 2013



Edited by
Dr. Akiyuki Kawasaki,
Dr. Kunnawee Kanipong,
Dr. Hyunmyung Kim,
Dr. Withit Pansuk

6th Joint Student Seminar on Civil Infrastructure

6-7 August 2013
Bangkok, Thailand

Co-Organized by

School of Engineering and Technology,
Asian Institute of Technology (AIT), Thailand

International Center for Urban Safety Engineering (ICUS)
Institute of Industrial Science
The University of Tokyo, Japan

Chulalongkorn University

Myongji University, Korea

Ajou University, Korea

and

Seoul National University of Science and Technology, Korea

Edited by

Dr. Akiyuki Kawasaki, Dr. Kunnawee Kanipong,
Dr. Hyunmyung Kim and Dr. Withit Pansuk

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Prof. Haruo Sawada (UT, Japan)
Dr. Wataru Takeuchi (UT, Japan)
Dr. Akiyuki Kawasaki (UT, Japan)

6^{th} JOINT STUDENT SEMINAR ON CIVIL INFRASTRUCTURE

August 2013

PREFACE

In this era of rapid globalization, having an international sense and broad human resource network is essential. In particular, building up a good relationship with various communities during young school days will be of advantage in the future. To give such an opportunity to students from Asian countries, we held the 1^{st}, 2^{nd} 3^{rd}, 4^{th} and joint student seminar in July 2008, July 2009, July 2010, August 2011 and August 2012, respectively, and following this success the “6^{th} Joint Student Seminar on Civil Infrastructures” was held on 6^{th} -7^{th} August, 2013.

The objectives of this seminar are:

1) to experience the international seminar,
2) to improve the presentation skill,
3) to share the research information and friendships.

The number of participants was 57, consisting of 1 faculties, 1 company and 20 students from Myong Ji University, Seoul National University of Science and Technology, Chulanongkorn University, The University of Tokyo and Asian Institute of Technology.

On the first day, we had a presentation session, having 1 faculties (Ajou University) and 1 company (Hilti Thailand Ltd) lectures and 20 students' presentation. The topics covered wide range areas of civil engineering and every student did their best in his/her presentation. During the seminar, students and faculties had lively exchange of views beyond their specialty, culture and nationality. At the end of the seminar, excellent presentation awards were given to the following 3 students.

1. Mr. Tsubasa Sasaki from University of Tokyo, Japan
2. Ms. Fei Jiang from University of Tokyo, Japan
3. Mr. Seemanta Bhagabati from Asian Institute of Technology, Thai

On the second day, participants went on a field trip to visit construction site of the new MRT Blue Line (Underground) at Hua Lampong area. The Project is a 27 kilometers underground and elevated heavy rail transit system with 4 underground stations and 15 elevated stations situated along the route, 3 intervention shafts, a depot with operation control center and 1 park and ride. In the afternoon, visited Hua Lamphong Railway Station, cultural sites of Bangkok Wat Kalayanimit, Kao Sarn Road, Wat Sraket Rajavaravihara and Bowonniwet Temple.

The seminar was quite successful and fruitful: this seminar gave not only knowledge and information but also a lot of other stimuli to the students. We hope to continue to hold this kind of interchange activities in the coming years. Finally, we would like to express our sincere gratitude for those who kindly supported and contributed to the success of this seminar.

AKIYUKI KAWASAKI, KUNNAWEE KANIPONG,
HYUNMYUNG KIM AND WITHIT PANSUK

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Seminar Venue

Opening ceremony (Dr. Akiyuki Kawasaki)

Dr. Jeong Whon Yu

Mr. Kunakorn Pragthong

Ms. Sung-Hi An

Mr. Tsubasa Sasaki

Mr. Seemanta Bhagabati

Ms. Noriko Okamura

Mr. Ryoichiro Hoshino

Ms. Dang Anh Nguyet

Mr. Shunya Kimura

Mr. Baekkyu Namkung

Ms. Aya Fujikawa

Mr. Tharadol Punlop

Mr. Shunya Suzuki

Ms. Onnicha Rongviriyapanich

Ms. Sae Shikita

Mr. Jetpan Wetwitooait

Ms. Nakashima Mari

Ms. Nao Sasaki

Mr. Choong-Shik Lee

Ms. Fei Jiang

Mr. Michael Coo

Mr. Niwat Apichartbutra

Chairperson (Dr. Hyunmyung Kim)

Chairperson (Dr. Sung Bong Chung)

Committee (Dr. Withit Pansuk)

Closing ceremony (Dr. Kunnawee Kanitpong)

discussion during sessions

Dr.Kunakorn Pragthong(left)

Present from Hilti (Thailand) Ltd

discussion during coffee break

Welcome Dinner

Welcome Dinner

Excellence Presenter Mr. Tsubasa Sasaki

Excellence Presenter Mr. Seemanta Bhagabati

Excellence Presenter Ms. Fei Jiang

Excellence Presenters

Briefing at Construction site of the new Metropolitan Rapid Transit (MRT) Blue Line

Process of excavating from the main tunnel

Mouth of the tunnel and see the Tunnel Boring Machine(TBM)


Entrance of the tunnel and Tunnel Boring Machine(TBM)


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Appreciation for Mr. Kanok Duangkhae


Enjoy a trip

Group Photo at Chulalongkorn University

Group Photo at Construction site of the new MRT Blue Line

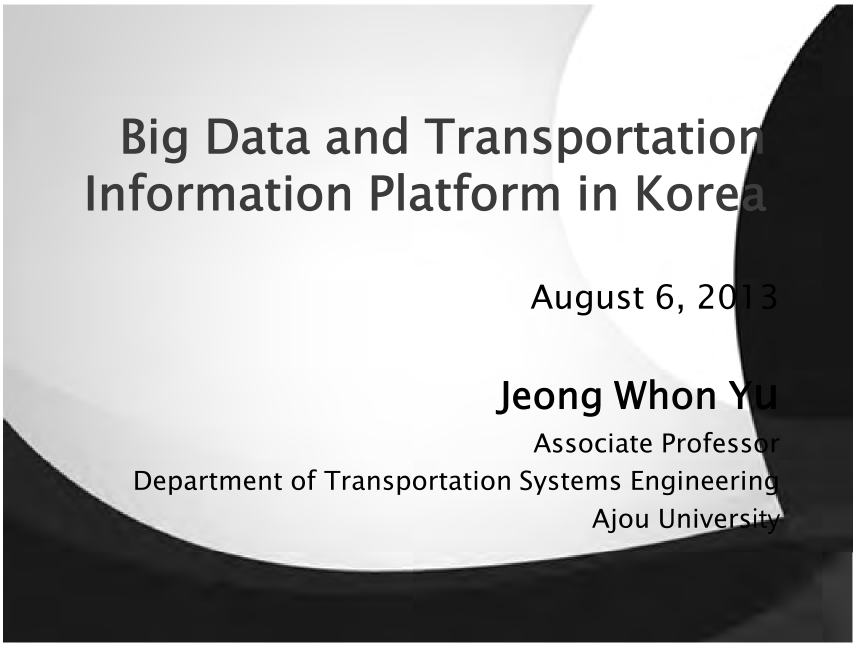
Group Photo at Hua Lamphong Railway Station

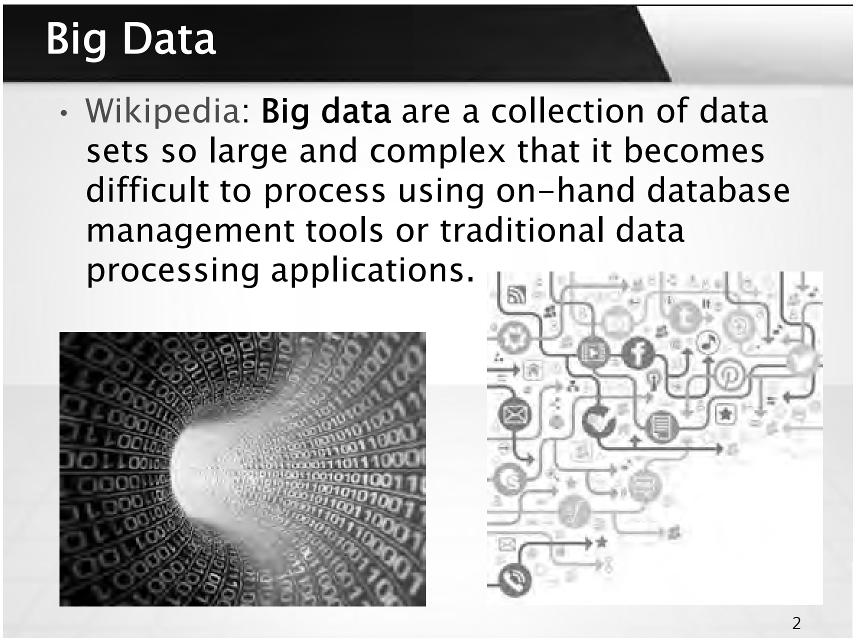
Group Photo at Bowonniwet Temple

Invited Lectures

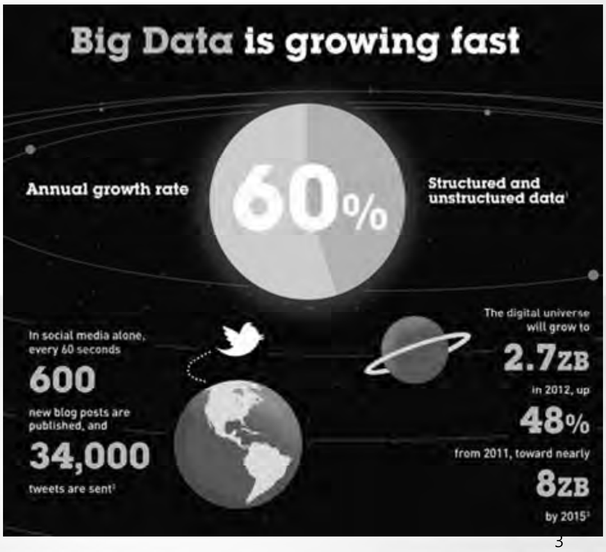
BIG DATA AND TRANSPORTATION INFORMATION PLATFORM IN KOREA

Jeong Whon Yu
Division of Environmental, Civil and Transportation Engineering
jeongwhon@ajou.ac.kr





Big Data



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Big Data in Transportation

http://www.youtube.com/watch?v=r37jt-PeL8k

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Why Platform in Korea?
• Korean Government's new strategies and policies
– Government 3.0
– All information must be open to public
– Creative economy
• Ministry of Land and Transportation
• Ministry of Safety and Administration
• Seoul City Government
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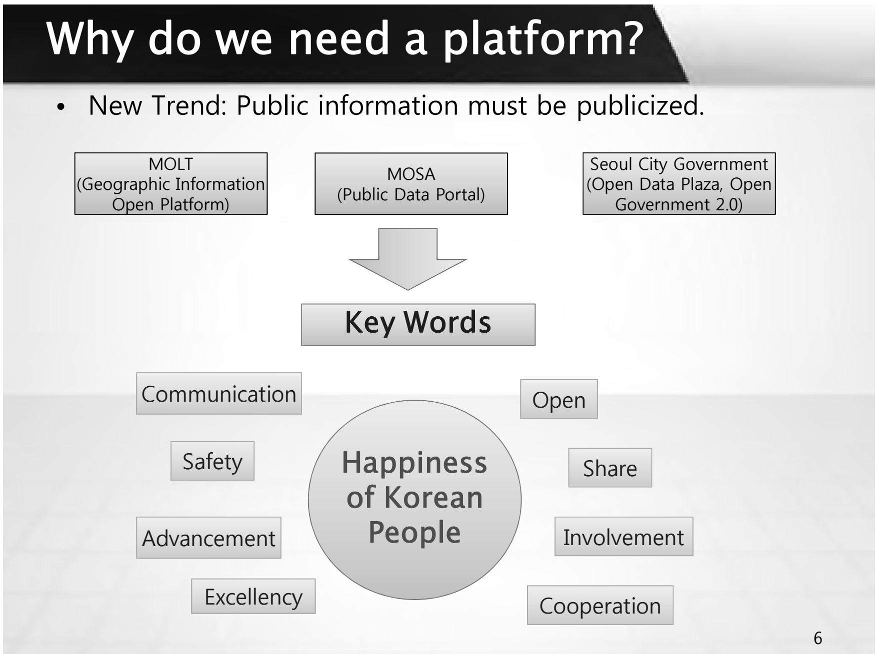
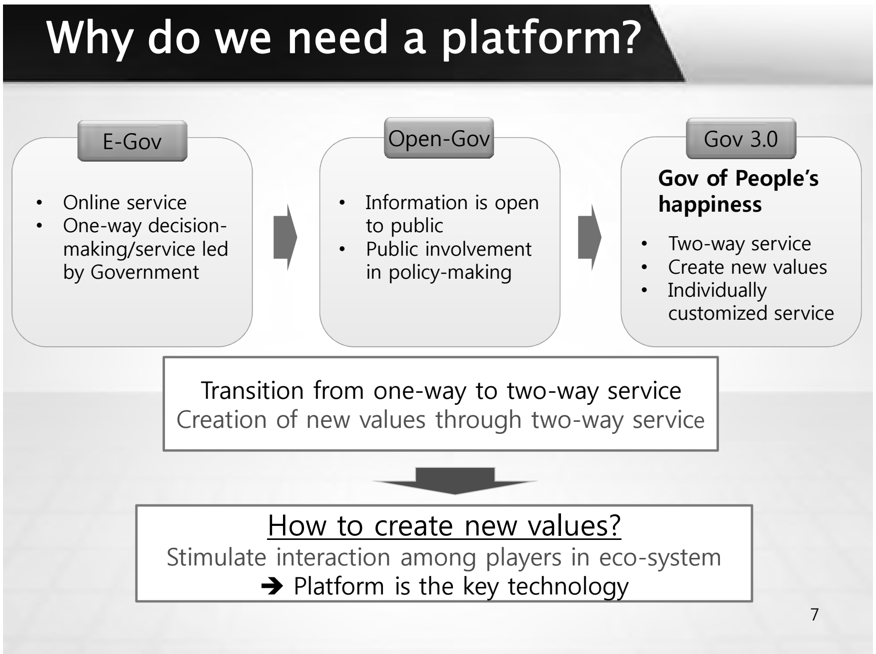

Why do we need a platform?
• New Trend: Public information must be publicized.
MOLT (Geographic Information Open Platform)
MOSA (Public Data Portal)
Seoul City Government (Open Data Plaza, Open Government 2.0)
Key Words
Communication
Safety
Advancement
Excellency
Happiness of Korean People
Open
Share
Involvement
Cooperation
6


Why do we need a platform?
E-Gov
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Open-Gov
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• Public involvement in policy-making
Gov 3.0
Gov of People's happiness
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Creation of new values through two-way service
How to create new values?
Stimulate interaction among players in eco-system
➔ Platform is the key technology
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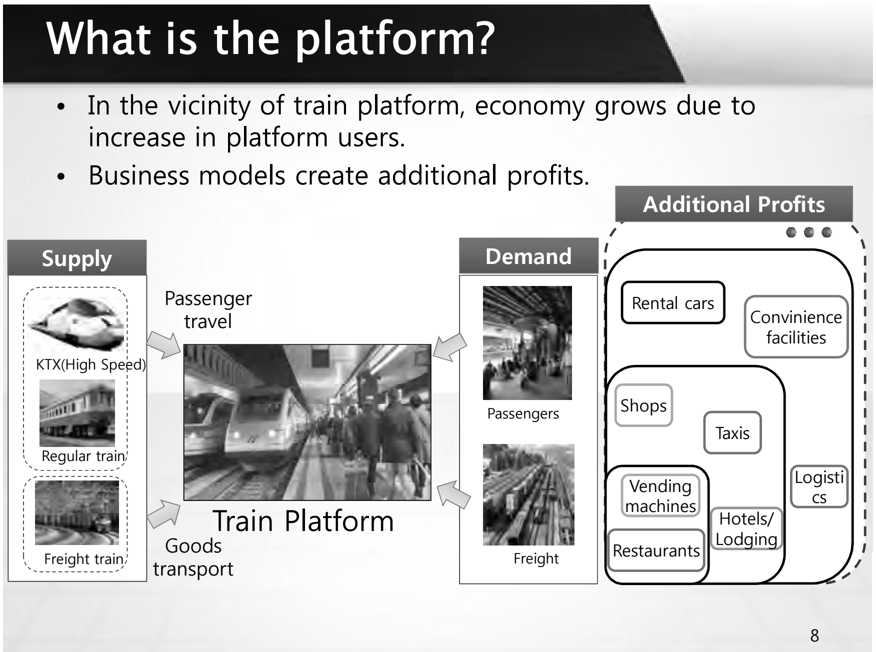
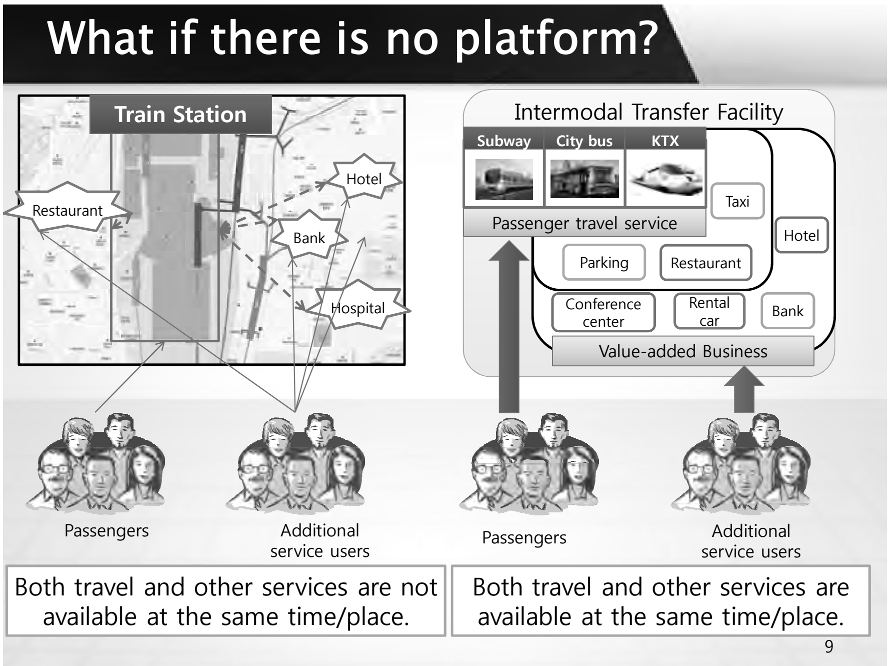

What is the platform?
• In the vicinity of train platform, economy grows due to increase in platform users.
• Business models create additional profits.
Supply
KTX(High Speed)
Regular train
Freight train
Passenger travel
Goods transport
Train Platform
Demand
Passengers
Freight
Additional Profits
Rental cars
Convinience facilities
Shops
Taxis
Vending machines
Restaurants
Hotels/ Lodging
Logisti cs
8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Train Station
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Bank
Hospital
Intermodal Transfer Facility
Subway
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Passenger travel service
Hotel
Parking
Restaurant
Conference center
Rental car
Bank
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Passengers
Additional service users
Passengers
Additional service users
Both travel and other services are not available at the same time/place.
Both travel and other services are available at the same time/place.
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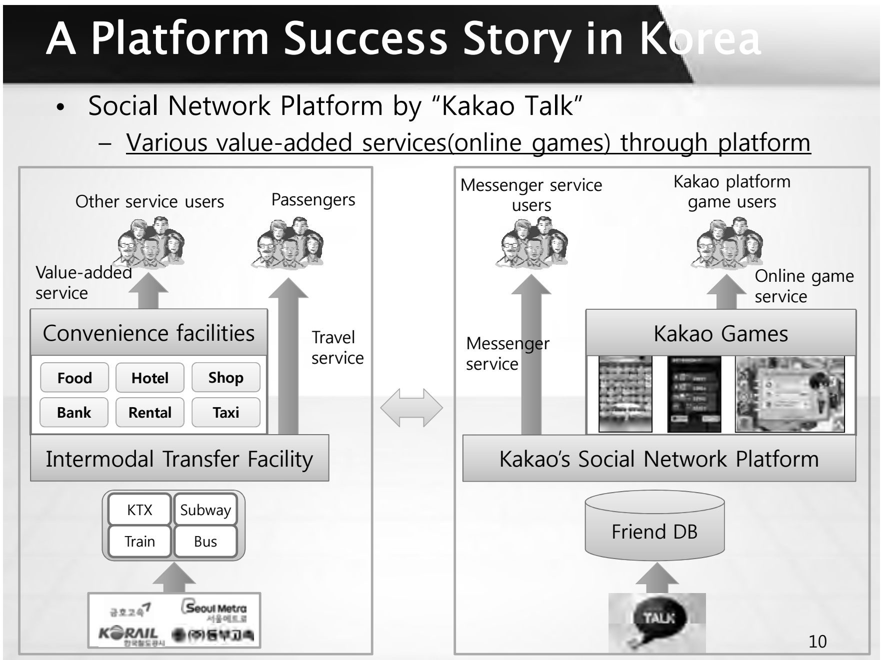
A Platform Success Story in Korea
• Social Network Platform by "Kakao Talk"
– Various value-added services(online games) through platform
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Passengers
Value-added service
Convenience facilities
Travel service
Food
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Shop
Bank
Rental
Taxi
Intermodal Transfer Facility
KTX
Subway
Train
Bus
Seoul Metro
KORAIL
Messenger service users
Kakao platform game users
Online game service
Messenger service
Kakao Games
Kakao's Social Network Platform
Friend DB
TALK
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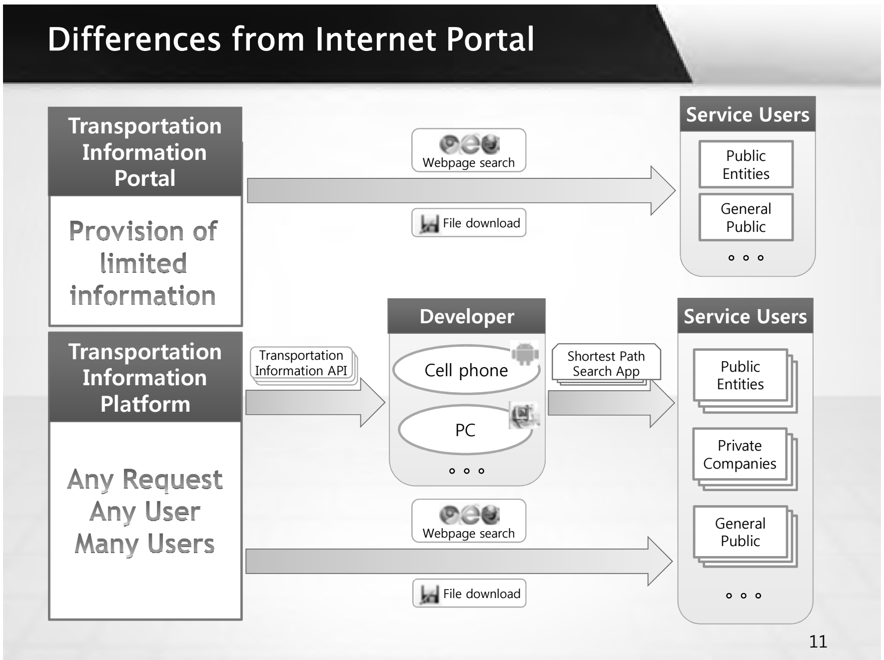
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Transportation Information Portal
Provision of limited information
Webpage search
File download
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Service Users
Public Entities
Private Companies
General Public
Webpage search
File download
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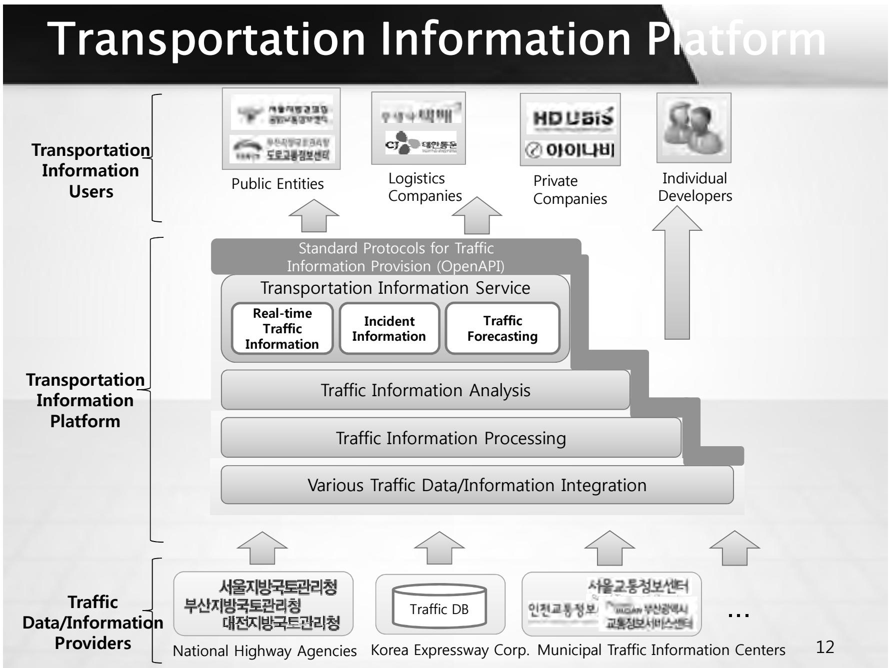
Transportation Information Platform
Transportation Information Users
Public Entities
Logistics Companies
Private Companies
Individual Developers
Standard Protocols for Traffic Information Provision (OpenAPI)
Transportation Information Service
Real-time Traffic Information
Incident Information
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Traffic Information Processing
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Transportation Information Platform
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부산지방국토관리청
대전지방국토관리청
Traffic DB
서울교통정보센터
…
National Highway Agencies
Korea Expressway Corp.
Municipal Traffic Information Centers
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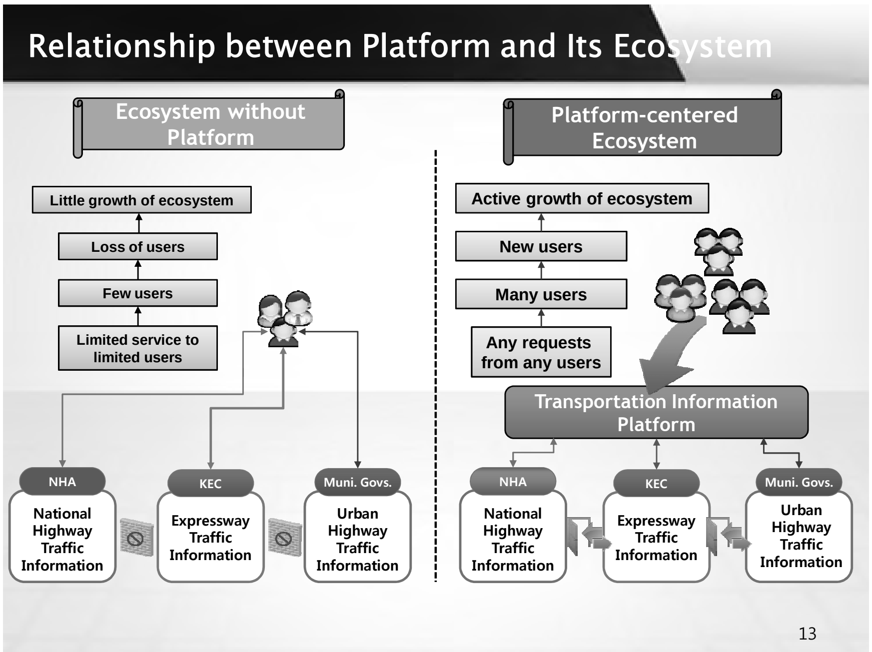
Relationship between Platform and Its Ecosystem
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Platform-centered Ecosystem
Little growth of ecosystem
Loss of users
Few users
Limited service to limited users
Active growth of ecosystem
New users
Many users
Any requests from any users
Transportation Information Platform
NHA
National Highway Traffic Information
KEC
Expressway Traffic Information
Muni. Govs.
Urban Highway Traffic Information
NHA
National Highway Traffic Information
KEC
Expressway Traffic Information
Muni. Govs.
Urban Highway Traffic Information
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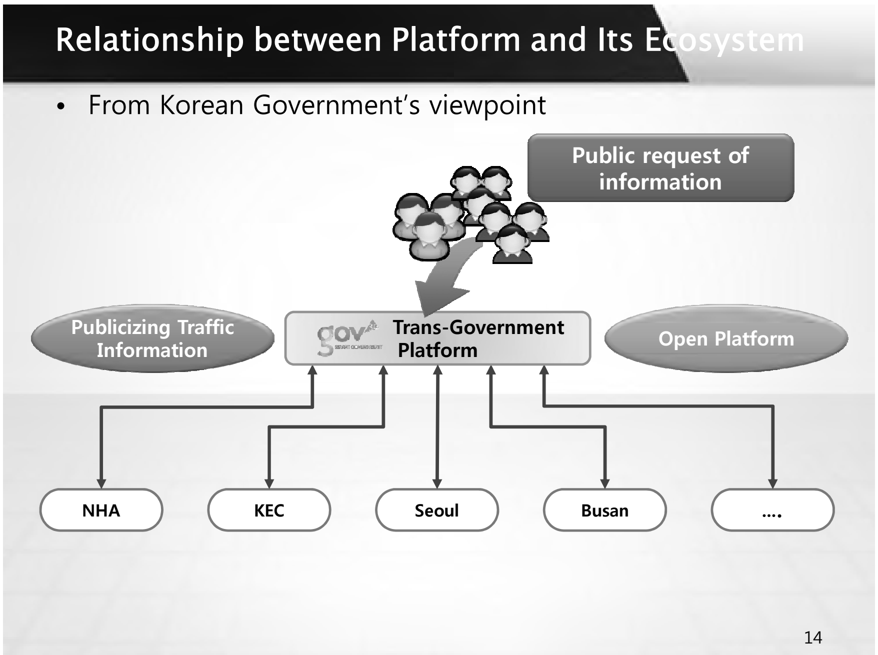
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Trans-Government Platform
Open Platform
NHA
KEC
Seoul
Busan
....
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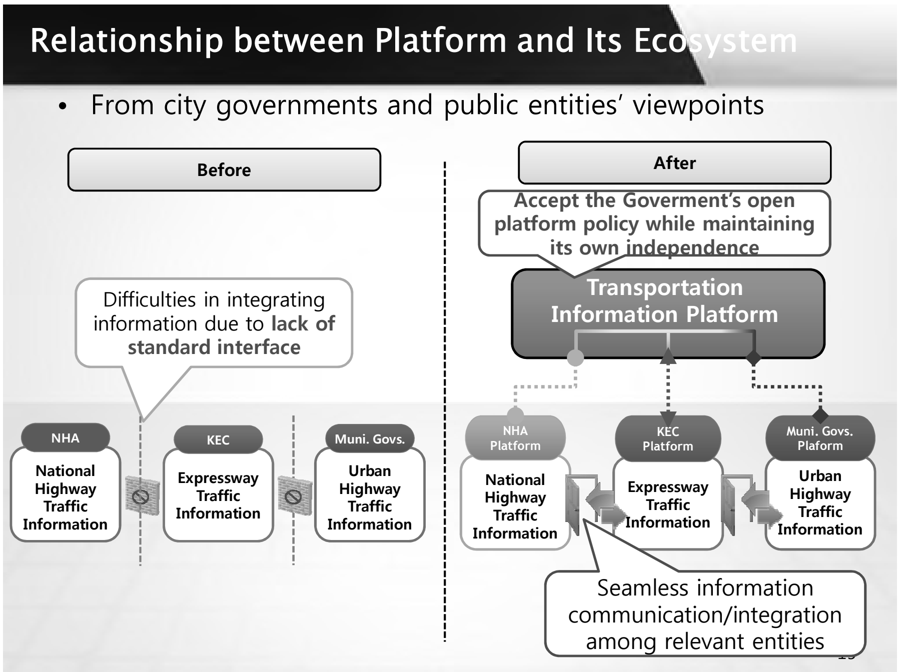
Relationship between Platform and Its Ecosystem
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Before
After
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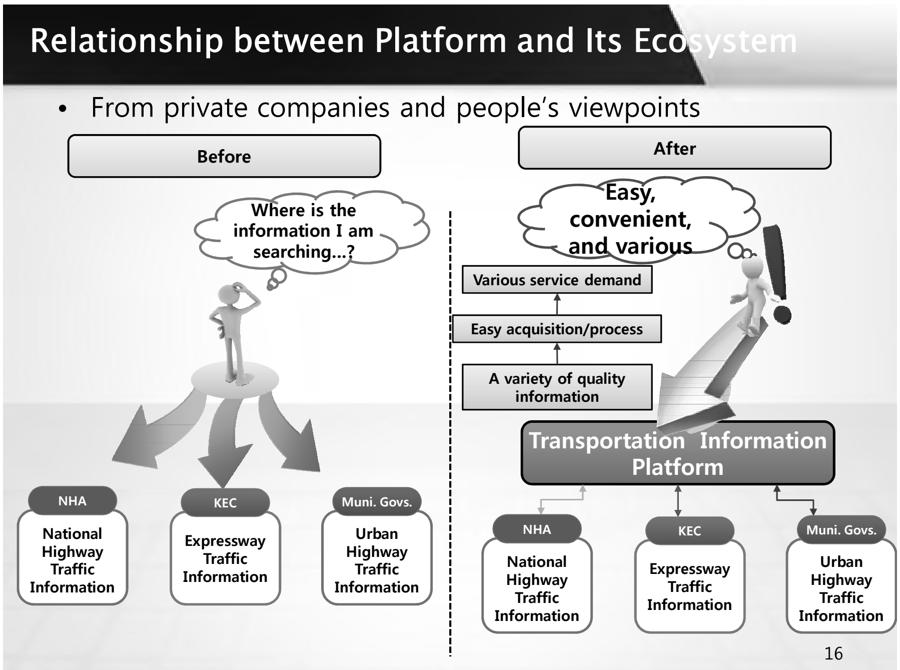
Transportation Information Platform
Difficulties in integrating information due to lack of standard interface
NHA
National Highway Traffic Information
KEC
Expressway Traffic Information
Muni. Govs.
Urban Highway Traffic Information
NHA Platform
National Highway Traffic Information
KEC Platform
Expressway Traffic Information
Muni. Govs. Plaform
Urban Highway Traffic Information
Seamless information communication/integration among relevant entities


Relationship between Platform and Its Ecosystem
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Before
After
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Transportation Information Platform
NHA
National Highway Traffic Information
KEC
Expressway Traffic Information
Muni. Govs.
Urban Highway Traffic Information
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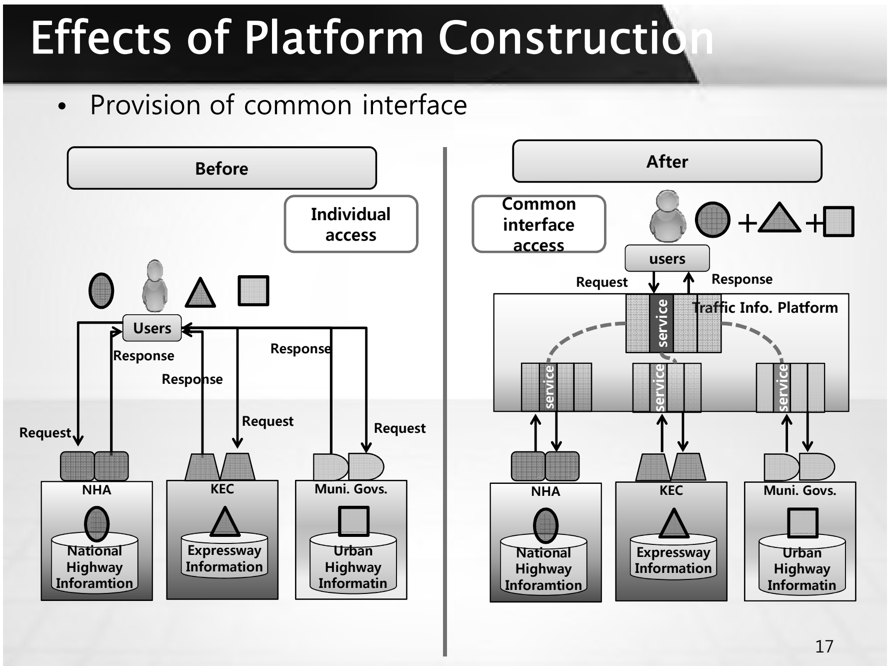
Effects of Platform Construction
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Users
Response
Response
Response
Request
Request
Request
NHA
National Highway Inforamtion
KEC
Expressway Information
Muni. Govs.
Urban Highway Informatin
After
Common interface access
users
Request
Response
Traffic Info. Platform
service
service
service
service
NHA
National Highway Inforamtion
KEC
Expressway Information
Muni. Govs.
Urban Highway Informatin
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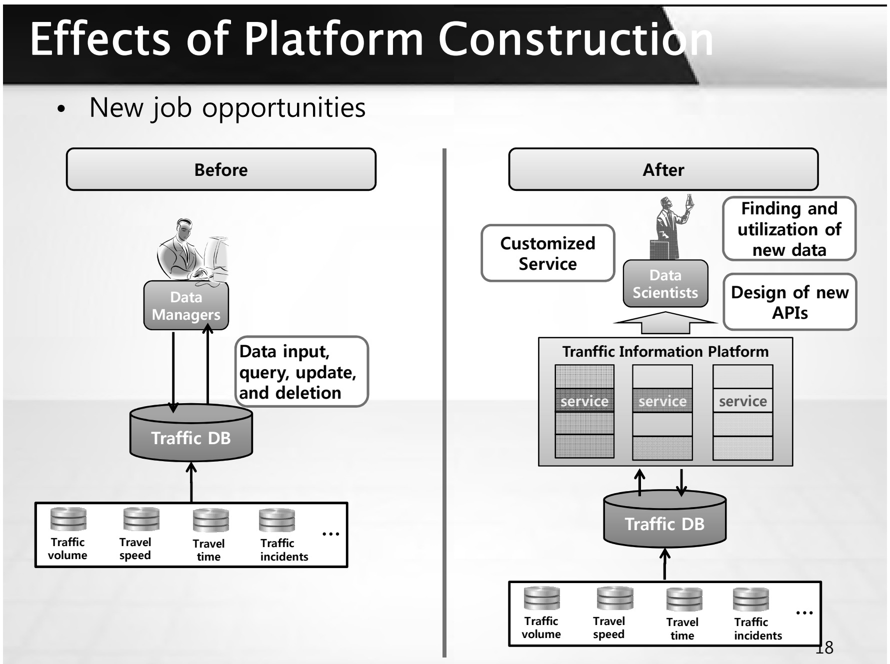
Effects of Platform Construction
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Traffic DB
Traffic volume
Travel speed
Travel time
Traffic incidents
…
After
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Tranffic Information Platform
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service
service
Traffic DB
Traffic volume
Travel speed
Travel time
Traffic incidents
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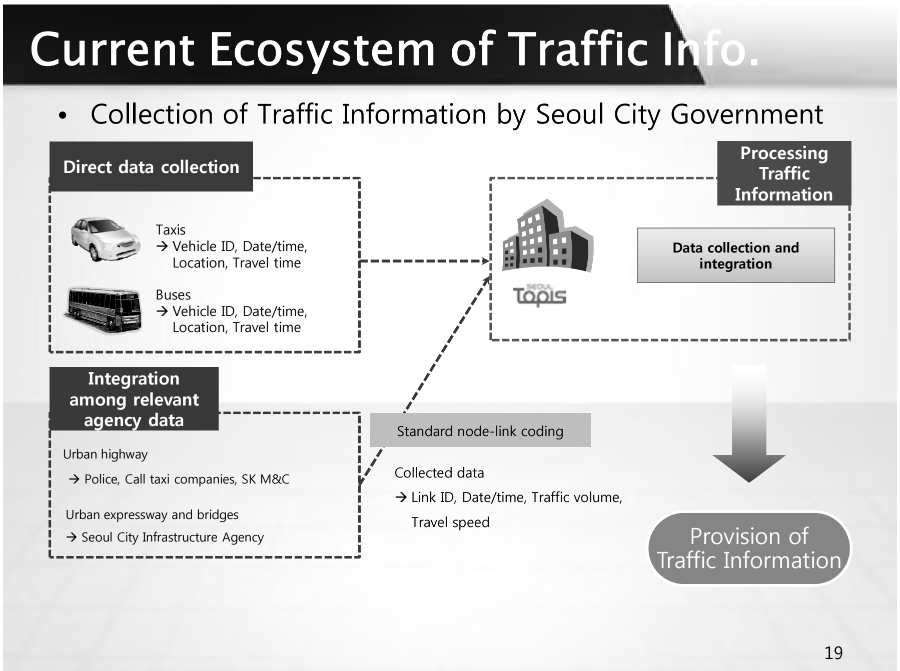
Current Ecosystem of Traffic Info.
• Collection of Traffic Information by Seoul City Government
Direct data collection
Taxis
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Buses
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Data collection and integration
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Integration among relevant agency data
Urban highway
→ Police, Call taxi companies, SK M&C
Urban expressway and bridges
→ Seoul City Infrastructure Agency
Standard node-link coding
Collected data
→ Link ID, Date/time, Traffic volume, Travel speed
Provision of Traffic Information
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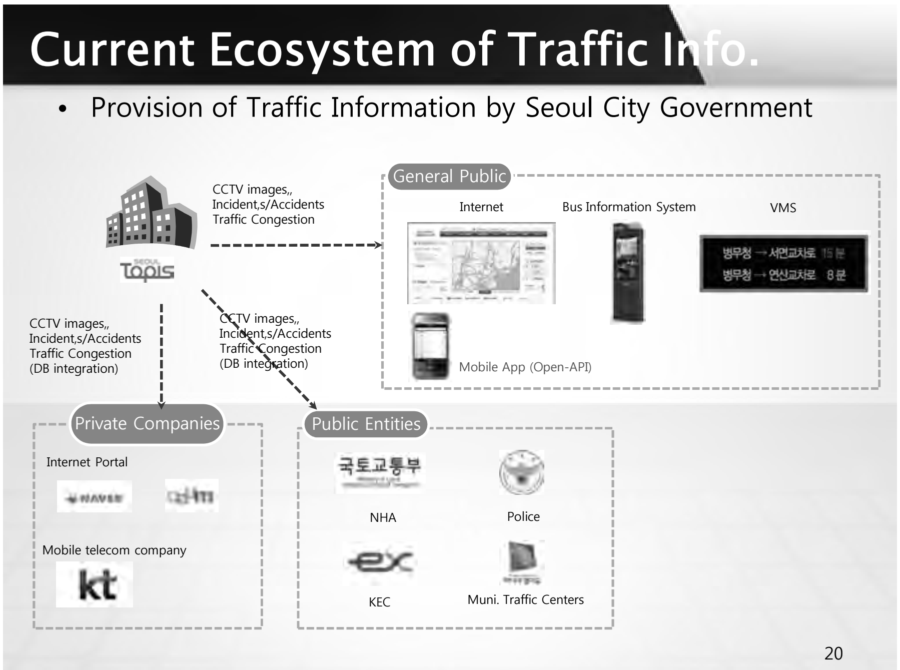
Current Ecosystem of Traffic Info.
• Provision of Traffic Information by Seoul City Government
SEOUL TOPIS
CCTV images,, Incident,s/Accidents Traffic Congestion
General Public
Internet
Bus Information System
VMS
Mobile App (Open-API)
CCTV images,, Incident,s/Accidents Traffic Congestion (DB integration)
CCTV images,, Incident,s/Accidents Traffic Congestion (DB integration)
Private Companies
Internet Portal
Mobile telecom company
kt
Public Entities
국토교통부
NHA
Police
ex
KEC
Muni. Traffic Centers
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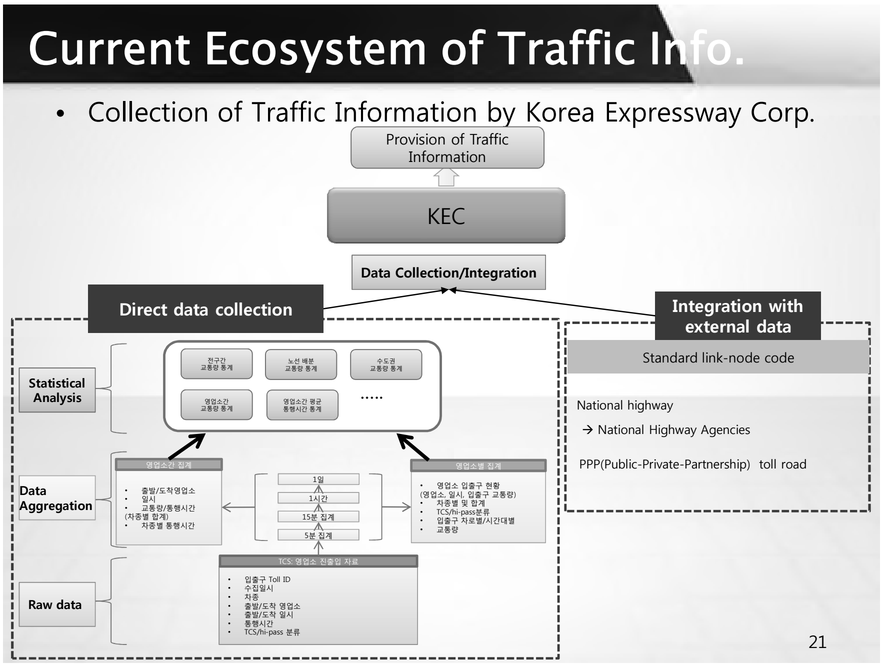
Current Ecosystem of Traffic Info.
• Collection of Traffic Information by Korea Expressway Corp.
Provision of Traffic Information
KEC
Data Collection/Integration
Direct data collection
Integration with external data
Statistical Analysis
Data Aggregation
Raw data
Standard link-node code
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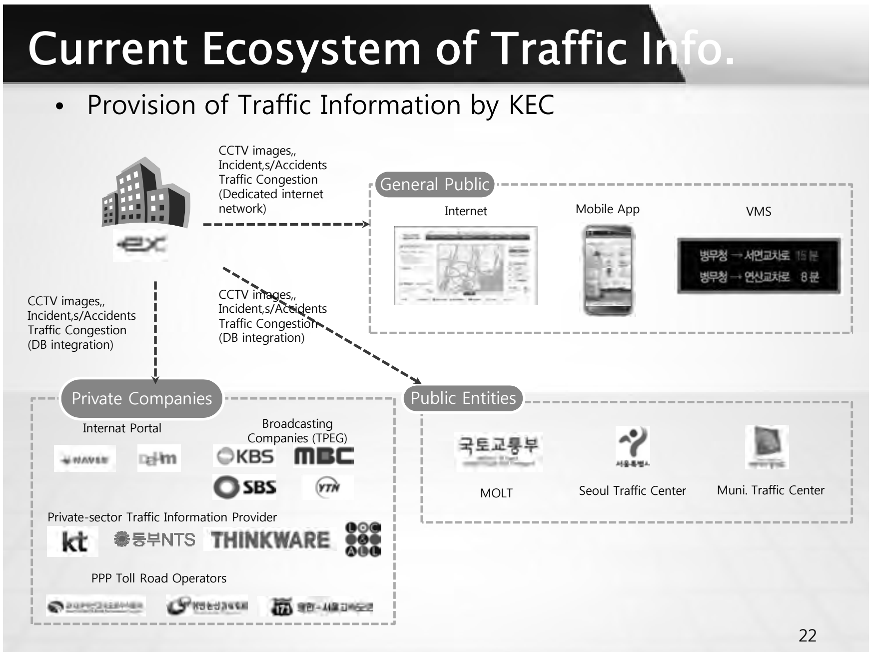
Current Ecosystem of Traffic Info.
• Provision of Traffic Information by KEC
CCTV images,, Incident,s/Accidents Traffic Congestion (Dedicated internet network)
General Public
Internet
Mobile App
VMS
CCTV images,, Incident,s/Accidents Traffic Congestion (DB integration)
CCTV images,, Incident,s/Accidents Traffic Congestion (DB integration)
Private Companies
Internet Portal
Broadcasting Companies (TPEG)
Private-sector Traffic Information Provider
PPP Toll Road Operators
Public Entities
MOLT
Seoul Traffic Center
Muni. Traffic Center
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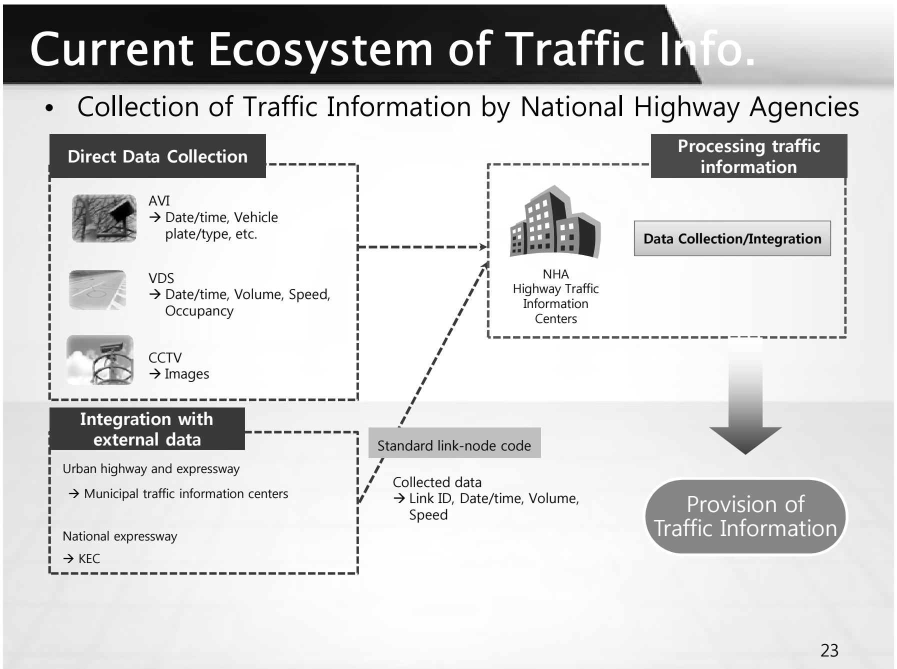
Current Ecosystem of Traffic Info.
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Direct Data Collection
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VDS
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CCTV
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NHA Highway Traffic Information Centers
Data Collection/Integration
Integration with external data
Urban highway and expressway
→ Municipal traffic information centers
National expressway
→ KEC
Standard link-node code
Collected data
→ Link ID, Date/time, Volume, Speed
Provision of Traffic Information
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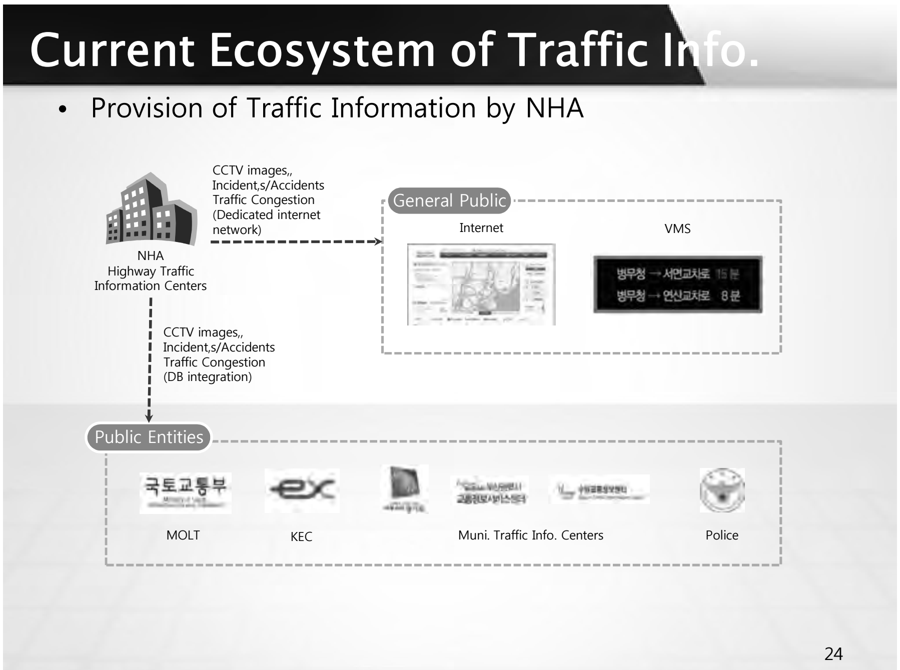
Current Ecosystem of Traffic Info.
• Provision of Traffic Information by NHA
NHA Highway Traffic Information Centers
CCTV images,, Incident,s/Accidents Traffic Congestion (Dedicated internet network)
General Public
Internet
VMS
CCTV images,, Incident,s/Accidents Traffic Congestion (DB integration)
Public Entities
국토교통부
MOLT
KEC
Muni. Traffic Info. Centers
Police
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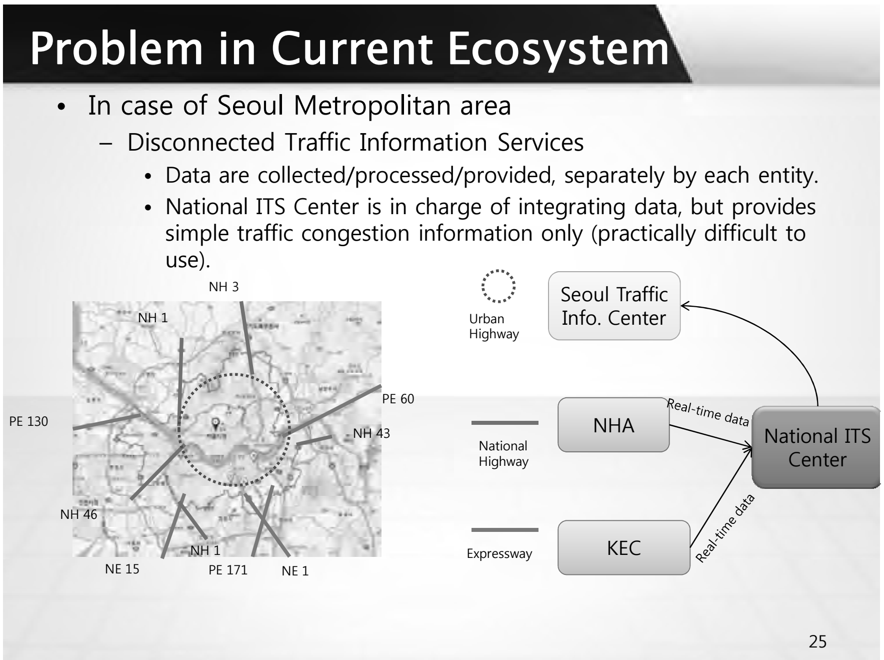
Problem in Current Ecosystem
• In case of Seoul Metropolitan area
– Disconnected Traffic Information Services
• Data are collected/processed/provided, separately by each entity.
• National ITS Center is in charge of integrating data, but provides simple traffic congestion information only (practically difficult to use).
NH 3
NH 1
PE 60
PE 130
NH 43
NH 46
NH 1
NE 15
PE 171
NE 1
Urban Highway
Seoul Traffic Info. Center
National Highway
NHA
Real-time data
National ITS Center
Expressway
KEC
Real-time data
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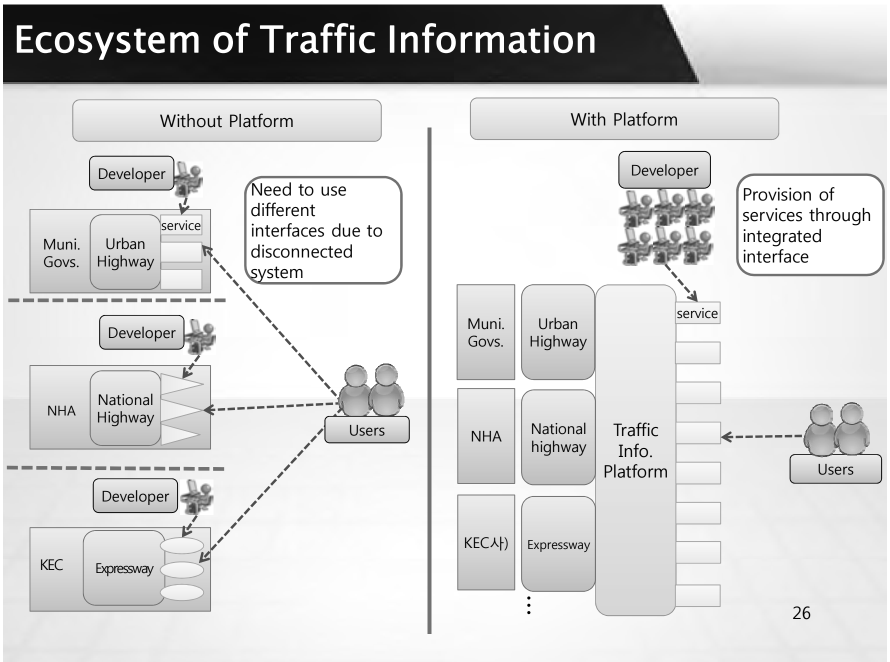
Ecosystem of Traffic Information
Without Platform
With Platform
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service
Muni. Govs.
Urban Highway
Need to use different interfaces due to disconnected system
Developer
NHA
National Highway
Users
Developer
KEC
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Developer
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service
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Urban Highway
NHA
National highway
Traffic Info. Platform
KEC사)
Expressway
Users
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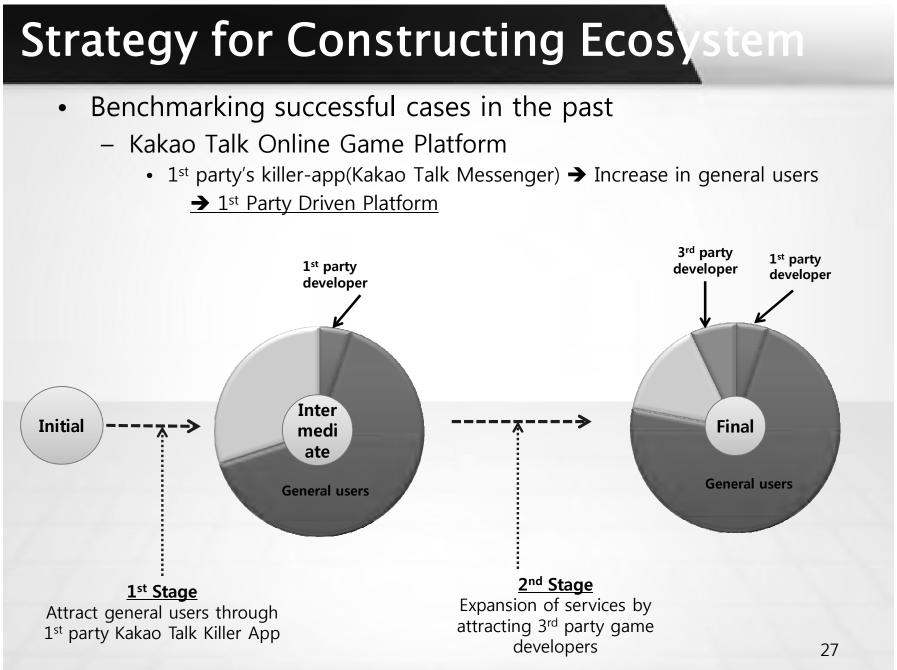
Strategy for Constructing Ecosystem
• Benchmarking successful cases in the past
– Kakao Talk Online Game Platform
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1st party developer
3rd party developer
1st party developer
Initial
Inter medi ate
General users
Final
General users
1st Stage
Attract general users through 1st party Kakao Talk Killer App
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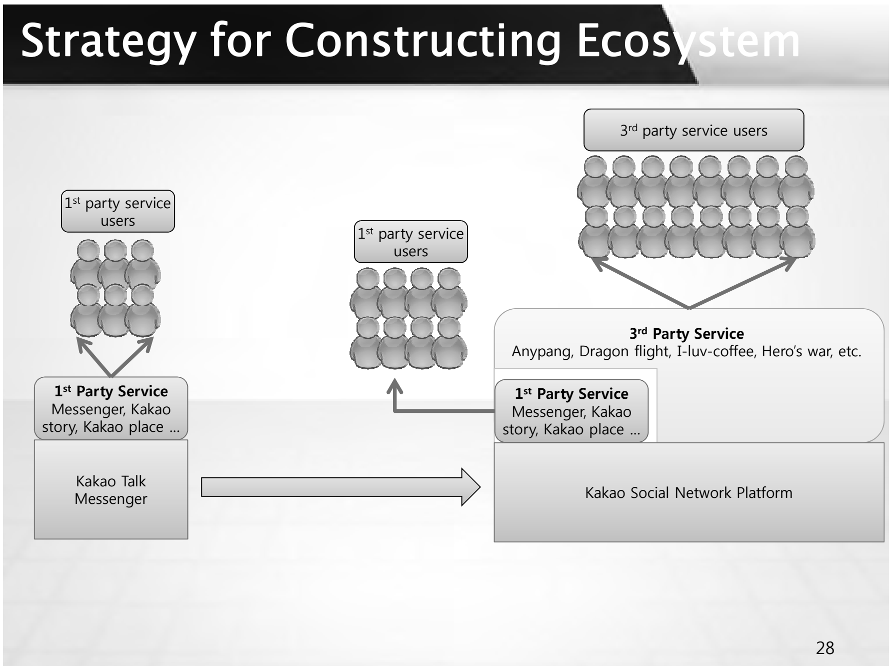
Strategy for Constructing Ecosystem
3rd party service users
1st party service users
1st party service users
3rd Party Service
Anypang, Dragon flight, I-luv-coffee, Hero's war, etc.
1st Party Service
Messenger, Kakao story, Kakao place …
1st Party Service
Messenger, Kakao story, Kakao place …
Kakao Talk Messenger
Kakao Social Network Platform
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Strategy for Traffic Info. Ecosystem

- Need to provide a quality 1st party service
  - Provision of traffic information through visualization
  - Education of data scientists for creating new services through advanced data analysis
  - Advertisement of traffic information services to general public
- Need to provide incentives to 3rd party developers
  - Creation of developer communities for active communication
  - Provision of convenient environments for developers
  - Education and advertisement of developers

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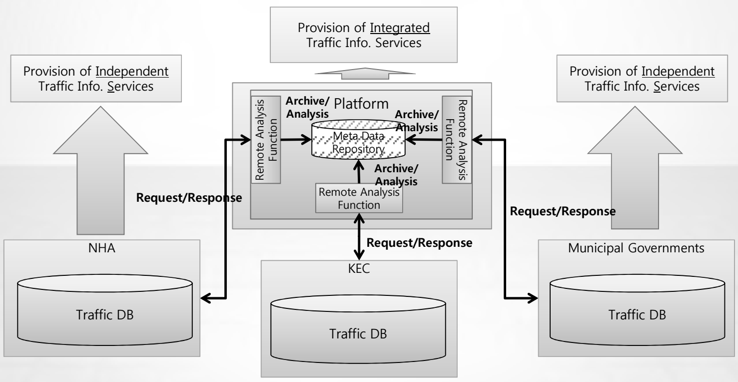
Strategy for Traffic Info. Ecosystem

- **Loose Interoperability**
  - Independent operation and service provision
  - Minimize the conflicts with external entities



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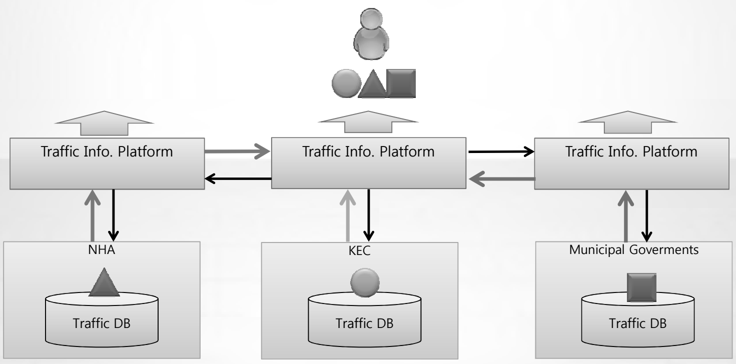
Strategy for Traffic Info. Ecosystem

- United Platforms
  - Keep its own autonomy
  - Seamless connection between unit platforms



31

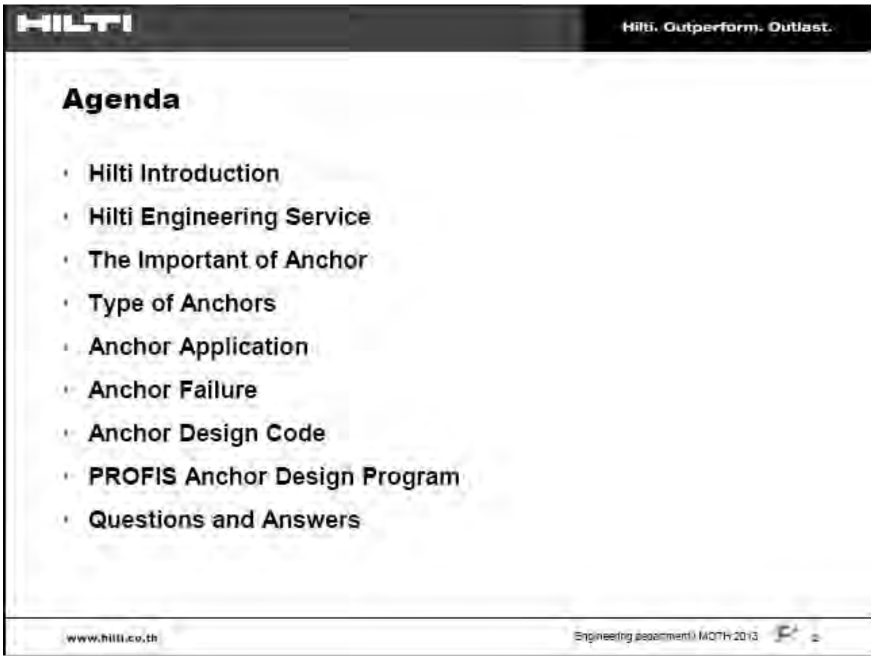
Summary

- Emergence of transportation big data
- Strong request of making public information publicized
- Strategies for constructing traffic information platform
  - Standardized platform
  - Independent platform having its own autonomy
  - United platform with seamless connection and service
- Socioeconomic effects
  - Creation of new job: data scientists
  - Enhancement of general public's satisfaction/happiness through providing individually customized traffic information service
- Current issues
  - Legal and institutional supports
  - Advertisement of transportation big data and platform
  - Creation of developer/expert groups: communities, forum

32

UNDERSTANDING POST-INSTALLED ANCHOR SYSTEMS & CODE DESIGN REQUIREMENTS

Kunakorn Pragthong
Hilti (Thailand) Ltd
moth@hilti.com




HILTI
Hilti. Outperform. Outlast.
The Hilti group – company introduction
LIECHTENSTEIN
35'000 citizens
160 square
Hilti Group
• 19,000 employees over 120 countries
• Anti-corruption agreement
• 5 Billion THB for R&D each year
• We do R&D throughout sale & service
Hilti Thailand
• 24th fl., TCIF tower (Nation Tower) Bangna -Trad KM. 4
• 40 Engineers degree
• 120 employees
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HILTI
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Our products
Anchor fastening
- ACI 318-11
- ICC approved
- Seismic approved
- Fatigue load
- Fire resistance
- Shock load
- Long-term certified
- Anchor for non structural
Firestop system
• ASTM
• UL standard
• 30 yrs. aging test
• FM Global
• LEED certified
• Green building
• F rating 30 min to 4 hrs.
Measuring & scanner
Drilling & Demolition
Diamond coring
Direct fastening
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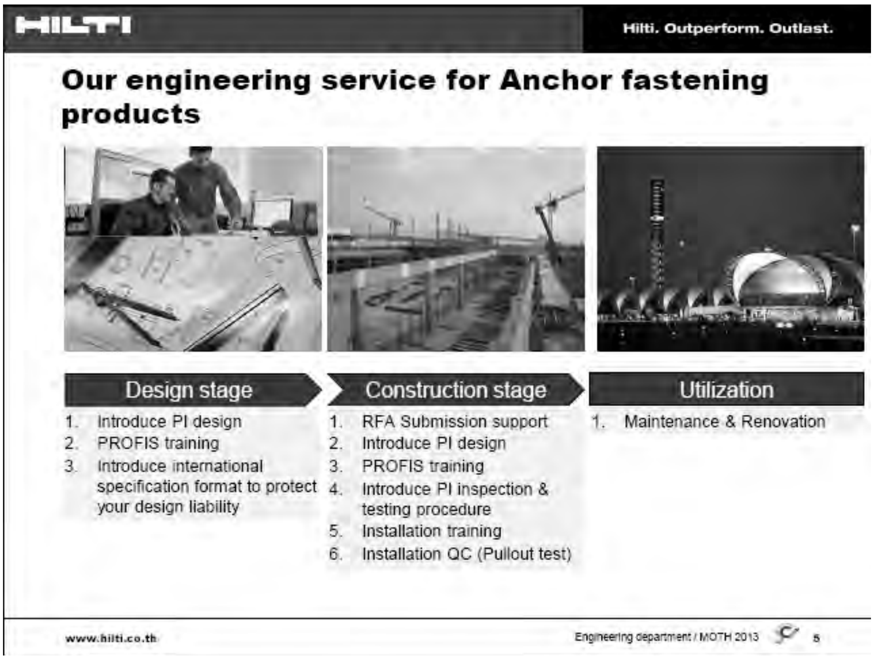
HILTI
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Our engineering service for Anchor fastening products
Design stage
1. Introduce PI design
2. PROFIS training
3. Introduce international specification format to protect your design liability
Construction stage
1. RFA Submission support
2. Introduce PI design
3. PROFIS training
4. Introduce PI inspection & testing procedure
5. Installation training
6. Installation QC (Pullout test)
Utilization
1. Maintenance & Renovation
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Why connections are very critical ?
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Why connections are very critical ?
Failure of whole 13 stories building in China
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Why connections are very critical ?
Failure of connection on structures
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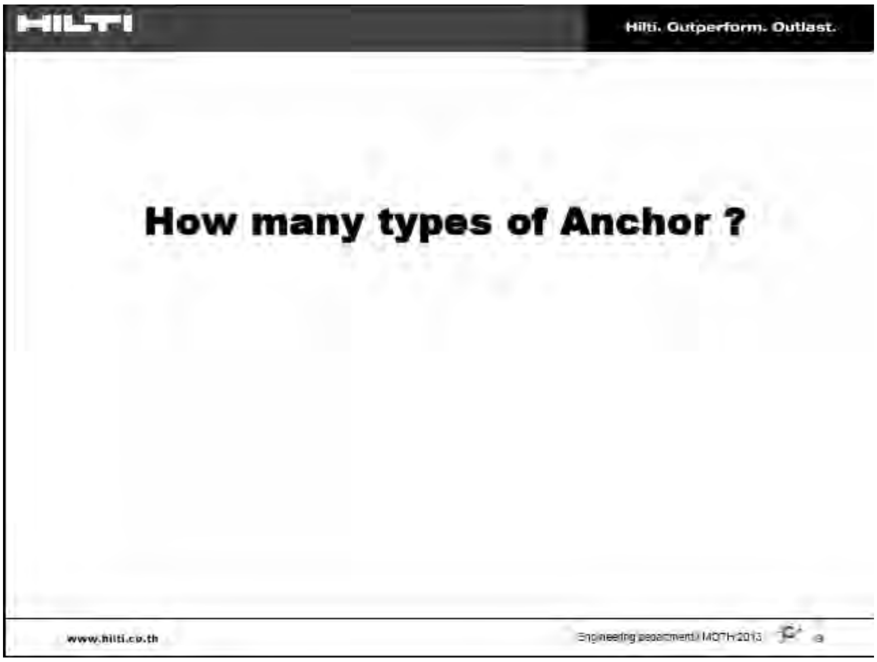
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How many types of Anchor ?
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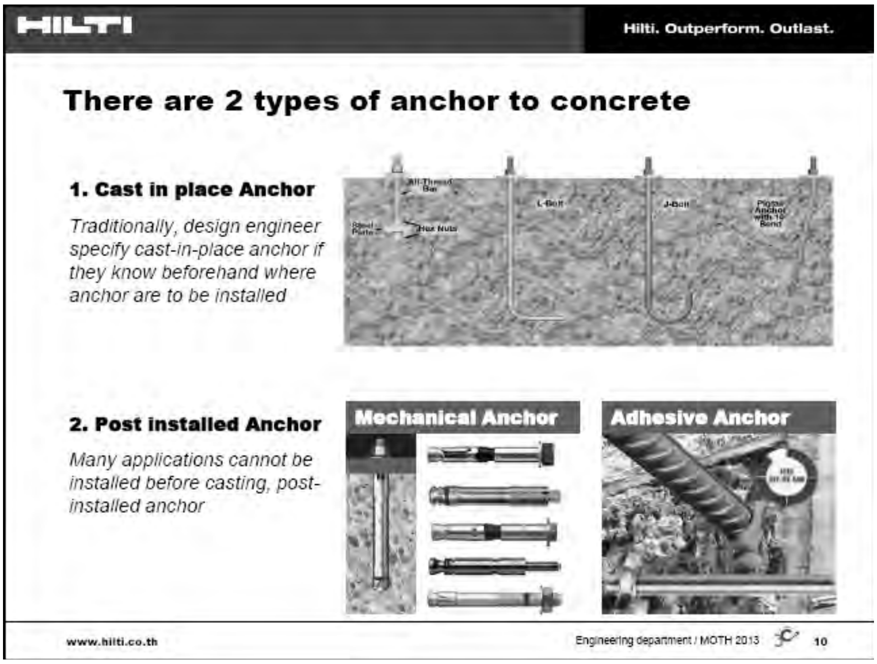
Hilti. Outperform. Outlast.
There are 2 types of anchor to concrete
1. Cast in place Anchor
Traditionally, design engineer specify cast-in-place anchor if they know beforehand where anchor are to be installed
L-Bolt
J-Bolt
Hex Nuts
2. Post installed Anchor
Many applications cannot be installed before casting, post-installed anchor
Mechanical Anchor
Adhesive Anchor
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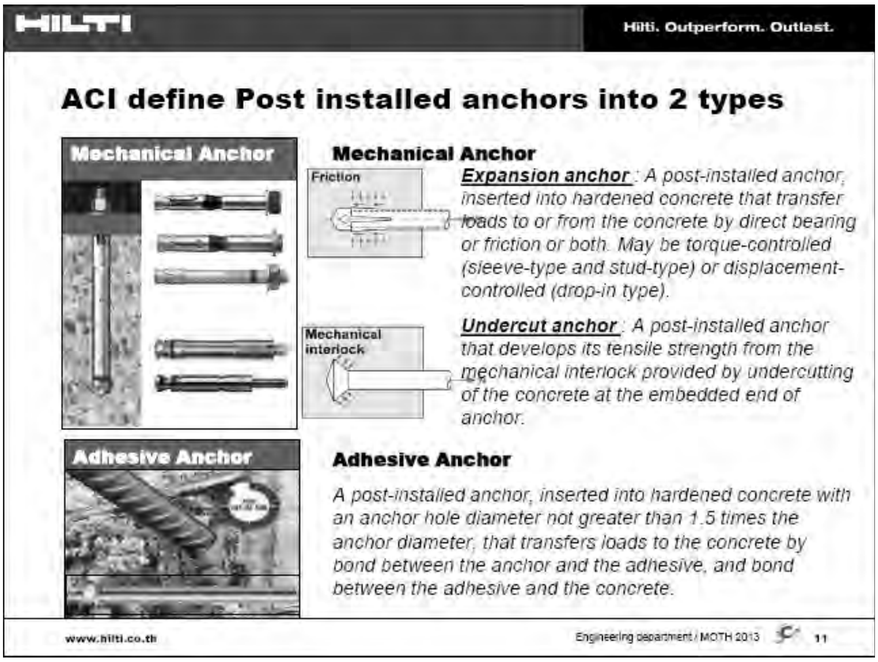
Hilti. Outperform. Outlast.
ACI define Post installed anchors into 2 types
Mechanical Anchor
Mechanical Anchor
Friction
Expansion anchor : A post-installed anchor, inserted into hardened concrete that transfer loads to or from the concrete by direct bearing or friction or both. May be torque-controlled (sleeve-type and stud-type) or displacement-controlled (drop-in type).
Mechanical interlock
Undercut anchor : A post-installed anchor that develops its tensile strength from the mechanical interlock provided by undercutting of the concrete at the embedded end of anchor.
Adhesive Anchor
Adhesive Anchor
A post-installed anchor, inserted into hardened concrete with an anchor hole diameter not greater than 1.5 times the anchor diameter, that transfers loads to the concrete by bond between the anchor and the adhesive, and bond between the adhesive and the concrete.
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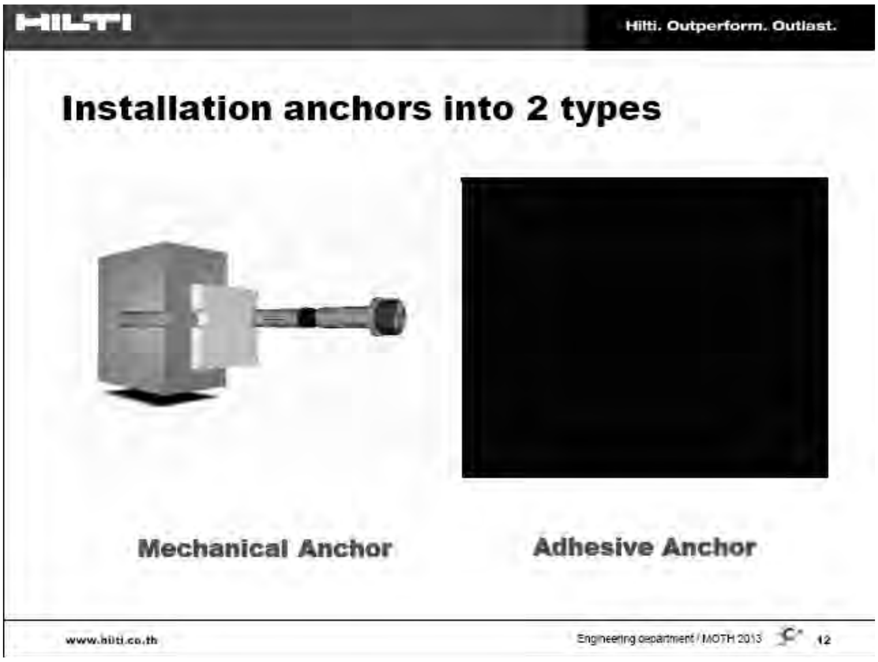
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Installation anchors into 2 types
Mechanical Anchor
Adhesive Anchor
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Where and when to use Post installed Anchor?
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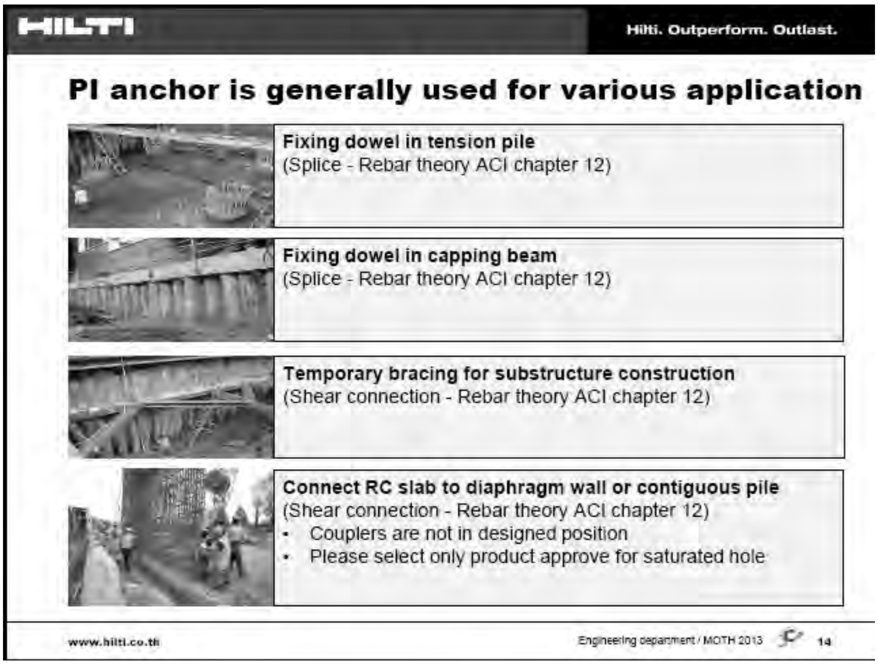
13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PI anchor is generally used for various application
Fixing dowel in tension pile
(Splice - Rebar theory ACI chapter 12)
Fixing dowel in capping beam
(Splice - Rebar theory ACI chapter 12)
Temporary bracing for substructure construction
(Shear connection - Rebar theory ACI chapter 12)
Connect RC slab to diaphragm wall or contiguous pile
(Shear connection - Rebar theory ACI chapter 12)
• Couplers are not in designed position
• Please select only product approve for saturated hole
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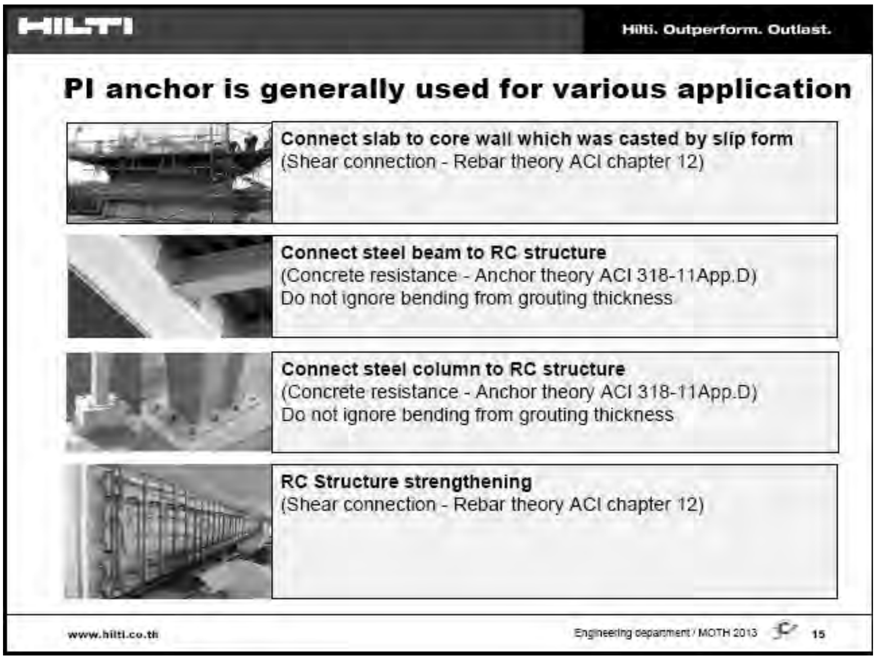
HILTI
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PI anchor is generally used for various application
Connect slab to core wall which was casted by slip form
(Shear connection - Rebar theory ACI chapter 12)
Connect steel beam to RC structure
(Concrete resistance - Anchor theory ACI 318-11App.D)
Do not ignore bending from grouting thickness
Connect steel column to RC structure
(Concrete resistance - Anchor theory ACI 318-11App.D)
Do not ignore bending from grouting thickness
RC Structure strengthening
(Shear connection - Rebar theory ACI chapter 12)
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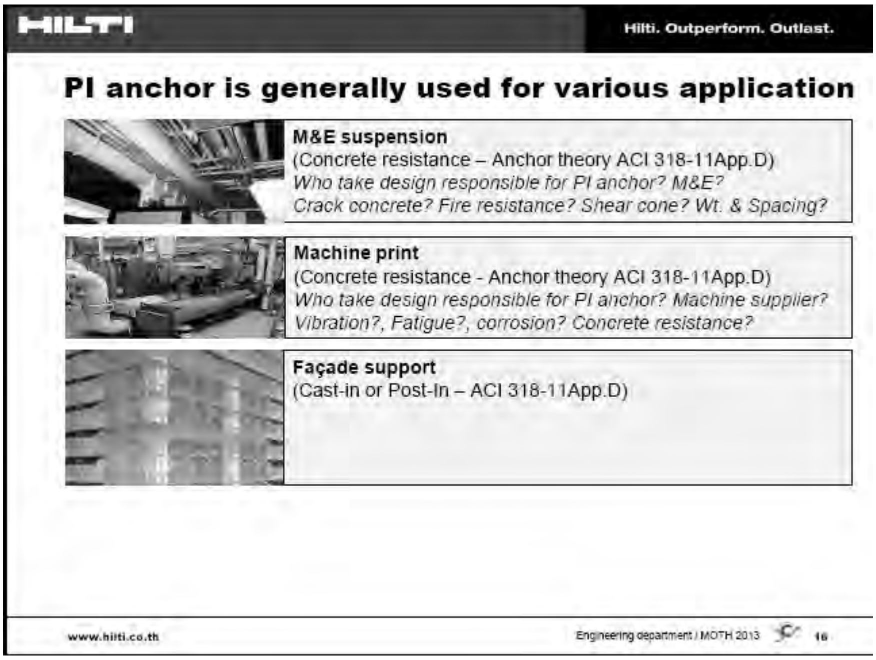
HILTI
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PI anchor is generally used for various application
M&E suspension
(Concrete resistance – Anchor theory ACI 318-11App.D)
Who take design responsible for PI anchor? M&E?
Crack concrete? Fire resistance? Shear cone? Wt. & Spacing?
Machine print
(Concrete resistance - Anchor theory ACI 318-11App.D)
Who take design responsible for PI anchor? Machine supplier?
Vibration?, Fatigue?, corrosion? Concrete resistance?
Façade support
(Cast-in or Post-In – ACI 318-11App.D)
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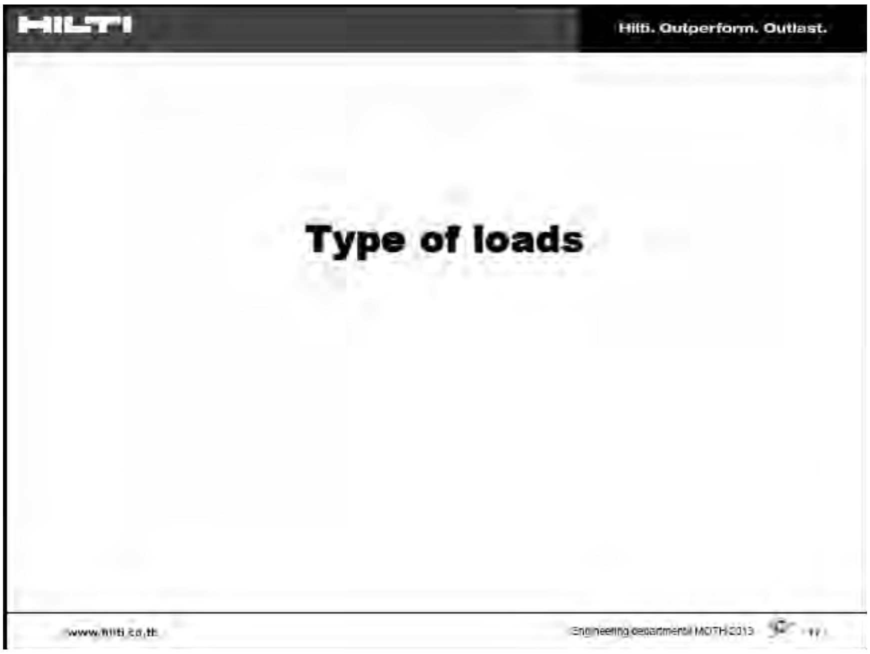
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Type of loads
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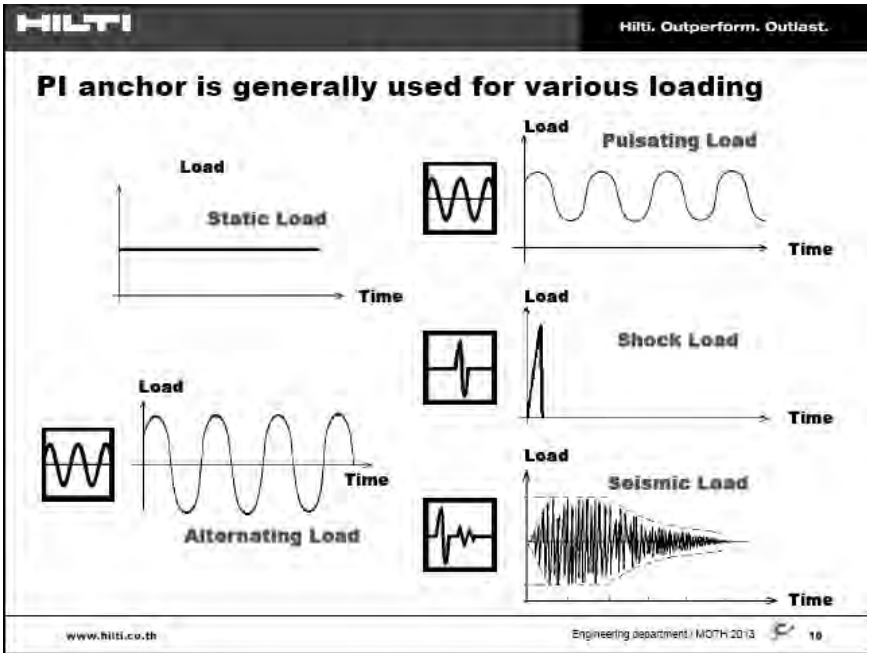
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PI anchor is generally used for various loading
Load
Static Load
Time
Load
Pulsating Load
Time
Load
Shock Load
Time
Load
Time
Alternating Load
Load
Seismic Load
Time
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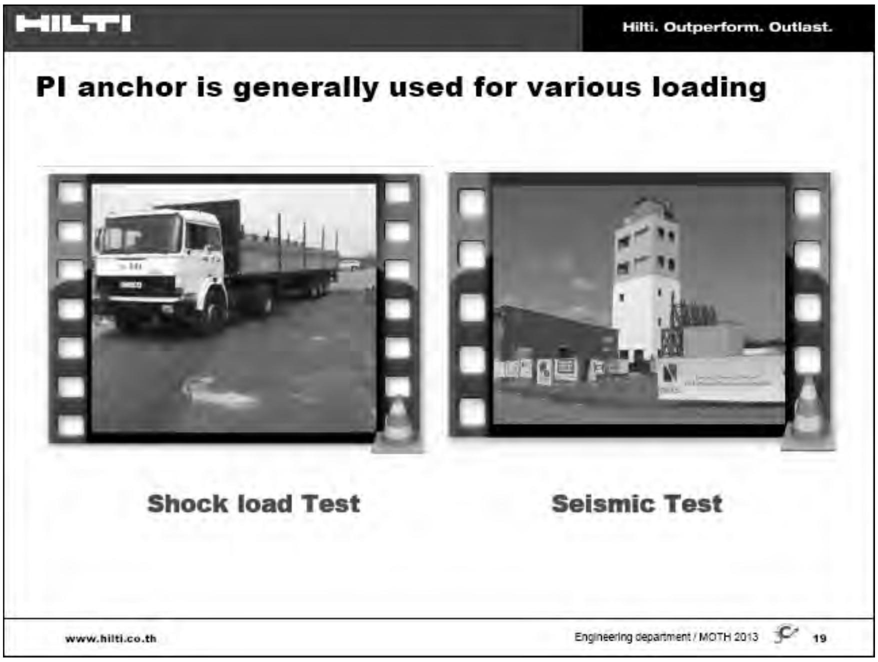
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PI anchor is generally used for various loading
Shock load Test
Seismic Test
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Have you ever seen anchor failure?
Yes, let's see!
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Many cases of anchor failure
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Many cases of anchor failure
(a) Concrete breakout
(b) Fractured anchors
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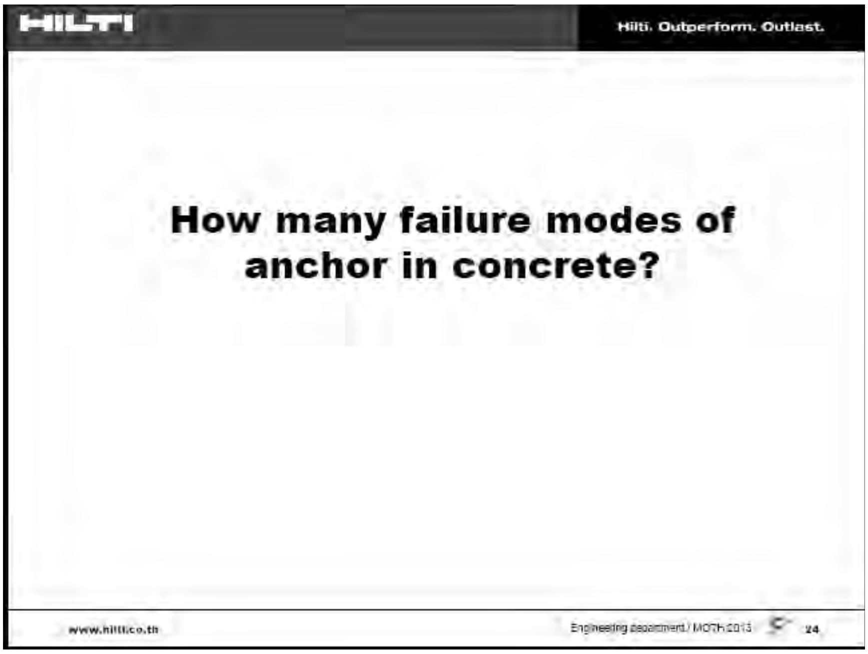
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How many failure modes of anchor in concrete?
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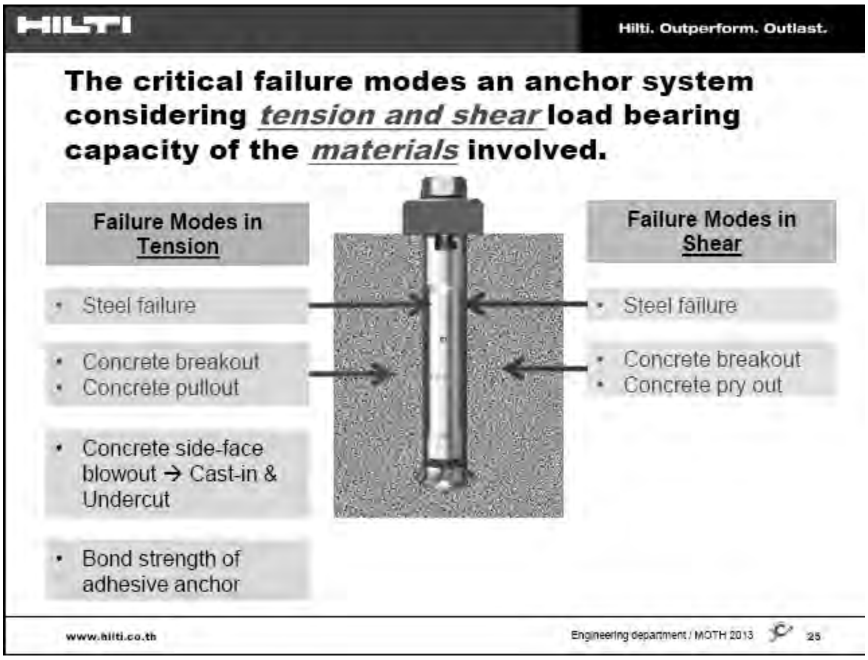
HILTI
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The critical failure modes an anchor system considering tension and shear load bearing capacity of the materials involved.
Failure Modes in Tension
• Steel failure
• Concrete breakout
• Concrete pullout
• Concrete side-face blowout → Cast-in & Undercut
• Bond strength of adhesive anchor
Failure Modes in Shear
• Steel failure
• Concrete breakout
• Concrete pry out
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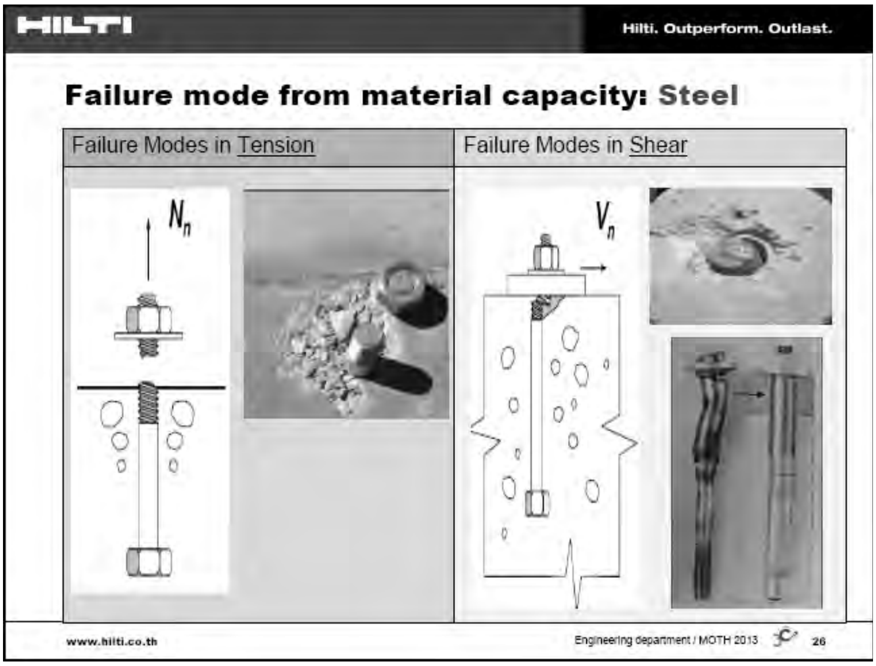
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Failure mode from material capacity: Steel
Failure Modes in Tension
Failure Modes in Shear
N
V
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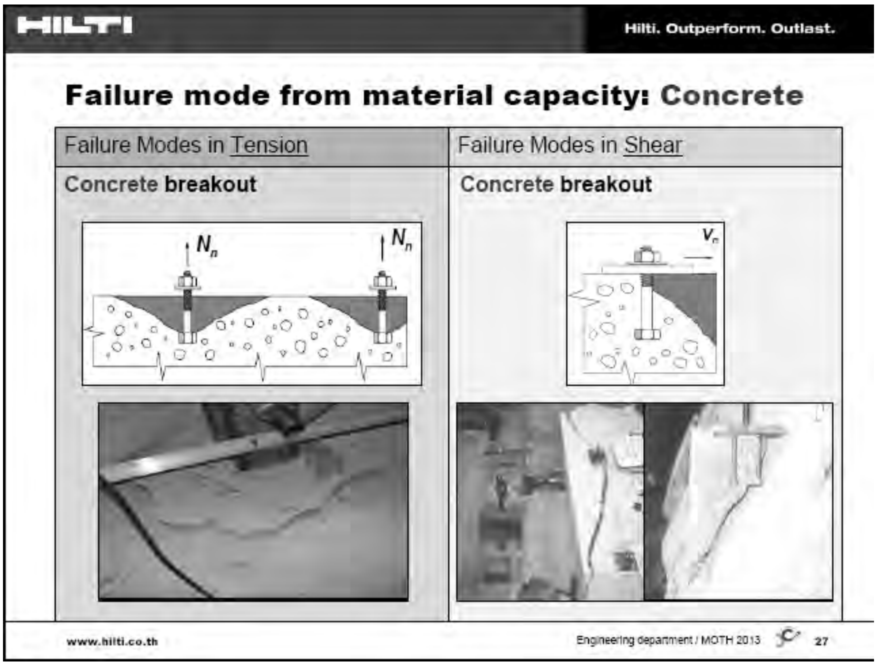
HILTI
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Failure mode from material capacity: Concrete
Failure Modes in Tension
Failure Modes in Shear
Concrete breakout
Concrete breakout
N
N
V
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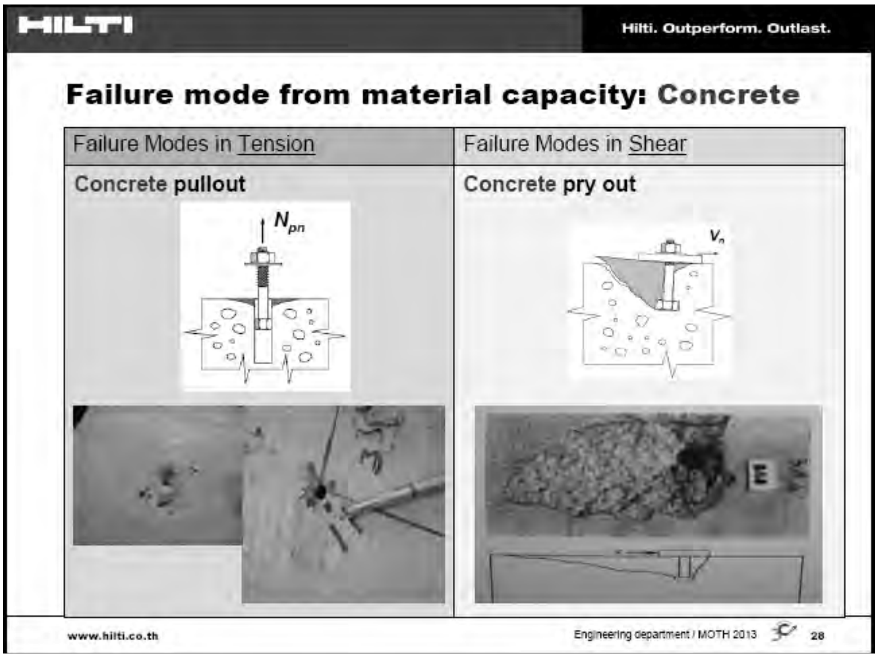
HILTI
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Failure mode from material capacity: Concrete
Failure Modes in Tension
Failure Modes in Shear
Concrete pullout
Concrete pry out
N_{pn}
V_n
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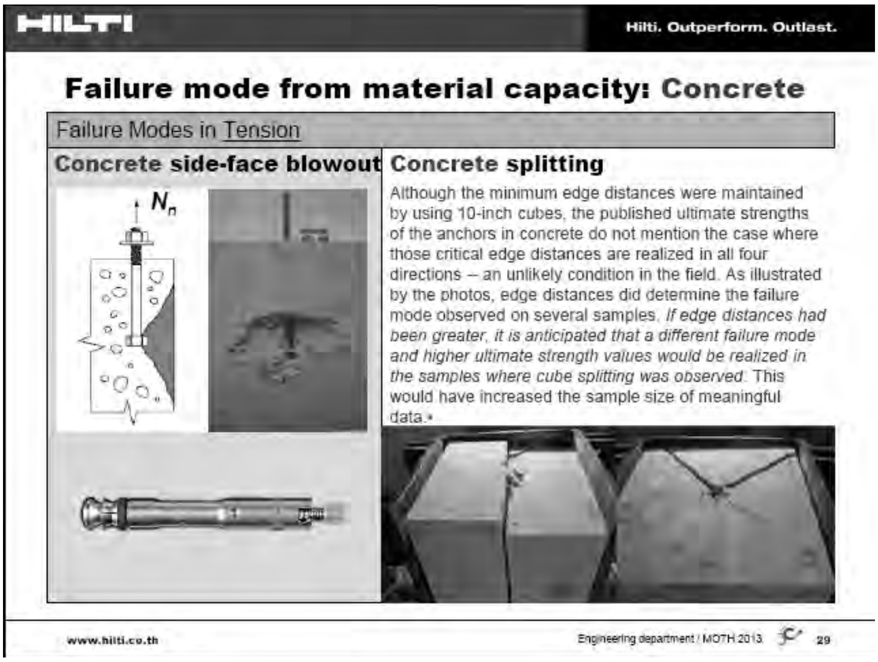
HILTI
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Failure mode from material capacity: Concrete
Failure Modes in Tension
Concrete side-face blowout
Concrete splitting
N_n
Although the minimum edge distances were maintained by using 10-inch cubes, the published ultimate strengths of the anchors in concrete do not mention the case where those critical edge distances are realized in all four directions – an unlikely condition in the field. As illustrated by the photos, edge distances did determine the failure mode observed on several samples. *If edge distances had been greater, it is anticipated that a different failure mode and higher ultimate strength values would be realized in the samples where cube splitting was observed.* This would have increased the sample size of meaningful data.*
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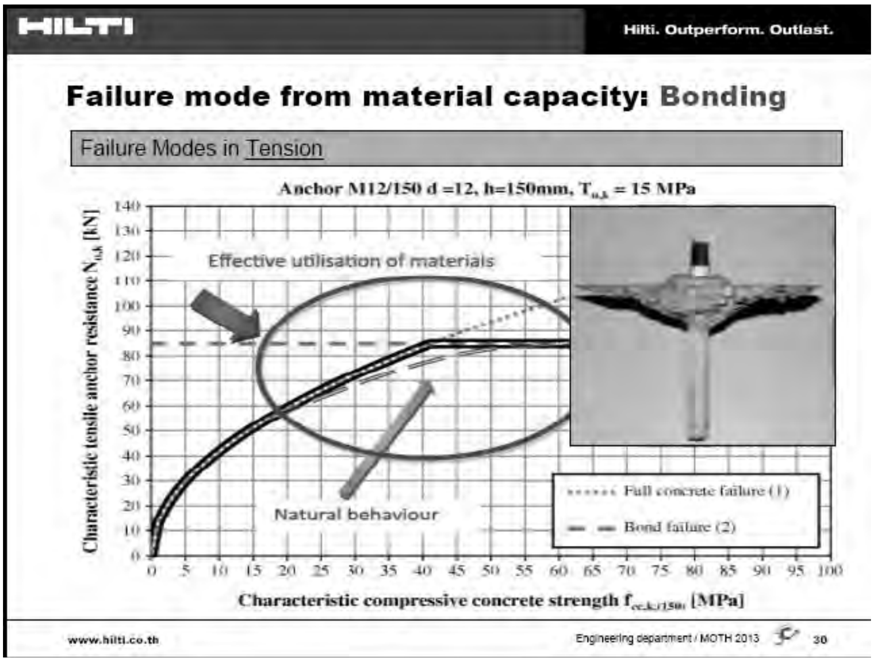
Hilti. Outperform. Outlast.
Failure mode from material capacity: Bonding
Failure Modes in Tension
Anchor M12/150 d =12, h=150mm, $T_{u,k}$ = 15 MPa
Characteristic tensile anchor resistance $N_{u,k}$ [kN]
Effective utilisation of materials
Natural behaviour
Full concrete failure (1)
Bond failure (2)
Characteristic compressive concrete strength $f_{cc,k,(150)}$ [MPa]
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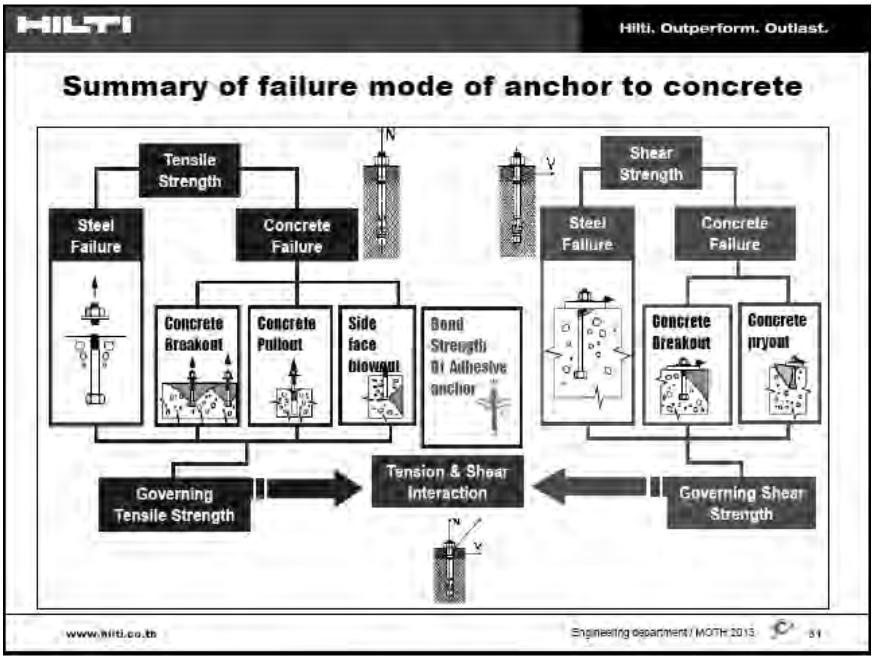
Hilti. Outperform. Outlast.
Summary of failure mode of anchor to concrete
Tensile Strength
Steel Failure
Concrete Failure
Concrete Breakout
Concrete Pullout
Side face blowout
Bond Strength of Adhesive anchor
Shear Strength
Steel Failure
Concrete Failure
Concrete Breakout
Concrete pryout
Governing Tensile Strength
Tension & Shear Interaction
Governing Shear Strength
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Development of design code for post install anchor
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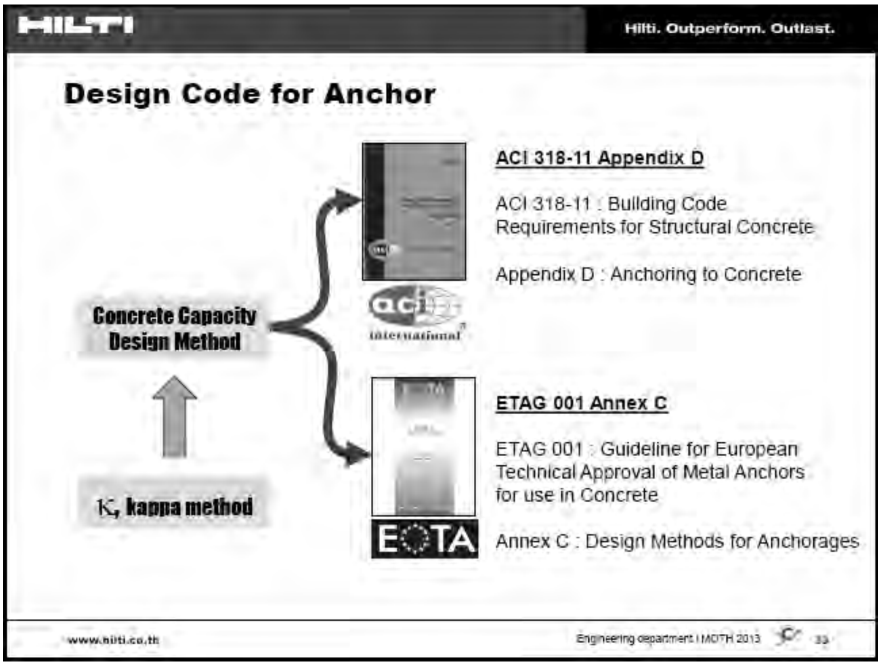
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Design Code for Anchor
Concrete Capacity Design Method
κ, kappa method
ACI 318-11 Appendix D
ACI 318-11 : Building Code Requirements for Structural Concrete
Appendix D : Anchoring to Concrete
ETAG 001 Annex C
ETAG 001 : Guideline for European Technical Approval of Metal Anchors for use in Concrete
Annex C : Design Methods for Anchorages
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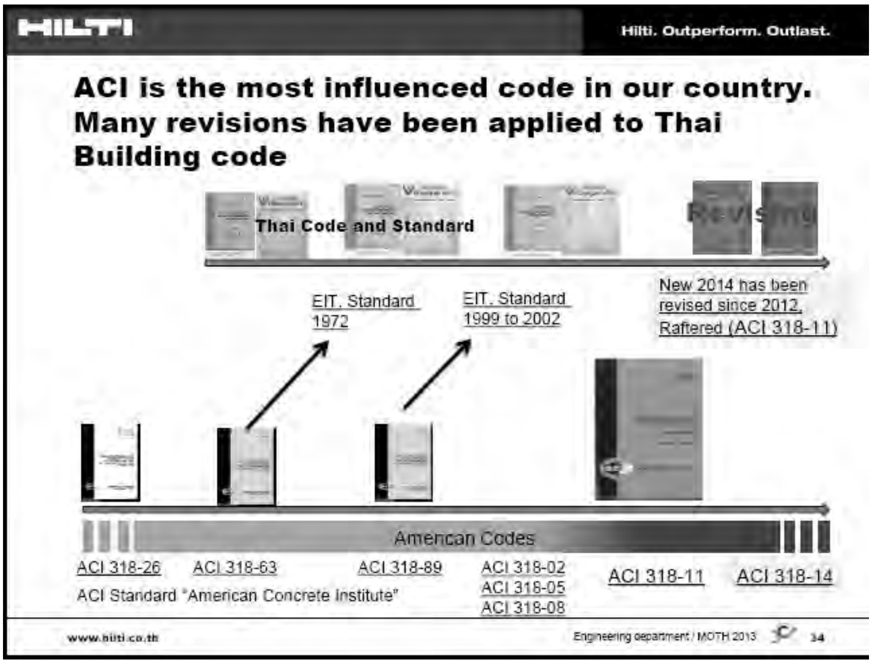
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ACI is the most influenced code in our country. Many revisions have been applied to Thai Building code
Thai Code and Standard
EIT. Standard 1972
EIT. Standard 1999 to 2002
New 2014 has been revised since 2012, Raftered (ACI 318-11)
American Codes
ACI 318-26
ACI 318-63
ACI 318-89
ACI 318-02
ACI 318-05
ACI 318-08
ACI 318-11
ACI 318-14
ACI Standard "American Concrete Institute"
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Now you know many things about anchors!
Let's start the design with ACI 318 appendix D
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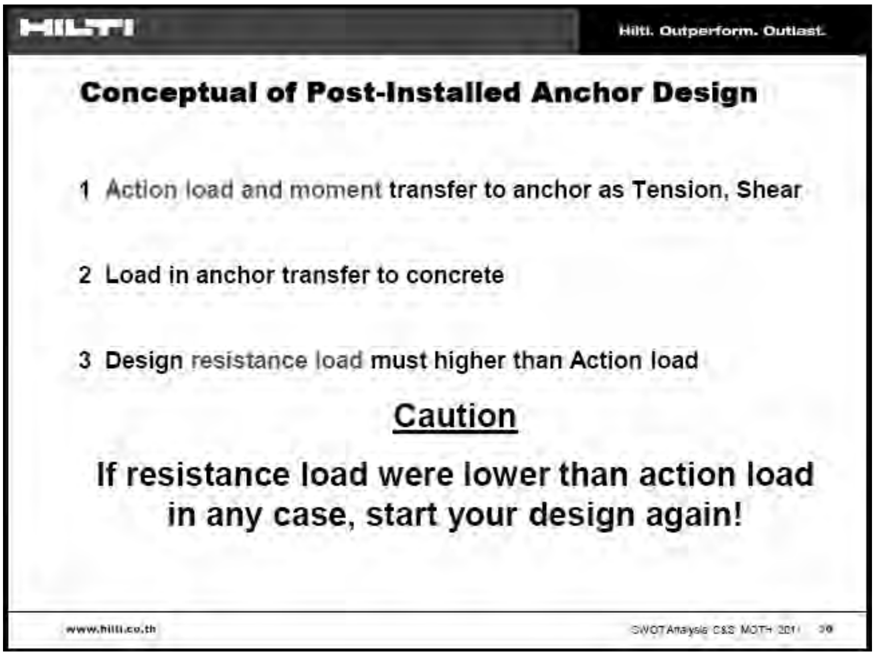
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Conceptual of Post-Installed Anchor Design
1 Action load and moment transfer to anchor as Tension, Shear
2 Load in anchor transfer to concrete
3 Design resistance load must higher than Action load
Caution
If resistance load were lower than action load in any case, start your design again!
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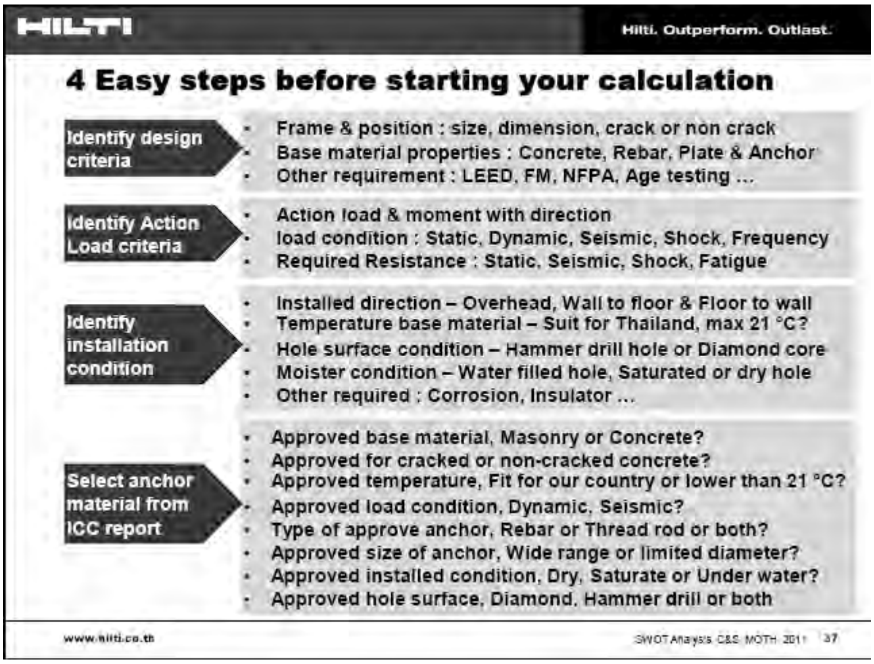
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4 Easy steps before starting your calculation
Identify design criteria
Frame & position : size, dimension, crack or non crack
Base material properties : Concrete, Rebar, Plate & Anchor
Other requirement : LEED, FM, NFPA, Age testing …
Identify Action Load criteria
Action load & moment with direction
load condition : Static, Dynamic, Seismic, Shock, Frequency
Required Resistance : Static, Seismic, Shock, Fatigue
Identify installation condition
Installed direction – Overhead, Wall to floor & Floor to wall
Temperature base material – Suit for Thailand, max 21 °C?
Hole surface condition – Hammer drill hole or Diamond core
Moister condition – Water filled hole, Saturated or dry hole
Other required : Corrosion, Insulator …
Select anchor material from ICC report
Approved base material, Masonry or Concrete?
Approved for cracked or non-cracked concrete?
Approved temperature, Fit for our country or lower than 21 °C?
Approved load condition, Dynamic, Seismic?
Type of approve anchor, Rebar or Thread rod or both?
Approved size of anchor, Wide range or limited diameter?
Approved installed condition, Dry, Saturate or Under water?
Approved hole surface, Diamond, Hammer drill or both
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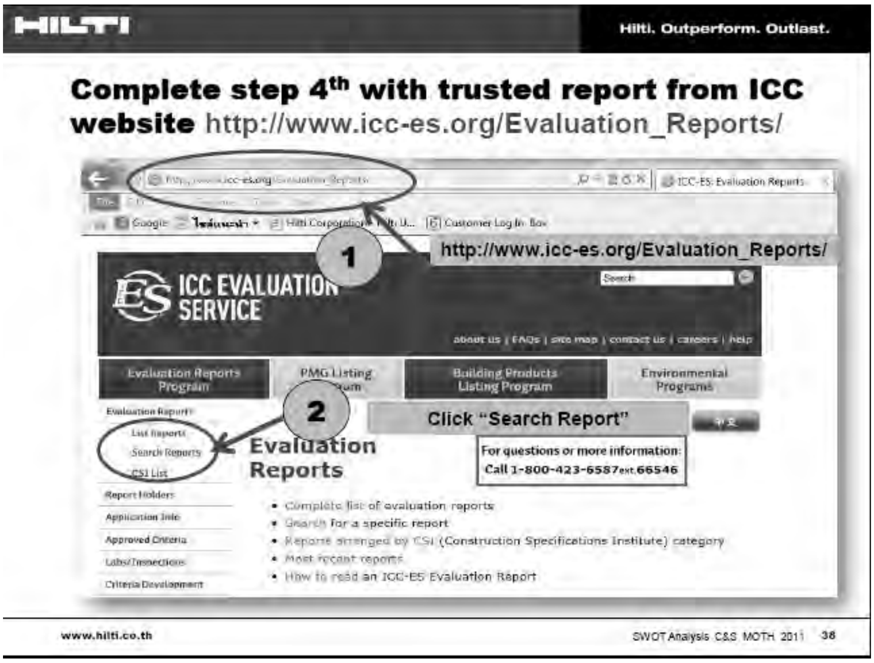
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Complete step 4th with trusted report from ICC website http://www.icc-es.org/Evaluation_Reports/
http://www.icc-es.org/Evaluation_Reports/
1
ICC EVALUATION SERVICE
Evaluation Reports Program
PMG Listing Program
Building Products Listing Program
Environmental Programs
2
Click "Search Report"
Evaluation Reports
For questions or more information: Call 1-800-423-6587ext.66546
Complete list of evaluation reports
Search for a specific report
Reports arranged by CSI (Construction Specifications Institute) category
Most recent reports
How to read an ICC-ES Evaluation Report
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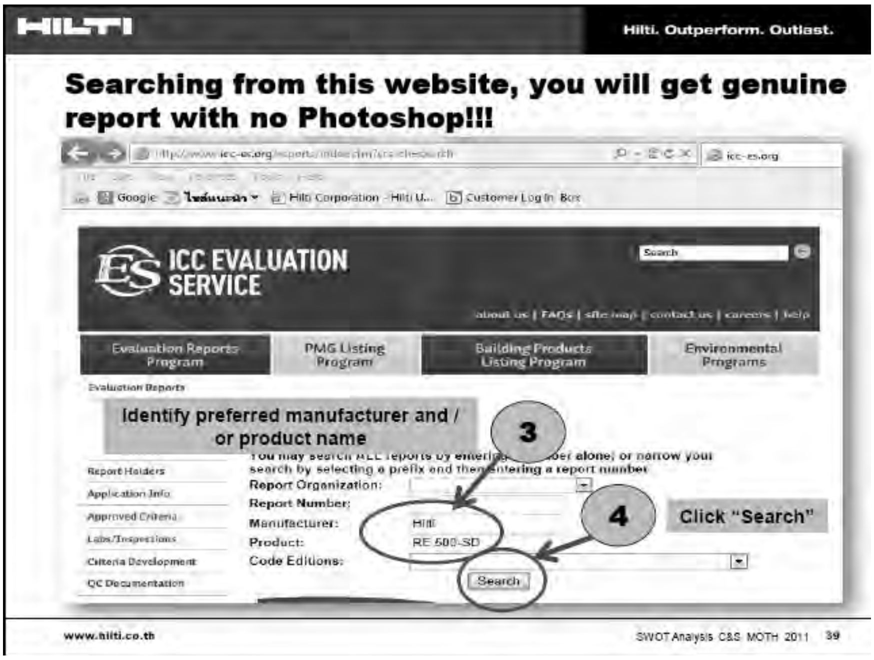
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Searching from this website, you will get genuine report with no Photoshop!!!
ICC EVALUATION SERVICE
Evaluation Reports Program
PMG Listing Program
Building Products Listing Program
Environmental Programs
Identify preferred manufacturer and / or product name
3
Report Organization:
Report Number:
Manufacturer:
Product:
Code Editions:
Hilti
RE 500-SD
4
Click "Search"
Search
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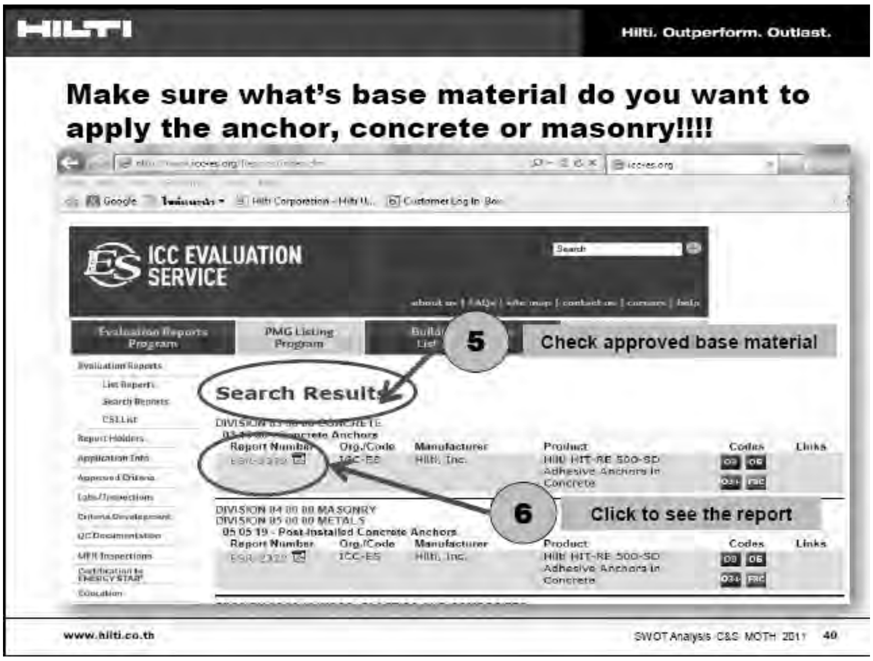
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Make sure what's base material do you want to apply the anchor, concrete or masonry!!!!
ICC EVALUATION SERVICE
5
Check approved base material
Search Results
6
Click to see the report
DIVISION 04 00 00 MASONRY
DIVISION 05 00 00 METALS
05 05 19 - Post-Installed Concrete Anchors
Report Number
Org./Code
Manufacturer
Product
Codes
Links
ICC-ES
Hilti, Inc.
Hilti HIT-RE 500-SD Adhesive Anchors in Concrete
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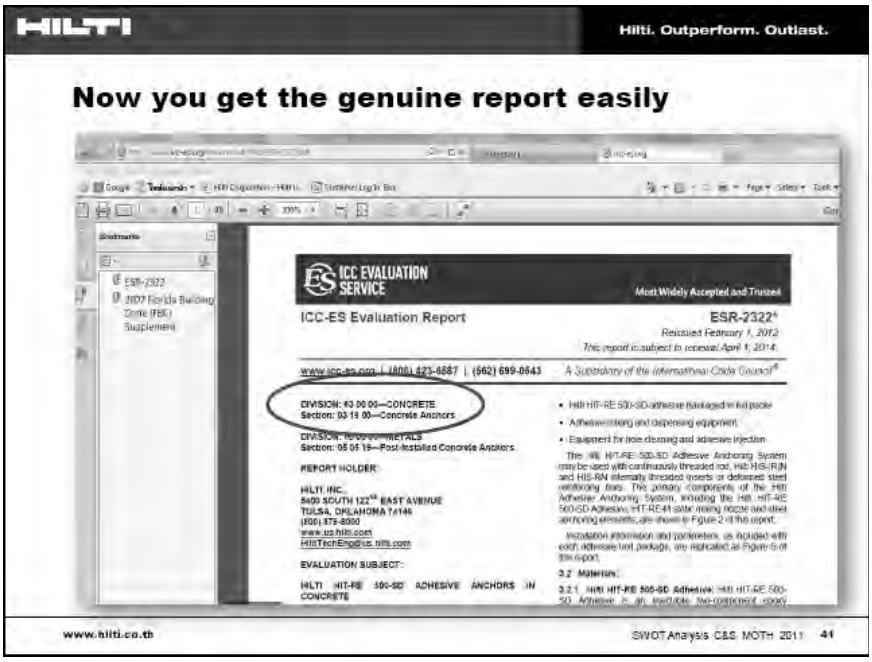
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Now you get the genuine report easily
ICC EVALUATION SERVICE
Most Widely Accepted and Trusted
ICC-ES Evaluation Report
ESR-2322*
Reissued February 1, 2012
This report is subject to renewal April 1, 2014.
DIVISION: 03 00 00—CONCRETE
Section: 03 16 00—Concrete Anchors
Section: 05 05 19—Post-Installed Concrete Anchors
REPORT HOLDER:
HILTI, INC.
EVALUATION SUBJECT:
HILTI HIT-RE 500-SD ADHESIVE ANCHORS IN CONCRETE
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You get approved anchor product for your design and ready to start the calculation by follow 5 easy steps
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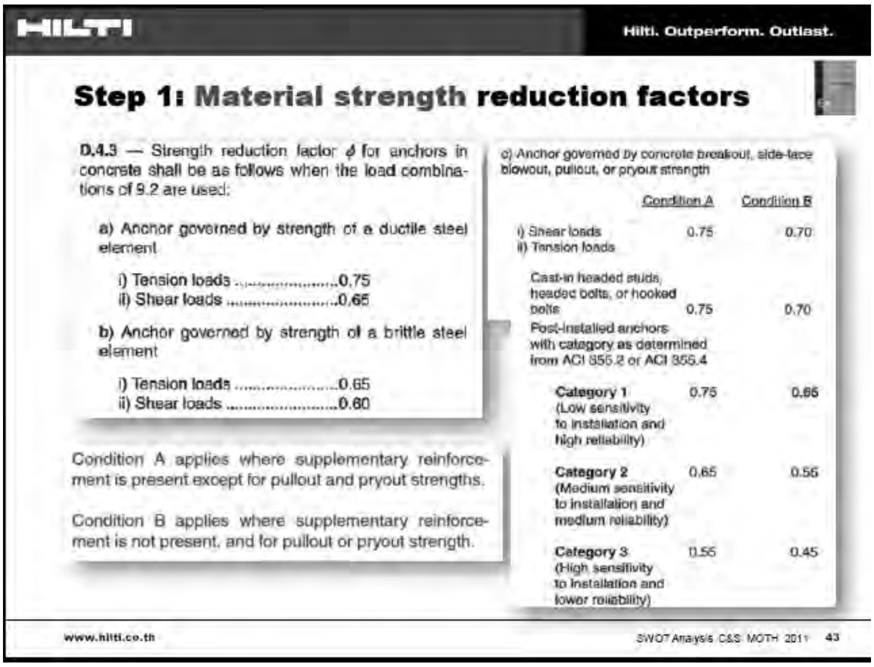
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Step 1: Material strength reduction factors
D.4.3 — Strength reduction factor φ for anchors in concrete shall be as follows when the load combinations of 9.2 are used:
a) Anchor governed by strength of a ductile steel element
i) Tension loads 0.75
ii) Shear loads 0.65
b) Anchor governed by strength of a brittle steel element
i) Tension loads 0.65
ii) Shear loads 0.60
Condition A applies where supplementary reinforcement is present except for pullout and pryout strengths.
Condition B applies where supplementary reinforcement is not present, and for pullout or pryout strength.
c) Anchor governed by concrete breakout, side-face blowout, pullout, or pryout strength
Condition A
Condition B
i) Shear loads 0.75 0.70
ii) Tension loads
Cast-in headed studs, headed bolts, or hooked bolts 0.75 0.70
Post-installed anchors with category as determined from ACI 355.2 or ACI 355.4
Category 1 (Low sensitivity to installation and high reliability) 0.75 0.65
Category 2 (Medium sensitivity to installation and medium reliability) 0.65 0.55
Category 3 (High sensitivity to installation and lower reliability) 0.55 0.45
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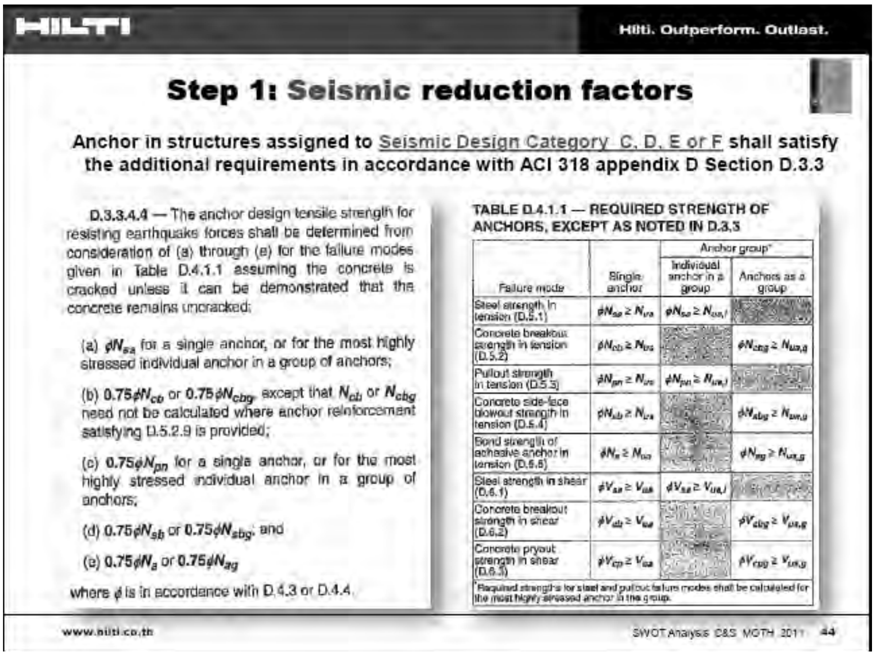
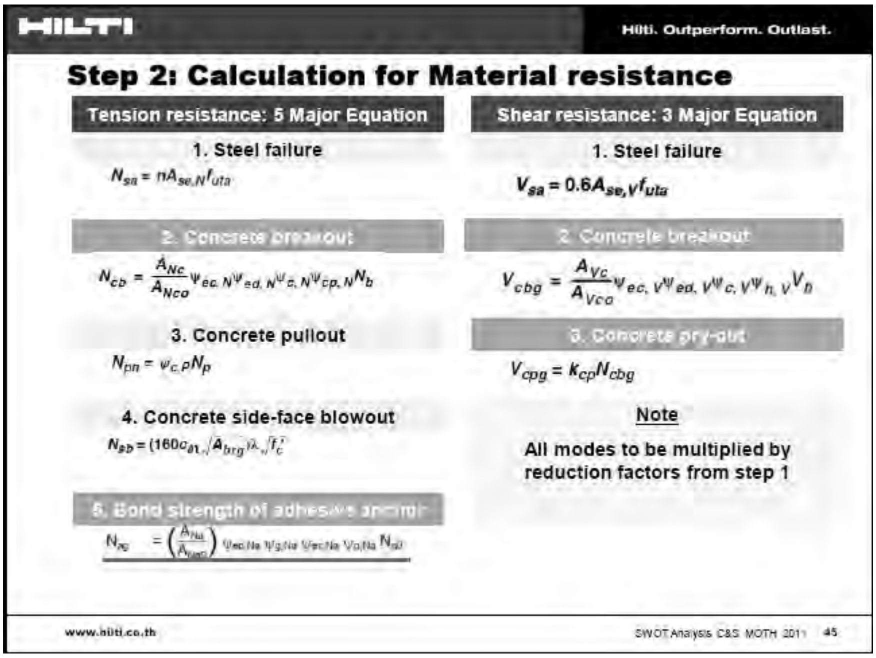
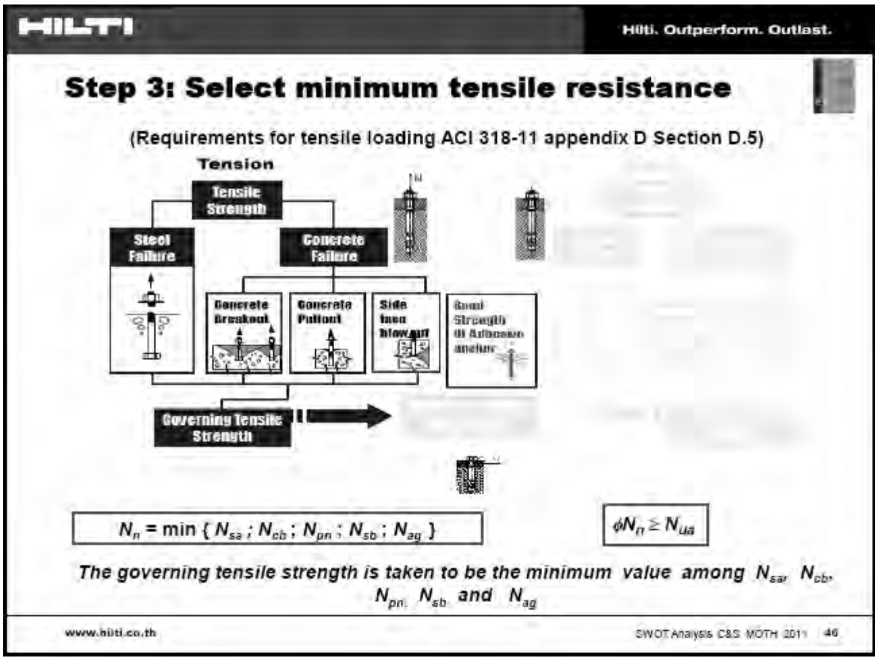


Failure mode	Single anchor	Anchor group*: Individual anchor in a group	Anchor group*: Anchors as a group
Steel strength in tension (D.5.1)	$\phi N_{sa} \geq N_{ua}$	$\phi N_{sa} \geq N_{ua,i}$	
Concrete breakout strength in tension (D.5.2)	$\phi N_{cb} \geq N_{ua}$		$\phi N_{cbg} \geq N_{ua,g}$
Pullout strength in tension (D.5.3)	$\phi N_{pn} \geq N_{ua}$	$\phi N_{pn} \geq N_{ua,i}$	
Concrete side-face blowout strength in tension (D.5.4)	$\phi N_{sb} \geq N_{ua}$		$\phi N_{sbg} \geq N_{ua,g}$
Bond strength of adhesive anchor in tension (D.5.5)	$\phi N_a \geq N_{ua}$		$\phi N_{ag} \geq N_{ua,g}$
Steel strength in shear (D.6.1)	$\phi V_{sa} \geq V_{ua}$	$\phi V_{sa} \geq V_{ua,i}$	
Concrete breakout strength in shear (D.6.2)	$\phi V_{cb} \geq V_{ua}$		$\phi V_{cbg} \geq V_{ua,g}$
Concrete pryout strength in shear (D.6.3)	$\phi V_{cp} \geq V_{ua}$		$\phi V_{cpg} \geq V_{ua,g}$

*Required strengths for steel and pullout failure modes shall be calculated for the most highly stressed anchor in the group.

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Step 3: Select minimum tensile resistance
(Requirements for tensile loading ACI 318-11 appendix D Section D.5)
Tension
Tensile Strength
Steel Failure
Concrete Failure
Concrete Breakout
Concrete Pullout
Side face blowout
Governing Tensile Strength
N_n = min { N_{sa} ; N_{cb} ; N_{pn} ; N_{sb} ; N_{ag} }
$\phi N_n \geq N_{ua}$
The governing tensile strength is taken to be the minimum value among N_{sa}, N_{cb}, N_{pn}, N_{sb} and N_{ag}
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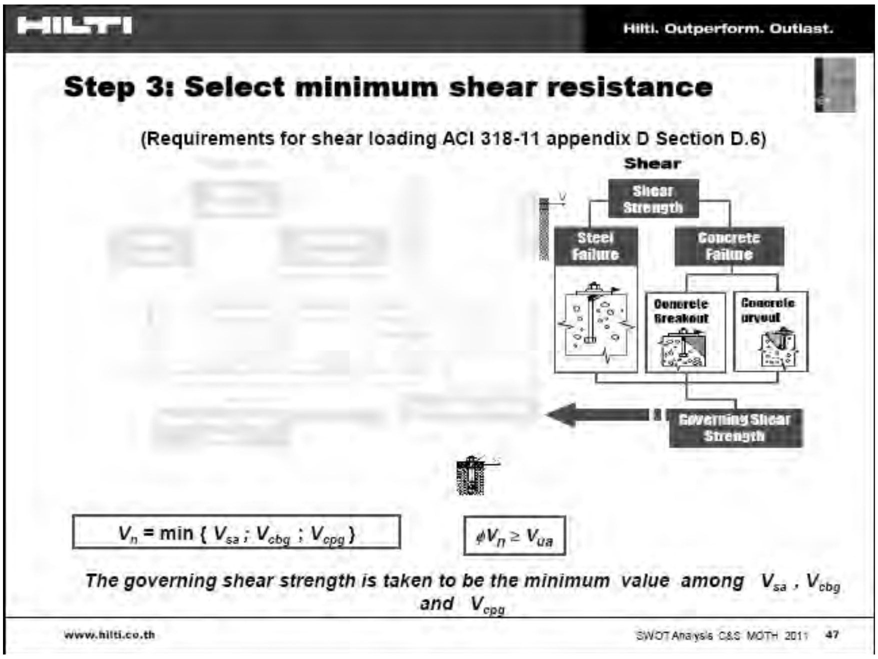
HILTI
Hilti. Outperform. Outlast.
Step 3: Select minimum shear resistance
(Requirements for shear loading ACI 318-11 appendix D Section D.6)
Shear
Shear Strength
Steel Failure
Concrete Failure
Concrete Breakout
Concrete pryout
Governing Shear Strength
V_n = min { V_{sa} ; V_{cbg} ; V_{cpg} }
$\phi V_n \geq V_{ua}$
The governing shear strength is taken to be the minimum value among V_{sa}, V_{cbg} and V_{cpg}
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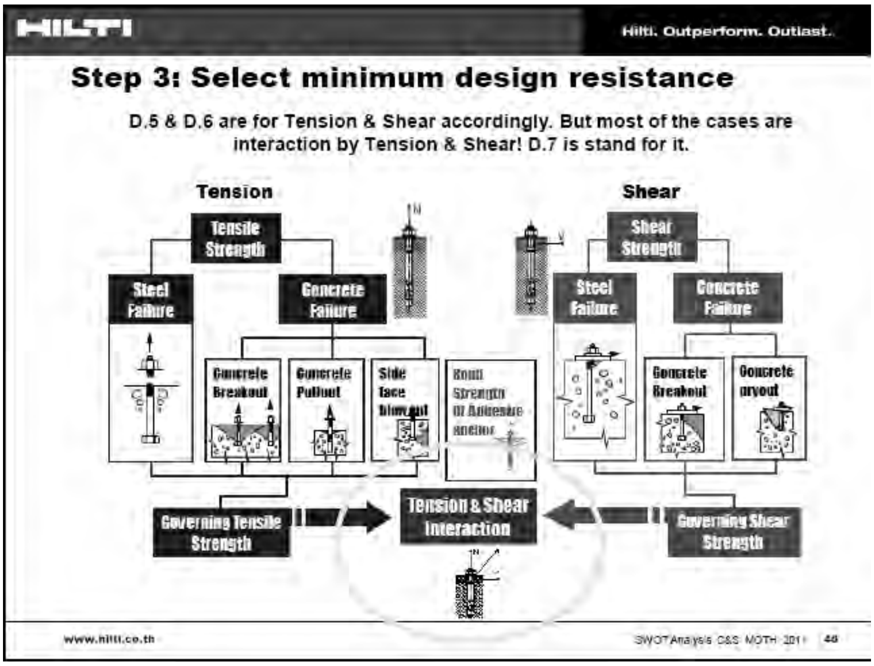
Hilti. Outperform. Outlast.
Step 3: Select minimum design resistance
D.5 & D.6 are for Tension & Shear accordingly. But most of the cases are interaction by Tension & Shear! D.7 is stand for it.
Tension
Shear
Tensile Strength
Shear Strength
Steel Failure
Concrete Failure
Steel Failure
Concrete Failure
Concrete Breakout
Concrete Pullout
Side face blowout
Concrete Breakout
Concrete pryout
Governing Tensile Strength
Tension & Shear Interaction
Governing Shear Strength
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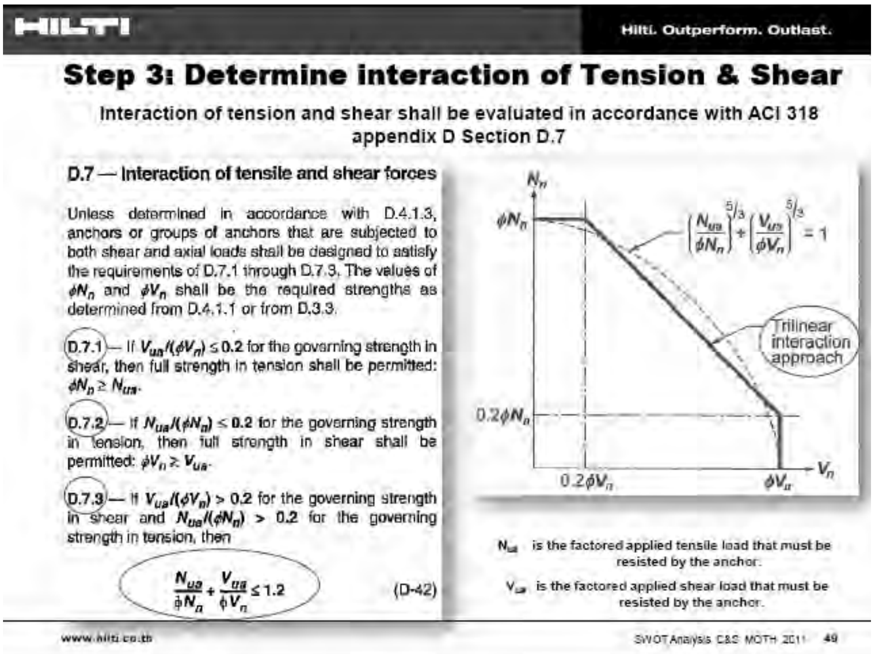
Hilti. Outperform. Outlast.
Step 3: Determine interaction of Tension & Shear
Interaction of tension and shear shall be evaluated in accordance with ACI 318 appendix D Section D.7
D.7 — Interaction of tensile and shear forces
Unless determined in accordance with D.4.1.3, anchors or groups of anchors that are subjected to both shear and axial loads shall be designed to satisfy the requirements of D.7.1 through D.7.3. The values of ϕN_n and ϕV_n shall be the required strengths as determined from D.4.1.1 or from D.3.3.
D.7.1 — If $V_{ua}/(\phi V_n) \le 0.2$ for the governing strength in shear, then full strength in tension shall be permitted: $\phi N_n \ge N_{ua}$.
D.7.2 — If $N_{ua}/(\phi N_n) \le 0.2$ for the governing strength in tension, then full strength in shear shall be permitted: $\phi V_n \ge V_{ua}$.
D.7.3 — If $V_{ua}/(\phi V_n) > 0.2$ for the governing strength in shear and $N_{ua}/(\phi N_n) > 0.2$ for the governing strength in tension, then
$\frac{N_{ua}}{\phi N_n} + \frac{V_{ua}}{\phi V_n} \le 1.2$ (D-42)
N_n
ϕN_n
$\left(\frac{N_{ua}}{\phi N_n}\right)^{5/3} + \left(\frac{V_{ua}}{\phi V_n}\right)^{5/3} = 1$
Trilinear interaction approach
$0.2\phi N_n$
$0.2\phi V_n$
ϕV_n
V_n
N_{ua} is the factored applied tensile load that must be resisted by the anchor.
V_{ua} is the factored applied shear load that must be resisted by the anchor.
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If resistance load were lower than action load in any case

Step 4: Start the design again?????

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Step 5: Specify all details in your drawings for construction

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To complete your post-installed anchor design, you have to apply 6 factors from ICC to 8 major formulas and 28 sub-formulas from ACI 318 Appendix D

	Major formula	Sub formula	Variable	ICC
Number of formulas for Tension resistance checking				
Steel failure	1		4	
Concrete breakout	1	7	12	1
Concrete pullout	1		3	1
Concrete side face blowout	1		5	
Bond strength (AC)	1	7	10	3
Number of formulas for Shear resistance checking				
Steel failure	1		4	
Concrete breakout	1	7	9	
Concrete pryout	1	7	13	1
Total	**8**	**28**	**60**	**6**

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PROFIS Anchor Design Software

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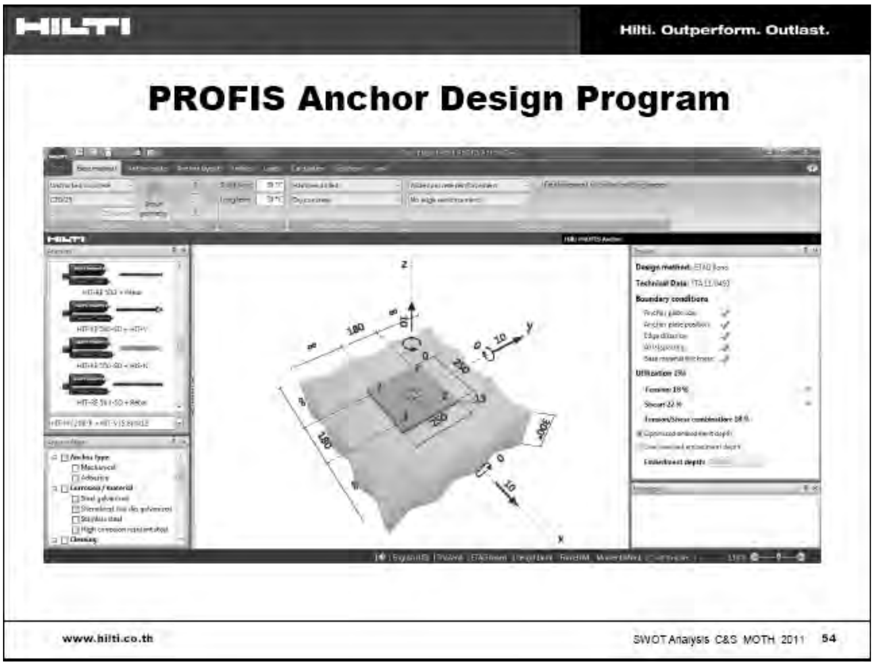
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E : moth@hilti.com

Student Presentations

CAR NAVIGATION DATA ANALYSIS FOR TRANSPORTATION PLANNING

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ABSTRACT

The purpose of this work is to analyze car navigation data as a verification data about Travel Time Fuction(TTF) for transportation planning. Navigation data are collected from Korean road network links through navigation terminals so we decide to use these data to replace preexistence velocity and travel time data. From this, we could obtain average OD travel time and variance database, average vehicle OD trip distance & Variance between origin and destination zone, number of link passing OD pair, and database of generating/arriving trip ratio by each link. And we could also get the customized data from car navigation database like rate of innerzonal trip for each link, average link passing vehicle travel distance & variance DB, sample database of OD traffic's link passing rate, and location of signal intersection node DB. So we calculate link priority. And if the distance between links is short and innerzonal trip rate is high, that link is evaluated as a link which has a low compatibility. To use navigation data for the future, we develop four strategy – that is 1) extend the range of data collecting network, 2) representative verification, 3) improve data collect system focus on passenger car, and 4) increase quantity of collected data. And, also, theoretical research and operational application are two considerations for applying navigation data on transportation planning. The navigation data, so called big data, has played an important role in transportation engineering field in the near future. Even though using navigation data is initial step, if more concerns are given to study how to use transportation-related big data, then we could get more accurate and realistic traffic data..

Keywords*: navigation data, travel time function (TTF), TTF verification, innerzonal trip analysis, link traffic.*

1. INTRODUCTION

In Korea, we use the Travel Time Function (TTF) for traffic assignment model by modeling travelers' route choice behavior. To do this, we have to calibrate TTF with reality.

In a prior study, TTF is calculated by observed traffic volume and traffic assignment model. The observed traffic contain both internal and external zone trip, however assigned traffic cover only external zone trip. For example, on arterials, 70% less assigned than traffic counts on 40% links. Because of the gap between these two data, it is impossible to analyze internal and external trip respectively with current traffic analysis technique. Also, it is hard to analyze reliability of TTF calculation.

Therefore, analysis of innerzonal traffic flow at a nationwide level in Korea has to be planned with navigation data.

For TTF, traffic counts survey for all links is impossible and proved car-based travel time survey costs huge time and budget. However, with navigation data, it is not only easy to get samples from widespread links but also possible to replace existing velocity and travel time data.

The important thing for analyzing is spatial data. Prior traffic data cannot define geospatial relationship between branch passage rate and traffic volume, but with navigation data it is easy to define spatiotemporal relationship between traffic network components. If we secure a relation between OD pairs and link, we could verify OD estimation and OD pairs' traffic volume. Then it is possible to apply these data for congestion management and ramp metering system, also, we could obtain path data and link data. Then we could know which links are overlapped on different paths.

2. NAVIGATION DATA COLLECTION AND PROVISION

We collect a navigation data from three navigation terminals – SOFTMAN, GINI, MAPPY – and data collecting period is August 1st 2011 to August 1st 2011. To increase a navigation data' quality and quantity, the navigation data is collected as node-link unit. With raw data, we produce approximately 120 million trip data. We follow a procedure as shown in Figure 1: to get geospatial data.

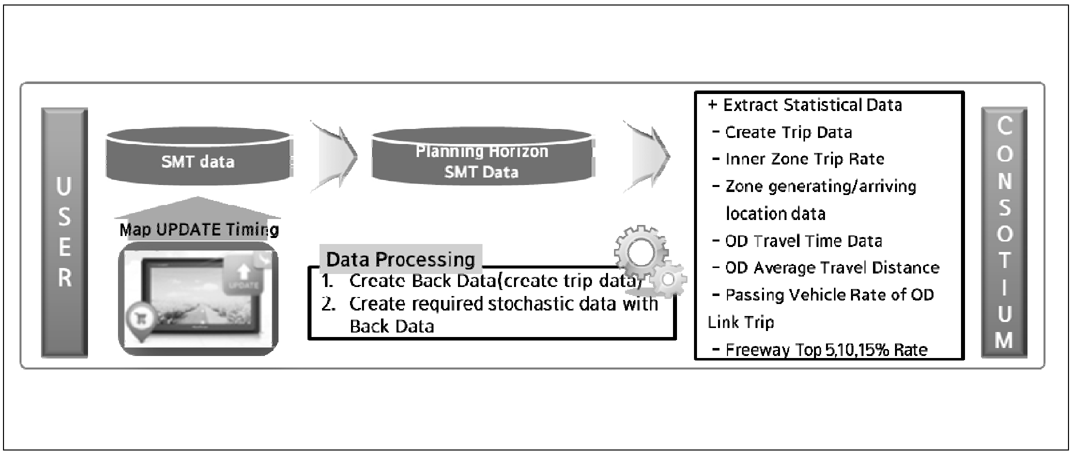

Figure 1: Data Provision

3. NAVIGATION DATABASE CONSTRUCTION

We follow this procedure to construct database.

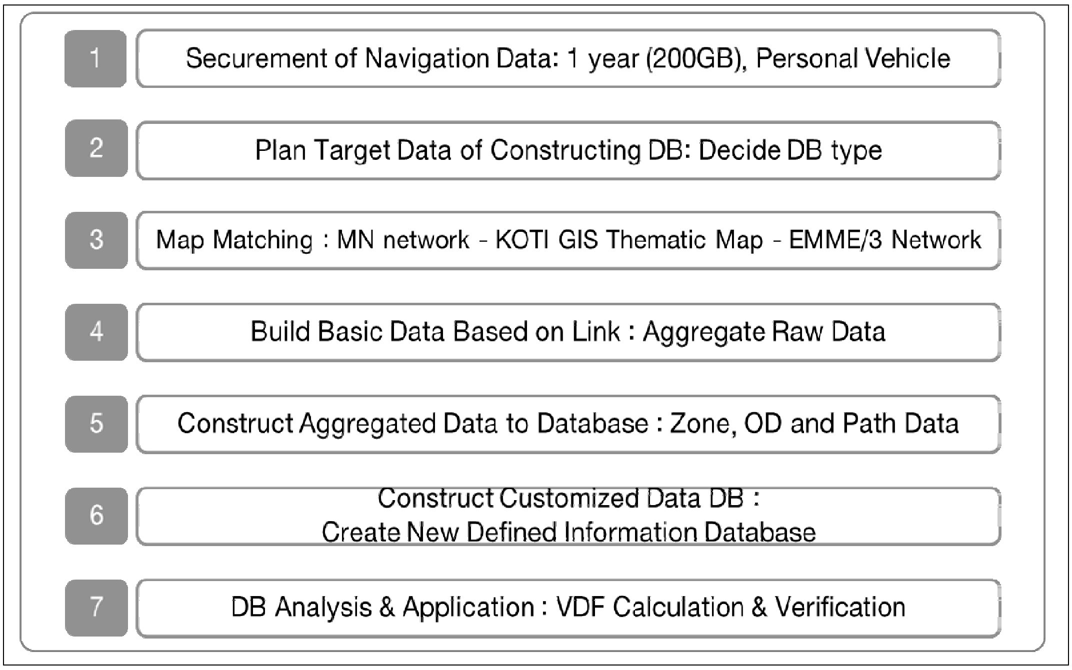

Figure 2: Procedure of Constructing Database

3.1 Aggregated link data

To construct database based on navigation data, we aggregate link basic data. An average link travel speed, passing vehicle sample size, and freeway top 5%, 10%, 15% velocity for each links are calculated.

The processed navigation data constructed by link travel time are utilized for TTF calculation and reliability verification. And, this data make it possible to analyze greenhouse gas emission

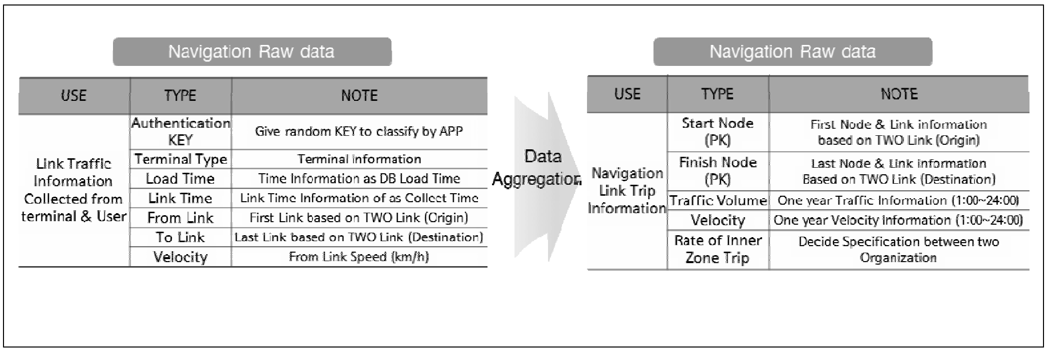

Figure 3: Data Aggregation

3.2 Aggregated navigation data

With link based data, we make navigation data. The elements of navigation data is as in the following. 1) Average OD travel time & variance DB, 2) Average vehicle OD trip distance & variance DB between origin and destination zone, 3) Number of link passing OD pair, and 4) DB of generating / arriving trip ratio by each link.

3.2.1 OD travel time database

We use average OD trip velocity data to make OD travel time database.

Table 1: Average OD travel time

O Zone	D zone	Ave. travel distance (km)	Ave. travel time (sec or min)				Travel time variance(sec^2 or min)				Ave. travel velocity (km/hr)				Number of valid Sample				Total
			morning	day	afternoon	night	morning	day	afternoon	night	morning	day	afternoon	night	morning	day	afternoon	night	

3.2.2 Enumeration of OD pairs on a link

To make database, we calculate the number of each link passing OD pairs. If a link has many OD pairs, it is regard as a main observing site. Then links are used for link criticality analysis.

3.2.3 Trip generation and attraction analysis

We verify zone centroids' location.

Table 2: Generating and arriving ration of links in the zone

from node	to node	VDF#	Zone	Generate Rate	Generated Traffic	Arrive Rate	Arrived Traffic	Innerzone Traffic rate	Innerzone Traffic	Original Traffic Volume	Modify Traffic	Modify Rate(%)	주요상관링크					Institution	Year
													1	2	3	4	5		

3.3 Customized navigation data

Customized navigation data is different with aggregated data. This data is estimated by algorithm. Customized navigation data contain four databases. 1) Rate of innerzonal trip DB for each link, 2) Average link passing vehicle travel distance and variance database, 3) Sample database of OD traffic's link passing rate, and 4) Location of signal intersection node database

3.3.1 Rate of innerzonal trip Database

Innerzonal traffic volume is main database to build a navigation data, so with this data we decide innerzonal reflect traffic ratio.

Table 3: Innerzonal traffic volume

from node	to node	Link #	Sample traffic volume					Sample velocity					Rate of inner zone traffic volume	relevant zone#
			1	2	~	23	24	1	2	~	23	24		

3.3.2 Link-based travel distance analysis

We use link passing vehicles' trip distance for reviewing a role of road and input data of network consistency analysis function.

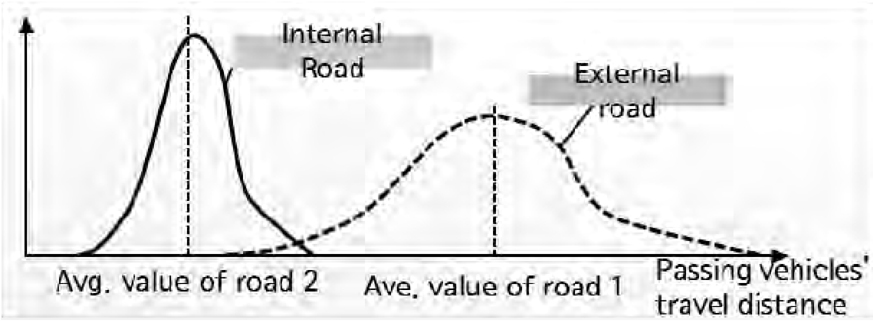

Figure 4: Link passing vehicles' trip distance

4. RESULT OF CONSTRUCTED LINK BASED DATA

4.1 Sample data analysis

To analyze KTDB navigation data, total number of vehicle tracking path data collected from MN-Soft is 125 million trips. Data are collected from August, 2011 to July, 2012. In April, 2012, most data are collected and in august, 2011 least data are collected. The general pattern of navigation data is that least data exists in the summer and number of data is constantly increasing throughout the winter.

Table 4: Distribution of number of navigation data by month

Month	Number of data	Data size
Aug. 2011	100,867,854	4,477.516 MB
	117,622,988	5,221.250 MB
	150,111,285	6,663.383 MB
	177,879,,140	7,895.984 MB
	223,420,038	9,917.492MB
	279,396,760	12,402.266 MB

	353,584,875	15,695.414 MB
	517,133,669	22,955.219 MB
	551,465,149	24,479.172 MB
	526,109,425	23,353.633 MB
	347,283,353	15,415.711 MB
Jul. 2012	138,557,074	6,150.500 MB

To analyze collected navigation data spatially, we express number of collected link passing traffic volume on transportation digital map. Links are concentrated in urban area.

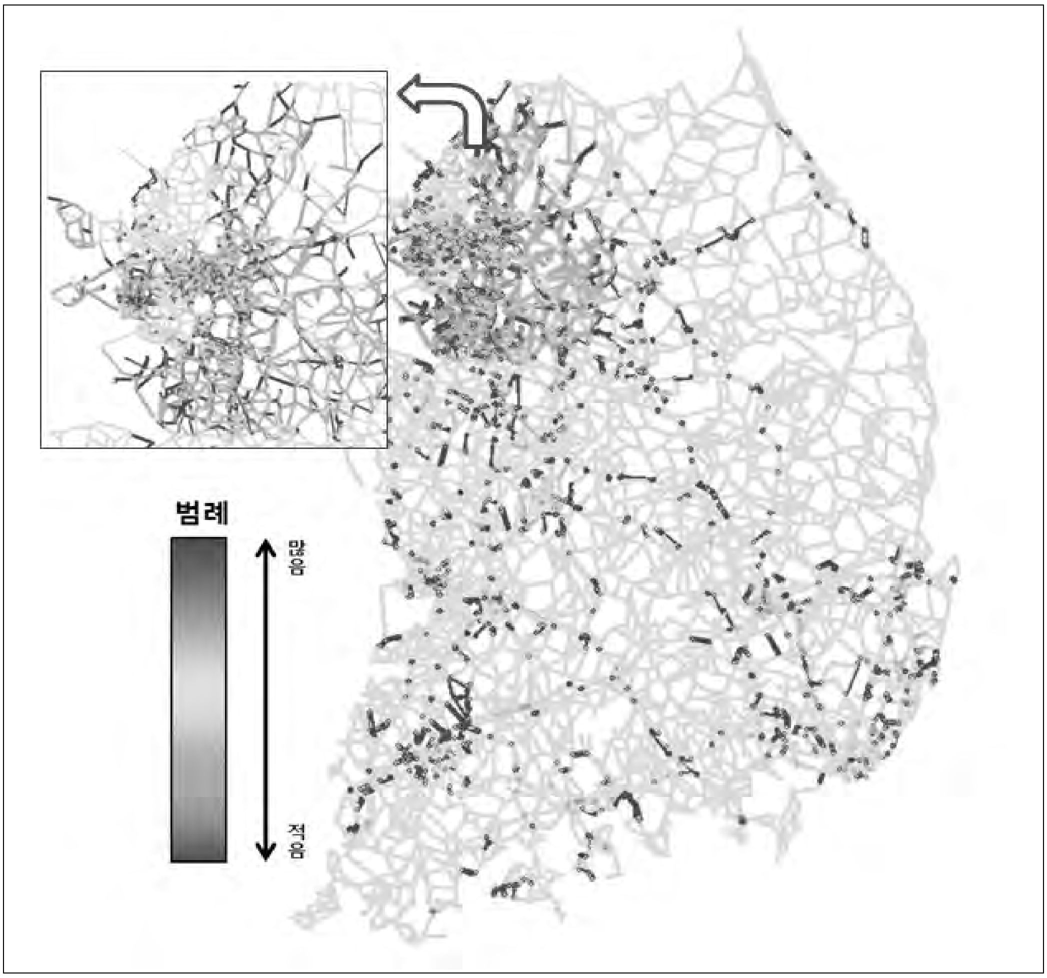

Figure 5: Distribution of number of navigation data

4.2 Innerzonal travel analysis

The reason for using navigation data is that TTF observed data reflect innerzonal traffic volume. With this data, we analyze innerzonal traffic volume with over 30 samples of whole network.

4.2.1 Innerzonal traffic ratio evaluation method

We review whole tracking path data which start at the same site and find the trips starting and finishing at the same zone. With these two data, we calculate each links' proportion of whole passing track. If sever links are passing a same EMME/3 link, that link takes a weighted average link length.

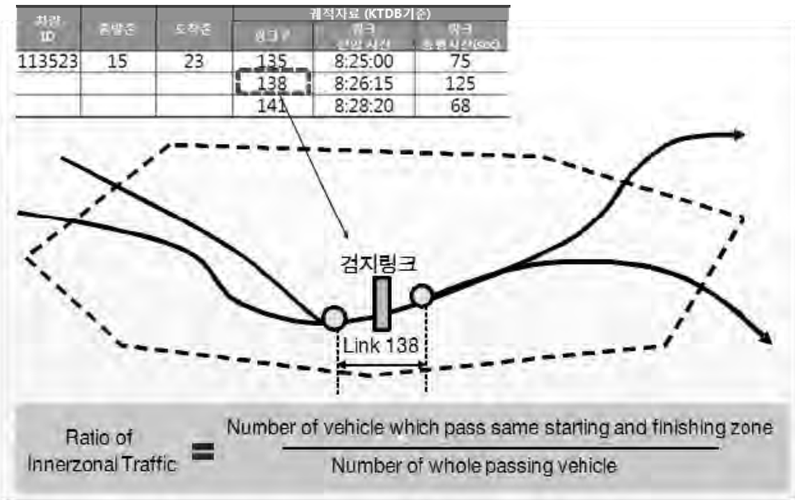

Figure 6: methodology of calculating innerzonal traffic rate

4.2.2 Innerzonal traffic calculation

On arterial which has low VDF grade, many links are calculated as ratio than on high TTF level.

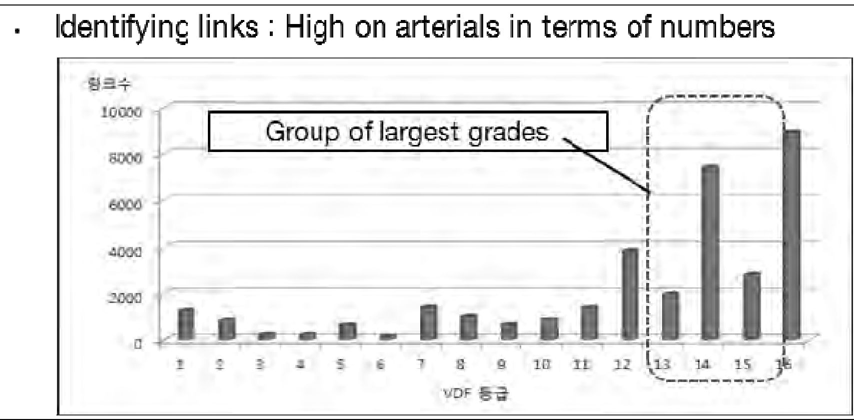

Figure 7: Identifying links : High on arterials in terms of numbers

4.2.3 Nationwide travel ratio

We analyze innerzonal traffic rate by TTF grades. Freeway and urban express are taking up to 10% and arterials take up to 45%. For all arterials, one-lane road has higher innerzonal traffic rate than two-lane road. As density of intersection is increasing, innerzonal traffic rate is decreasing. And low VDF grade road and urban road have high rate.

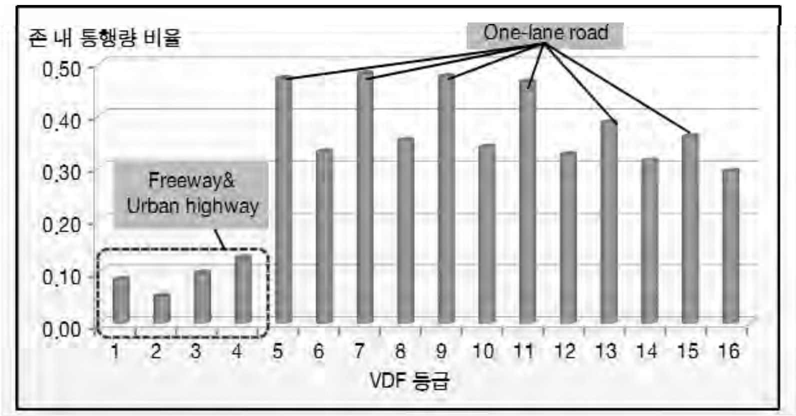

Figure 8: Ratio of innerzonal traffic

4.2.4 Analysis of urban/rural area innerzonal traffic respectively

Innerzonal traffic rate in urban area is lower than rural area. And innerzonal traffic rate gap between one-lane road and two-lane road is getting smaller when number of intersection is increasing.

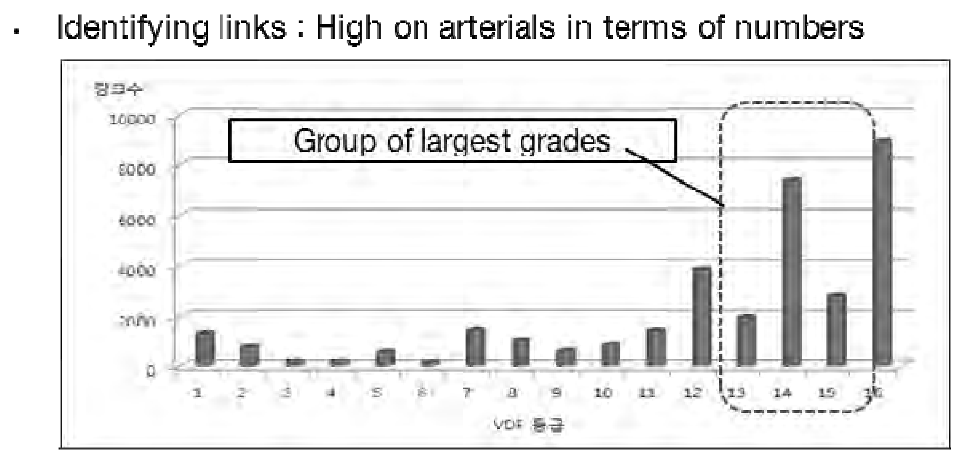

Figure 7: Identifying link: High on arterials in terms of numbers

4.2.5 Spatial innerzonal traffic analysis

With innerzonal traffic rate, it is possible to give a trip spatial distribution which is an important role in transportation planning. On the national scale, urban area has lower innerzonal traffic rate. Innerzonal traffic rate is higher at rural area and regional road than urban area. This is because size of zone in urban area is smaller than rural area, so short trip is considered as external zone trip.

We do detail analysis to capital area. With this, we find there is a great different between innerzonal traffic ratio in a same city. It means there is a difference of road function in a city, so we separate interregional road and innerregional road with navigation data. In addition, innerzonal traffic rate make it possible to define a road function for national land use.

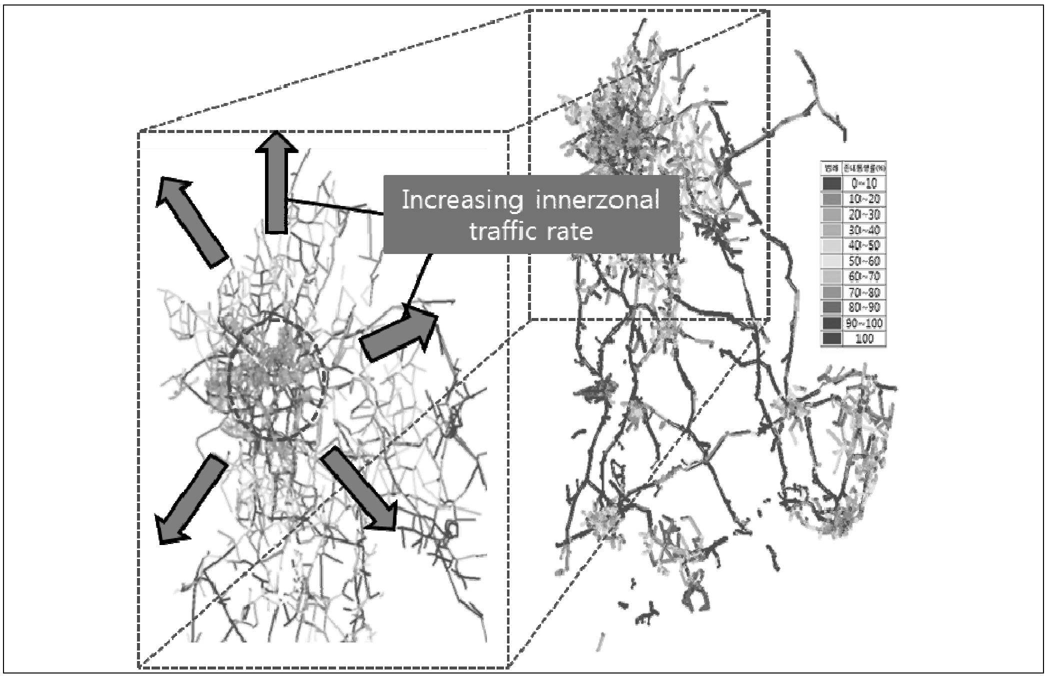

Figure 8: Ratio of innerzonal traffic on rural area

4.2.6 Unobserved links' innerzonal traffic ratio

The number of links which secure minimum innerzonal traffic rate is 31,932 after passing more than 30 sample links. To modify innerzonal traffic rate on unobserved link, we follow a step as shown in Figure 9:

Technique 1, we estimate innerzonal traffic rate about other observed point for arterial TTF calculation. Technique 2, if at least 10 links have experimental traffic volume, it is possible to calculate average rate by city. Technique 3, if link has less 10 links, we apply other external cities' average value. If links are not estimated after Technique 3, we use urban/regional estimated average value.

Tech	Data Creating Method	# of link
1	Estimated value based on navigation data	31,932
2	Average estimated value based on middle size zone	11,726
3	Average estimated value based on big size zone	23,702
4	Urban/Rural area average estimated value	6

Figure 9: Flow step for modifying innerzonal traffic rate on unobserved links

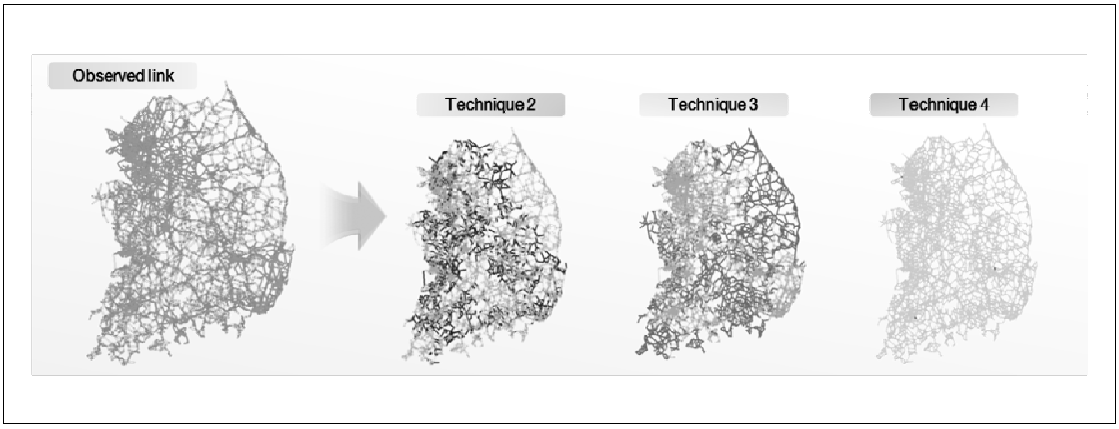

Figure 10: Example of data creating method

4.2.7 Result of application

We apply innerzonal traffic volume rate on the national network with observed rate (technique 1), and estimated rate (technique 2, technique 3 and technique 4).

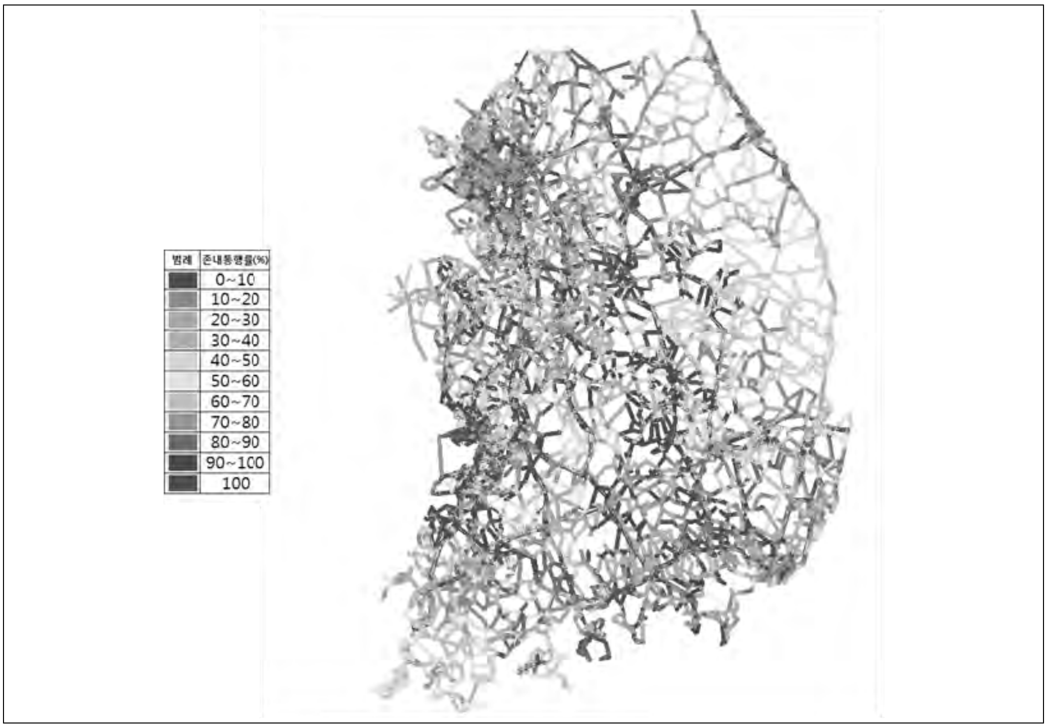

Figure 11: Innerzonal traffic volume on the national network

4.2.8 Limitation and problem

With navigation data we get many useful data for transportation planning, however there are limitation and problems for using navigation data.

In principle we have to use observed data to analyze traffic volume but we still use estimated data with technique 2,3 and 4. Second problem is that even though some cities have a same TTF grade among every 247 cities, a gap between zones which have a same grade may exist. Because of this reason, there is a limit to apply a average value to cities which have a same grade.

On arterials, 30~40% of traffic is innerzonal traffic. However, there is huge deviation even on a same VDF road. Therefore we have to extend traffic networks' spatial bounds to collect navigation data and, also have to improve map-matching technique to increase observed traffic rate.

4.3 Analysis of innerzonal trip generating-arriving on main link

With navigation data, it is possible to verify zone centroid's connectivity analysis. Navigation data shows each vehicle's OD trips, so we calculate each link's generating-arriving traffic volume. We evaluate current centroid connector link validity with innerzonal trip generating-arriving on main links and it could be used as a connector modification normative reference.

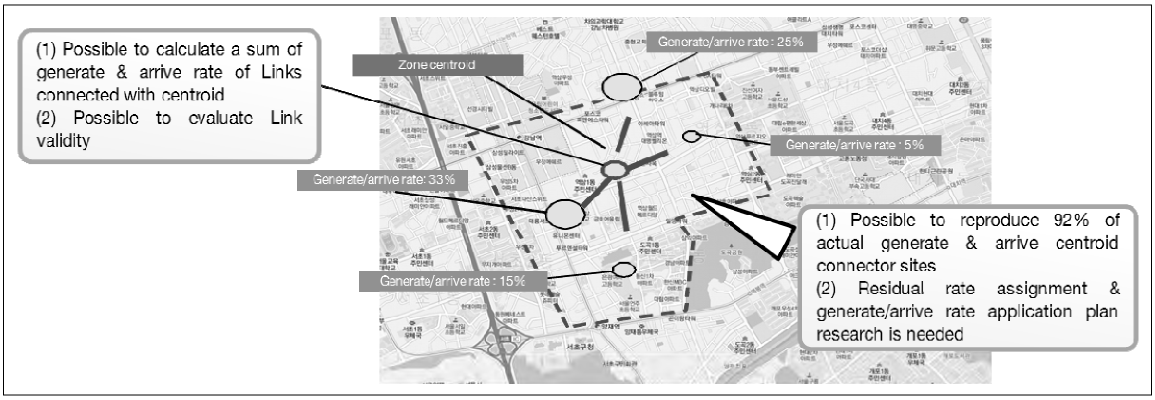

Figure 12: Example of assessing zone centroid connector link validity

To assess validity of suggested technique, we evaluate Gangnam-gu, Seoul centroid link validity. Separating links in Gangnam-gu at KTDB network from other zone's links is needed, so we color yellow as a centroid connectors and purple which is directly connected with centroid connectors. Especially traffic generating rate on plume colored links explain exact traffic generate location from centroid connector.

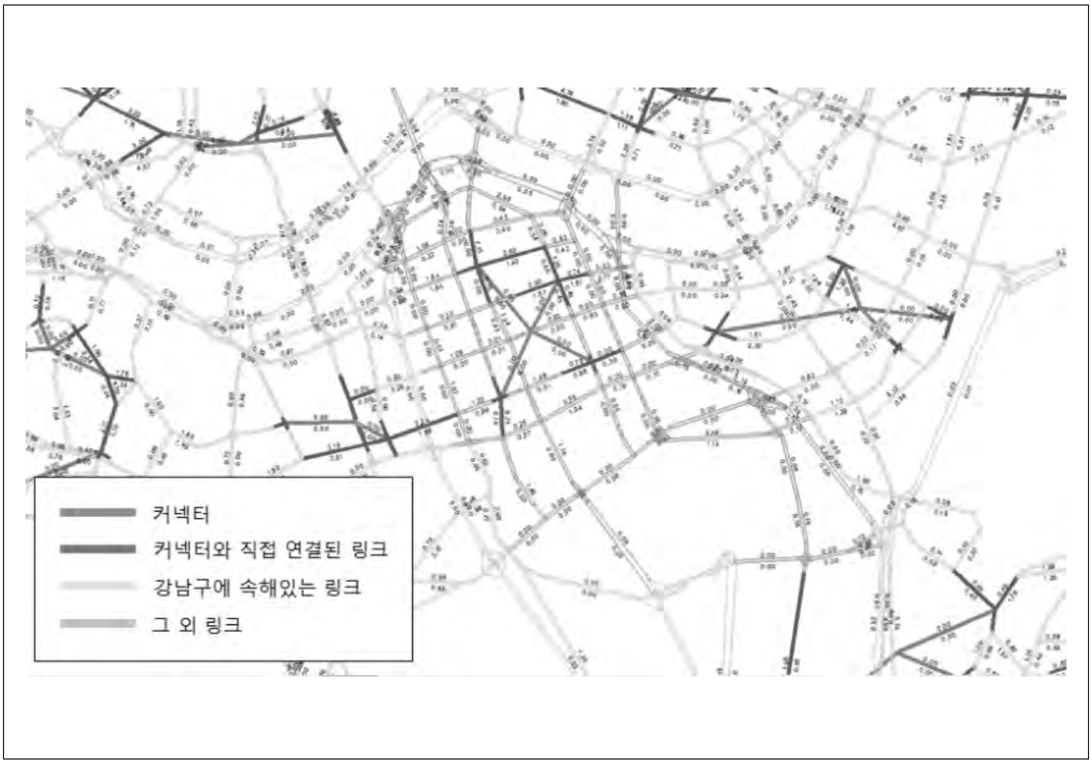

Figure 13: Example: validity of zone centroid connect in Gangnam-gu

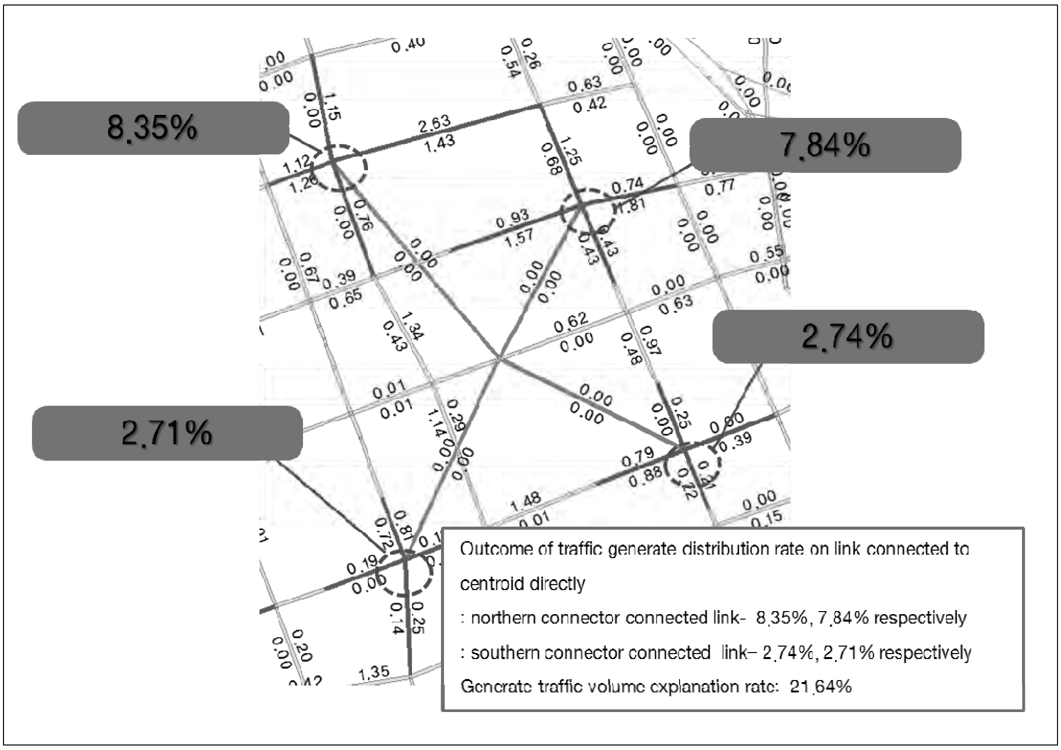

Figure 14: Trip generation rate in Gangnam-gu

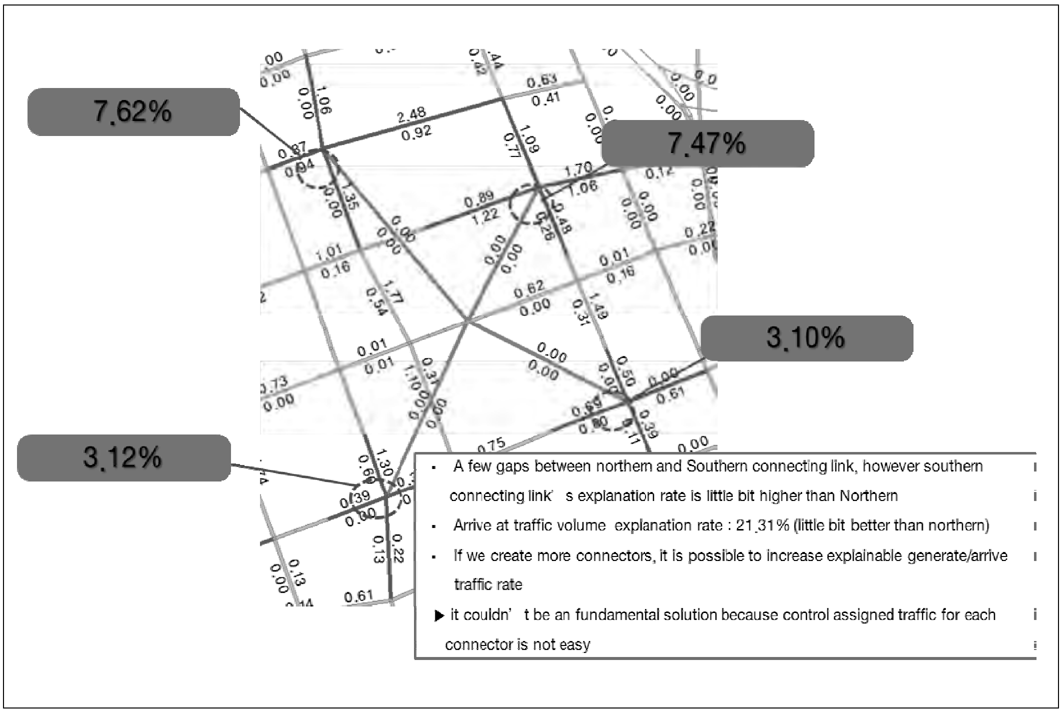

Figure 15: Trip arrival rate in Gangnam-gu

Both Figure 14: and Figure 15: is examples of validity of zone centroid connectors in Gangnam-gu. Figure 14: shows innerzonal trip generation rate and Figure 15: provides innerzonal trip arrival rate.

4.4 OD travel pattern analysis

The number of link OD passing data is a data to evaluate how many links between regions to determine whether the passage is not treated. Also it identify how largely a link give an impact on travel demand in the network spatially. We calculate average number of link passing OD for each TTF level. As a result there are more link pass OD pairs in the city than in the rural area.

Average number of link passing OD on urban freeway is hight than national expressway. On arterial road, a reado which has low TTR grade has more links passing OD pairs.

4.4.1 Spatial analysis of number of link passing OD pairs

Number of link pass OD pairs in the city is much more than in the rural area.

If OD pairs have many links pass, it could be effect on extensive area when a road has problems like car accident, etc. So this is an important data for further study like disaster evacuation and so on.

4.5 Link priority analysis

Link priority takes high score if link has more links passing navigation sample data, more passing OD pairs, and more lower inner traffic rate. Link priority is calculated with this formula.

Link priority = 0.333*(grade of sample navigation data) + 0.333*(grade of passing OD pairs)
+ 0.333*(grade of inner traffic rate) (1)

Link priority shows importance of each links on KTDB network and it could be used for selecting investigation area as evidentiary material in the future.

To recognize link priority, we mark on a map with TTF grade. An interest thing is sometimes link priority shows different scale among neighbor links.

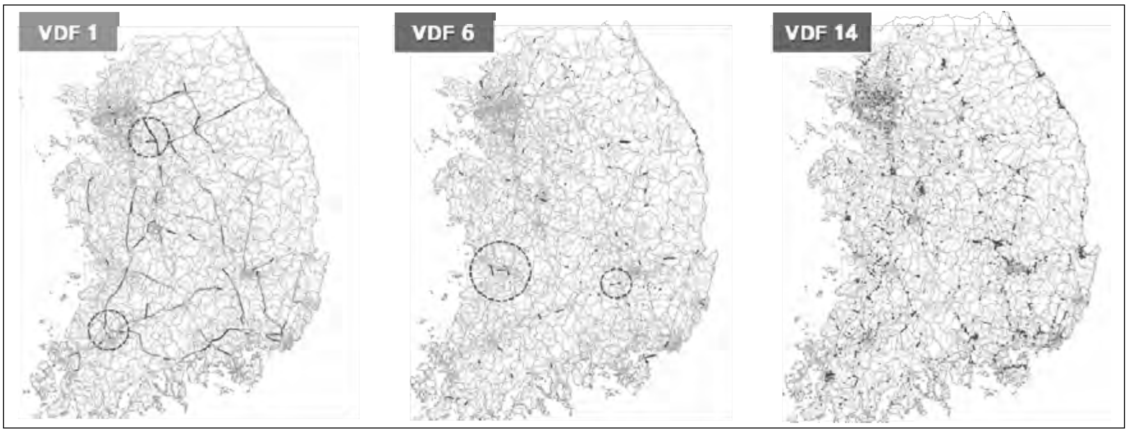

Figure 16: Example: difference of link priority

4.6 Zone network compatibility analysis

If link passing vehicles' distance is short and innerzonal travel rate is high, then we evaluate that link has low compatibility. On freeway, identification which link has low compatibility relatively is possible. In case of TTF 14, urban fringe has low consistency links, especially Seoul inner city highway.

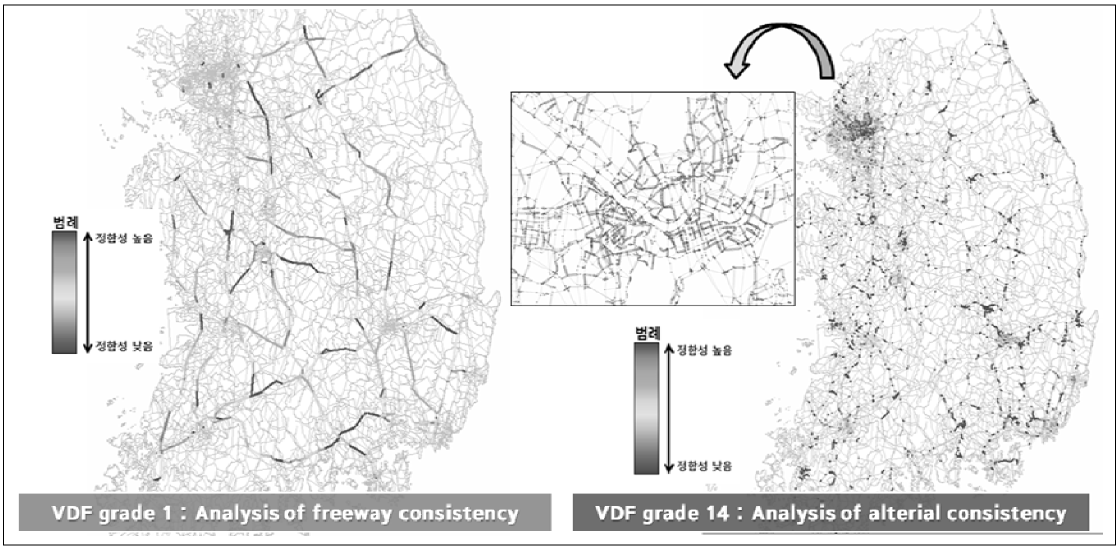

Figure 17: Example of link compatibility

5. FUTURE CHALLENGE

Through this study, we find navigation data has many benefits for traffic research. However, we still have to improve navigation data for traffic research or other transportation parts. So, we make a strategy. Figure 18: shows strategies what we make.

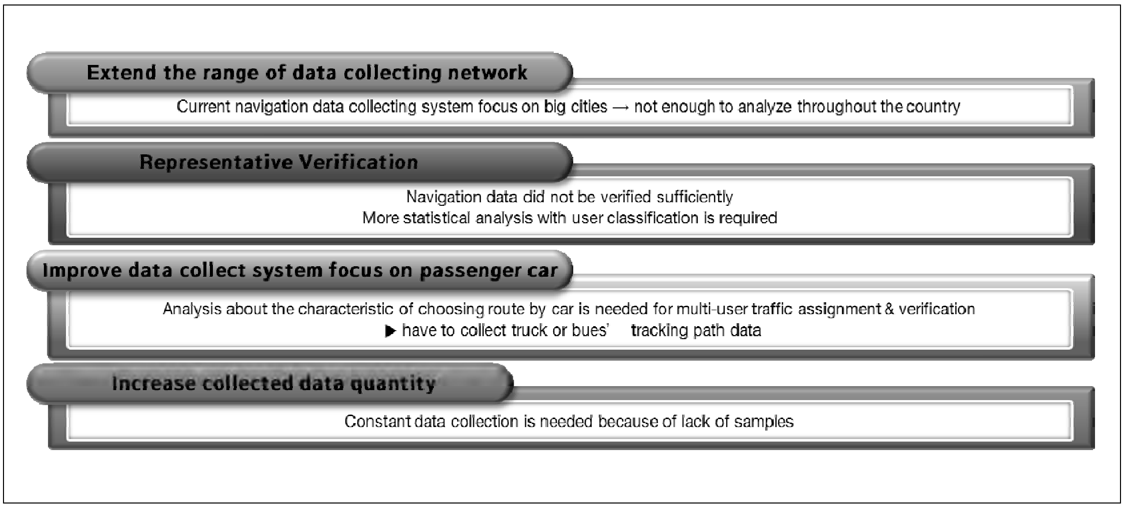

Figure 17: Example of link compatibility

First, range of data collecting network should be extended. This is because current navigation data collecting system focus on big cities so it is not enough to analyze throughout the whole country. Second, representative verification is needed. The navigation data are not verified sufficiently so more statistical analysis with classification is required. Then, we have to improve data collect system focus on passenger car. Analysis for the characteristic of route choice by car is needed for multi-user traffic assignment and verification so trucks' tracing path data or buses' tracking data should be collected. Last one is we need to increase collected data quantity. Constant data collection is needed because of lack of samples.

5.1 Theoretical research

The navigation data on transportation planning is applied into two parts. First one is theoretical research part and second one is operation application part.

Main point of theoretical research is route information, relationship between OD-Link, tracking path by car and travel time – velocity.

1) Develop traffic assignment model based on route

To remedy user equilibrium traffic assignment’s shortcoming, we need to develop a model which can calculate route choice based on observed data.

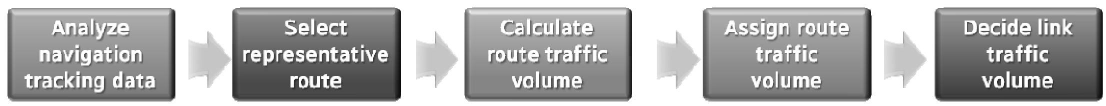

Figure 18: Flow chart

2) OD estimation based on navigation data

OD estimation is a method to estimate OD trip based on observed link traffic. Prior methods are using UE traffic assignment model. However it cannot calculate exact route choice rate and link passing rate which is changed every iterations, it means that there is a limit to estimate accurate OD trip. So analysis of relationship between OD and Link with navigation data could improve OD estimation accuracy.

3) Traffic assignment model based on OD link choice probability

We need OD trip link passing rate to determine representative route. By using this rate on traffic assignment, it is possible to calculate realistic traffic pattern. Also, link passing rate helps to analyze average and variance in long-term analysis. It is useful to develop theoretical traffic assignment model like stochastic traffic assignment. Traffic assignment model with link choice probability can be developed.

4) Analysis of reliability of road travel time

Travel time reliability is considered a traffic network analysis because the number of data is not enough to analyze. Probabilistic analysis is possible since navigation data has iterative travel choice behavioral information. Probabilistic analysis makes it possible to evaluate reliability of route or OD travel time.

5.2 Operational application

To apply navigation data for transportation planning, immediately available method should be developed to operate current navigation data information. In network verification, other data cannot verify a traffic network. Analysis of OD travel time and link travel time's standard deviation is possible to validate reliability of national road travel time. We need to develop verification method with navigation OD trip data which has a high percentage of the KTDB component.

(1) Truck-bus priority assignment multi-user vehicle model.

Some traffic assignment package supports MUV model. So, theoretically Multi-user class assignment is suggested. However, route choice description has less reality, so utilitarian value and solution algorithm is inefficient and it is hard to get a unique solution. Therefore, truck and bus' routes should be captured with navigation data.

(2) Develop network verification method with navigation data

Verifying network components is possible with navigation data. Generating and arriving links for a zone will be useful for checking centroid connectors' reasonability. If sufficient navigation data is cumulated, it could be an important data to construct physical network. \

(3) Network service level evaluation index

We can analyze the reliability of network travel time for a whole network. To analyze travel time variance, enough sample data should be collected. With this it is possible to analyze road grad or regional travel time.

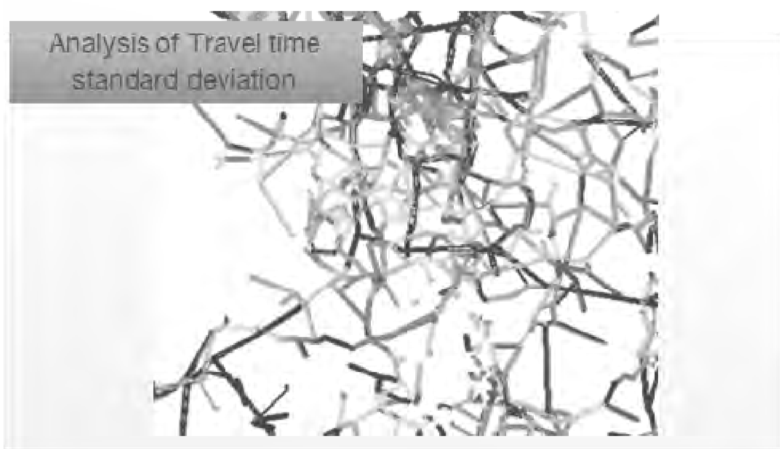

Figure 19: analysis of travel time standard deviation

(4) KTDB OD trip verification method

We construct trip OD table with observed data but it is hard to verify and use screen link method, cordon line method or link traffic verification method. There is a limitation to using indirect verification method with traffic assignment. Starting from the navigation data through the data to identify definition and innerzonal trip ratio, it is possible to develop a direct OD verification methodology.

THE IMPACT OF FLOW VELOCITY ON MICROBIAL PRECIPITATION OF CALCIUM CARBONATE AMONG SOIL

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ABSTRACT

Microbial precipitation of calcium carbonate has the potential to mitigate the geodisasters with minimal adverse effects on the environment. One of the remaining challenges for its field-scale implementation is nonuniform distribution of calcium carbonate precipitation among soil. In this research, bacterial solution and cementation solution, both of which is necessary to make the precipitation occur, were infiltrated to sandy specimens with varying flow velocity to see the effects of flow velocity on the distribution of the precipitation. The uniformity of the precipitation was examined by means of needle penetration tests. In addition, precipitation efficiency and effluent pH were recorded. The result indicated that slower delivery of cementation solution resulted in more uniform precipitation when bacteria had been equally distributed over the specimen. Furthermore, the quicker the injection of bacterial solution was, the more uniform precipitation occurred, which suggested that fast transfer of bacterial solution led to their uniform deployment in the specimen. Precipitation efficiency and effluent pH were not affected by flow velocity within the range examined in this study.

Keywords*: soil improvement, microbes, infiltration, flow velocity, calcium carbonate precipitation.*

1. INTRODUCTION

Microbial calcium carbonate precipitation has a great prospect of mitigating soil-related disasters such as liquefaction and landslides while presenting a minimal level of harsh effects on the environment, as opposed to the conventional cement improvement that are often accompanied by dangerous side effects (Kamon et al. 2005). The aforementioned precipitation is usually mediated by bacterial species possessing urease, an enzyme which decomposes urea into ammonia and carbon dioxide. The produced ammonia raises pH, helping carbon dioxide to become carbonate ion, which triggers calcium carbonate precipitation near particle-particle contacts among soil with the presence of ample calcium ion, thereby reinforcing soil structures. Previous research has already suggested that calcium carbonate precipitation can be effective in improving sand's behavior under undrainded condition (DeJong et al. 2006). However, a successful implementation of calcium carbonate precipitation could be hindered by the degree of precipitation being nonuniform among the target soil, since the actual effects of the improvement cannot be fully guaranteed without quantitatively assessing the distribution of precipitated calcium carbonate. So far laboratory-scale tests have been facing the nonuniformity of the precipitation. For instance a laboratory experiment, in which small sandy columns (ϕ50 mm*100 mm) were injected with bacterial solution and cementation solution from one side of the column at flow rates as slow as 2 ml/min, came out with the results of calcium carbonate precipitation being concentrated near the injection point (Mortensen et al. 2011). Other research, where 0.5m sandy columns were treated in a similar manner, also showed an unequal distribution of calcium carbonate (Martinez et al. 2011, Martinez et al. 2013). Larger scale experiments revealed the same tendency. For example, 5 m column and 100 m^3 box experiments resulted in the amount of precipitation peaking at regions close to the injection points (Whiffin et al. 2007, Van Passen et al. 2009). Moreover, effectiveness of the treatment cannot be verified from the results of triaxial experiments with nonuniformly cemented specimens. Therefore, it is imperative to achieve uniform precipitation of calcium carbonate among the target soil. In this research, attempts at inducing uniform calcium carbonate cementation among sandy specimens were made by injecting bacterial and cementation solution at different flow rates. This study aims to create an effective way of preparing uniformly cemented specimens so that they can be examined in triaxial experiments, in order to evaluate their improved properties appropriately. Furthermore, this research is to provide an insight into optimum implementation of the microbial calcium carbonate precipitation on a larger scale.

2. MATERIALS AND METHODS

2.1 Bacterial Solution

Bacterial solution was prepared by inoculating an arbitrary amount of Sporosarcina pasteurii (ATCC 11859), which had been cultivated on culture plates, into 0.13M Tris buffer at around pH 9.0 that also contains 20 g of yeast extract and 10 g of ammonium sulfate per 1 l. These two ingredients were put into separate flasks containing the Tris buffer, and they were sterilized at 121 ^{o}C for 20min before mixing. The recipe for the culture plate is identical to the chemical solution mentioned above except 20 g of agar per liter being added to make the solution gelled. After the inoculation, the solution was incubated for 24 to 26 hours at 30 ^{o}C in order to let the bacteria to augment up to a stationary phase.

2.2 Cementation Solution

Cementation solution was mainly comprised of urea and a calcium source; the former provides energy for the bacteria and the latter is essential to induce calcium carbonate precipitation. Specifically, the chemical solution employed in the experiment contains 30.03 g of urea, 73.507 g of calcium chloride bihydrate, 3 g of nutrient broth, 10 g of ammonium chloride and 2.12 g of sodium bicarbonate per liter of distilled water. Nutrient broth provides necessary nutrition for the bacteria to augment themselves, and ammonium chloride and sodium bicarbonate play a role in stabilizing pH of the solution. The chemical solution was not sterilized prior to the injection to the specimen. All the chemicals used to prepare the bacterial and cementation solution were obtained from Wako Pure Chemical Industries, Ltd., Japan.

2.3 Specimen Preparation

The specimens were prepared by water-pluviating Toyoura sand (G_s = 2.656, e_{max} = 0.992, e_{min} = 0.632, d_{50} = 180 μm) into cylindrical plastic molds (ϕ50 mm*100 mm) aiming at the relative density around 90%. A filter paper was placed at the top and bottom of the sand column to prevent a loss of sand particles from the mold. Tow different types of preparation were performed in the experiment. In the first series of testing (i.e. Test 1) the specimens were created by pouring Toyoura sand into bacterial solution in the same manner as the water pluviation method, in order to deploy the bacteria uniformly over the specimen. Cementation solution was infiltrated through the specimen from the top afterward. In the second series of testing (i.e. Test 2) the specimens were formed in the same way, but distilled water was used instead of bacterial solution during water pluviation. Then bacterial solution was injected from the top of the specimen followed by cementation solution.

2.4 Testing Procedure

The water-pluviated specimens were fitted with an acrylic hollow cylinder at the top of the mold and a plastic tube at the bottom so that the infiltration of solution from the top to the bottom became possible. The tube was connected to a small tank where negative pressure was applied to control the flow velocity of solution (Figure 1). Various levels of negative pressure were used, ranging from -1 kPa to -40 kPa, and the pressure was kept constant during infiltration. Since the water level of the solution declined as the infiltration progressed, the flow velocity could not be maintained constant. In Test 1, four specimens were prepared with the bacteria already distributed uniformly among each specimen. 90 ml of cementation solution was transferred to each sand column at varying flow velocity and the infiltration was stopped while the top surface of the column was still slightly covered by the solution. The specimen was detached from the tank after the infiltration, and its top and bottom end were sealed properly in order to prevent drying of the sand. In Test 2, firstly 90 ml of bacterial solution was injected to the specimen at different flow velocity. Then 90 ml of cementation solution was poured by the force of gravity. In both tests, the time needed for the solution to infiltrate the first 10 ml, and from that onward every 20 ml, was recorded, which was then used to calculate flow velocity. The flow velocity, v, was derived using Equation (1).

$$v = \frac{q}{A}\frac{1+e}{e} \tag{1}$$

where q = flow rate, A = area of sand column's cross section perpendicular to its length and e = void ratio.

In addition, the specimen was retained for 20 hours after the infiltration of cementation solution to let calcium carbonate precipitation develop. Then distilled water was added from the top to stop the precipitation process and to wash out all remaining chemical substances in the specimen. The details about the testing condition are shown in Table 1.

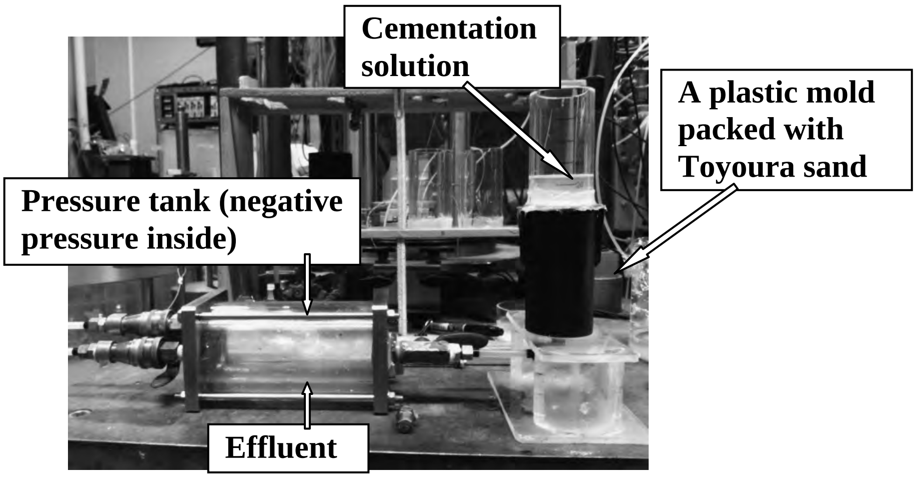


Figure 1: Infiltration of cementation solution to the specimen

The degree of cementation and its distribution was evaluated by needle penetration tests, in which the cemented sand columns were pierced for 20 mm from the surface along the length of the column with a needle made of brass (Figure 2(a) and (b)). The resistance on the needle was recorded as it moved down in the specimen at a speed of about 30 mm/min. After the first 20 mm of layer was done, that layer was removed from the mold, and the next 20 mm of layer underwent the test. This was repeated until the entire length of the column had been finished with the penetration test. Specifically, the length of the sand column was 100 mm so the penetration test was performed for five layers for a single specimen (Figure 2(c)). The five lines, representing the relationship between penetration resistance and penetration depth for each of five layers in a specimen, are hypothesized to be similar to each other if the cementation is distributed uniformly over the specimen. The results for the cemented specimens were compared with those for an untreated specimen, in order to see the level of reinforcement by the precipitation of calcium carbonate. In addition to the needle penetration test, the amount of precipitated calcium carbonate was calculated in two different ways; one was based on the concentration of calcium ion in the effluent of cementation solution ejected from the specimen (i.e. referred to as precipitation efficiency Ⅰ in Table 1), and the other is derived by comparing the weight difference of the specimen before and after the treatment (i.e. precipitation efficiency Ⅱ). The effluent was further examined to assess its pH, which could affect the environment adversely if its value becomes too high.

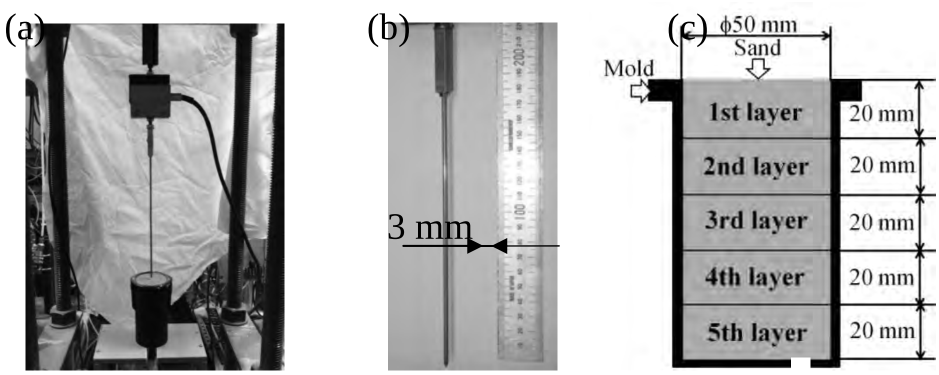


Figure 2 : (a) An overview of the penetration apparatus; (b) the needle; (c) division of the sand column into five layers for the penetration test

3. RESULTS AND DISCUSSION

The results of the penetration tests are shown in Figure 3, 4 and 5. Specifically the results with the specimens in which the bacteria were deployed uniformly during specimen preparation are shown in Figure 3 (i.e. Test 1), and Figure 4 reveals those for the specimens that were infiltrated with both bacterial and cementation solution after the preparation (i.e. Test 2), while the result for the untreated specimen is illustrated in Figure 5 as a bench mark. Each legend shown in the graphs (e.g. 1-A) corresponds to those in the Table 1.

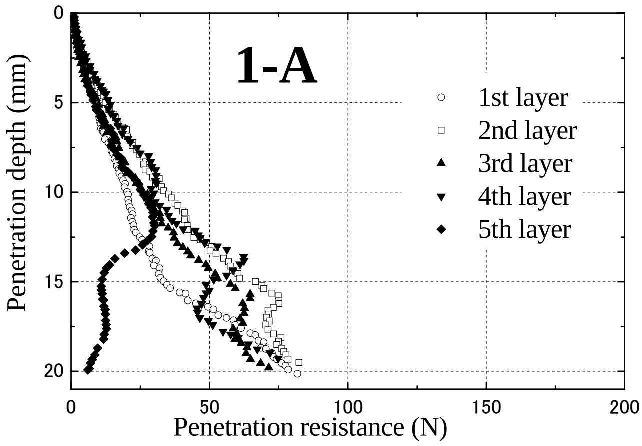
Table 1: Details of testing condition and results

Test number	1				2				Bench mark
Column	A	B	C	D	A	B	C	D	
Relative density (%)	93.1	95.1	94.7	92.6	89.3	91.1	96.9	91.5	102.5
Pore volume (ml)	78.6	78.1	78.2	78.7	79.6	79.1	77.6	79.0	76.1
Infiltrated BS volume (ml)	-	-	-	-	90	90	90	90	0
Infiltrated CS volume (ml)	90	90	90	90	90	90	90	90	0
Precipitation efficiency Ⅰ (%)	96.5	97.3	98.1	96.5	96.5	97.3	98.1	97.0	0
Precipitation efficiency Ⅱ (%)	86.9	91.1	87.7	87.5	91.1	89.1	82.1	72.6	0
Effluent pH	7.5	7.3	7.3	7.3	7.5	7.3	7.5	7.3	-

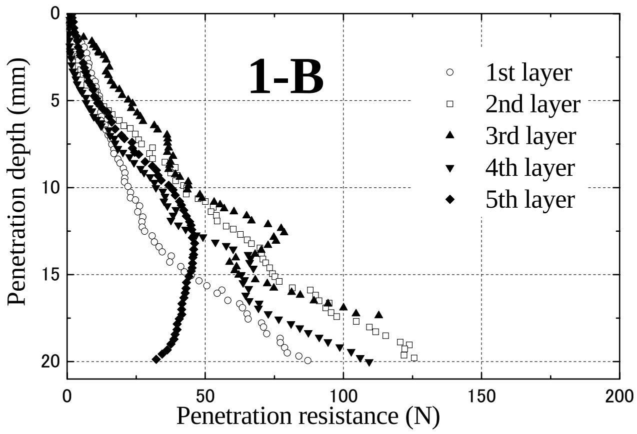
Note: BS = bacterial solution; CS = cementation solution

Figure 3(d) shows the level of calcium carbonate cementation and its distribution for the specimen in which cementation solution was transferred by the force of gravity, i.e. very slow delivery. It was evidenced that the specimen was cemented fairly uniformly under that condition (i.e. uniform distribution of bacteria prior to slow infiltration of cementation solution), as each layer showed similar responses to each other. The penetration resistance also increased by more than 100 per cent compared to the bench mark, indicating the effectiveness of calcium carbonate precipitation as a way to reinforce soil. In the case of quicker delivery of cementation solution than by gravitational force, the uniformity seemed to be disturbed (Figure 3(b) and (c)). Moreover, the penetration resistance declined slightly when the solution was transferred very quickly (Figure 3(a)), even though precipitation efficiency was as high as the other specimens. Figure 3(e) shows the flow velocity during infiltration for each specimen. Precipitation efficiency and effluent pH were not affected by flow velocity (Table 1). Note that the drop in penetration resistance in the fifth layer does not mean that this part was not cemented with calcium carbonate. This is because the bottom of the mold was drilled as the outlet for solution, which provided much less reaction force to the needle. A similar behavior was observed for the untreated specimen (Figure 5).

(a)



(b)



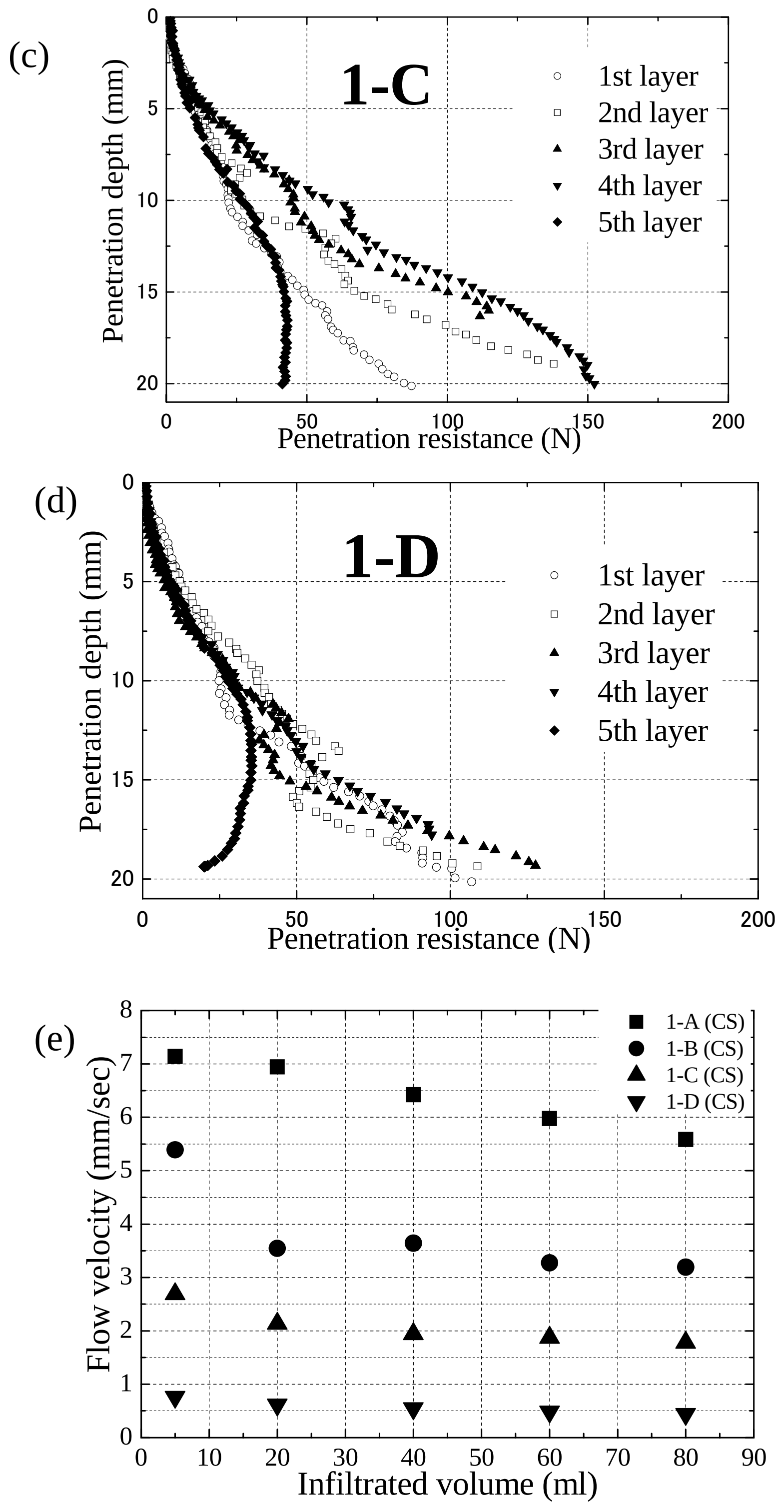
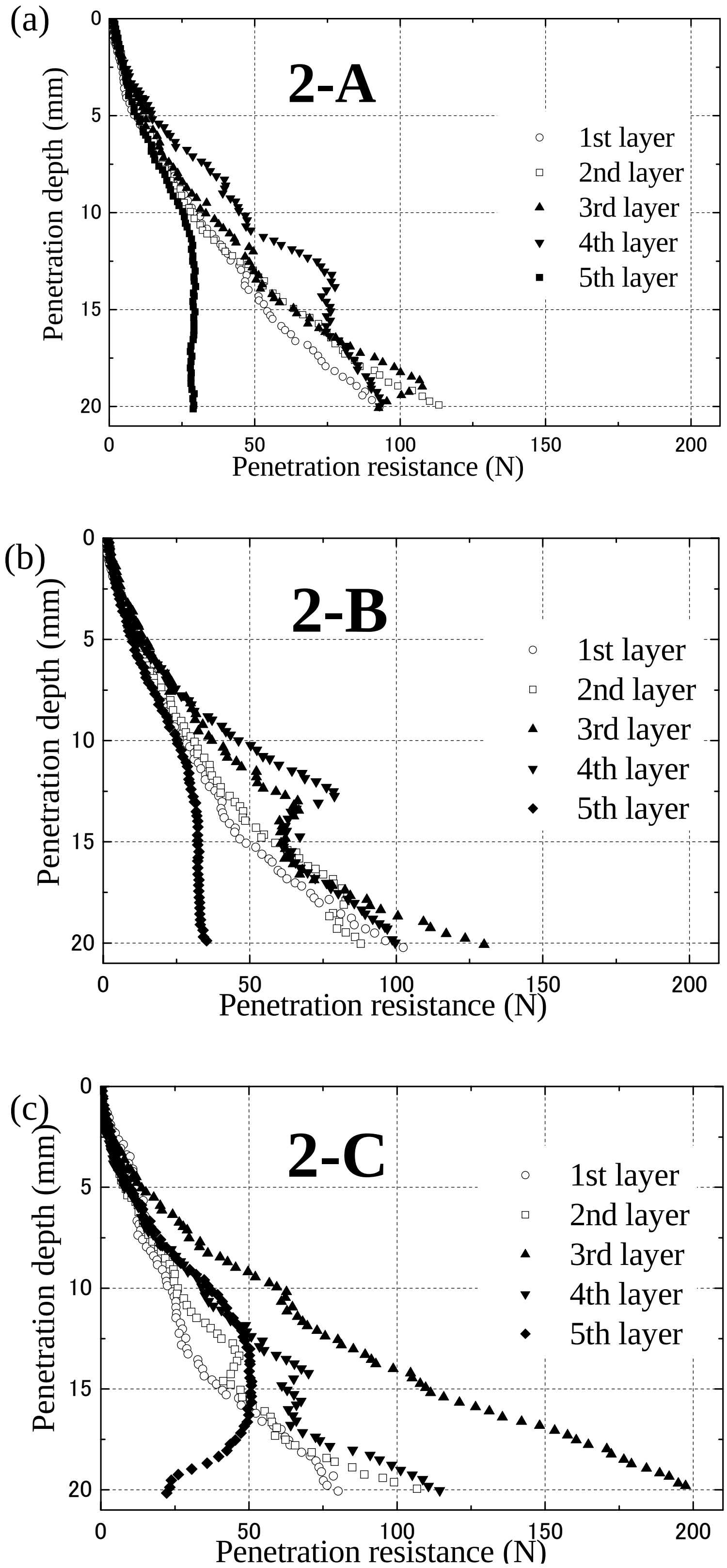


Figure 3: (a) to (d) results of penetration tests for Test 1;
(e) flow velocity of cementation solution (CS) during its infiltration to the specimen


(a)
2-A
1st layer
2nd layer
3rd layer
4th layer
5th layer
Penetration depth (mm)
Penetration resistance (N)
0
5
10
15
20
0
50
100
150
200
(b)
2-B
1st layer
2nd layer
3rd layer
4th layer
5th layer
Penetration depth (mm)
Penetration resistance (N)
(c)
2-C
1st layer
2nd layer
3rd layer
4th layer
5th layer
Penetration depth (mm)
Penetration resistance (N)

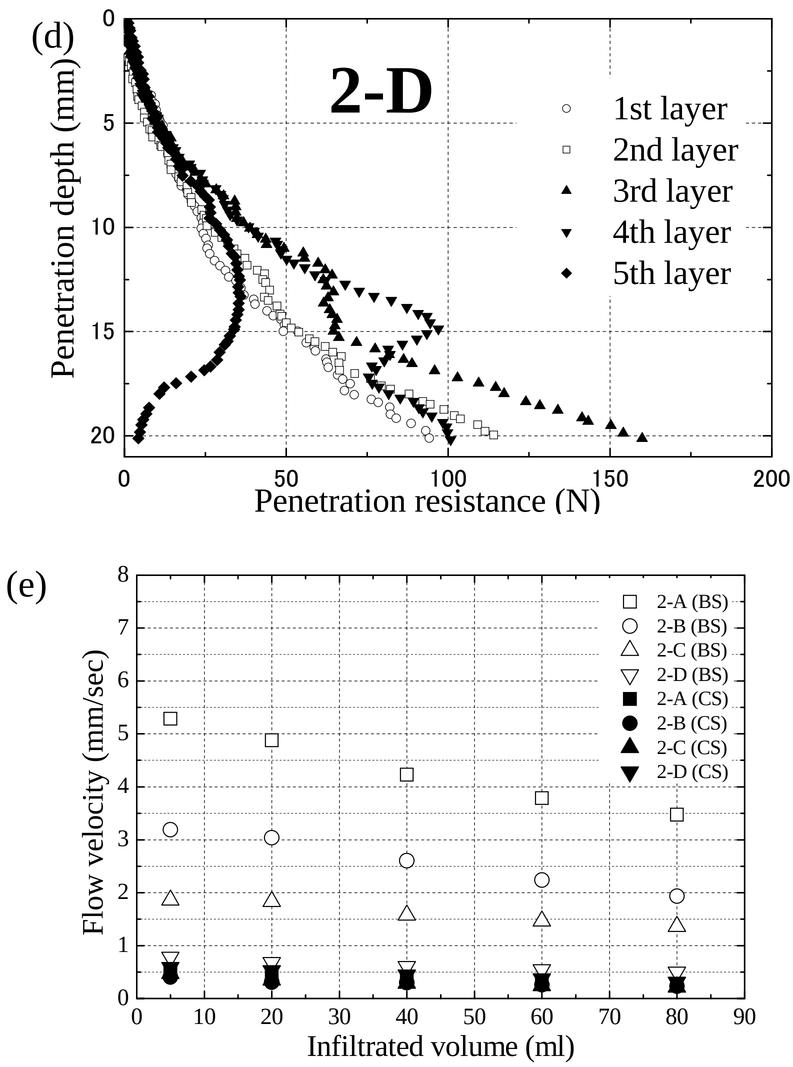


Figure 4: (a) to (d) results of penetration tests for Test 2;
(e) flow velocity of each solution (BS and CS) during their infiltration to the specimen

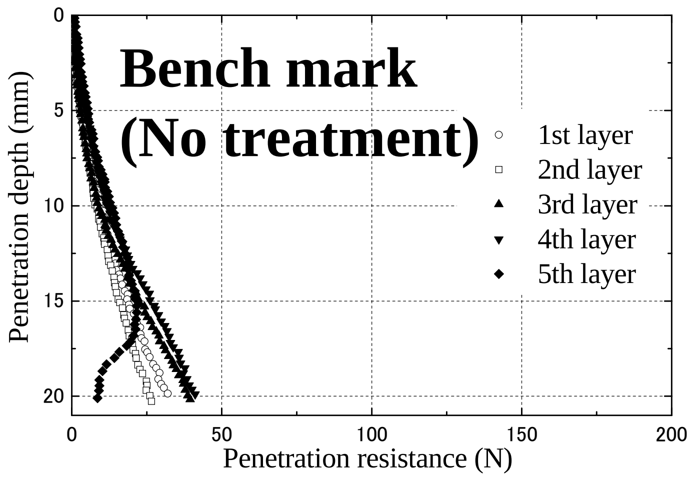


Figure 5: Penetration test result for the untreated specimen

The results for Test 2, where both bacterial and cementation solution were infiltrated after specimen preparation, are shown in Figure 4. By and large, the uniformity of cementation was no better than that for Test 1. A relatively large difference in penetration resistance for each layer in Figure 4(a) and (b) indicates the slow delivery of bacterial solution led to nonuniform distribution of bacteria, which then resulted in the concentration of cementation around the middle of the specimen. By contrast when bacteria were migrated at faster rates, more uniform cementation took place (Figure 4(c) and (d)). This could be due to the bacteria having been scattered over the specimen uniformly with higher rates of injection.

Therefore, these results suggest that the key to successful implementation of the calcium carbonate precipitation, i.e. uniform cementation among the target soil, is to inject bacterial solution at fast rates, followed by slow infiltration of cementation solution. Furthermore, effluent pH was no higher than 7.5 in all the test cases, indicating almost no negative impact on the environment in terms of pH changes.

4. CONCLUSIONS

In this study, small sandy specimens of Toyoura sand were microbially precipitated with calcium carbonate by infiltration bacterial and cementation solution from the top to the bottom of the specimen at varying flow velocity. The quicker the bacterial solution was transferred, the more uniformly the bacteria seemed to be distributed. By contrast, the delivery of cementation solution needed to be slow enough to induce the precipitation equally over the specimen. Therefore, a better strategy for the uniform cementation of the target soil could be injections of bacterial solution at fast rates, followed by slow infiltration of cementation solution. As far as the flow velocity employed in this research, precipitation efficiency was not affected and remained as high as just below 100 %. Effluent pH was no higher than 7.5, indicating minimal harsh effects on the environments with regard to pH changes.

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COMPARISON OF BENEFITS FOR POLITICAL BOUNDARY AND NATURAL BOUNDARY FROM HYDROPOWER DEVELOPMENT IN THE MEKONG

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ABSTRACT

Hydropower seems to be a very promising source of energy, although it has huge economic, social and environment impacts at a local, national, and trans-national level which may result to transboundary conflicts among the riparian countries. Past literature has suggested that these conflicts may be approached through benefit sharing. Selecting different sets of riparians (such as countries (Political boundary) and river sub-basins (Natural boundary)) within the same study area may lead to different benefit sharing system. While a lot of research has been done in the country aspect (political boundary), the natural boundary aspect has been left simply untouched. This study shows promising results of the natural boundary approach. The study attempts to investigate the difference in benefit sharing in the transboundary sub-basin, the Sesan and Srepok sub basin, covering areas of Cambodia and Vietnam in the Mekong River Basin using a game theory approach. Two sets are defined, based on Political boundary (National boundaries) and based on Natural boundary (Sub-basin boundaries). A wide range of parameters such as energy production, irrigational benefits, flood control socio-economic costs etc. have been incorporated to define models and methodologies. This study then compares these two sets using the game theory concepts, such as core stability and incentive compatibility. Here we show that depending on the type of riparians chosen, the extent of benefit sharing changes. The results of the study will provide a basis for local policy decisions and regional planning in the Mekong River and beyond.

Keywords*: Mekong River Basin, sub-basin, Hydropower development, Game Theory, Natural boundary, Political boundary, Optimization*

1. INTRODUCTION

Rivers are one of the main sources of fresh water. They play a dominant role in sustaining ecosystems. Rivers have always played a vital role in the economic development of mankind. A healthy river is typically one with protected watersheds, conserved wetlands, protected aquatic and riverine terrestrial biodiversity and controlled water abstraction and wastewater discharge (Sadoff et al., 2002).

There are hundreds of rivers in the world, of which 261 rivers are shared by two or more countries, hence the name International rivers (Wolf et al., 1999). Proper water resources allocation is an important issue and there have been many critical debates and conflicts throughout the world in the history of mankind (Falkenmark and Lundqvist, 1995; Postel, 2000; Tarlock, 2001). Many multilateral agreements on transboundary cooperation of international rivers have been drafted in the 20th century (Beach et al, 2000), yet it is unclear how the interactions among the riparian states will proceed in the near future (Ward, 2002).

Watersheds have their own natural boundaries. These boundaries have nothing to do with the political boundaries such as national boundaries and provincial boundaries, etc. In case of international rivers; it is often found that that river watershed is shared between two or more countries. Each country has its own policies and agreements about the watershed. A number of multilateral agreements on such transboundary watershed cooperation has been established. Although, a lot of research has been performed in the country extent (political boundary), the watershed extent (natural boundary) has been simple left untouched. There exist very little to no history on such research.

This paper tries to include the natural boundary extent for policy implementations. It tries to show how natural boundary extent can also be used in case of transboundary scenarios. The Sesan and Srepok sub-basins of the Mekong are selected as the study area. A number of parameters were selected to form a model to optimize the benefits from hydropower development. Optimization is performed for both country-wise (political boundary) and sub-basin wise (natural boundary). The study tries to provide a new basis for local policy makers

2. GAME THEORY

Game theory models strategic situations, or games, in which an individual's success in making choices depends on the choices of others (Myerson, 1991). According to Langlois (1996), Game Theory can be described as the science of strategy or that of conflict resolution; at its core, it has the characteristics of a mathematical construct: a set of concepts and assumptions, fundamental theorems, and applications to real world issues.

2.1 Core stability and incentive compatibility

For a scenario to be successful, it must provide a non-empty core. Core, here, refers to the benefit arising out of cooperation among the three countries. The larger the size of the core, the greater is the amount of benefit.

Formally the core is defined as the set of all benefit allocation vectors $\underset{x}{\rightarrow} \in R^N$

which satisfy two conditions:

Efficiency:

$$\sum_{j \in N} x_j = v(N)$$

Coalition rationality:

$$\sum_{j \in c} x_j \geq v(c) \quad \forall c \subseteq N$$

where N is the grand coalition that includes all players j, and v is the characteristic function value, or the total benefits to the members of the coalition. Efficiency states that the sum of benefits to each player is equal to the value of the grand coalition. Coalitional rationality states that players are not incentivized to leave the grand coalition for a subset coalition (i.e. individual action or partial coalitions).

3. STUDY AREA

3.1 The Sesan and Sre Pok sub-basin

The Mekong River, the longest international river of Asia, is the ninth largest river in the world, spanning 4,909 km and draining an area of 795,000 km^2, discharging 475 km^3 of water annually. The river basin is thickly populated with over 72 million inhabitants (Campbell 2009). The Sesan and Sre Pok sub-basins, is a large tributary system of the Mekong River, with a total area of 56,085 km^2 covering the border areas of the "Indochina Junction" in Cambodia and Vietnam. It is shared among the two countries, Cambodia (25,975 km^2; 46.3%) and Vietnam (30,110 km^2; 53.7%).

3.2 Hydropower scenario of the sub-basins

Hydropower potential of these sub-basins has attracted attention for more than 50 years. The total number of HEPs already constructed, under construction or in the designing or master planning stage amount to 21, as of April 2009 (Asian Development Bank (ADB, 2009)). These HEPs are grouped into 4 groups, viz. Group 1 – under operation HEPs, Group 2 – HEPs under construction, Group 3 – HEPs in the design stage and Group 4 – HEPs in the master plan stage. These plants are shown in the Figure 1 based on their group. The total number of HEPs in each group and the total annual production of each country are shown in table 1(MRC, 2009).

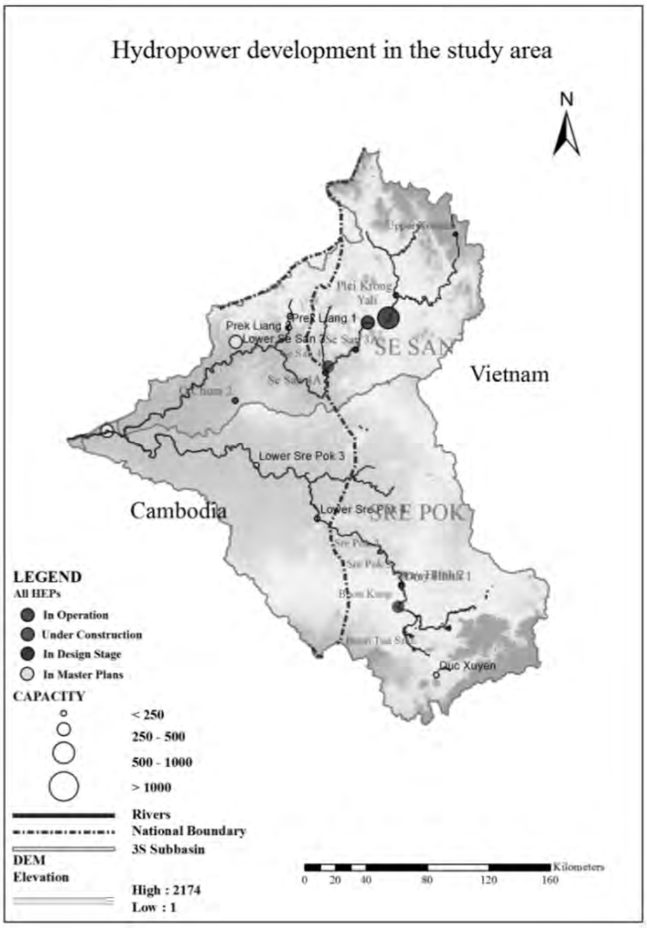


Figure 1: Hydropower development in the study area

Table 1: Hydropower data of the study area

	Land Area (km^2)	Total Annual Production (Number of HEP), GWh					Total Reservoir Area
		Group 1 In Operation	**Group 2 Under Construction**	**Group 3 In Design stage**	**Group 4 In Master Plan stage**	**Total**	
Cambodia	**25,975**	3 (1)	0 (0)	0 (0)	6,538 (6)	6,541(7)	106,323
Vietnam	**30,110**	5,955 (7)	4,623 (5)	1,056 (1)	181 (1)	11,815(14)	94,335
Total	**56,085**	5,958 (8)	4,623 (5)	1,056 (1)	6,719 (7)	18,356(21)	241,141

Source: MRC, 2009

4. METHODOLOGY

This chapter provides the research procedure and followed methods of the study to achieve the objectives. This study uses the concept of game theory to optimize the hydropower scenario and minimize the conflicts and disputes arising due to hydropower plants and show that cooperation will lead to a better outcome.

4.1 Parameters considered

There are two types of parameters; one provides the benefits while the other causes us losses. In the first category, parameters like energy production, irrigational benefits, benefits from fisheries and flood control are considered; while annual cost of project, cost of transmission lines, socio-economic costs, loss of fish, navigational loss and environmental losses fall into the second category.

4.2 Estimation of investment funds available

To optimize the different scenarios, the investment funds of each unit (country or sub-basin) have been used as a constraint. It has been calculated based on two factors, viz. (a) past construction activity and (b) future projects. In calculating the average cost of past HEPs, Group 1 and Group 2 HEPs are considered, while for future projects, Group 3 and Group 4 HEPs are considered. The maximum of the two costs is rounded-off and fixed as the unit's hydropower construction investment funds. The funds for Cambodia, Vietnam, Sesan and Srepok were assumed as US$ 1000, 300, 900 and 200 Million respectively.

4.3 Optimization model and scenarios considered

A very simple model has been in this study. Each country or sub-basin (unit) is a player having two options: to build or not to build additional damns. The objective is to maximize the net total annual benefits in the sub-basin. The grand coalition case seeks to maximize total benefit.

Sets	I	HEPs identified by Project ID
	J	Countries – Cambodia, Vietnam Sub-basins – Sesan, Srepok
Parameters	group_i	1 – in operation, 2 – under construction, 3 – in design, 4 – in master plan
	$unit_i$	1 – Cambodia, 2 – Vietnam, 3 – Sesan, 4 - Srepok
	$budget_j$	unit hydropower investment fund
	$b_{i,j}$	benefits of HEP i on unit j
	$c_{i,j}$	costs of HEP i on unit j
Variables	$x_i = \{0,1\}$	HEP decision variable

Objective Function:

$$\text{Maximize} \sum_{j \in c} \left\{ \sum_{i \in I} x_i [b_{i,j} - c_{i,j}] \right\} \quad \forall\ c \in C$$

where C is a particular coalition status among the set of all the possible coalitions.

The constraints of this optimization models were the individual unit's investment funds and the benefit-cost ratio (b-c ratio) of individual HEPs, i.e., while optimizing, the first priority was to select HEPs within the available fund having the highest b-c ratio. Then the second best HEP in terms of b-c ratio was selected and so on.

A total of five different coalition scenarios were selected including joint and individual funds as well as partial coalitions for present and future scenarios. These are discussed below:

0 Status quo: The present hydropower situation. Only the existing HEPs in operation, group 1 HEPs, are selected.
1 Complete under-construction projects: The existing HEPs in operation (group 1) and the under construction HEPs (group 2) are considered.
2 Individual unit maximization: Each unit maximizes its benefits by constructing additional HEPs in group 3 and 4 within individual fund constraints; all groups.
3 Two units' simultaneous maximization (separate funds): Both the countries/sub-basins maximizes simultaneously but within their individual fund limits; all groups.
4 Two units' simultaneous maximization (joint funds): Both the countries/sub-basins combines their funds and then jointly maximize; all groups.

5. RESULTS AND DISCUSSION

The optimization has been performed in two steps; first for the two countries (political boundary) and second for the two sub-basins (natural boundary). The results of optimization are described in detail in the following sub-sections.

5.1 Optimization for two countries (political boundary)

Referring to table 2 (results of optimization – political boundary), Cambodia at present is in loss because of the construction and operation of HEPs in Vietnam. These HEPs are operating along the Cambodia-Vietnam border; hence almost all of the downstream costs of these HEPs were suffered by Cambodia. Currently, Cambodia is suffering a total of 4.1 Million US$ as downstream costs. Cambodia will also be suffering the downstream costs of the currently under construction HEPs (an additional 3.24 Million US$). Vietnam, on the other hand, is getting high benefits of 271.89 Million US$. The benefit will further increase by 199.13 Million US$ as the currently under construction HEPs are completed.

For individual maximization, highest benefit is achieved when Cambodia maximizes, (Max Cambodia) (346.59 Million US$). This is because of the fact that, Vietnam has already exploited its hydropower by building a number of HEPs and doesn't have much scope for further development, whereas Cambodia has just started to construct HEPs and has a lot of HEPs in the design and master plan stage (group 3 and 4).

When two countries maximizes together (Max Cambodia + Vietnam), a higher total net benefit is attained (618.42 Million US$). This benefit can be further increased by 13.1 Million US$ when they cooperate and maximize jointly with combined funds (Max j(Cambodia + Vietnam)). The highest net benefit of 631.52 Million US$ is reaped in this scenario (increase in net benefit of 363.73 Million US$).

Table 2: Results of optimization based on countries (political boundary)

Scenario		Net Benefits (Million USD)			Change in Net Benefits (Million USD)		
		Cambodia	Vietnam	Total	Cambodia	Vietnam	Total
Status Quo		-4.1	271.89	267.79	-	-	-
Complete current projects		-7.34	471.02	463.68	-3.24	199.13	195.89
Individual sub-basin maximization	Max Cambodia	**119.73**	**494.65**	**614.38**	**123.83**	**222.76**	**346.59**
	Max Vietnam	-7.34	475.06	467.72	-3.24	203.17	199.93
Two sub-basin Maximization	Max (Cambodia + Vietnam)	119.73	498.69	618.42	123.83	226.8	350.63
Two sub-basin Maximization (Join Funds)	Max j(Cambodia + Vietnam)	**132.83**	**498.69**	**631.52**	**136.93**	**226.8**	**363.73**

5.2 Optimization for two sub-basins (natural boundary)

Referring to table 3 (results of optimization – natural boundary), it can be seed from the results that no downstream costs were borne by Sesan sub-basin when any HEP is constructed in the Sre Pok sub-basin, and vice-versa. This is because of the fact that, downstream costs were suffered only along the downstream area of the same river basin.

At present, Sesan sub-basin has a very high benefit of 235.45 Million US$ compared to only 6.81 Million US$ of Srepok sub-basin. This is because a large number of HEPs (6 HEPs) are operating in the Sesan sub-basin compared to Srepok sub-basin (only 2 HEPs).

When the under-construction HEPs are completed, the net benefit for Sesan and Srepok sub-basins are increased by 53.41 and 119.6 Million US$ respectively with a total increase of 173.01 Million US$.

In case of individual maximization, highest benefit is achieved when Sesan maximizes (455.96 Million US$) (Max Sesan), a net increase of 213.69 Million US$. The reason behind this trend is that there are 7 HEPs in group 3 and 4 for Sesan sub-basin compared to only 1 HEP for Srepok sub-basin, i.e., there is not much scope for Srepok sub-basin to construct more HEPs.

For two sub-basin simultaneous maximization (separate funds) (Max (Sesan + Srepok), a slightly higher net benefit of 458.32 Million US$ is achieved. But when the two sub-basin maximize with joint funds (Max j(Sesan + Srepok), a much better net benefit is achieved (551.33 Million US$). This net benefit is the highest among all the scenarios considered (increase in net benefit of 309.07 Million US$).

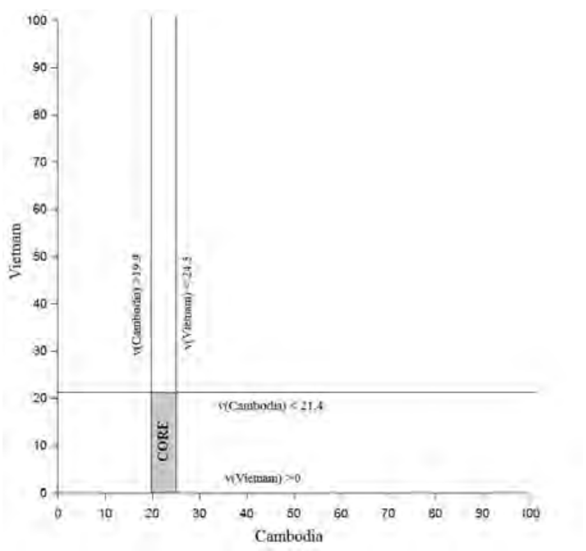
Table 3: Results of optimization based on sub-basins (natural boundary)

Scenario		Net Benefits (Million USD)			Change in Net Benefits (Million USD)		
		Sesan	Srepok	Total	Sesan	Srepok	Total
Status Quo		235.45	6.81	242.26	-	-	-
Complete current projects		288.86	126.41	415.27	53.41	119.6	173.01
Individual sub-basin maximization	Max Sesan	**329.54**	**126.41**	**455.95**	**94.09**	**119.6**	**213.69**
	Max Srepok	288.86	128.78	417.64	53.41	121.97	175.38
Two sub-basin maximization	Max (Sesan + Srepok)	329.54	128.78	458.32	94.09	121.97	216.06
Two sub-basin maximization (Join Funds)	Max j(Sesan + Srepok)	**404.83**	**146.5**	**551.33**	**169.38**	**139.69**	**309.07**

5.3 Core stability and incentive compatibility

Figure 2 (a) is plot of individual maximization and joint maximization for the two countries (political boundary). The benefit of Cambodia is plotted in the x-axis and the benefit of Vietnam is plotted along the y-axis. The values obtained in table are normalized w.r.t. the total net benefits of the two country maximization with joint funds.

The first line (at 19.9) shows the benefit achieved by Cambodia in individual maximization and the second line (at 24.5) shows the benefit Cambodia can achieve from joint cooperation (x-axis). Similarly, the first line (at 0.0) is the benefit to Vietnam from individual maximization and the second line (at 21.4) shows the benefit Vietnam can achieve from joint cooperation. The box thus formed by these intersecting lines is the core, which is non-empty.



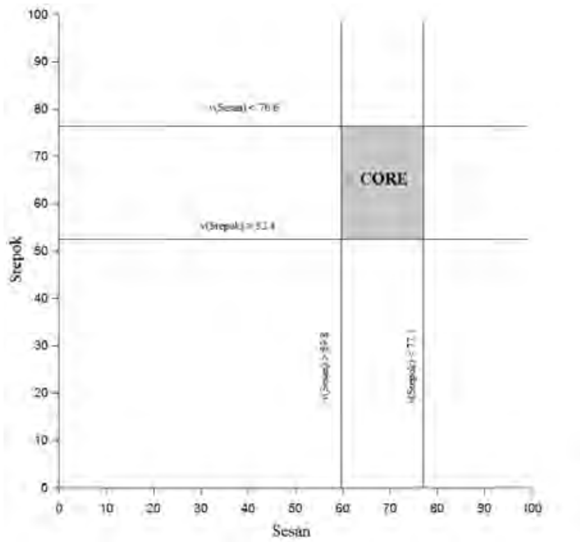


Figure 2: Graphical representation of the core for (a) country optimization (normalized) and (b) sub-basin optimized (normalized)

Similarly figure 2 (b) is the plot of individual maximization and joint maximization for the two sub-basins (natural boundary). Here again the normalized values are used for plotting.

The benefits of Sesan sub-basin are plotted along the x-axis and that of Srepok sub-basin are plotted in the y-axis. The first line (at 59.8) shows the benefit achieved by Sesan sub-basin in individual maximization and the second line (at 77.1) shows the benefit that can be achieved from joint cooperation (x-axis). Similarly, the first line (at 52.4) is the benefit to Srepok sub-basin from individual maximization and the second line (at 76.6) shows the benefit that can be achieved from joint cooperation. The box thus formed by these intersecting lines is the core, which is non-empty as well.

The existence of a core means that there exist several feasible allocations of benefits among the units (countries/sub-basins) where there are economic incentives for the units to cooperate.
The core in figure 2 (b) is much bigger compared to the core in figure 2 (a). This shows that the possibility of benefit sharing is higher in the case of sub-basins (natural boundary), which in turn means that the concept of optimization based on natural boundary is actually feasible.

6. CONCLUSIONS

Based on the optimization results (shown in table 2 and table 3), it can be seen that cooperation can lead to increased benefits from hydropower development. From table 2 it should be observed that Vietnam is getting the highest benefits (498.69 Million US$) in the two sub-basin maximization with separate funds (Max (Cambodia + Vietnam)) which is equal to the benefit it is getting in the case of joint funds (Max j(Cambodia + Vietnam)). Hence, if some incentives are not provided to Vietnam, it may not opt for joint fund cooperation. Hence, in order for the cooperation schemes to be successful, there must be economic incentives for individual players to stay in a particular coalition. The concepts of game theory, such as core stability and incentive compatibility, can be applied to show that there exists, in this case study, large benefits from full cooperation with joint budget planning. Benefit sharing is critical to achieving a distribution that will incentivize all players to cooperate, but the proof of the existence of a non-empty core points to the existence of several feasible benefit allocation schemes that are viable.

As mentioned earlier, from figure 2 (a) and figure 2 (b) it can be observed that the core for sub-basin (natural boundary) maximization was much bigger compared to the core of country (political boundary) maximization. This leads to the fact that the approach of optimizing based on natural boundary is acceptable and is in fact quite feasible.
Also, from the results of optimization, it should be noted that by changing the extent of optimization (country or sub-basin), the net benefits are changed although all the input parameters were the same.

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EVALUATING THERMAL COMFORT IN CITY LIFE AND ITS RELATION TO SOCIO-ECONOMIC ACTIVITIE

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ABSTRACT

Measuring composite temperature, indexes expressing sensible climate, by satellite remote sensing is useful for evaluating thermal comfort in city life in large area in real time. The purpose of this study is to develop a method for calculating Wet Bulb Globe Temperature (WBGT), a composite temperature used to prevent heat disorder, and Wind Chill Temperature (WCT) from thermal infrared data of Multi-functional Transport Satellite (MTSAT).

Firstly we prepared WBGT and WCT calculated from in-situ measurement data in three cities and then did regression analysis with IR1 and IR2 bands of MTSAT data. From that, formulas expressing relations between the indexes and MTSAT data was obtained. Next the formulas of WBGT and WCT obtained by each city's data were applied for other cities and compared the results. The comparative analysis leads to making one equation useful in whole area.

The derived formulas could express the tendency of WBGT and WCT changes. However they were likely overestimated by satellite when in-situ value was low and underestimated when in-site was high.

Besides, as one of the indexes of socio economic activity, we examined the relationship between WBGT and GDP per capita of each country. It showed a possibility of that this system, calculating thermal comfort with MTSAT, would be useful in analyses about relationships between thermal comfort in cities and socio economic activities.

***Keywords**: Wet Bulb Globe Temperature (WBGT), Wind Chill Temperature (WCT), Multi-functional Transport Satellite (MTSAT)*

1. INTRODUCTION

Heat island is one of the urban problems in recent years. Satellite remote sensing is widely used for evaluating its effect. For example algorithms have been developed for land surface temperature retrieval from Multi-functional Transport Satellite (MTSAT). However, human's health and thermal comfort are affected by not only the temperature but also other factors including humidity, wind speed and solar radiation. Thus we usually use composite temperatures like Wet Bulb Globe Temperature (WBGT), which are indexes expressing sensible climate, for assessing environment. Measuring sensible climate by satellite remote sensing is useful for evaluating thermal comfort in city life in large area in real time.

In this study, we developed a method for calculating WBGT, a composite temperature used to prevent heat disorder, from thermal infrared data of MTSAT.

WBGT is useful in hot, therefore another method for cool season was needed to evaluate thermal comfort all year around. We used Wind Chill Temperature (WCT) index, a cold index used to avoid injuries from the cold, in cold season as well as WBGT in hot season. We tried to develop a method for calculating WCT and enable evaluating thermal comfort with MTSAT data in cold season too.

2. METHODOLOGY

2.1 Data selection

2.1.1 Surface Data

Surface data (atmospheric temperature, dew point, atmospheric pressure, wind speed) of three cities in Asian-Pacific region were downloaded from NNDC Climate Data Online provided by NCDC(National Climate Data Center).

Table 1: Station data

Station	**TOKYO**	**SAPPORO**	**TAIPEI**	**SEOUL**	**URUMQI**
Latitude	35.683	43.06	25.033	37.567	43.8
Longitude	139.767	141.329	121.517	126.967	87.65
Data	hourly	hourly	3 hourly	3hourly	3hourly
	2011/1/1 - 12/31	2011/1/1 - 12/31	2011/1/1 - 12/31	2011/1/1 - 12/31	2011/1/1 - 12/31

2.1.2 MTSAT data

We used IR1 and IR2 channel of MTSAT data archived by IIS, The University of Tokyo.

Table 2: MTSAT technical specifications

Channel	Wavelength	Spatial Res.
IR1	10.5-11.5μm	4km
IR2	11.5-12.5μm	4km
IR3	6.5-7.0μm	4km
IR4	3.5-4.0μm	4km
VIS	0.55-0.90μm	1km

2.2 WBGT

2.2.1 What is WBGT?

WBGT (wet bulb globe temperature) is a composite temperature used to estimate the effect of temperature, humidity, and visible and infrared radiation on humans. It is widely used to determine appropriate exposure levels to high temperature (Table 3), and is derived from the following equation (1).

$$WBGT = 0.7Tw + 0.2Tg + 0.1Td \quad (1)$$

Where, Tw=wet-bulb temperature(℃) Tg=globe temperature(℃)
Td= dry-bulb temperature(℃)

(C.P.Yaglou and Minard,1957)

Table 3: Risk level of heat disorder

WBGT(℃)	Level*
>31	Danger
28-31	Alert
25-28	Advisory
21-25	Caution

*The risk level is proposed by the Japan Amateur Sports Association(1994)

In this study, the following simple estimate formula(2) was used. The equation(2) was derived with a relation between Tg and Td, "Tg = 1.45Td – 7.09" (Niigata Agricultural Research Institute, Horticultural Center, 2004).

$$WBGT = 0.7Tw + 0.4Td - 1.4 \quad (2)$$

2.2.2 Developing a method for calculating WBGT

Figure 1 is a flow chart of making regression equations between WBGT and MTSAT data.

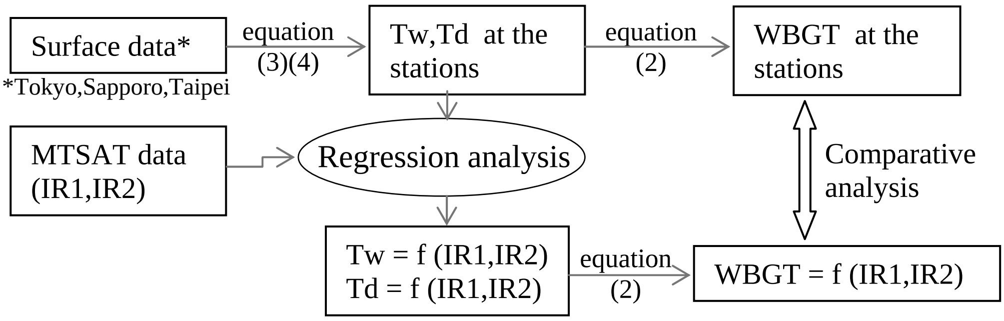

Figure 1: flow chart of making relational expression between WBGT and IR1, 2

Calculating WBGT with surface data

WBGT were calculated in use of equation (2) with surface data. Dry-bulb temperature(Td) and Wet-bulb temperature(Tw) were needed to use (2). We substituted the values of atmospheric temperature for Td in the equation and calculated Tw from the surface data by using the following formulas(3)(4).

$$es = 6.1078 \cdot 10^{(7.5T/T+237.3)} \quad (3)$$

Where, es=saturation vapor pressure(hPa) T=air temperature(℃)

(Tetens, 1930)

$$e = e's - 0.000662 \cdot P(Td-Tw) \quad (4)$$

Where e=vapor pressure(hPa) e's=saturation vapor pressure at Tw(hPa) P=atmospheric pressure(hPa)

(Sprung, 1855)

Regression analysis

Regression analysis was conducted to derive relational expressions between Tw and MTSAT data, and Td and MTSAT data. We used IR1, (IR1-IR2) and(IR1-IR2)^2 as terms of equations. Then we got relational expressions between WBGT and MTSAT data by substituting Tw and Td's expressions for equation(2).

Comparative analysis

Relational expressions of WBGT obtained by each cites' data were applied for other cities and compared the results.

2.3 WCT

2.3.1 What is WCT?

WCT (Wind Chill Temperature) index is used to provide a formula for calculating the dangers from winter winds and freezing temperatures. It is based on the rate of heat loss from exposed skin caused by the effects of wind and cold as below.

$$WCT = 13.12 + 0.6215 \cdot T - 11.37 \cdot V^{0.16} + 0.3965 \cdot T \cdot V^{0.16} \quad (5)$$

Where, T=air temperature(℃) V=wind speed(km/h)

Table 4: Risk level of frostbite

WCT	Level
0- -9	Low
-10 - -27	Low
-28 - -39	Risk: exposed skin can freeze in 10 to 30 minutes
-40 - -47	High risk: exposed skin can freeze in 5 to 10 minutes
-48 - -54	Very high risk: exposed skin can freeze in 2 to 5 minutes

2.3.2 Developing a method for calculating WCT

Figure 2 shows how to make relational expression between WCT and MTSAT data.

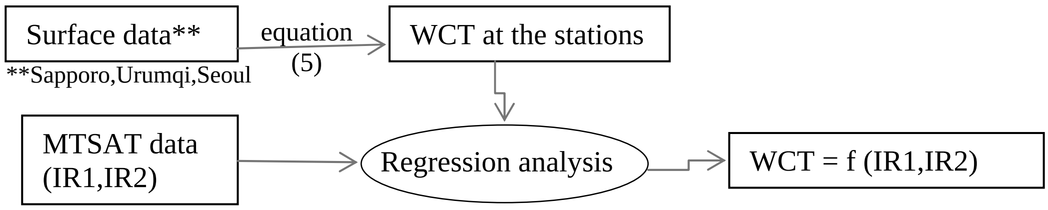

Figure 2: flow chart of making relational expression between WCT and IR1,2

Calculating WCT with surface data

WCT were calculated in use of equation (5) with surface data.

Regression analysis

Regression analysis was conducted to derive relational expressions between WCT and MTSAT data. We used IR1, (IR1-IR2) and(IR1-IR2)^2 as terms of equations.

Comparative analysis

Relational expressions of WCT obtained by each cites' data were applied for other cities and compared the results.

3. RESULTS

3.1 WBGT

The following relational expressions were derived as the results.

From the data of Tokyo,

$$Tw=0.0141\cdot IR1 +5.12(IR1-IR2) -0.363(IR1-IR2)^2 +2.09$$
$$Td=0.0470\cdot IR1 +5.30(IR1-IR2) -0.351(IR1-IR2)^2 -2.65$$
$$WBGT=0.0287\cdot IR1 +5.71(IR1-IR2) -0.395(IR1-IR2)^2 -0.997 \tag{6}$$

From the data of Sapporo,

$$Tw=0.0239\cdot IR1 +5.83(IR1-IR2) -0.481(IR1-IR2)^2 -6.52$$
$$Td=0.0330\cdot IR1 +6.35(IR1-IR2) -0.522(IR1-IR2)^2 -6.98$$
$$WBGT=0.0299\cdot IR1 +6.62(IR1-IR2) -0.545(IR1-IR2)^2 -8.75 \tag{7}$$

From the data of Taipei,

$$Tw=0.00204\cdot IR1 +3.50(IR1-IR2) -0.248(IR1-IR2)^2 +14.5$$
$$Td=0.0294\cdot IR1 +4.04(IR1-IR2) -0.248(IR1-IR2)^2 +9.26$$
$$WBGT=0.0132\cdot IR1 +4.05(IR1-IR2) -0.273(IR1-IR2)^2 +12.4 \tag{8}$$

Figure 3 and Figure 4 show the annual change in Tw and Td in Tokyo. "In-situ" is from surface data and "satellite" is calculated with regression equations. In Figure 5~Figure 7, "in-situ" shows annual change of WBGT calculated with surface data, "satellite(Tokyo)" shows it calculated from equation(6), "satellite(Sapporo)" from equation(7) and "satellite(Taipei)" from equation(8). Table 5 shows RMSEs between "in-situ" and each "satellite".

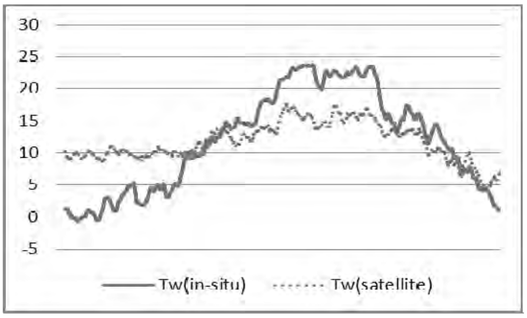

Figure 3:Annual change in Tw in Tokyo(2011)

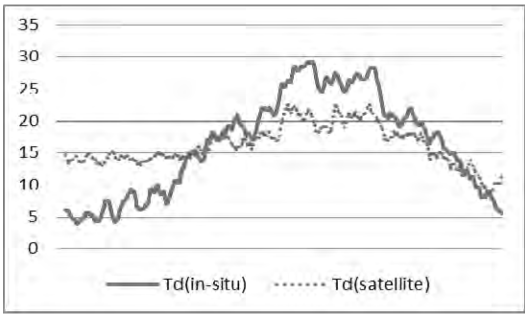

Figure 4:Annual change in Td in Tokyo(2011)

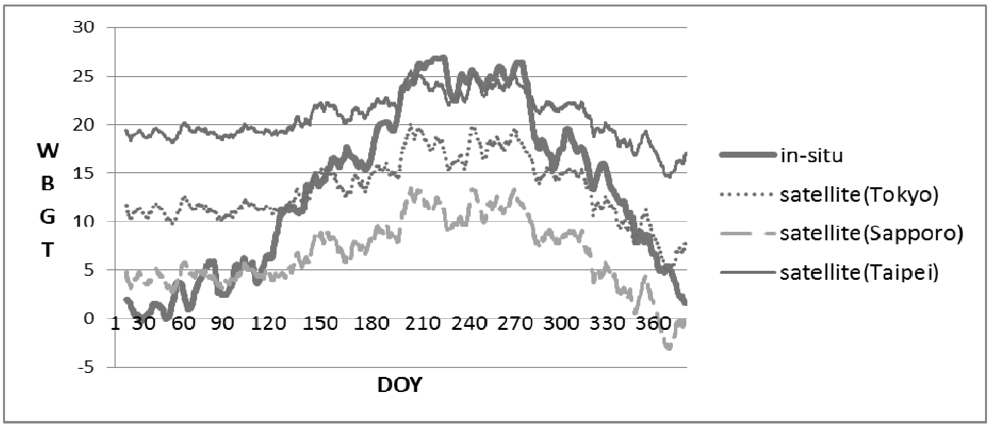

Figure 5: WBGT annual change in Tokyo(2011)

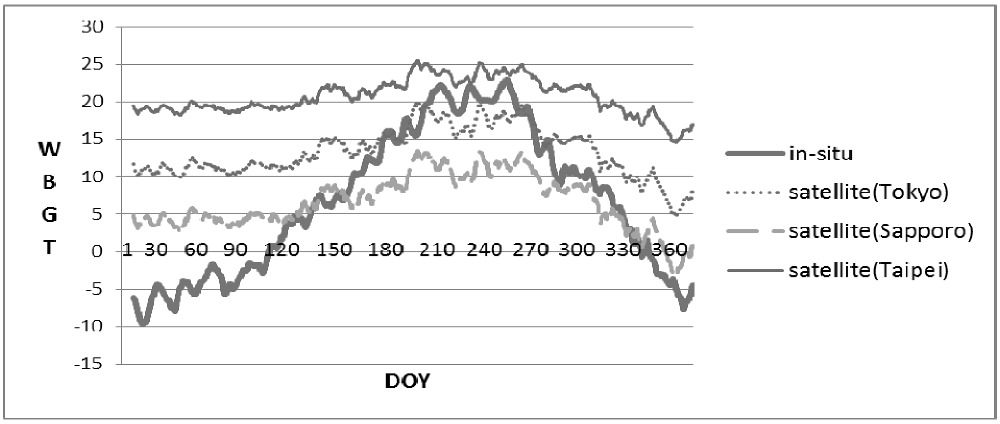

Figure 6: WBGT annual change in Sapporo(2011)

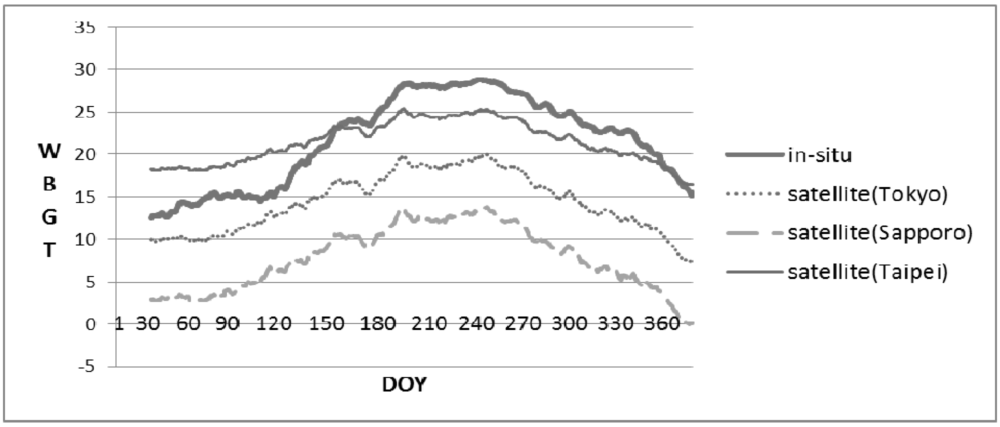

Figure 7: WBGT annual change in Taipei(2011)

Table 5: RMSEs between "in-situ" WBGT and each "satellite" WBGT

		Formula		
		Tokyo	Sapporo	Taipei
City	Tokyo	7.27	9.90	10.5
	Sapporo	10.6	8.26	16.4
	Taipei	8.65	14.7	4.58

3.2 WCT

The following relational expressions were derived as the results of regression analysis.

From the data of Sapporo,

$$WCT=0.0305 \cdot IR1 + 4.09(IR1-IR2) + 0.0576(IR1-IR2)^2 - 6.706 \quad (9)$$

From the data of Urumqi,

$$WCT=0.360 \cdot IR1 + 6.96(IR1-IR2) + 0.132(IR1-IR2)^2 -93.0 \quad (10)$$

From the data of Seoul,

$$WCT=0.0909 \cdot IR1 + 6.54(IR1-IR2) + 0.109(IR1-IR2)^2 - 20.2 \quad (11)$$

In Figure 9~Figure 11, "in-situ" shows annual change of WCT calculated with surface data, "satellite(Sapporo)" shows it calculated from equation(9), "satellite(Urumqi)" from equation(10) and "satellite(Seoul)" from equation(11). Table 6 shows RMSEs between "in-situ" and each "satellite".

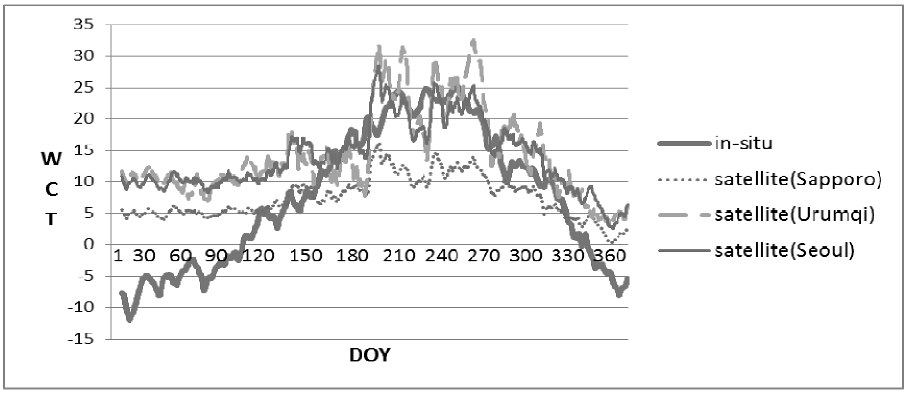

Figure 8: WCT annual change in Sapporo(2011)

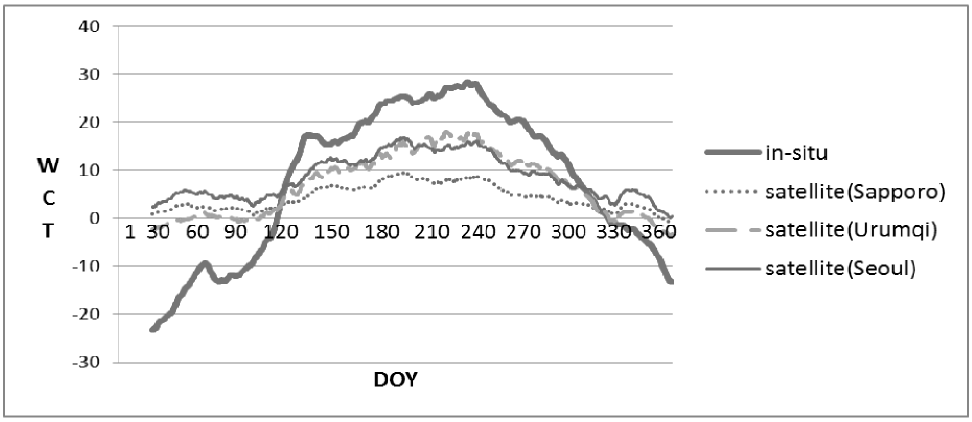

Figure 9: WCT annual change in Urumqi(2011)

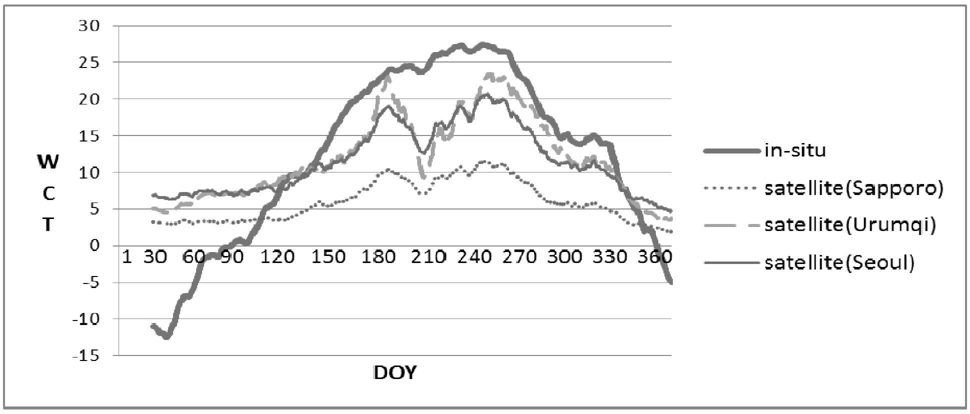

Figure 10: WCT annual change in Seoul(2011)

Table 6: RMSEs between "in-situ" WCT and each "satellite" WCT

		Formula		
		Sapporo	Urumqi	Seoul
City	Sapporo	9.84	14.4	12.3
	Urumqi	15.2	13.2	14.3
	Seoul	12.1	11.5	10.4

3.3 Relation between WBGT and WCT

Figure 11 shows WBGT and WCT annual change in Sapporo in 2011. The graphs of both WBGT and WCT were very close. The tendency of these indexes by satellite data was similar.

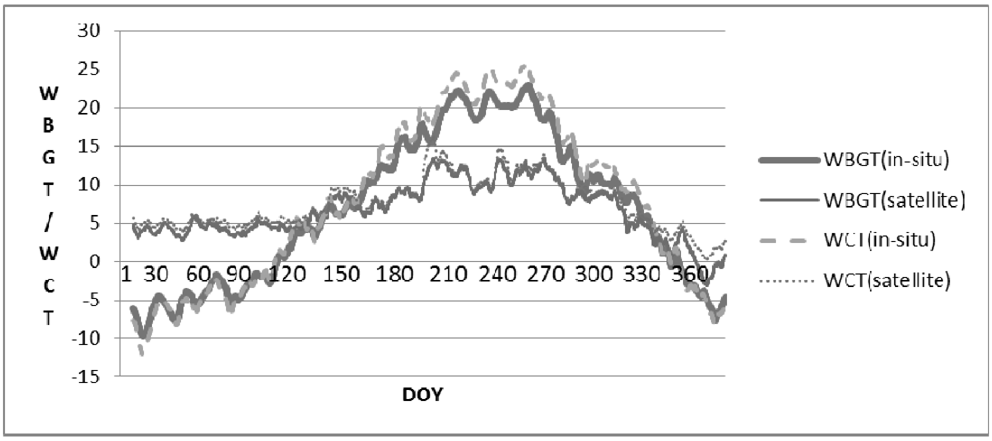

Figure 11: WBGT and WCT(in-situ/satellite) annual change in Sapporo(2011)

3.4 Relation to socio economic activity

As one of the indexes of socio economic activity, we examined the relationship between WBGT and GDP per capita of each country. Figure 12 shows the relevance. It can be said that countries where WBGT is high tend to have low GDP per capita.

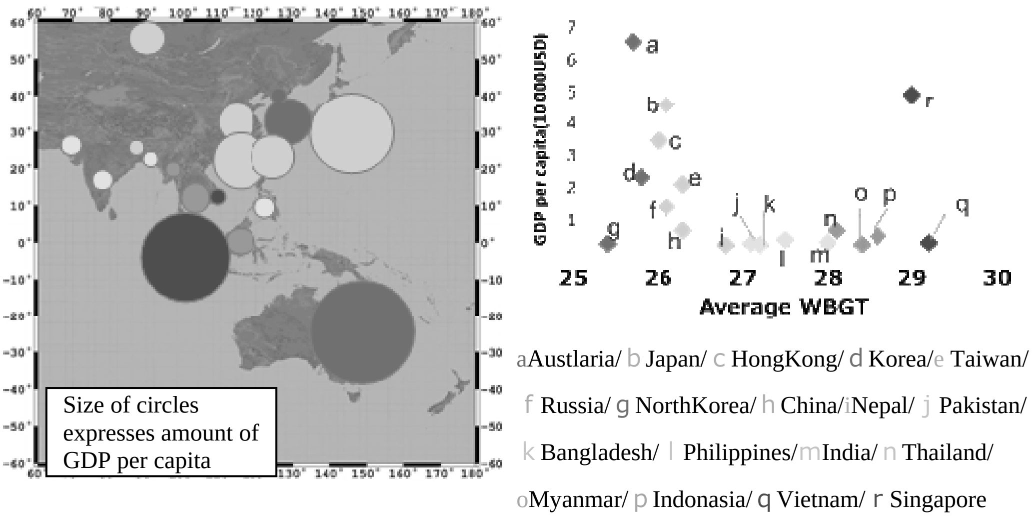

Figure12: relation between WBGT and GDP per capita

4. DISCUSSION AND CONCLUSION

This study demonstrated a method for evaluating thermal comfort by calculating WBGT and WCT using MTSAT data. Regression analyses were conducted and relational expressions between WBGT and MTSAT data, WCT and MTSAT data. It enabled evaluating thermal comfort in resolution of 4km by remote sensing. The formulas can express the tendency of WBGT and WCT changes. However they are likely overestimated by satellite when in-situ value is low and underestimated when in-site is high. Further study is required to derive more accurate formulas. We try to express the indexes by each one equation with MTSAT data in whole area referring to the RMSE by comparative analysis.

In addition, as one of the indexes of socio economic activity, we examined the relationship between WBGT and GDP per capita of each country. It could be said that countries where WBGT was high tended to have low GDP per capita. It showed a possibility of that this system, calculating thermal comfort with MTSAT, would be useful in analyses about relationships between thermal comfort in cities and socio economic activities.

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DEVELOPMENT OF REAL WIND TURBINE BLADE VIBRATION MEASUREMENT TECHNIQUE BY 3D MOTION ANALYSIS SOFTWARE

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ABSTRACT

The number of large-size wind turbine has been increasing at a remarkable rate. However, the characteristics of wind turbine blade vibration under operation are not fully understood. Therefore, we analyzed the vibration of the blade tip by using a three-dimensional motion analysis software on the data retrieved by two sets of high speed video cameras. Since application of usual calibration method which requires to place a calibration scale near the blade on site was technically difficult, we developed a devised method. It consists of two steps; we take video records on site and do calibration independently in the university by reproducing a similar camera setting. In analyzing the video data, we improved the existing procedure by adopting coordinate transformation. As a result, we could detect what we think one of the natural frequencies of the blade.

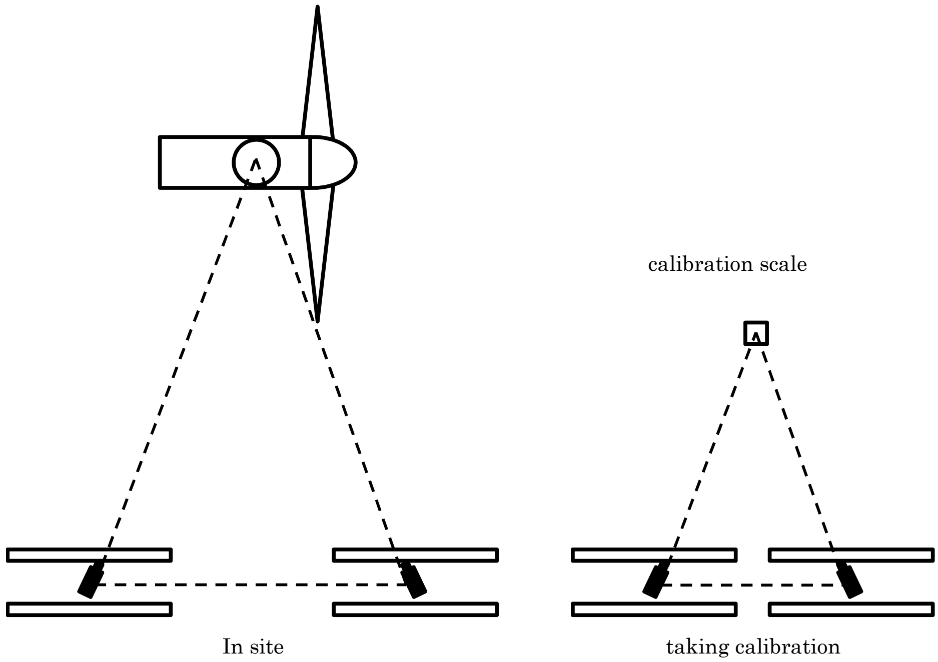
Keywords*: wind turbine, blade vibration, high speed video, 3D motion analysis, calibration, coordinate transformation.*

1. INTRODUCTION

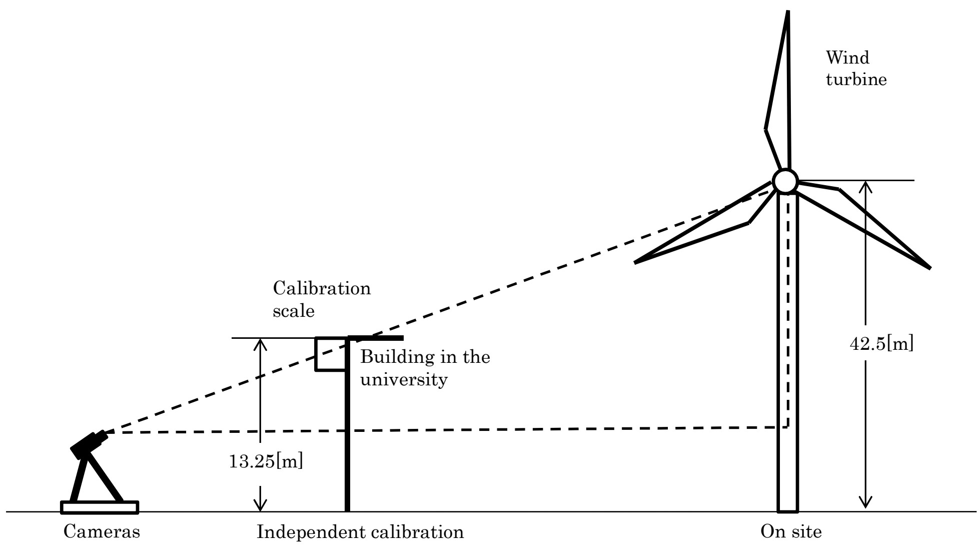
The number of large-size wind turbine has been increasing at a remarkable rate in Japan. However, the characteristics of wind turbine blade vibration under operation which cause fatigue damage are not fully understood. Considering these circumstances, the goal of this study is set to evaluate characteristics using a three-dimensional motion analysis software. Following the preceding relevant studies, we developed a simplified method of vibration measurement of the wind turbine blade.

2. OUTLINE OF MEASUREMENT METHOD

We used a three-dimensional motion analysis software with a commercial name of DIPP-Motion PRO developed by DITECT corp., Japan. We took video records of a real wind turbine under operation by two high speed cameras HAS-L1, DITECT corp. at the rate of 500 frames per second. We need to conduct high accuracy calibration in order to convert the video records into three-dimensional data, which requires to place a calibration scale near the blade on site. Such usual calibration is, however, time-consuming and unrealistic. Therefore we developed a devised method which it consists of two steps; we take video records on site and do calibration independently in the university by reproducing a similar camera setting, as schematically shown in Figure 1. We used surveying instruments and made some numerical programs to help the placement of cameras in a speedy and highly accurate manner.



(a) plan view



(b) elevation view

Figure 1: Schematic view on similarly relation image

3. RESULT OF MEASUREMENT AND ANALYSIS

3.1 Result of measurement

Figure 2 shows a medium-size wind turbine, KWT300 model, which is located at Futtsu factory of KOMAIHALTEC Inc., Chiba prefecture, Japan. We took video records of blade vibration there and conducted calibration independently in Noda campus of Tokyo University of Science by reproducing a similar camera setting. In order to understand the characteristics of blade tip vibration, we needed to analyze the blade tip vibration continuously for relatively long time. Therefore, we used a wide-angle lens for the camera.

One example of preliminary analysis result is shown in Figure 3. We set the origin of the time independently when we start tracking of each blade tip. As a result, motion of the three blade tips in the x-coordinate direction of the original scale employed for the calibration, as illustrated in Figure 4a, was similar to each other. This behavior confirms the validity of the three dimensional motion analysis conducted in this study. However, the direction of this x-coordinate did not match the wind direction (i.e., the normal direction of the rotor's rotation plane). Therefore, the above motion was not caused by the vibration of the rotor but was caused by its rotary motion.

Figure 2: Wind turbine in Futtsu, Chiba prefecture,

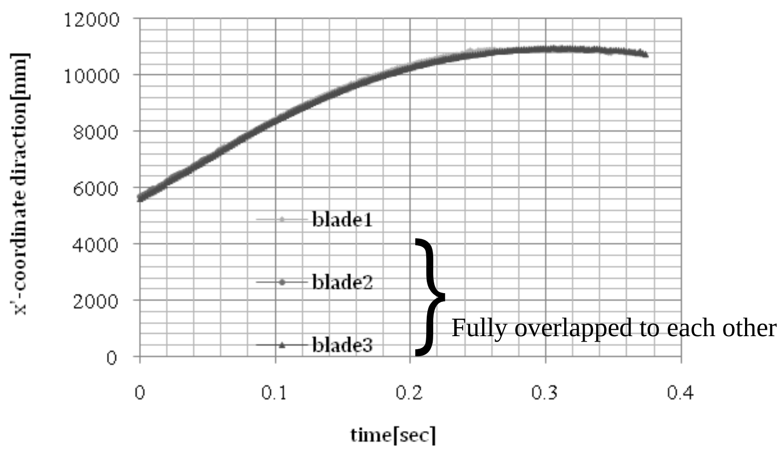
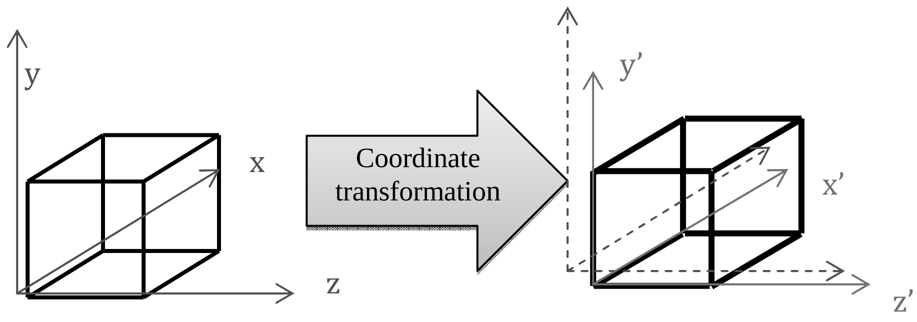


Figure 3: X-coordinate direction before coordinate transformation



a) Original scale

b) Modified scale

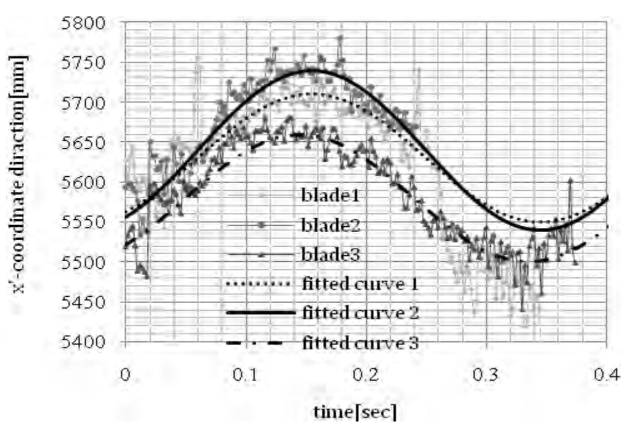
Figure 4: Coordinate transformation image

3.2 Coordinate transformation

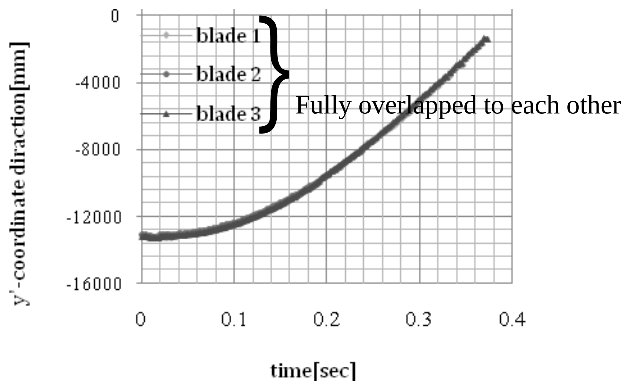
In order to cope with the problem described in 3.1, we applied coordinate transformation from the original scale to the modified scale as illustrated in Figure 4. In the modified scale, x'-coordinate corresponds to the wind direction, and y'- and z'-coordinates correspond, respectively, to the vertical and horizontal directions in the rotor's rotation plane.

The motions of the three blade tips in x'-, y'- and z'-coordinate directions are shown in Figure 5 for the same record as shown in Figure 3. From Figure 5, we could observe that the period of the blade motion in x'-coordinate direction was much shorter than those in y'- and z'-coordinate directions. Therefore, we regarded that we can evaluate the blade vibration in the wind direction by conducting such coordinate transformation.

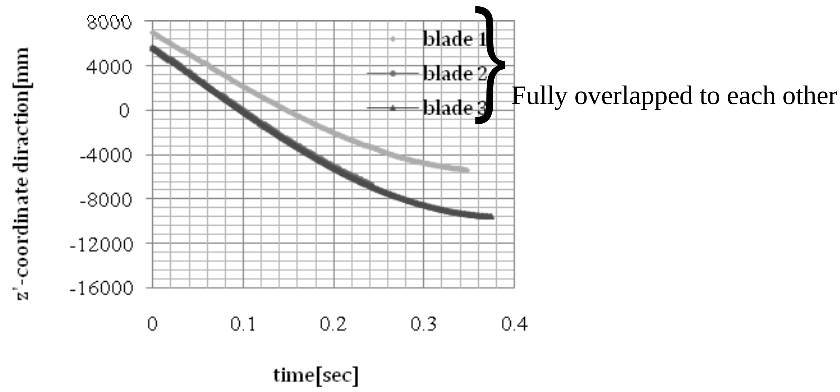
It is to be noted that the motion in the y'-coordinate direction was almost the same among the three blades, while the motion of the blade 1 in the z'-coordinate direction was different from those of the other blades. We do not know the reason for such discrepancy, but it may be linked to the accuracy of the measurement and/or that of the coordinate transformation.



(a) X'-coordinate direction



(b) Y'-coordinate direction



(c) Z'-coordinate direction

Figure5: After coordinate transformation

3.3 Analysis of the blade vibration in the wind direction

In this measurement, we could record the motion data for limited duration of about 0.4 second (i.e., about 200 frames could be recorded). Thus, we couldn't apply spectral analysis on the recorded data. Alternatively, in order to calculate the period of vibration, we fitted the measured motion in the wind direction with a sinusoidal curve as shown in Figure 5a. As a result, the period of the measured motion was 0.38 sec., which was common value among the three blades.

It should be noted that this motion data was recorded at a blade rotation speed of 39.5 rpm, which corresponds to strong wind conditions. Another motion data recorded under similar strong wind conditions yielded a period of about 0.38 sec., suggesting that this value is the predominant period under the strong winds.

Figure 6 shows a result from analysis of the motion data recorded at lower blade rotation speed of 29.7 rpm. In this case, the estimated period was 0.43 sec., while the sinusoidal curve fitting was not so relevant as was the case with the data shown in Figure 5a. These different periods may be affected by the centrifugal force induced by the rotor rotation but it is not clear. In addition, we could observe that the amplitude of the blade vibration in the wind direction was reduced with the decrease in the blade rotation speed.

As a whole, the estimated period of the blade vibration was approximately 0.4 sec., and thus one of the natural frequencies of these blades could be evaluated to be around 2.5 Hz. This evaluation result is affected by several factors, such as the shade of the tower which interferes with tracking of the blade tip, the focusing condition of the cameras that depends on the distance of the target from the cameras, and the accuracy of the coordinate transformation. Due possibly to these factors, some of the data recorded when the wind direction changed could not be analyzed in a reasonable manner.

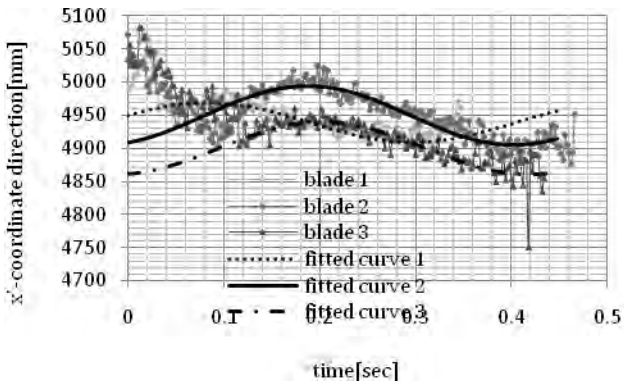


Figure 6: The motion data of lower blade rotation

4. SUMMARY

In order to measure vibration of real wind turbine blade, we developed a devised method consisting of two steps; we take video records on site and do calibration independently in the university by reproducing a similar camera setting. In analyzing the video data, we improved the existing procedure by adopting coordinate transformation. As a result, we could detect what we think one of the natural frequencies of the blade.

In the above method, even under strong wind conditions, we needed to set cameras with high accuracy both on site and in conducting the calibration. We also needed to apply coordinate transformation to the data obtained from three-dimensional motion analysis.

FOREST CARBON ESTIMATION USING THE COMBINATION OF LIDAR DATA AND HIGH RESOLUTION IMAGERY IN LUDIKHOLA WATERSHED, NEPAL

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ABSTRACT

Carbon dioxide (CO_2) is believed the main anthropogenic greenhouse gas which causes global climate change. In the carbon cycle, forest plays an important role both as source and sink. Therefore, forest carbon inventories and emission reduction programs, in particular REDD, are one of the main efforts to combat climate change. REDD provides opportunities for Nepal and other developing countries to take part in the international carbon market and to promote sustainable forest management. In this research, the combination of LiDAR data and high resolution satellite imagery was carried on in order to assess the forest carbon sequestration in Nepal. The application of LiDAR data and high resolution satellite imagery in carbon estimation are mostly based on the strong relationship between tree parameters, crown projection area (CPA) and height, with field based carbon stock of individual trees. The crown projection area is delineated from a very high resolution Geo-Eye satellite imagery with Region growing algorithm. Modelling the relationship between CPA and LiDAR derived height with carbon stock of Shorea robusta and Other species results in R^2 values of 0.76 and 0.68 respectively.

***Keywords**: above ground biomass, forest carbon estimation, very high resolution image, LiDAR, object based image analysi*

1. INTRODUCTION

Carbon dioxide (CO_2) is believed to be the major greenhouse gas which causes global climate change. In the carbon cycle, forest plays an important role both as a carbon source and a carbon sink. When forest is cleared or degraded, its stored carbon is released into the atmosphere as CO_2. Consequently, forest turns into the carbon source which enhances climate change. Therefore, forest carbon inventories and emission reduction programs are crucial for combating climate change.

At the Bali Climate Change Conference in 2007, REDD, which stands for Reduced Emissions from Deforestation and Forest Degradation, was adopted by the parties of the United Nations Framework Convention on Climate Change (UNFCCC). It opened new opportunities for developing countries to participate in forest carbon financing (MOFSC, 2009). Within the concepts of REDD, countries that demonstrate forest carbon reserves and emission reductions are able to sell carbon credits on the international carbon market (UNFCCC, 2005). Similar to other forest carbon inventories and emission reduction programs, estimates of forest carbon stock are required to generate baseline information for REDD application.

The main carbon pools in the forest are biomass (above-ground and below-ground biomass), dead organic matter (dead wood and litter) and soil organic matter (IPCC, 2006). Among these, above ground biomass (AGB) governs the potential carbon emission that could be released to the atmosphere due to deforestation (Gibbs et al., 2007). Estimation of AGB, therefore, is the most critical step in quantifying carbon stocks from the forest (Gibbs et al., 2007). According to the IPCC definition, AGB is all living biomass above the soil including stem, stump, branches, bark, seeds, and foliage; the carbon makes up approximately 47% of AGB. Because of difficulties in collecting field data of below-ground biomass, most previous research focused on AGB (Lu, 2006) and this present study also focuses on the carbon stock contained in AGB.

As with most forest measurement, field methods can be employed for AGB estimation with high accuracy but this approach is generally time consuming, labour intensive, and difficult to implement in remote areas (Lu, 2006). Meanwhile, remote sensing methods can be combined with field measurements to estimate AGB at a wide range of scales with relatively low cost (Popescu, 2007). As a result, remote sensing methods have been increasingly applied and become the primary source of data for AGB or carbon estimation (García et al., 2010; Lu, 2006).

A variety of satellite data are used for AGB or forest carbon estimation. These data are broadly classed into optical sensor data, radar data and light detection and ranging data (LiDAR). Each type of data has its own characteristics, both advantages and disadvantages. Hence, the integration of different sources of remotely sensed data may enhance the information extraction process and overcome the drawbacks of using one type of data alone (Sohn et al., 2007). In the light of this, the combination of low density LiDAR data and high resolution satellite image is also one of potential approaches to individual tree-based carbon estimation (Jochem et al., 2009; Kim et al., 2010).

2. STUDY AREA

The Ludhikhola watershed is in the Gorkha, the Western development region of Nepal and has an area of 3,610 km^2. The Ludhikhola watershed area is located in the southern part of Gorkha district between 27^{o}55’02’’ to 27^{o}59’43’’N and 84^{o}33’23’’ to 84^{o}40’41’’E and covers an area of 5750 ha.The Ludhikhola watershed was selected for this study based on three main criteria. Firstly, the watershed is representative for hilly areas which in the sub-tropical ecological zone of Nepal. The specific species for this ecological zone are *Shorea robusta*, *Schima Wallichi* and *Castanopsis indica*. The interest of local people is important to any forest management and conservation programmes. Involving local communities help to increase the local people’s awareness of the benefits that they receive when deforestation and forest degradation is reduced. Local people, therefore, are ready to support and assist the research. Last but not least, the accessibility is should be considered because of the limitation of time for field work as well as specific terrain in Nepal. The study area meets this requirement because it has good road access.

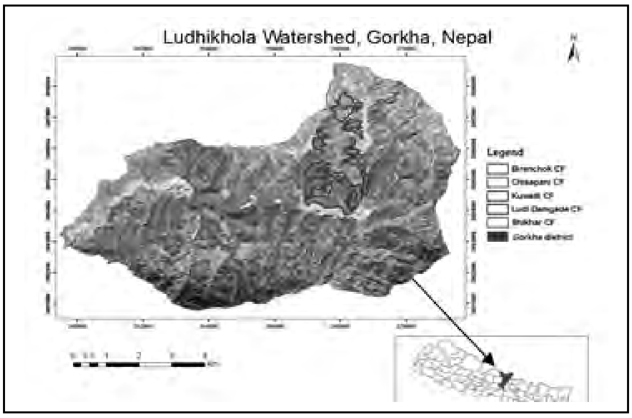

Figure 1: The Ludhikhola watershed

3. DATA AND METHODOLOGY

3.1. Data

The field data of DBH (Diameter at breast height), tree height and canopy density were collected in 86 Circular plots of diameter 12.62 m (area of 500m^2). The Geo-Eye imagery used for this research are Geo-Eye panchromatic 0.50 cm and Geo-Eye multispectral 2m images recorded on 2 September 2009 (Source: ICIMOD, Nepal). The Airborne LiDAR data used for this research was recording using a Leica ALS50-II LiDAR-scanner consisting of a laser scanner, a geodetic-quality GPS receiver and an inertial measurement unit (IMU), which provide information about scan angle and the aircraft coordinates. The data was collected from 16 March to 2 April 2011 in UTM WGS 84 coordinate system (Source: FRA, Nepal). The average point density of the LiDAR data is 0.8 points per m^2. The LiDAR scanning process was at an absolute altitude of 2200m and recorded with a scan frequency of 52.9 kHz. The other data includes Topographic maps 1:25000, Digital Elevation Model (DEM) with 20 m resolution.

3.2. Methodology

3.2.1. Image pre-processing

The Geo-eye imagery was obtained in five separate images (4 multispectral bands and 1 panchromatic band). The first operation done was to stack the image before images fusion in Erdas Imagine 2011. And then, a panchromatic (PAN) image was fused with multispectral imagery, using HPF (high pass filter) pan-sharpening method, in order to acquire the image that has the spatial resolution of the panchromatic imagery and the spectral resolution of the multispectral imagery. As a result, a MSS pan-sharpened image with 0.5 resolution has 4 bands which will be useful for tree species classification and identification. After fusion step, Image filter was applied to sharpen the image objects. In this study, 5-by-5 filter was used because it avoids removal of small peaks in the canopy (small trees) while maximizing the smoothing function.

3.2.2. Creating the DSM, DTM and CHM from the LiDAR data

DTM and DSM were created directly using LasTools software. Digital surface model values (DSM) were computed for each point by gridding the point to desired pixel size. If a cell contained no laser reflection point, the value of this cell was determined by averaging the height values found in the eight neighboring cells (St-Onge et al., 2008). The DTM is generated using the ground return (last returns) elevation values using an initial triangulated irregular network (TIN). The interpolated grid cell size for both DTM and DSM was 0.5m which is the spatial resolution of Geo-Eye imagery. The tree height information on the field data collection was used to threshold the laser height values in order to eliminate the effect of shrubs and understory vegetation.The Canopy height model (CHM) is computed as the difference between DSM and the corresponding DTM values.

3.2.3. Image- to- image co-registration

The dissimilarities between the Geo-Eye imagery and the CHM due to differences in the acquisition process (different sensors, platforms, time of recording) need to be corrected by co-registration procedures. In this research, manual registration with polynomial transformation was used to co-register Geo-Eye imagery with the Digital camera imagery as reference image instead of using CHM. The reason is that it would hardly to find the control points from CHM. Meanwhile, the ortho-rectified Digital camera imagery was simultaneously acquired with LiDAR data and matches with the LiDAR. Root mean square error is used to validate the co-registration result.

3.2.4. Tree crown delineation

Tree crown delineation was done in eCognition Developer 8.7 using the hybrid method. This technique makes use of the phenomenon that in high spatial resolution imagery, trees appear as bright objects surrounded by a shaded area and the tree tops typically the brightest spot within the bright object. Local maxima and minima have frequently been used to detect tree tops and define crown boundaries, respectively. Local maxima are used as seeds for growing and local minima are used as a restriction for growing region. Starting at a potential seed pixels, neighboring pixels are examined sequentially and merged to growing region based on the similarity to the seed pixels, which is defined through both the spectral variance and geometry of the object. This process continues until a significant boundary is found and then these pixels are considered to belong to the region corresponding to the seed pixel. One to one correspondence method was use to validate the segmentation.

3.2.5. LiDAR derived height

The height of a tree is defined as the maximum value of CHM corresponding to the tree crown. The delineated crowns from Geo-Eye imagery were used as the zone to extract the local maximum value from the CHM. Within each crown, the maximum pixel value was extracted from CHM using Zonal statistic tool in ArcGIS 10. Linear regression is performed between ground-measured heights and LiDAR derived heights yielded a R^2 to validate CHM created.

3.2.6. Object-based classification

Once the tree crowns have been delineated, the tree species can be classified by means of the nearest neighborhood algorithm in eCognition Developer 8.7 software. In comparison to pixel based training, the object based approach of nearest neighbour requires fewer training samples. The training samples are image objects which are the result of the segmentation process. The species information of the object was taken from the field sample data. The field sample data was divided into two parts, 2/3 was used for training data and 1/3 was used for classification validation. The feature space was created based on the training samples. The object features that were selected for feature space creation are layer value of each MSS bands, panchromatic band; object geometry and the thematic layer information related to each object. Starting from the selected sample, nearest neighbor classification looks for the closet sample in the feature space for each image object and assigns the class for that object. The descriptive statistic as well as the observation from the field shows that more than 70% of the trees in study area are *Shorea robusta.* Therefore the image was classified in two classes: 1) *Shorea robusta* and 2) *Other species*. The accuracy of the classified image is assessed by comparing it to reference (ground truth) data.

Accuracy assessment is done using the error matrix or confusion matrix which compares the classification result with true world in Erdas Imagine 2011.

3.2.7. *Multiple regression for carbon estimation*

Research of Nakai (2009) has indicated that the multiplicative equation offered better results than the ones using tree height or crown area alone. Therefore, multiple regression models relating field-based carbon stock with tree height (from CHM) and crown projection area (CPA) were developed. Prior to regression analysis, the detected and delineated trees are automatically linked with the field measured trees to combine the information for each tree. Each tree has the information about tree height (extracted from the CHM), CPA (extracted from the tree crown delineation result) and field-based carbon (calculated using the appropriate allometric equation). Microsoft Excel was used to develop regression analysis. The independent variables are height and CPA, the dependent variable is carbon (C). The developed model is called the *regression predictive model of carbon*. The significance of the model was tested through an analysis of variance (ANOVA)

3.2.8. *Carbon model validation*

The model was validated using the test data set obtained from the field. Validation of the model was done by comparing the amount of carbon predicted by the model and amount calculated from the field data. Root mean square error (RMSE) is calculated to check the amount of error in the carbon stock map.

$$RMSE = \sqrt{\sum \frac{(Cp - Co)^2}{N}}$$

Where Cp- Carbon predicted by the model, Co-Carbon calculated
N-Number of observations

4. RESULT

4.1. Tree crown delineation

Individual tree crown was delineated using Region Growing approach, the result of image segmentation process is shown in flowing figure:

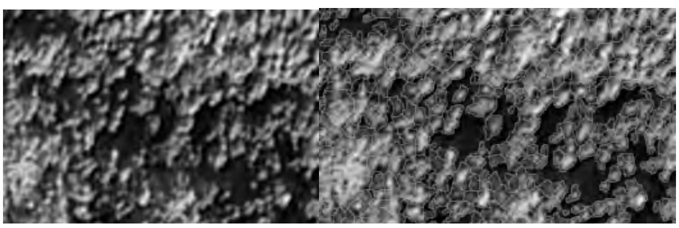

Figure 2: Image segmentation result

The total 369 trees were digitised as the reference to assess the accuracy of segmentation, classification result as well as the extracted height from the CHM. Accurate segments are the segments that have one to one matching with the corresponding reference crown. The one to one matching criteria were introduced in the Methodology chapter.

Out of 369 trees, there are 265 trees meet the one to one matching criteria. Thus, the segmentation accuracy in general is 71.9 % (28.1% error. Over segmentation yields commission errors as one tree is segmented to more than one object for one reference tree. If there is no tree is identified for one reference tree exist, under segmentation or omission errors are made.

4.2. Canopy height model validation

The linear regression model was used to relate the LiDAR-derived heights with the field inventory data of the individual trees. The independent variable is LiDAR-derived height and dependent variable is the measured height. Of the 369 trees, one third was selected randomly to validate the LiDAR-derived height of individual tree. The obtained coefficient of determination is 0.72. The RMSE is 2.68 (m), RMSE in percentage is 17.9%.

4.3. Object-based image classification

The reference dataset of 369 trees was randomly divided into two parts, two third was used as training data, one third was used as validation data. The delineated crowns were used to classify into two classes: *Shorea robusta* and *Other species*.

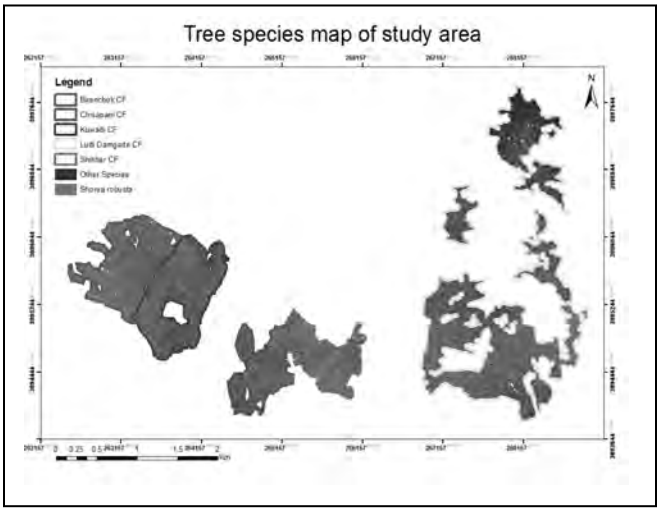

Figure 3: Map of tree species in the study area

Overall classification accuracy is 81.30% (19.7% error) and kappa is 0.4023. *Shorea robusta* was classified better compared to *Other species* with Producer's accuracy is 79.6% and Users accuracy is 96.3%.

4.4. Regression analysis

Out of a total of 369 trees, 73 *Shorea robusta* trees and 29 *Other species* trees was used for regression analysis. Firstly linear regression analysis was used to test whether CPA and LiDAR-derived height of individual crown could explain the amount of carbon stock of individual tree. The test was applied for the two classless: *Shorea robusta* and *Other species*. Analysing the result will help us to make sure that it makes sense to include both independent variables (CPA and Height) in multiple regression models. The F significant of ANOVA test examining this relationship of Shorea robusta and Other Species are really low: 2.91E-16 and 1.46E-06. It can be concluded that both CPA and height have a significant relationship with the amount of carbon of each individual tree. Therefore, it is significant to involve both CPA and height in the multiple regression analysis to estimate carbon. In the multiple regression model, the independent variables are CPA and height and the dependent variable is carbon. The carbon model was built for species class.

4.5. Model validation

A linear regression model was applied to validate the developed carbon predictive model above. Measured and predicted carbon stocks were plotted against each other and the regression co-efficient was calculated. The coefficient of regression for *Shorea robusta* is 0.68 and for *Other species* is 0.62. The RMSE is equal to 36% for *Shorea robusta* and 23.8% for *Other species*

Shorea robusta		***Other Species***	
Regression Statistic		**Regression Statistic**	
Multiple R	0.872763	Multiple R	0.82393
R Square	0.761716	R Square	0.678861
Adjusted R Square	0.754908	Adjusted R Square	0.654158
Standard error	29.40335	Standard error	26.45676
Observations	73	Observations	29
Coefficient		Coefficient	
Intercept	-139.75	Intercept	125.3983
Slope CPA	5.886757	Slope CPA	-3.85821
Slope Height	7.133373	Slope Height	3.500388
P-value		P-value	
Intercept	1.49E-13	Intercept	0.002566
Slope CPA	2.82E-06	Slope CPA	0.002087
Slope Height	6.05E-09	Slope Height	0.009776
One Way ANOVA test		One Way ANOVA test	
F	111.8833	F	27.48093
F significant	1.58E-22	F significant	3.86E-07

Table 1: Multiple regression analysis results

5. DISCUSSION

5.1. Tree crown delineation

The Region growing algorithm for individual tree delineation releases the satisfactory results in previous study (Broadbent et al., 2008; Darius et al., 2002). The accuracy of segmentation achieved in this study is almost exactly similar to the results of research of Bunting *et al* (2006) who obtained 72% well isolated trees. Tiede *et al.* also reported 72% accuracy of crown delineation of the tree in forest area Germany. Ke *et al.* (2011) obtained the accuracy of 70% while using region growing to delineate the tree crown for Norway spruce trees.

However, in dense forest area, the neighbouring trees might have shade and obscure the edges of their neighbours which results in darker image values at tree boundaries and leads to the identification of false seeds (local minima and local maxima) (Li et al., 1992). The over-segmentation produced multiple segments overlapping with a single reference object. On the other hand, under-segmentation may produce larger segments which contain the reference (Ke et al., 2010). In our study, the number of tree over segmentation was found more than the tree under segmentation. Among the reference crowns, *Shorea robusta* has 81 over-segmented crowns and only 4 under- segmented crowns; *Other species* class poses 16 over segmented crowns and 3 under segmented crowns. The reason for these uncertainties may also be explained by the complex forest structure in the study area. We have observed the overlapping and intermingling situation in almost sampling plot.

The shadow is also the main factor causing uncertainties in crown delineation (Martinez Morales et al., 2008). The shadow in the image is due to the effect of view angle, topography and sun elevation. The image for this study was acquired around 10a.m with view area within $\pm 22^0$ off-nadir with sun angle 45^0. The view of $\pm 22^0$ off-nadir may result in casting high shadows because the trees trend to lean away from the nadir. In addition, the study area is on the mountainous terrain, therefore, topographic distortions is observed negatively affect the image quality by causing more shadow effect. The poor spectral separability between different species is also one of reasons causing poor delineated crown. Additionally, there are a number of trees cannot delineated because of the weak signal.

5.2. LiDAR derived height

Each crown delineated from the Geo-Eye imagery is considered an individual tree. The height of one individual tree is the maximum pixel value of CHM which is inside the boundary of the tree crown. In general, the height derived from LiDAR data (point density of $0.8/m^2$) fitted quite well with the measured height from the field with the R^2 of 0.72. Compared to the research of Leckie *et al* (2003) in coniferous forest, the R^2 when fitting measured height and predicted height yields 0.84 with the LiDAR point density of $2/m^2$ for . With the same point density ($2/m^2$), St-Onge

(2000) archived the R^2 of 0.90 for coniferous forest. Reitberger *et al* (2007) results indicate that the detection rate for coniferous trees is 61 % and for deciduous trees 44 %, respectively 7 % of the detected trees are false positives. There are a limited number of researches on the LiDAR derived height in the deciduous forest and tropical forest (Asner et al., 2011). Drake *et al*.(2002) examined the relationship between corresponding LiDAR and field profile metrics and achieved R^2 of generally 0.83.

There are many reasons causing the error of LiDAR derived height. Firstly, the LiDAR point does not hit the top of the tree (St-Onge *et al*., 2001), especially in dense forest like the study area, and leads to the inaccurate predicted height. In addition, the extracted tree height in this study also depends on the delineated crown from Geo-Eye imagery. If the crown is poor delineated, the top of tree A may be placed in the crown of tree B. The residual of DTM and DSM interpolation process is also one source of errors.

5.3. Model Development

Multiple regression analysis was used to develop the relationship between CPA, height and carbon stock of the individual tree. The regression analysis shows that tree height of *Shorea robusta* has stronger relationship with the carbon stock (R^2=0.67) compare to CPA. Meanwhile, for other species, the opposite is the case, the CPA (and not the height) of *Other species* is more strongly link to carbon stock.

The coefficient of determination obtained for *Shorea robusta* was 0.76 and 0.67 for *Other species*. The reason why *Other species* has lower coefficient of determination is that many different species are used the same allometric equation for this class. Different species each have their own characteristics, for example, *Schima wallichhii* is short but the crown is large mean- while *Castanopsis indica* is tall but the crown is medium in size.

Both CPA and height can be include in the multiple regression model because, CPA and height is tested and has no relationship. The reason is that the leaves of *Shorea robusta* are always collected to make traditional bow by the local people, there for many tree has the deformed crown.

5.4. Biomass and Carbon stock estimation

The results of this research show that the carbon stock of the study area was approximately 41 Mg Cha-^{1}. This result is comparable to the carbon stock estimated with the range of 34.30 – 97.86 MgCha-^{1} in Nepal forest of Baral *et al*. (2009). Rachna (2011) also chose Ludhikhola watershed as the study area. However the research of Rachna (2011) focused on the carbon estimation Ludi-damgade community, one of five community forests in our research, with the carbon estimate of 31MgCha^{-1}.

6. CONCLUSION AND RECOMMENDATION

For each class (*Shorea robusta* and *Other species*), linear regression analysis was used to relate carbon stock of individual tree with CPA and height, one after other. The results of linear analysis show that, both CPA and height have relatively good relationships with the carbon stock of individual tree. Therefore, the multiple regression analysis was applied to use both CPA and height to explain carbon stock. The developed model then was called the *regression predictive model of carbon*. The multiple coefficient of regression obtained from regression predictive model of carbon for *Shorea robusta* is higher than the one of *Other species*, R^2= 0.76 and 0.68 respectively.

The combination of LiDAR data and VHR Geo-Eye imagery provides a good source of information which can be used for forest carbon stock estimation. In order to increase the accuracy carbon estimation using the combination of LiDAR data and VHR Geo-Eye imagery, the foreseen uncertainties should be reduced by: (i) developing local level allometric equations for Nepal for better carbon stock estimation, (ii) finding a method to better integrate the CHM and Geo-Eye imagery in tree crown delineation process.

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THREE-DIMENSIONAL SIMULATION OF FLOW OF FRESH CONCRETE IN MULTI-DIMENSIONAL STEEL BAR ARRANGEMENT BY MPS

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ABSTRACT

As the amount of steel bars in buildings increases, it gets more difficult to compact a fresh concrete in the congested area of steel bars. It becomes important to establish a numerical model to predict the compaction and flow behavior of flesh concrete. The aim of this research is to simulate the flow behavior of fresh concrete under multidirectional bar arrangement condition by three dimensional MPS (Moving Particle Semi-implicit) method, one of the particle methods. It is based on a fluid mechanics in which Bi-viscosity model is applied to the particle element where yield value and plastic viscosity are set as the yield point parameter and hence different from methods such as the Distinct Element Method (DEM) used in the previous researches in the similar field.

L-shape box flow tests were simulated where the steel bars were set multi-directionally at the distance of 75mm and 150mm in grid and compared with the experimental results. Considering the computational time and the gap between steel bars, the particle size in the simulation is set to 10mm. From the analysis, flowability and passing behavior of concrete through the steel bars is examined by changing material models and distance between steel bars. Simulation of flow behavior of the viscous fresh concrete is found to be similar to that observed in the experiment.

Keywords*: MPS, flow analysis, Bingham fluid, flowability of flesh concrete, flow behavior under obstacles.*

1. INTRODUCTION

Recently, as the amount of steel bars in the building structure is increasing, it gets more difficult to compact a fresh concrete in the congested area of steel bars. It becomes important to establish a numerical model to predict the compaction and flow behavior of flesh concrete in congested arrangement of steel bars where means of compaction is self-weight of concrete and injection of pump only. Therefore, in case of some structures, flow experiment with full-scale model is needed. But many cases of experiments cannot be done because of high cost and time. However, if evaluation of workability by flow analysis of concrete is established, many parametric studies can be done, and prediction of workability in advance becomes possible (Tanigawa and Mori, 1988).

Recently, MPS (Moving Particle Semi-implicit), one of particle methods, is proposed as an analysis method suitable for large deformation problem (Y. Chikazawa, S. Koshizuka and Y. Oka, 2001). MPS is one of the analysis methods analyzing incompressible flow. It is different from DEM (Distinct Element Model) applied in the previous research in this field in this point. MPS can solve large deformation problem of free boundary without cells and elements. Based on such an advantage, 3-dimension flow analysis of flesh concrete; which is non-Newtonian fluid, has been tried. Constitutive model of flesh concrete is regarded as bi-viscosity model, and it is reported that flow of flesh concrete is modeled. It is also reported that flow stop and stuck of flesh concrete can be expressed by shear velocity of particles (Urano, Nemoto and Sakihara, 2012). The aim of this research is to simulate the flow behavior of fresh concrete under multidirectional bar arrangement condition. In this research, we examine slump flow experiment analysis and L-shape box flow analysis on distance between steel bars and material properties effect. Next, results of numerical simulation are compared with that of experiment.

2. METHOD OF ANALYSIS

2.1. Summary of MPS

MPS, one of particle methods, is the analysis method that analyzes incompressible flow by Lagrangian Method which calculates every particle movement (Figure 1).

Generally, wall boundary is replaced with particles in MPS. However, in this research, surface mesh is used as wall boundary. This enables it to decrease number of particles and computational time.

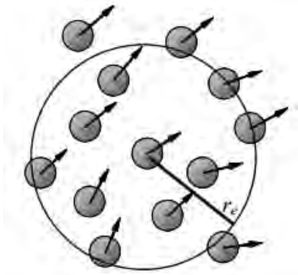


Figure 1: Conceptual diagram of MPS

2.2. Establishment of distance between particles

Flesh concrete is presumed as Bingham fluid and homogeneous continuum model. Therefore, aggregates and mortar are not distinguished and movement of aggregates in concrete is not covered by the analysis. And smaller the distance between particles, larger will be the number of particles, and hence flow behavior can be expressed in detail. Considering the computational time and distance between steel bars in preliminary analysis, the particle size is set to 10mm. Preliminary analysis on the particle size effect is described in 4.1.

2.3. Constitutive model of flesh concrete

In Bingham fluid, if shearing stress is less than yield value, it is regarded as immobility, and shear velocity is zero. Therefore, stress cannot be calculated and analysis does not work (Japan Society of Civil Engineers, 2003). In this research, bi-viscosity model is applied to particle element as shown in Figure 2. Bi-viscosity model behaves as highly viscous fluid until shearing stress reach yield value. Constitutive equations are expressed as follows (equations 1 and 2).

$$\tau_{ij} = -P\delta_{ij} + 2(\eta + \frac{\tau_y}{\sqrt{\Pi}})\dot{\varepsilon}_{ij} \qquad \Pi \geq \Pi_c$$

(1)

$$\tau_{ij} = -P\delta_{ij} + 2(\eta + \frac{\tau_y}{\sqrt{\Pi_c}})\dot{\varepsilon}_{ij} \qquad \Pi \leq \Pi_c$$

(2)

where;

P = pressure

η = plastic viscosity

τ_y = yield value

$\dot{\varepsilon}_{ij}$ = shear velocity

δ_{ij} = Kronecker delta

$\Pi = 2\varepsilon_{ij}^2$

Π_c is index determining mobility or immobility, and expressed as follows (equation 3).

$$\Pi_c = \left(\frac{2C_y \tau_y}{\eta} \right)^2$$

(3)

where;

C_y = yield point parameter

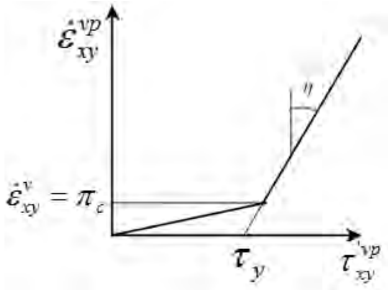


Figure 2:Bi-viscosity model

3. ANALYSIS MODEL

3.1. Slump Flow Experiment Model

Slump flow experiment model is as shown in Figure 3, number of particles in numerical model is 5277.

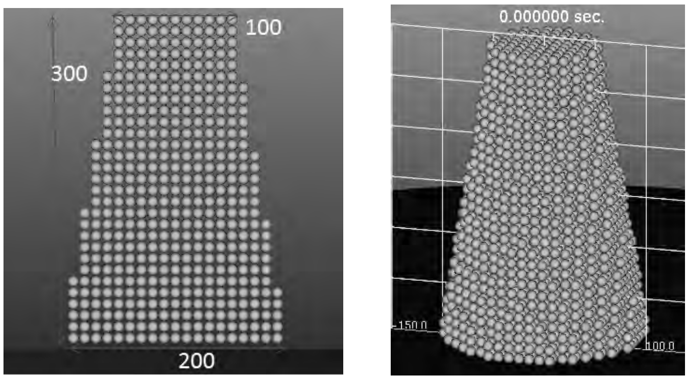


Figure 3: Particle model of slump flow experiment

3.2. L-shape Box Flow Model

L-shape box flow model is created having 39117 numbers of particles as shown in Figure 4. Arrangement of steel bars is as shown in Figure 5, and c/c distance between bars (=D) is 75mm and 150mm in grid. Diameter of steel bar is 22mm.

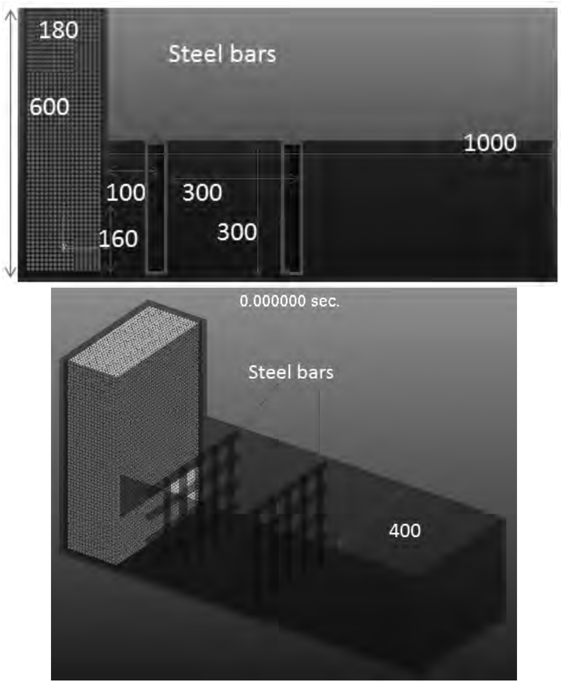


Figure 4: L-shape box model

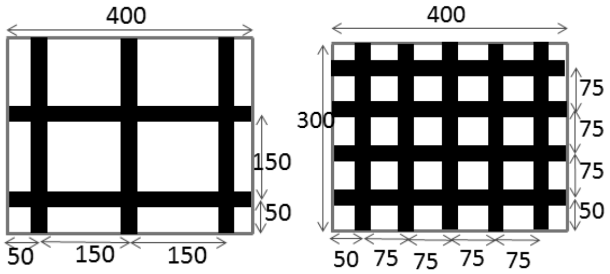


Figure 5: arrangement of steel bars

3.3. Material Model

Material properties, which are yield value and plastic viscosity, are adopted from previous analysis (Urano, Nemoto and Sakihara, 2012). They are named as Material 1 and 2. To study the effect of variation of plastic viscosity, Material 3, 4 and 5 are adopted. Detail of material properties are shown in Table 1.

Table 1: Material properties

Material	Yield value(Pa)	Plastic viscosity(Pa*s)
1	1000	300
2	160	300
3	500	300
4	500	500
5	500	700

3.4. Analysis cases

Analysis is done in two steps as shown in Tables 2 and 3. In preliminary analysis, D is set to 75mm because particle size will have a significant influence while passing through steel bars. Aim of preliminary analysis is to examine the effect of particle size variation. And after studying the result of preliminary analysis, particle size is set to 10mm in further analysis cases.

Table 2: Preliminary analysis cases

case	Material	D(mm)	Particle size(mm)
Pre1	1	75	5
Pre2	1	75	10
Pre3	1	75	20

Table 3: Analysis cases

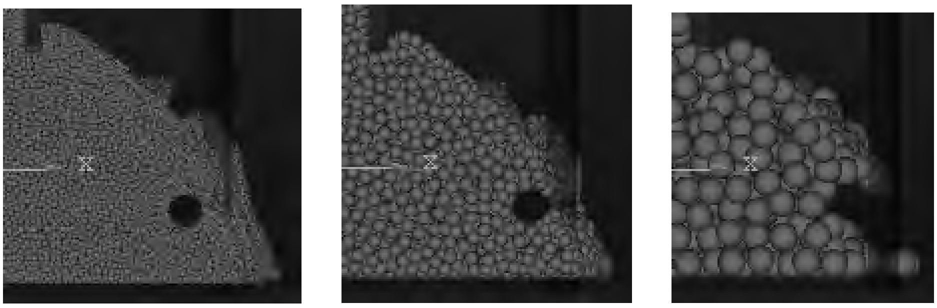
case	Material	D(mm)	Particle size(mm)
1	2	75	10
2	5	75	10
3	5	150	10

4. RESULT

4.1. Preliminary analysis

Result of preliminary analysis is as shown in Figure 6. In case of Pre3, particles seem to be stuck when they pass through steel bars. From the result, it is observed that larger the particle size, smaller will be flow distance.

Also computational time increases as particle size decreases. Hence in further research, considered computational time and particle size effect, particle size is set to 10mm.

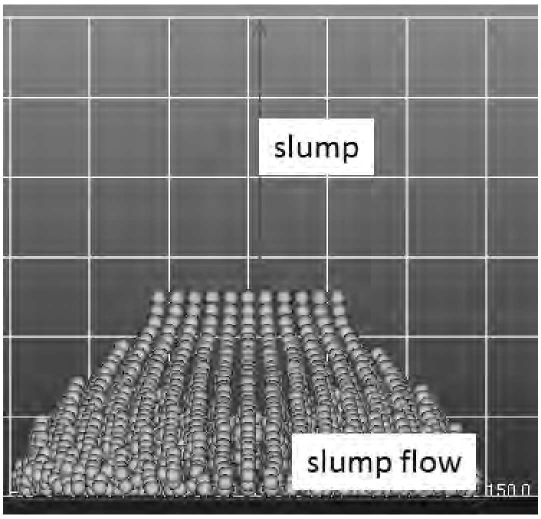


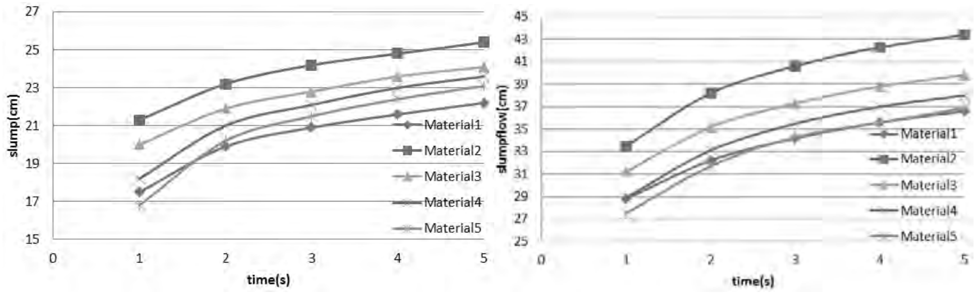
(a) Pre1(5mm) (b) Pre2(10mm) (c) Pre3(20mm)

Figure 6: Result of preliminary analysis

4.2. Slump flow experiment analysis

Result of slump flow experiment analysis is shown in Figure 7. It is observed that as yield value and plastic viscosity increase, slump and slump flow decrease. From the result, it is observed that fluid property is determined by yield value and plastic viscosity.



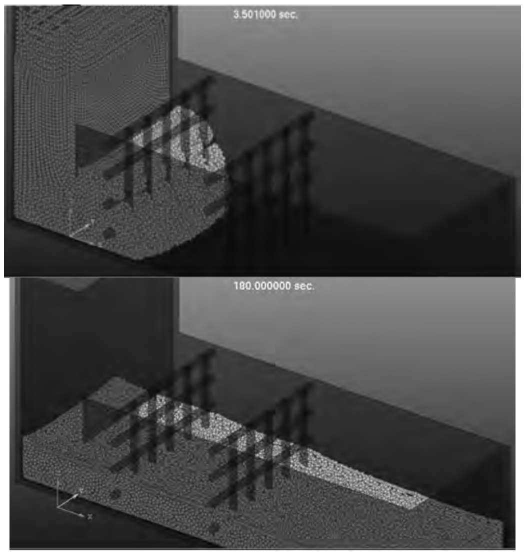


(a) slump *(b) slump flow*

Figure 7: Result of slump flow experiment analysis

4.3. L-shape box flow analysis

Result of L-shape box flow analysis in case 1 is as shown in Figure 8. Figure 8 (a) shows that particles pass through steel bars, and Figure 8 (b) shows that flow of particles stopped by compaction.



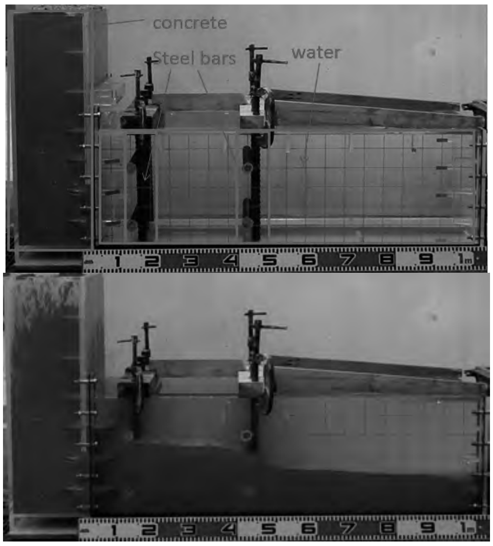
(a) at 3.5 seconds *(b) at 180 seconds*

Figure 8: Result of analysis case 1

4.4. Comparison with experiment

4.4.1. Experiment

Experimental results used for comparison is taken from a study done by Penta Ocean Construction. In this research, L-shape box model is based on same experiment. Experimental setup is shown in Figure 9 (a). In this experiment, anti-washout underwater concrete having high viscosity is used.

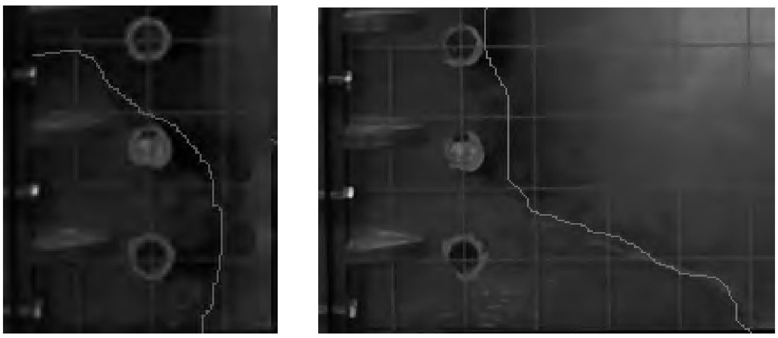


(a) at 0 seconds (b) at 600 seconds

Figure 9: Experiment setup

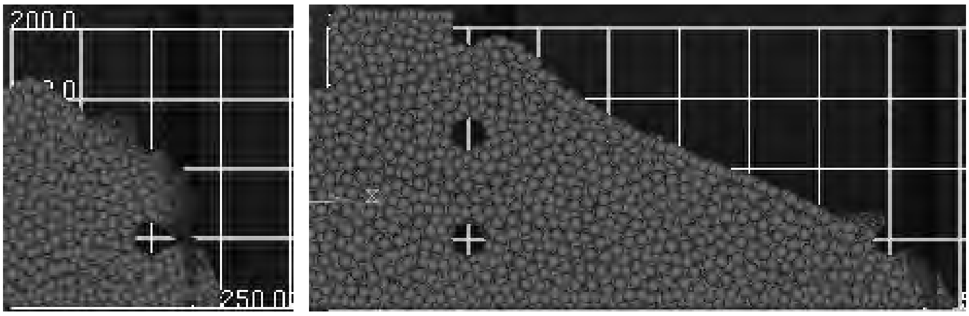
4.4.2. Analysis

In the experiment study, it is stated that high viscosity material model is chosen. But value of plastic viscosity of concrete is not available; hence simulation results shown here are based on Material 5. Results of experiment and these analyses are shown in Figures 10, 11, 12 and 13. In case of D=150mm, flow behavior in analysis is similar to that observed in experiment. On the other hand, in case of D=75mm, flow distance in analysis is larger than that in experiment. The reason is in case of small D, flow of flesh concrete is obstructed by formation of arches of aggregates. Our analysis model does not consider mortar and aggregates separately; hence formation of arch of aggregates is not modeled perfectly as found in experiment. As a result, flow behavior in analysis is found to be different from that in experiment is case of smaller value of D (=75mm). But in case of D=150mm, formation of arches of aggregates is not found, hence experiment and analysis results hold a better match.



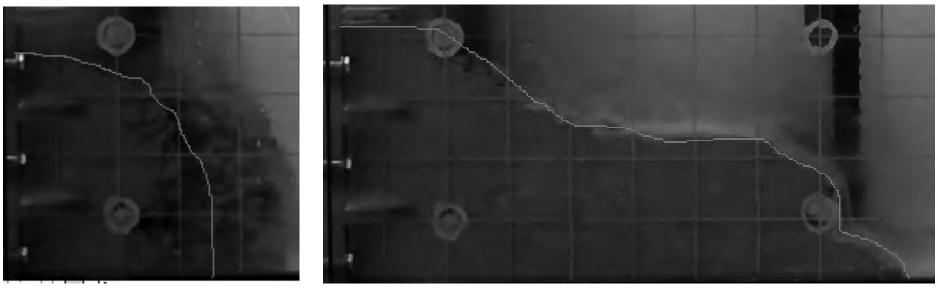
(a) at 5 seconds (b) at 40 seconds

Figure 10: Result of experiment in D=75mm



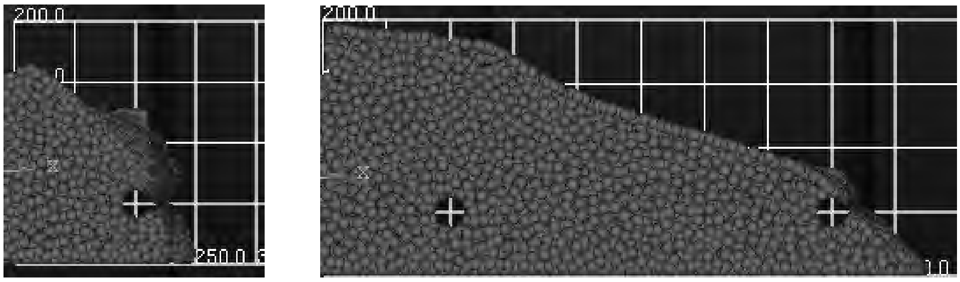
(a) at 5 seconds *(b) at 40 seconds*

Figure 11: Result of analysis in case 2



(a) at 5 seconds *(b) at 40 seconds*

Figure 12: Result of experiment in D=150mm



(a) at 5 seconds *(b) at 40 seconds*

Figure 13: Result of analysis in case 3

5. CONCLUSION

Flow analysis of flesh concrete can be done by using MPS. Further, flow behavior in multi-dimensional steel bar arrangement is compared with experiment with high viscosity material model. In case of large distance between steel bars, flow behavior similar to experiment is found. But in case of small distance, in which formation of arch of gravels can occur, and hence result of experiment does not match with the numerical simulation. Therefore, gravels need to be considered in case of small distance.

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APPLICATION OF RISK MANAGEMENT TO FORECASTING TRANSPORTATION DEMAND

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ABSTRACT

Transportation SOC investment feasibility is analyzed by forecasting transportation demand. In order to reflect the change of future trip-pattern, O/D is adjusted according to the land-use development plan. However, social & economic indicators and land-use development plan in developing counties such as Korea are apt to change rapidly, thus the errors in forecasting demand occur. For instance, the future traffic volume analyzed in Korea's LRT projects (Yong-in, Uijeongbu, etc.) has a margin of error of -70~-90% because they did not reflect the change of future development plan. In most countries such as Korea, to analyze the uncertainty of future plan, a simple sensitivity analysis is performed. In some countries such as Japan and the UK transport demand, they have their own risk management systems to respond to the risks and prepare countermeasures to minimize the risks of the project. However, the standard procedure and methodology of risk management which can be applied during forecasting traffic demand does not exist. In this study, the errors in forecasting demand system are reviewed and to deal with these errors effectively the methodology of risk management is developed. To develop it, general risk management techniques such as risk identification, risk assessment, risk responses are applied.

***Keywords**: SOC investment feasibility, land-use development plan, uncertainty of future plan, risk management, transportation demand error.*

1. INTRODUCTION

Since the enactment of "Act of Private Investment Inducement on SOC Facilities", both the government and private sector have increased their investment in transportation SOC. However the risk of SOC investment is increasing in terms of the uncertainty of cost such as financial crisis and price rise of raw materials and of transportation demand such as the reduction of future development plans and the changes in trip patterns. For instance, regarding Uijeongbu LRT, Uijeongbu-si has signed a transportation demand agreement for 79,000 passengers without reviewing the uncertainty of transportation demand in future, yet it turned out only 11,000 passengers used the service. As a result, Uijeongbu-si's burden on MGR (Minimum Revenue Guarantee) increased, with the actual demand of Uijeongbu LRT being 10% of the agreed demand, which lead to an increase of the government assistance. Eventually, KORAIL(Korea Railroad) has acquired the shares of private capital, 2.5 years after the opening of service.

An investment evaluation system such as pre-feasibility study or feasibility assessment conducts an analysis of sensitivity which increases or decreases discount rate, cost or benefit in response to the changes in social and economic environment, which in fact does not respond to the changes systematically. Given the need of the introduction of a systematic risk management system to a investment assessment system approving transportation SOC investment, this study is intended to suggested step–by-step risk management in order to cope with the risks and uncertainty of projects through continued transportation SOC projects management from the perspective of transportation demand forecast.

2. THE REVIEW OF PREVIOUS STUDIES

Sungbong CHUNG and Justin S. CHANG (2007) have categorized the error factors which may occur in each step of 4-Step Demand Forecast Method into: Measurement or data error, Model specification error and External or exogenous error (Mackie & Preston, 1998; Flyvberg, 2005 Flyvberg et al., 2005, 2006; World Bank, 2005), typed errors and then conducted an effect analysis in accordance with the error factors of demand forecast. The results suggested the demand variation is affected by 'car occupancy' and 'relevant plans' the most. Taking account of the fact the social and economic uncertainty may change the results of transportation demand forecast, Sungbong CHUNG (2011) suggested 'step-by-step risk management plans' such as trip generation and distribution, modal split and trip assignment by using Delphi technique in order to apply the risk management to the process of transportation demand forecast. The results of Delphi analysis suggested 'the uncertainty of relevant plans', 'problems of model application' and 'problems of major parameter calculation' are critical risk factors in 'trip generation and distribution', 'modal split' and 'trip assignment', respectively.

3. CASE STUDIES IN HOME AND ABROAD, IMPLICATION AND IMPROVEMENTS

3.1 The state of Risk Management in Home and Abroad

In Korea, as shown in Table 1, the economic analysis of pre-feasibility study and feasibility assessment focuses on B/C due to the variation of cost, benefit and discount rate, which has the limitation in systematically responding to the changes of conditions in future.

Table 1: Standards of a sensitivity analysis

Classification	Scope of application
Cost	· +10%, +20%, +30%, +40%, +50%
Benefit	· -30%, -20%, -10%, +10%, +20%, +30%
Discount rate	· 3.5%, 4.5%, 6.5%, 7.5%

In the case of private capital projects in Korea, 'quantification of risk' item is assessed via ‘private capital eligibility review’ (Korea Development Institute). However the countermeasures of PSC project model and PFI project model are suggested and included in VFM assessment. (see Figure 1).

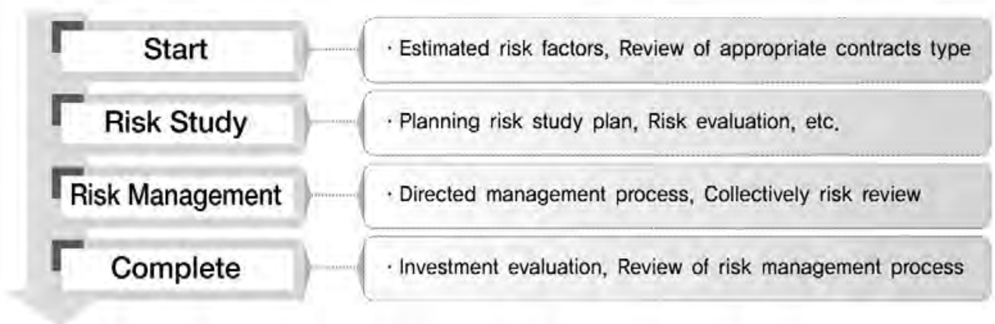

Figure 1: Private investment projects risk management process

In Japan, unlike other countries, a structured process of risk analysis and risk quantification has not been established, yet risk-sharing is specified in details. In the event of natural disasters, inflation, changes in demand and changes economic conditions which were not considered when making an agreement, additional expenditure may incur. Thus the disputes arising from the risk factors in future are minimized through the identification of risk factors and clear definition of assessment, partakers and ways of sharing.

Table 2: Risk factors identified during the review of risk sharing (Japan)

Classification	Risk factors
Survey , design	• Delay in design and construction, excess of expenditure above the agreed amount, defects of products such as designs, etc.
Land acquisition	• Land acquisition, Land use right acquisition for a certain period of time
Construction	• Excess of expenditure above the agreed amount due to the delay in construction, damages to third parties during construction, defects after the completion of projects
Maintenance	• Delays in operation, differences in public service demand forecast, maintenance, operational interruption, property damage, accidents relating to maintenance and operation, defects in repaired parts, etc.
Completion of projects	• Restoration after removal, transfer of public facilities

In UK, the Exchequer checks all risk factors and assesses the effect and probability; makes Risk Register agreed by Integrative Project Management Team; and reviews the risk factors in every Gateway Process

to check if the project can progress to the next stage in order to reduce the overall projects risks from A to Z.
After deciding the balance between cost and risk regarding the benefit to be transmitted to the ordering body, the Exchequer focuses on risk management and the opportunities which will increase values.

Table 3: Risk Management Structure in UK

Step	Description
① Risk check	• Workshop methods, Check-list
② Risk evaluation	• Understanding the likelihood and the impact on business results, and quantifying them: • Estimated risk cost= Probability × Risk effect • Qualitative evaluation and • Quantitative evaluation: Cost exceeding basic cost (risk provision), cost increase arising from the delay in construction
③ Risk response	• Avoidance • Reduction - Re-design and detailed design, site investigation - Alternative construction methods to avoid the existing risk factors - Selecting alternative procurement path

In Canada, it is stipulated that Project Management Manual needs to be prepared. Manual covers work management, quality management, time management, cost management, risk management and communication management, etc. across the entire project.

Table 4: Structural risk analysis framework in Canada

Classification	Description
① Preparation	• Forming Risk Review Team consisting of stake-holders and experts and scheduling projects
② Risk assessment	• Calculating risk factors at workshop through brainstorming • Analyzing the risk factors and likelihood on the basis of the assessment reports in the past • Analyzing the size of risk effect and grouping them in accordance with the severity of risk • Assessing risks in accordance with risk factors in each group
③ Risk response	• Deciding measures against major risk factors and establishing plans • Transferring strategies and plans to Risk Review Team
④ Risk management	• Applying established plans and monitoring
⑤ Publishing assessment report	• Comparing estimated effect with actual effect and analyzing them • Writing items to be supplemented and improvement plans

3.2 Risks of Errors in Transportation Demand Forecast

In Korea, traffic demand is forecasted via traditional 4-Step Traffic Demand Forecast. Traditional traffic demand forecast is based on the assumption- the current traffic pattern will be maintained in the future, which may lead to wide margin of error in the event of sharp changes in future population, and socio-economic indicators or additional development plans.

Table 5 shows the comparison of the total of O/D in the metropolitan areas provided by the National Transportation DB. Traffic varies up to 30% depending on the publication year, indicating the results of project demand forecast may vary depending on the distribution year.

Table 5: Korea Transportation DB (KTDB) O/D in Capital area (Based 2021)

(unit : thousand trip/day, %)

Year		Total	Auto	Bus	Rail	Taxi	Other
2002	Trip	56,166	18,564	17,235	14,600	2,918	2,850
	Growth	-	-	-	-	-	-
2006	Trip	58,487	20,867	15,884	14,301	3,420	4,015
	Growth	4.13	12.41	-7.84	-2.05	17.21	40.87
2007	Trip	53,671	20,988	15,821	9,962	3,220	3,680
	Growth	-8.23	0.58	-0.40	-30.34	-5.84	-8.34
2011	Trip	48,810	20,387	11,870	10,045	3,846	5,463
	Growth	-9.06	-2.86	-24.97	0.82	19.41	48.45

Recently the errors in forecasting the demand of Incheon International Airport Railroad (A'REX) is controversial. As shown in Table 6, an error of about 90% in demand forecast compared to 2010 occurred. Regarding the realization of future development plans reflected in demand forecast, the size of future land plan was reduced and the transportation network plan was candled after the completion of project, and wide margin of error in modal split occurred, which led to the overestimation demand. Thus it is essential to manage such risk factors systematically as uncertainty factors during demand forecast may threaten the feasibility of project.

Table 6: Comparing the actual demand and demand agreement in A'REX

(unit : person/day, %)

Classification	Opening	1 year after opening	2 year after opening
Forecasted Demand	207,421	226,642	248,294
Actual Demand	13,329	16,595	18,063
Error	-194,092	-210,047	-230,231
Error Ratio	-93.57	-92.68	-92.73

3.3 Implications and Improvements

Korea's investment evaluation system reviews the changes of B/C roughly via a sensitivity analysis, and thus has the limitation in coping with the future risk factors. To resolve these problems, studies on Risk Management have been conducted in Korea too, yet the results are not reflected in reality. In Korea, risk management in transportation SOC investment focuses on a total construction cost and it is stipulated that appropriate measures by project stage against risks need to be prepared. Risk management implementation process is in general based on 3-Step:

Risk Aawareness->Risk Assessment->Risk Response for the purpose of systematic risk response, indicating that it is essential Korea's investment evaluation system also need to introduce such systematic risk management system as soon as possible.

In other words, it is essential to prepare measures against the demand changes arising from the uncertainty in the future conditions during the project implementation through more systematic risk management and furthermore introduce overseas 3-Step Risk Management System (Risk Aawareness->Risk Assessment->Risk Response) for the purpose of preparing the systematic risk management measures according to the transportation project investment stage.

4. INTRODUCTION OF RISK MANAGEMENT

4.1 Outline of risk management

Oren and Rothkopf (1975) defined Risk as the likelihood of 'Loss', 'Injury', 'Disadvantage' and 'Destruction'. Risk Management is a total process which identifies/controls/removes and minimizes the risk effects on projects, and the insurance theories in the US in the 1950s had addressed this notion for the first time. In general, Risk Management identifies causes of risks under the certain circumstances; analyzes risk effect; measures and evaluates the consequences; and then finally establishes and takes the countermeasures to reduce negative effects of risks or eliminate the risk itself.

Risk Identification is a process to: (1) identify the causes of the risks associated with certain projects and classify them systematically according to a consistent standard, (2) determine the gravity of consequences, (3) select the critical risk factors to consider in priory during risk analysis.

A risk analysis processes all available quantitative data mathematically and statistically and quantifies the likelihood of specific risks and potential consequences. As for the materials that require subjective judgment during risk analysis and risk assessment, the judgment by experts and hands-on officers is useful. In this case the judgment by experts and hands-on officers is not just their opinions but the assessment systematically and consistently organized. It is critical to use a methodology that is able to display the judgments with objective probability after eliminating prejudices and errors in judgments, and quantify them systematically.

The purpose of Risk Response is to eliminate the adverse effect of risks as much as possible and increase control over risks. Risk Response is based on two basic directions: the establishment of counterstrategies and the allocation of the counterstrategies against specific risks.
Risk Response strategies included: Risk Avoidance, Risk Reduction, Risk Transfer and Risk Retention. The purpose of Risk Avoidance is to avoid the potential loss and avoid exposure to risks, yet in compensation for potential

benefit or opportunities. The purpose of Risk Reduction is to reduce the degree of exposure to risks by reducing the likelihood of risks by taking every possible measure, which can be accomplished through a clear understanding of assumptions, more concrete design and the re-design of incomplete parts. Risk Transfer is a way to transfer or share the potential consequences of risks to and with other groups (organization) through an agreement. Risk Retention is a strategy which is to intentionally and consciously take risks which cannot be transferred or avoided in accordance with the requirements, finance and capabilities of project managers.

4.1 Outline of risk management

This study has suggested the step-by-step measures against risks by applying risk management techniques to future demand forecast and economic analysis in terms of total project cost. Furthermore, this study has analyzed the uncertainty risk factors in each step of 4-Step Demand Forecast Method (risk assessment) in order to suggest specific countermeasures against risks. As for risk response methods, this study has suggested specific countermeasures regarding 4 alternatives (Risk Avoidance, Risk Reduction, Risk Transfer and Risk Retention) for the purpose of selecting the best alternatives.

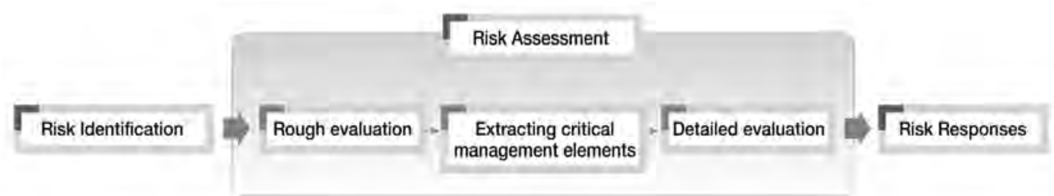

Figure 2: Introduction of risk management (idea)

First, as for Risk Identification, it needs to extract the risk factors which are expected to occur through the consultation with experts or responsible departments after extracting risk factors by step as shown in table 7. It shows examples of risk factors by demand forecast step and suggests the risk factors-future development plan, uncertainty of traffic network plan, uncertainty of socio-economic indicators and the variation of Korean currency.

As for the selection of means, Table 7 suggests response to the changes in the fare by transportation means and the risk factors regarding the changes in modal split in accordance with the introduction of new transportation; and as for trip distribution, suggests the change of national traffic network and the uncertainty of project type. Thus it needs to suggest all possible risk factors for seamless project implementation by calculating risk factors additionally.

Table 7: Risk factors by demand forecast stage (examples)

Step	Description
Trip generation	• Realization of reflected future development plans and traffic network plans • Rapid change in socio-economic indicators such as population employees • Changes of basic unit needed for forecasting future development plans demand
Trip distribution	• Rapid changed in trip patterns(present and future) due to the changes in land use plans and introduction of new transportation • Reduction of long-distance trip due to the development of information technology including Internet
Selection of means	• Rapid changes of fuel costs and vehicle operating costs • An increase of public transportation fare • Sharp differences between agreed fare and actual fare(private investment project) • Change in the use of means due to the introduction of new transportation means
Trip Assignment	• Changes in national traffic network due to the modification of national plans • Changes in car occupancy due the change of life style • An increase of toll due to a project shift from public project to private investment project • Changes in trip time and demand due the construction of intermediary stations in future(railroad)

Risk Assessment step assesses the risk level of risk factors extracted by Risk Identification and the degree of Risk Response may vary depending on the results of risk assessment. Risk Assessment first judges whether risk factors are able to affect the feasibility of projects and then identify the risk level of risk factors through sensitivity analysis used in the current investment evaluation system. It establishes the risk factors extracted from rough evaluation as the critical management elements and then analyze the changes of actual demand and benefit and the effect of the risk factors on the feasibility of projects by reflecting the above critical management elements in to actual demand forecast step.

Table 8: Risk assessment methods

Step	Description
① Rough evaluation	• Judging if feasibility of project is secured by applying the demand variation rate to benefits
② Extracting critical management elements	• Designating the projects which are difficult to secure feasibility during rough evaluation as critical management elements • Excluding the projects which will secure feasibility through the adjustment of total project cost even it they did not have the feasibility during rough evaluation
③ Detailed evaluation	• Identifying the degree of effect of project feasibility by applying the critical management elements to demand forecast step • Establishing the standards for increase/decrease of demand by countermeasures in each project step

Risk Response step suggests the countermeasures against risks by project step after feasibility assessment on the basis of the findings of a risk assessment. The countermeasures in general include Risk Avoidance, Risk

Reduction, Risk Transfer and Risk Retention. It categorizes the risk response measures into 4 steps according to the results of risk assessment and also suggests the project promotion directions which will be used as the guidelines when projects face difficulties during implementation.

Table 9: Risk Responses (examples)

Project Step	Risk Avoidance	Risk Reduction	Risk Transfer	Risk Retention
Basic (Implementation) design	• Detouring • Step by step project implementation • Re-review of project feasibility	• Project reduction • Investment cost reduction • Delay in opening	• Adjustment of project cost sharing • Increasing project cost by issuing bonds	• Continue to proceed
Under construction	• Discontinuing construction temporarily and reviewing the facility efficiency plans (Change of facility use)	• Reduction of project cost by reducing the size of project	• Shifting project from government project to private investment project	• Continue to proceed
After completion of construction	• Delay in opening	• Opening of some facilities	• Operational subsidies	• Complete opening

5. CONCLUSION

With respect to transportation demand forecast, this study has suggested risk management measures from the perspective of transportation demand forecast on the basis of the risk management system suggested by Oren and Rothkopf (1975). The results of foreign case study suggest most countries use 3-steps (Risk Awareness->Risk Assessment->Risk Response). Thus this study has reconstituted above framework in such a way as to satisfy the investment evaluation system in Korea and then suggested application. The replacement of a rough sensitivity analysis conducted in the investment evaluation system in Korea with the risk management suggested in this study will enable the timely response to risks arising from the uncertainty of transportation demand forecast through early awareness of risks that may occur during project implementation.

This study has suggested step-by-step risk management measures with respect to transportation demand forecast for the purpose of reducing the uncertainty factors in the investment evaluation system on the traffic facilities in Korea. However there is a need of further studies on detailed step-by-step countermeasures on the basis of the results of the those studies, risk assessment indicators and risk response classification standards in order to establish a rational and objective risk management system in Korea.

If the awareness of the uncertainty of transportation demand forecast expands and studies to reduce the uncertainty continues, the unnecessary financial losses due to incorrect demand forecast will be prevented. Furthermore the further studies on cost-calculation, benefit calculation and economic evaluation in decision-making process will ensure more rational and effective investment.

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CHARACTERIZATION OF AIR QUALITY IN GLOBAL MEGA-CITIES BY REMOTE SENSING AND INVENTORY DATA

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ABSTRACT

According to previous study, aerosol is classified into two types – natural or artificial. However, it isn't so clear that what rate does aerosol contain in the air and how much two types aerosol affects. The objective of this study is to clear the relation between air pollution and human activity, so we use indexes as angstrom exponent (ANG), Aerosol Optical Depth (AOD) by MODIS. Firstly, aerosol condition was classified by ANG-AOD. A scatter plot was made about 61 mega cities. Air conditions of cities were revealed three characteristics- the environmentally friendly cities(European cities, Tokyo, New York, etc) ・the cities influenced artificial aerosol(Shanghai, Lagos, etc) ・the cities influenced natural aerosol (Kabul, Baghdad, etc). Secondly, the value of ANG-AOD was transformed to the value of RGB color space. Not only chosen cities but also cities where are not chosen and the other areas are categorized. Thirdly, the value of RGB was found trend. The RGB data of monthly average were compared in Tokyo, Kabul and Shanghai. The superiority of RGB was different with seasons and the combination of cross values(R&G, G&B, B&R) was different with cities. In the future, the result of this research could be an index of the choice to invest for the air pollution improvement.

Keywords*: MODIS, Angstrom exponent, Aerosol Optical Depth, secular.*

1. INTRODUCTION

1.1 Background & Objective

Today, it is considerably revealed that what is the aerosol itself. However, it isn't so clear that how much range natural or artificial aerosol affects and that how different it affects by each seasons. Especially, it isn't so clear how much degree aerosol in the field of transportation affects atmosphere. So, I focus on Angstrom exponent (ANG) and optical thickness of aerosols (AOD) to analyze the state of the atmosphere.

The objective of this research is to find the characteristic of each cities or the regionality by researching Angstrom exponent (ANG) and optical thickness of aerosols (AOD) and comparing the data of each year or monthly average.

1.2 METHODOLOGY

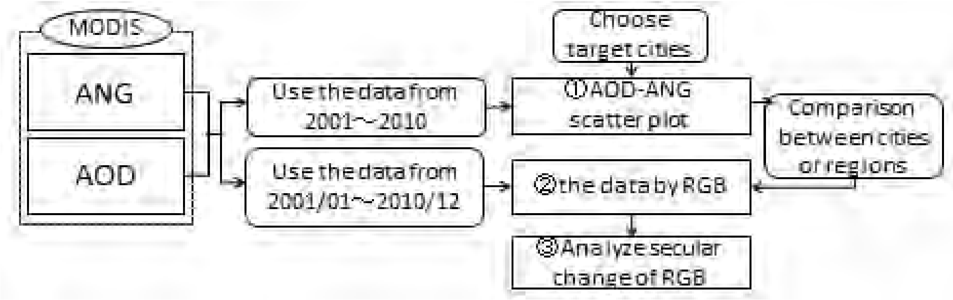


Figure 1: Flow chart of this research

Figure 1 is flow chart of this research. Firstly, AOD-ANG scatter plot is made by using the data from 2001 to 2010 given MODIS. The number of vehicle or acuteness of air pollution is taken into account to choose target cities. Secondly, the value of RGB is transformed the data of AOD-ANG. Thirdly, the value of RGB is analyzed secular change.

2. RESULT

2.1 AOD-ANG data

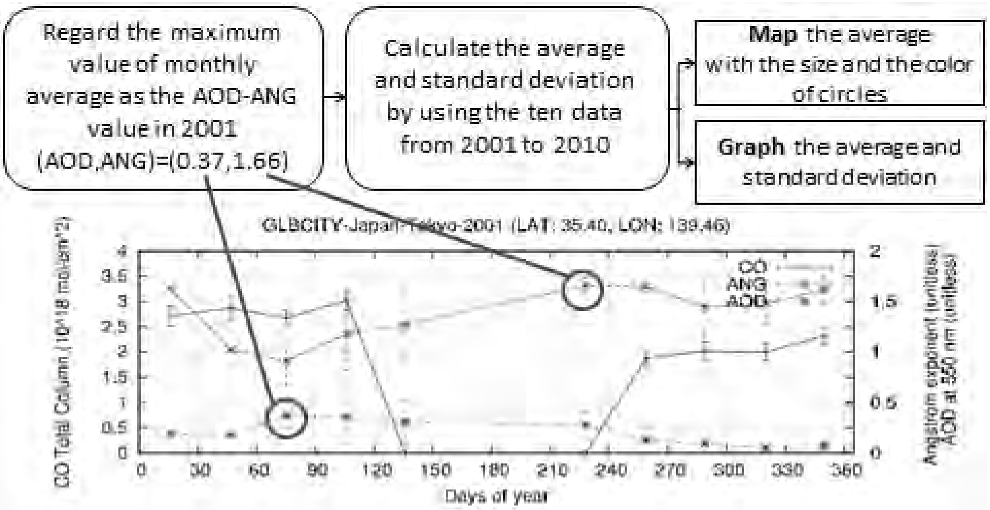


Figure 2: Method of AOD-ANG scatter plot

Hara et al. (2012) analyze only AOD trend. This research analyzes AOD and ANG. The ten years' data from 2001 to 2010 in each city are used. The maximum value of monthly average is regarded as the AOD-ANG value in this year. By using the ten data from 2001 to 2010, the average and standard deviation are calculated to map the average and to graph the average and standard deviation. Table 1 shows 61 target cities.

Table 1: the list of 61 target cities

Country	City	Country	City
Austria	Vienna	Belarus	Minsk
Belgium	Brussels	Bulgaria	Sofia
Czech	Prague	England	London
France	Paris	Germany	Berlin
Greece	Athens	Hungary	Budapest
Italy	Rome	Poland	Warsaw
Romania	Bucharest	Spain	Madrid
Sweden	Stockholm	Switzerland	Bern
Ukraine	Kiev		
Afghanistan	Kabul	Azerbaijan	Baku
Bangladesh	Dhaka	China	Beijing
China	Chongqing		Hong Kong
	Shanghai		Ulumuti
India	Bangalore	India	Kolkata
	Mumbai		New Delhi
Indonesia	Jakarta	Iraq	Baghdad
Japan	Tokyo	Kazakhstan	Almaty
Myanmar	Naypyidaw	Myanmar	Yangon
Nepal	Kathmandu	North Korea	Pyongyang
Pakistan	Islamabad	Philippines	Manila
Russia	Khabarovsk	Russia	Moscow
	Novosibirsk	Singapore	Singapore
South Korea	Busan	South Korea	Soul
Thailand	Bangkok	Vietnam	Ho Chi Min
Argentina	Buenos Aires	Australia	Sydney
Brazil	Rio Dejaneilo	Brazil	Sao Paulo
Chile	Santiago	Mexico	Mexico City
Peru	Lima	United States	Los Angeles
United States	New York		Washington DC
Nigeria	Lagos	South Africa	Johannesburg

2.1.1 Mapping AOD-ANG

Figure 3 shows the average of AOD and ANG. The size of circle means the value of AOD and the color means the value of ANG. Kitajima et al. (2002) says the bigger the value of AOD is, the worse the air is and the bigger the value of ANG is, the more artificial aerosol is in the air. In other words, bigger circles mean the value of AOD is bigger and the air is the dirtier. More red means the value of ANG is bigger and the rate of artificial aerosol in air is bigger. More blue means the value of ANG is smaller and the rate of natural aerosol is bigger.

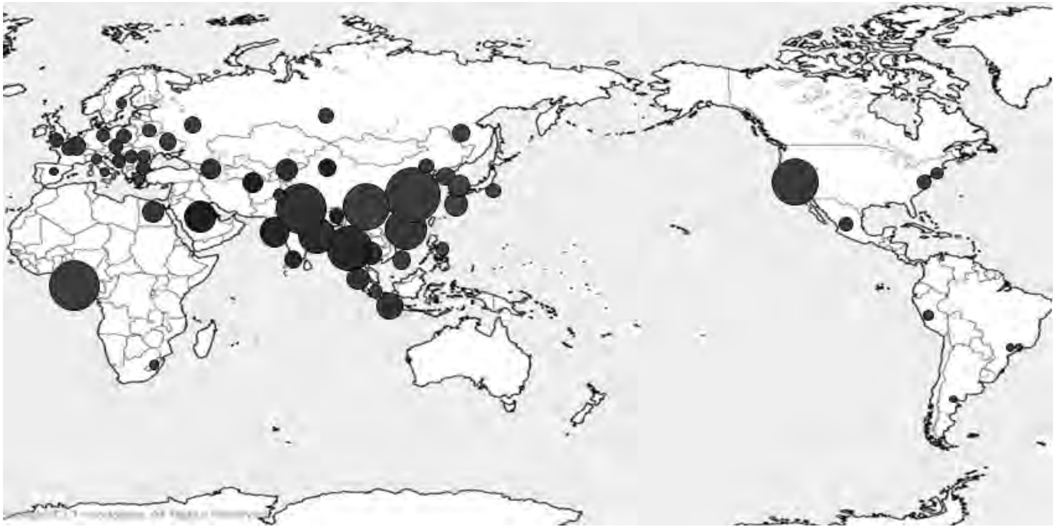


Figure 3: Mapping AOD and ANG

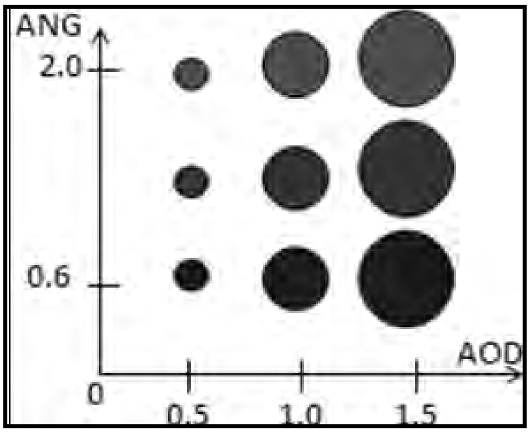


Figure 4: Legend for figure 3

2.1.2 Scatter plot

Figure 5 is AOD-ANG scatter plot. A point is average and a bar is standard deviation. This result shows air condition is divided there characteristics –the environmentally friendly city (European cities, Tokyo, New York, etc.) · the city influenced artificial aerosol (Shanghai, Lagos, etc.) · the city influenced natural aerosol (Kabul, Baghdad, etc.). Figure 6 shows three atmosphere characteristics.

Around green Area is the environmentally friendly city, around red area is the city influenced artificial aerosol and around blue area is the city influenced natural aerosol**.**

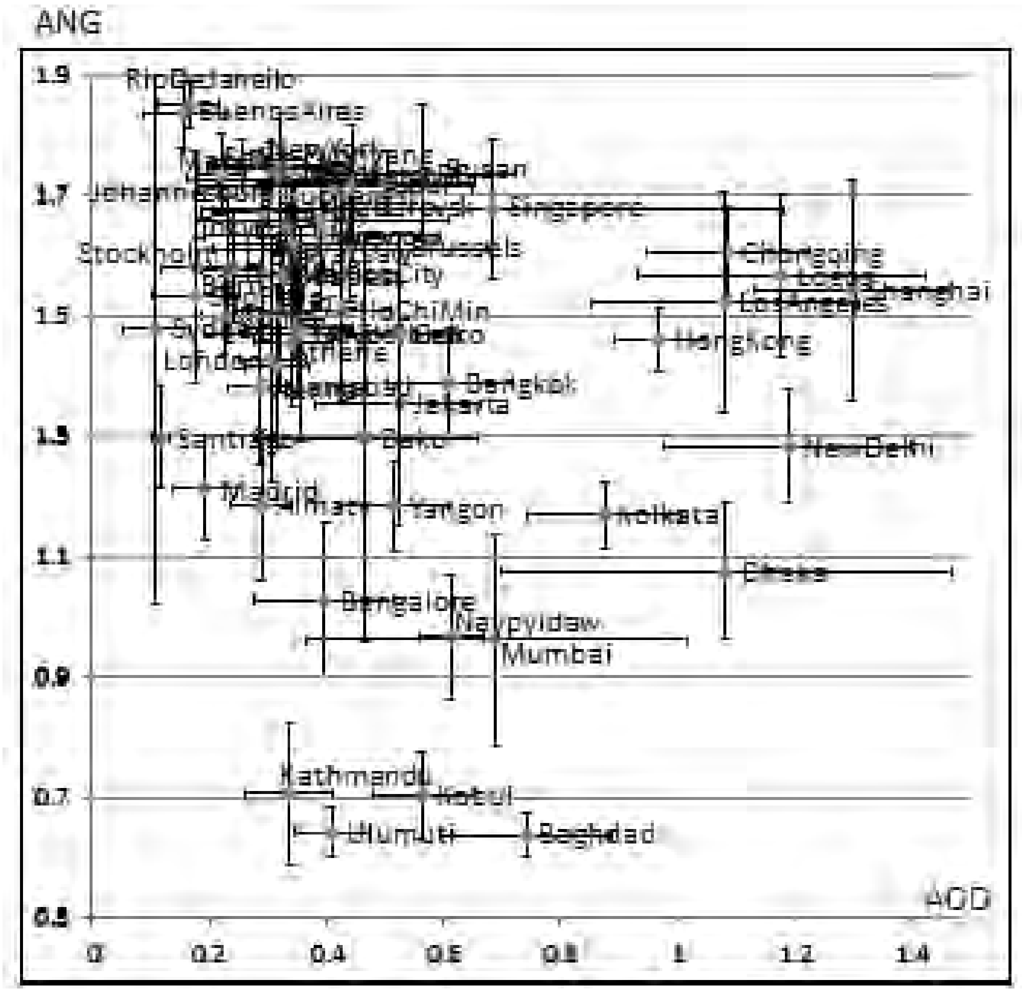


Figure 5: AOD-ANG scatter plot

2.2 RGB data

By using the result of 2.1.2, the reference point is determined. Table 2 shows the value of AOD, ANG, R, G and B. Figure 7 shows a method to refer to Yamagata et al. (1997).

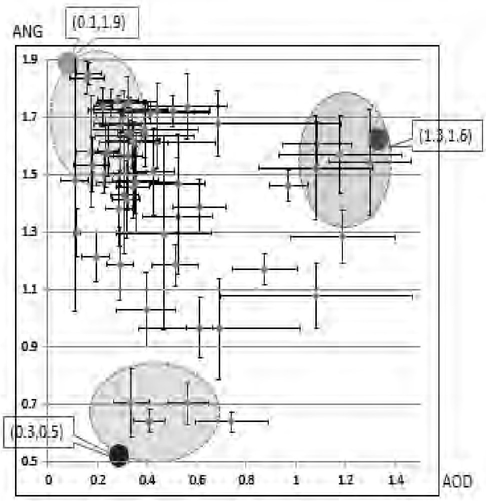


Figure 6: Three atmosphere characteristics

Table 2: Each value of each color point

Point	AOD	ANG	R	G	B
Red	1.3	1.6	255	0	0
Green	0.1	1.9	0	255	0
Blue	0.3	0.5	0	0	255

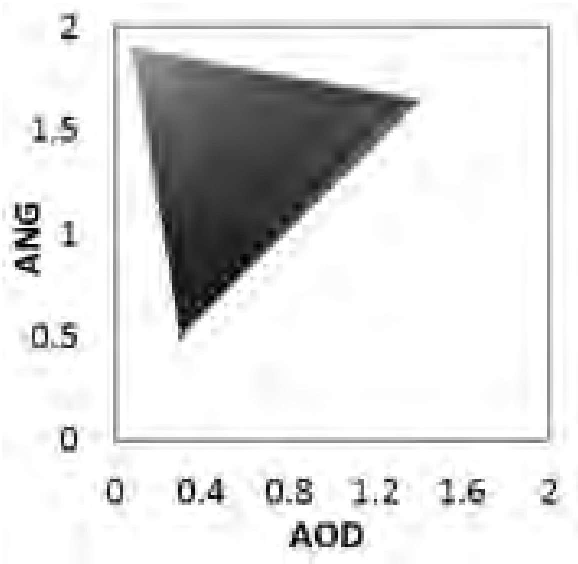


Figure 7: Legend of RGB

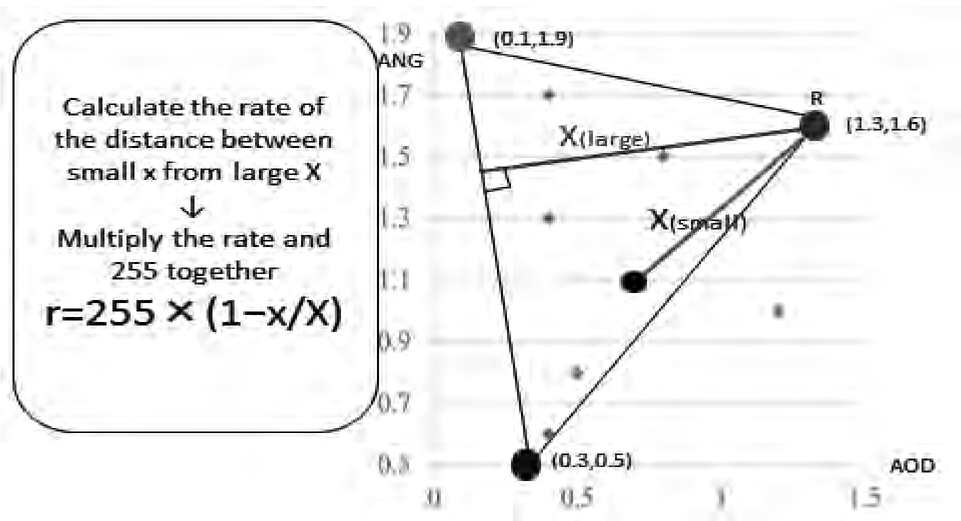


Figure 8: Method of RGB transformation

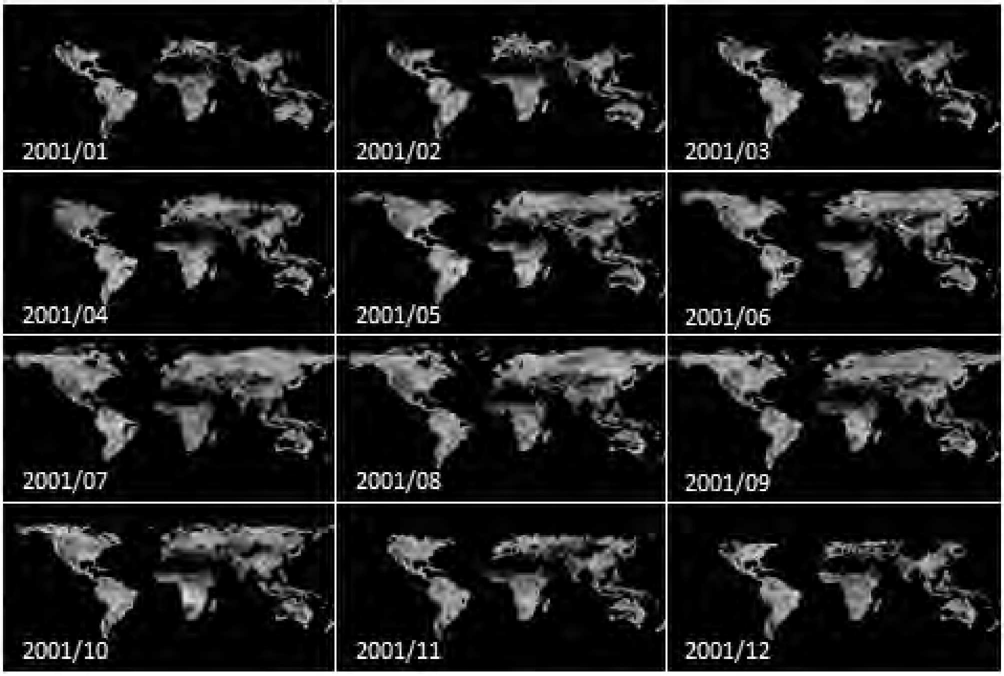


Figure 9: RGB data in 2001(monthly average)

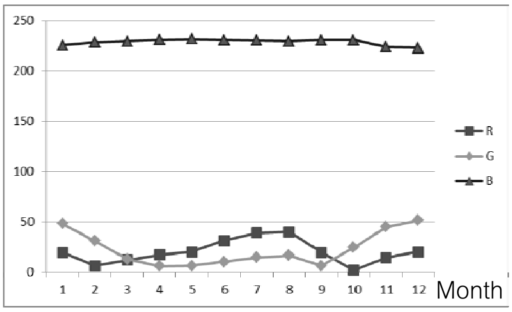


Figure 10 Around Kabul of monthly average

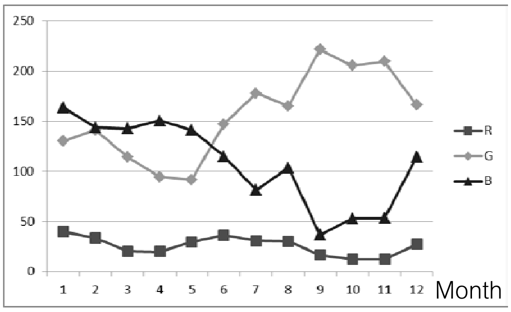


Figure 11 Around Tokyo of monthly average

Kabul, Tokyo and Shanghai are chosen as the standard place of RGB. Figure 10 shows the RGB data of 10 years monthly average around Kabul, figure 11 is around Tokyo and figure 12 is around Shanghai. Figure 10~12 are found characteristic of each city. Figure 10 shows the value of B is the biggest all year round. This means around Kabul is influenced natural act all year round but the air is steady. Figure 11 shows in spring the value of B is the biggest but in autumn and winter the value of G is the biggest. In addition, the value of R is the smallest and steady. This means artificial aerosol is steady all year round and air is clean. Figure 12 shows the value of B is the biggest except summer and the value of R is bigger than that of Kabul and Tokyo. This means the air around Shanghai is the dirtiest.

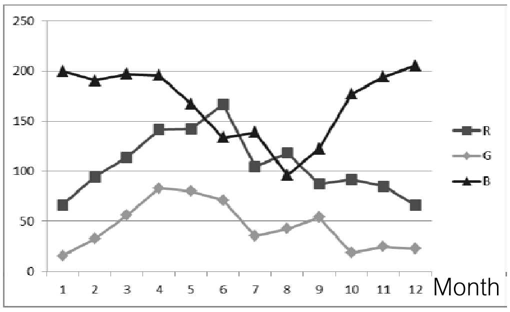
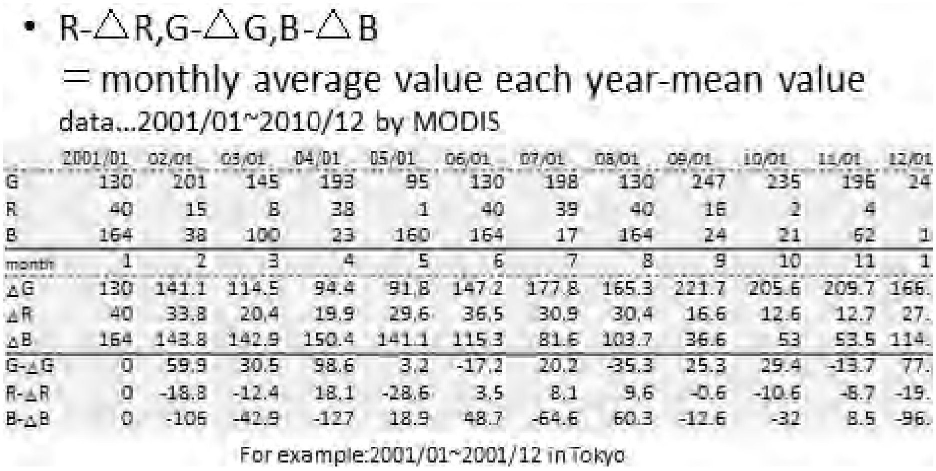


Figure 12: Around Shanghai of monthly average

2.3 Secular change of RGB

Secular change of RGB is analyzed around Kabul, Tokyo and Shanghai.



- R-△R,G-△G,B-△B
  = monthly average value each year-mean value
  data...2001/01~2010/12 by MODIS

	2001/01	02/01	03/01	04/01	05/01	06/01	07/01	08/01	09/01	10/01	11/01	12/01
G	130	201	145	193	95	130	198	130	247	235	196	24
R	40	15	8	38	1	40	39	40	16	2	4	
B	164	38	100	23	160	164	17	164	24	21	62	1
month	1	2	3	4	5	6	7	8	9	10	11	1
△G	130	141.1	114.5	94.4	91.8	147.2	177.8	165.3	221.7	205.6	209.7	166.
△R	40	33.8	20.4	19.9	29.6	36.5	30.9	30.4	16.6	12.6	12.7	27.
△B	164	143.8	142.9	150.4	141.1	115.3	81.6	103.7	36.6	53	53.5	114.
G-△G	0	59.9	30.5	98.6	3.2	-17.2	20.2	-35.3	25.3	29.4	-13.7	77.
R-△R	0	-18.8	-12.4	18.1	-28.6	3.5	8.1	9.6	-0.6	-10.6	-8.7	-19.
B-△B	0	-106	-42.9	-127	18.9	48.7	-64.6	60.3	-12.6	-32	8.5	-96.

For example:2001/01~2001/12 in Tokyo

Figure 13: Method of secular change

Figure 13 shows method of secular change of RGB. This result is Figure 14~17 below.

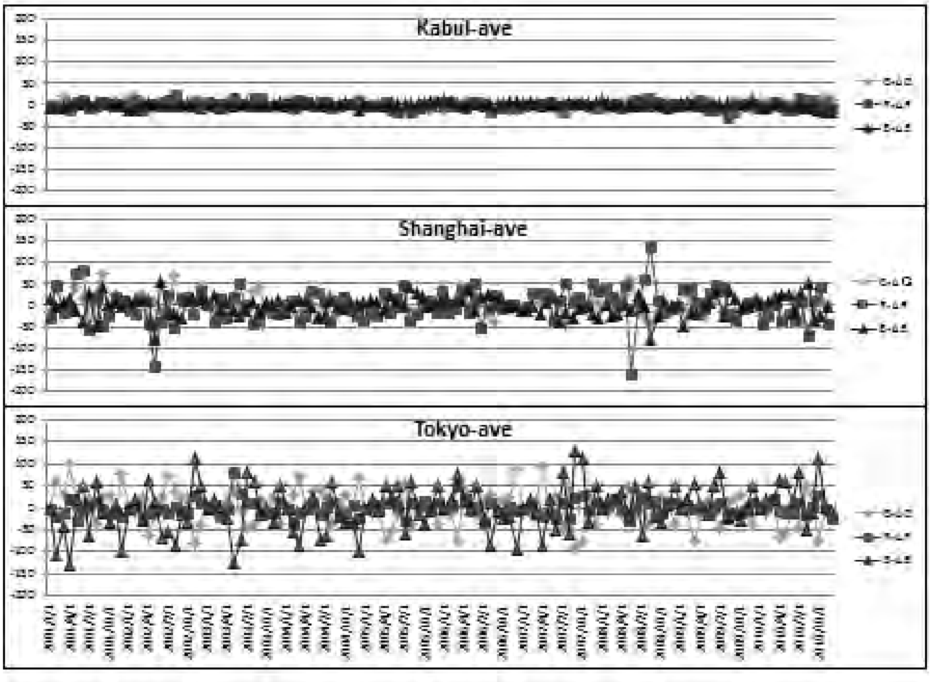


Figure 14: Secular change of three cities

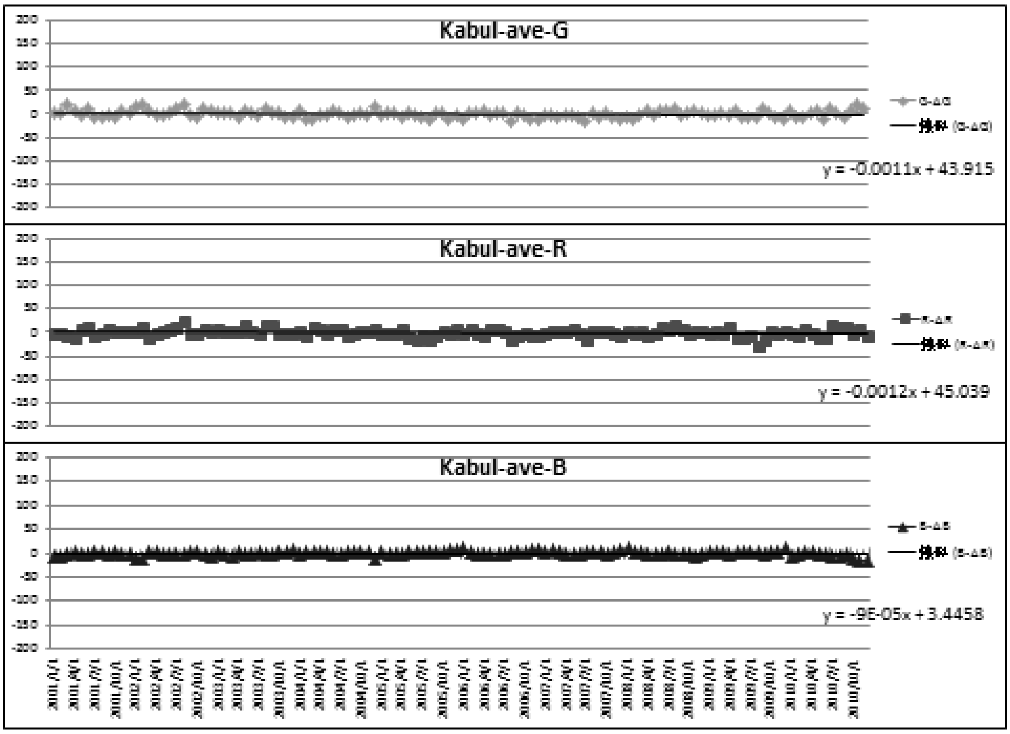


Figure 15: Secular change of Kabul

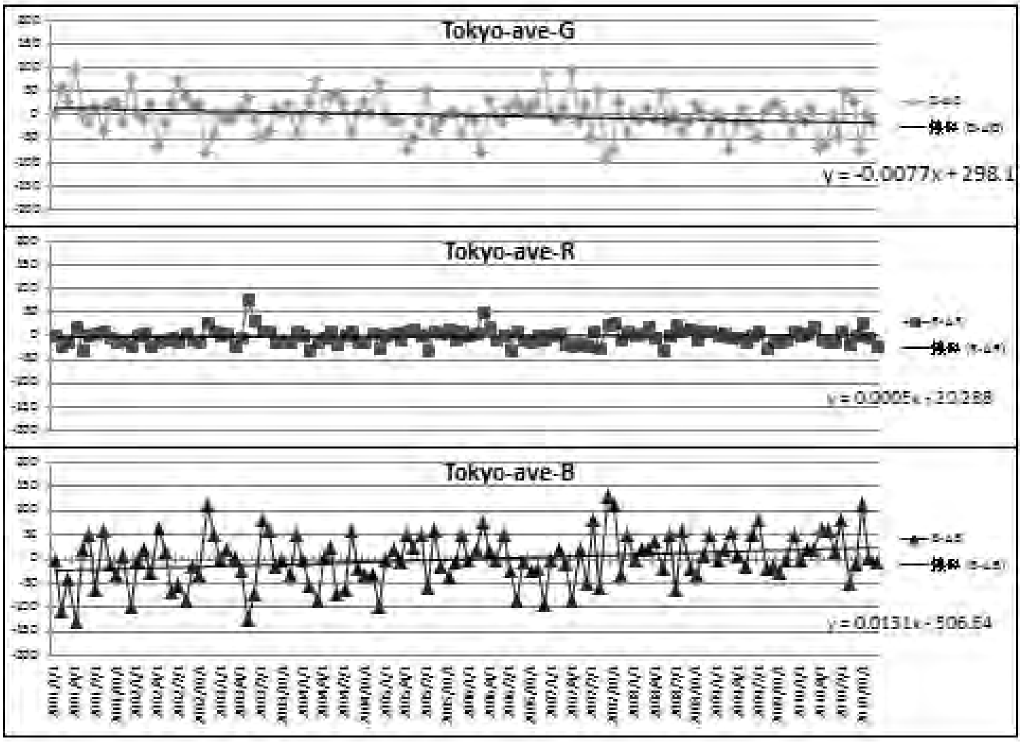


Figure 16: Secular change of Tokyo

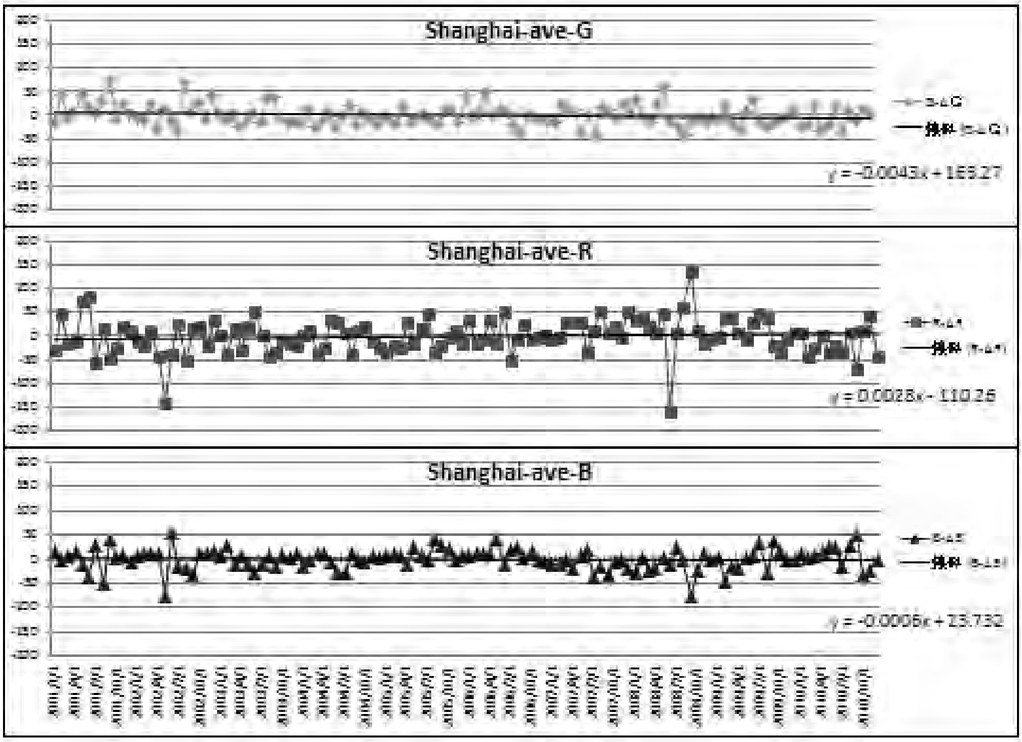


Figure 17: Secular change of Shanghai

Figure 14 shows secular change around Kabul is less than that of Tokyo or Shanghai. Figure 15 shows each value of RGB hardly changes. This means The air condition in Kabul has been steady from 2001 to 2010. Figure 16 shows tha value of B is changing greatly. This means natural effect may be increasing year by year. Figure 17 shows the value of R is more incresing year by year than that of G and B. This means something of human act may increase.

3. CONCLUSION & FUTURE WORK

AOD and ANG can be understood visually by mapping or scatter plot. 61 cities in the world is divided three atmosphere characteristics –the environmentally friendly city, the city influenced artificial aerosol, the city influenced natural aerosol-. It is clear air condition all over the world is close to three characteristics. Focusing on the unit of city, the superiority of RGB is different with seasons and the combination of cross values (R&G, G&B, and B&R) is different with cities. Secular change may be characteristic each city or region. It is clear some value of RGB is changing year by year.

As future work, it needs adding NO2 that comes from exhaust gas as an index to analyze the value of red means the effect of artificial origin including natural fire and exhaust gas. In addition, inventory data mixture these results to research whether there is a relation between these results and real ground activities.

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STRUCTURAL EQUATION MODELS REGARDING TO INTER-CITY VAN TRANSIT IN THAILAND: A CASE STUDY OF DIFFERENCE OF TRAVEL DISTANCE

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ABSTRACT

In the recent years, public van transit has been grown up with decreasing in public bus ridership. Therefore, the situation seems to be more critical when public bus providers decided to cancel the service and invest more on the van. However, the van service is notable in such dangerous to get accidents. Many passengers cannot accept this risk and still looking forward to take the public bus. Hence, understanding the attitudes of van passengers might be necessary for the next move. Most of studies about the van completed with urban transportation, thus, the gap of some fields of knowledge is still appeared. To fulfill this gap, the study with longer traveling of the public van need to be proceeded. An inter-city type of the public van should be appropriated. Short-distance and long-distance inter-city van transit are obvious to see the difference of individual's attitudes. Structural equation modeling (SEM) has been selected to be the measured tools of this study. Its advantages are helpful and suitable with all attitudinal and behavior studies. By using a questionnaire survey applied to inter-city van transit passengers, 2 SEM models which are different by scope of the study were conducted. One was for the travel within 100 km of distance while the another was responded to a traveling between 100 km to 250 km. Moreover, willingness to pay (WTP) attitudes were included in the study to extend more possible details beside the basic attitudinal variables. The findings were what the situation be. Passengers who are careless to safety and WTP will accept the van service. But the interested result was that serviceability is important to short-distance traveling while convenience should be managed for long-distance journey. The countermeasures were also suggested to improve the van transit and make the public open their mind to the better service.

Keywords*: attitudinal data, inter-city transportation, public transportation, road safety, structural equation modeling, van transit, willingness to pay.*

1. INTRODUCTION

Thailand, the developing country of south-east Asia has been improved economic and transportation system from time to time. We have public transit providing by vans. Normally this mode of transportation is not famous to carry mass passenger. However, when the van was used as the public transit, it attracted passengers by its serviceability and flexibility. Therefore, an idea to use vans as a transit vehicle is becoming popular for service providers especially to the public bus providers. The result of policy change in many companies resulted in reduction of the public bus services, moreover, in some provinces have been canceled the former buses. The trend seem to be a gradually change from the bus to the van. But the van service has been noticed in such dangerous to get an accident easily. Furthermore, many sources found that public van operators use excessive speed over the limit. While some passengers cannot accept the risk of the van service, then canceling the bus service is inappropriate. Before making the future decision, understanding the attitudes of van passengers might be necessary to support the shifting plan. Because of investment in public services affects to national transportation and commuting, it should be careful to avoid economic drawback when we have to return to invest on buses. Thus, the objective of this research is to investigate attitudinal factors that influence passengers to use the van service and prioritize what the van passengers need. However, most of studies about the van have been finished about urban services. Hence, the gap of some fields of knowledge is still appeared. To react to the current situation, the study with longer traveling of the public van is a good choice. Thus, an inter-city type of the public van was selected. Short-distance and long-distance inter-city van transit were picked as the scope of the study to differentiate individual's attitudes.

2. RELATED STUDIES

Because of this study has the unique characteristics (the van transit has been used majorly only in Thailand), a few research papers are close to. However, according to attitudinal and behavioral studies, structural equation modeling (SEM) technique is becoming popular to use as the analysis tool. This study attempted to achieve the result of inter-city van passenger's thought by using this modeling analysis. Moreover, even though foundations of safety and department of land transportation of Thailand have been propagated how dangerous of the van transit is and also used more advance speed detectors to reflect and enforce the service, but the van passengers are still use the service and some van transit operators keep find the way to break the speed limit without be able to detect. Thus, willingness to pay of van passengers can be the one of indicators to investigate the service acceptance and also display to the impact on service satisfaction. Thus, research papers about structural equation models on transit services and willingness to pay (WTP) have to be involved.

2.1 Transit usage studies

Kunasol (2000) studied about the factors that related to the use of urban van transit by passengers. He suggested that passengers in developing counties require transport services which can give then the high level of flexibility. Therefore, the service also can adept itself to satisfy the passenger's need. By use of utility theory, passengers were asked to rate the score and weight important level on each van characteristic. He found that only travel time and convenient factors were necessary for daily transit van satisfaction. However, utility theory cannot investigate how correct and possible of attitudes factors that were used in the models. Thus, SEM is an alternative. This method can test a model as overall linear combination and specify observed variables into latent variables (Thomus F. and Golob, 2001). Another thing is SEM can test causal hypotheses and can customize its components flexibly by appropriate assumption. And because of WTP variables may include both of revealed preference and stated preference data, SEM can allow jointing of their error terms. Fillone et al. (2005) used this technique to assess the variables which affected to mode selection behavior. By addition of demographic variables, they concluded that demographic characteristics were greater influenced to consider traveling rather than the mode characteristic. However, to encourage passengers the use the public service, safety, security, convenience, accessibility and reliability were the things which should be conserved and improved. Most of structural equation models were conducted under using of questionnaire survey. Due to many types of data that can be analyzed by the method, agreement (Likert's scale), interval scale and also integer scale are all usable. Investigation of public transportation by Ngatia et al. (2010) was the study that aim to measure overall satisfaction of transit services in Kenya (in summarized of both bus and Matatus, the minibus). Therefore, the influenced factors were found by using structural equation technique. Latent variables of service quality, safety, and travel cost were the major impacts of overall transit service satisfaction. Matatus is close to the van transit in Thailand. Consequently, it makes traffic congestion and has risk taking behavior of drivers. But it is very popular because of its flexibility.

2.2 Willingness to pay studies

In the current study, WTP takes place as the one of latent variables of all SEM models. The way to select the question on the questionnaire is very important. Normally, the best solution to adjust the model that was insignificant is editing of questionnaire until the model has passed. Thus, careful design of the questions is the key to avoid loss of time and funds. However, the inventory data of inter-city van transit in Thailand have been disabled so that use of contingent valuation method to conduct WTP in stated preference is impossible. Svensson (2009) said revealed preference approach is more actual and reliable. However, it is not flexible because of its use depends on the context of a public investment. While the reviews of Kahneman et al. (1999) found that stated preference questions are better for attitude expression. In case of valuation exercise, closed-end survey will be valuable if it uses with subsequent of the same question either revealed preference or stated preference (Horowitz, 2005). In addition, the provision of WTP questions should be concern. Public-related question will give the result different from the private-related question. However, Svensson and Johnsson (2010) followed the economic theory that a selfish individual should give the same WTP values of both public and private goods on risk reduction. Therefore, a pure altruist should have the value of public goods higher than private goods. But the result did not follow the assumption condition which the private WTP were around three times more than public WTP (by using a contingent valuation survey). Thus, both private and public provision questions will be used in the current study to attempt the best solution. Nevertheless, when use for public purposes, the WTP elicited scenario should also be in public.

3. METHODOLOGY

The data of attitudes of inter-city van passengers was collected from November, 2012 to February, 2013. This cross-section data carries demographic characteristics and individual's agreement on each factor that might affect to overall satisfaction (by assume that the service usage is under the basic of transit mode satisfaction). By using of interviewing questionnaire survey in total 8 representative provinces and Bangkok, 906 samples were picked which around 879 samples were completely filled in. Therefore, the scope of the study has been anticipated to separate into 2 definitions, short-distance inter-city van traveling which allocates under 100 km and long-distance inter-city van traveling which allocate beyond 100 km to 250 km from Bangkok. Figure 1 displays the area of each scope of the study. However, 444 fulfilled samples were used for short-distance analysis while another 435samples were used in long-distance calculation.

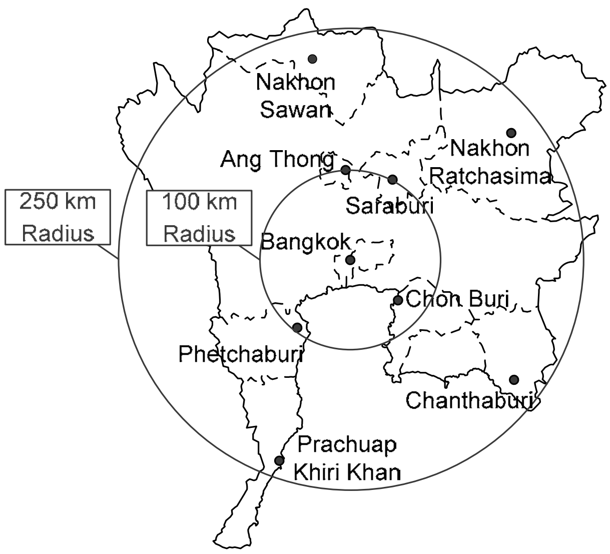


Figure 1: The study areas and data collection locations

In this study, the tool to develop the models of inter-city van transit usage attitudes is SEM. Every input data should be treated as scale variable or dummy variable. Table 1 shows up all possible variable in the models both observed variables and latent variable followed the influent assumption in Figure 2. However, under certain direction of the study, factor categorization is obviously match with using of confirmatory factor analysis (CFA). Thus, CFA was used as the measurement model to indicate usable factors which will be able to develop each SEM model.

Table 1: The detail of variables in SEM models

Variable type	Latent variable	Observed variable	Remark	Scale
Dependent variable	-	overall satisfaction		5-scale (score)
Independent variable	Demography	female		Dummy
		age		6-scale (interval)
		family status		3-scale (level)
		provincial hometown		Dummy
		education level		8-scale (level)
		workability	Currently working	Dummy
		monthly income		6-scale (interval)
Independent variable	Convenience	privacy		5-scale (agreement)
		accessibility		5-scale (agreement)
		connectivity		5-scale (agreement)
		conditioner		5-scale (agreement)
		seat comfort		5-scale (agreement)
		attractiveness		5-scale (agreement)
		station comfort		5-scale (agreement)
		flexibility		5-scale (agreement)
	Safety	belt usage avoidance		5-scale (agreement)
		dangerous speeding		5-scale (agreement)
		feel about get off risk		5-scale (agreement)
		over capacity		5-scale (agreement)
		security weakness		5-scale (agreement)
	Serviceability	PREtime satisfaction	PRE ▸pre-mode	5-scale (agreement)
		OVtime satisfaction	OV ▸on-vehicle	5-scale (agreement)
		POStime satisfaction	POS ▸post-mode	5-scale (agreement)
		PREcost satisfaction	PRE ▸pre-mode	5-scale (agreement)
		OVcost satisfaction	OV ▸on-vehicle	5-scale (agreement)
		POScost satisfaction	POS ▸post-mode	5-scale (agreement)
		schedule information		5-scale (agreement)
		service rate		5-scale (agreement)
		reliability		5-scale (agreement)
	Environment	energy saving		5-scale (agreement)
		pollution reduction		5-scale (agreement)
		congestion reduction		5-scale (agreement)
	WTP	attitudinal WTP		5-scale (agreement)
		ACCinsurance owing	ACC ▸accident	Dummy
		ACCinsurance WTP	ACC ▸accident	5-scale (level)

Figure 2 displays the ideal SEM model under the assumption that each service characteristics can influence passengers to use the inter-city van transit beside demographic characteristics. Moreover, WTP can lead passengers to think about the service as well. Thus, WTP might relate to each service characteristics implicitly and individually. In addition, all observed variables should be tested by CFA first to group the variables under their categories, then the remaining factors after adjustment will be able to build up the SEM model. Figure 3 shown the example of CFA result of measurement.

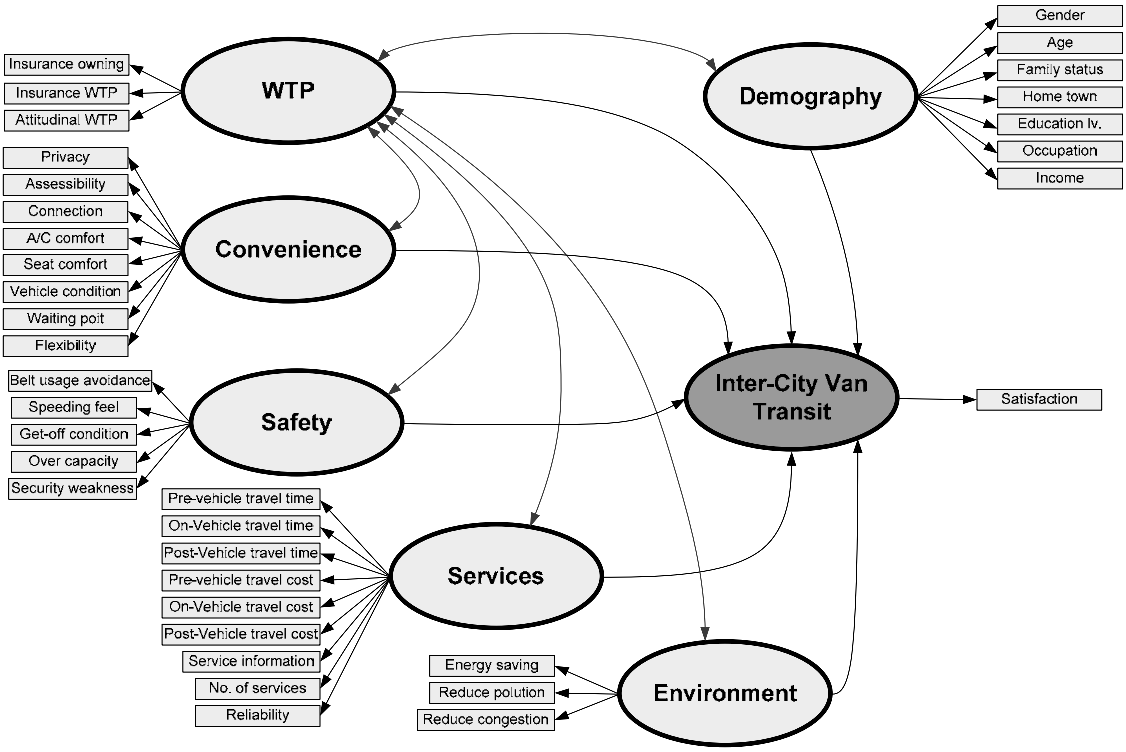


Figure 2: The ideal SEM model regarded to the assumption

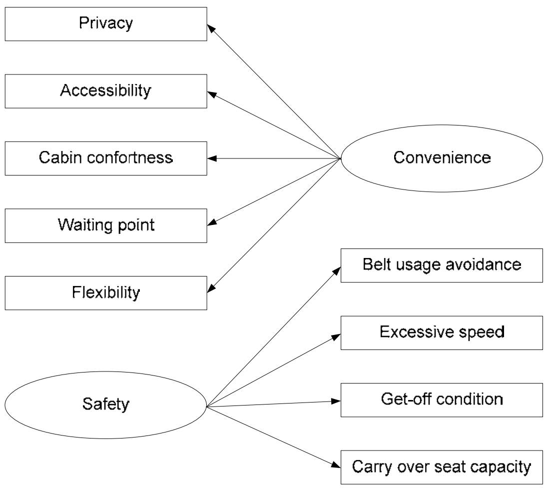


Figure 3: The example of CFA result of measurement

About the accuracy of the model, Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), Goodness of Fit Index (GFI) and Adjusted Goodness of Fit Index (AGFI) will be used to indicate the model fit. Based on Shi et al. (2011), the model will be significant when RMSEA is less than 0.08, and CFI, GFI and AGFI are above 0.90, also P-value is higher than 0.05, and CMIN/df is lower than 3.

4. INITIAL DATA ANALYSIS

For the overall respondents, inter-city van transit users were around 60% female. And 40% of their age were 20-29 years old. Most of them were single in family status (almost 60%). Therefore, passengers who have their hometown outside Bangkok and perimeter were the main population of the van users. Around a half of passengers got or was still studying bachelor degree. However, their occupations were students (almost 27%) following by merchants (or handle own business) and company staffs with the same rate (just above 20%). For relative monthly income, more than one third of passengers got 10,000 to 19,999 Thai baht per month while another just over one third got the income lower than 10,000 Thai baht per month. Moreover, passengers who are rarely use the service (lower than 2 days per month) were the main group around 38% of the service's passengers. By the way, the average satisfaction score of inter-city van transit was 3.34 out of 5, somewhere between medium and pretty high.

5. ATTITUDINAL DATA ANALYSIS

Because observed variables on each journey phase might appear in the models. Thus, to make clearer vision about journey characteristic of inter-city van transit, Figure 4 demonstrates how passengers travel from their origin to their destination. The attitudinal analysis features with 2 SEM models which calculated separately. Therefore, the outcomes were as follows.

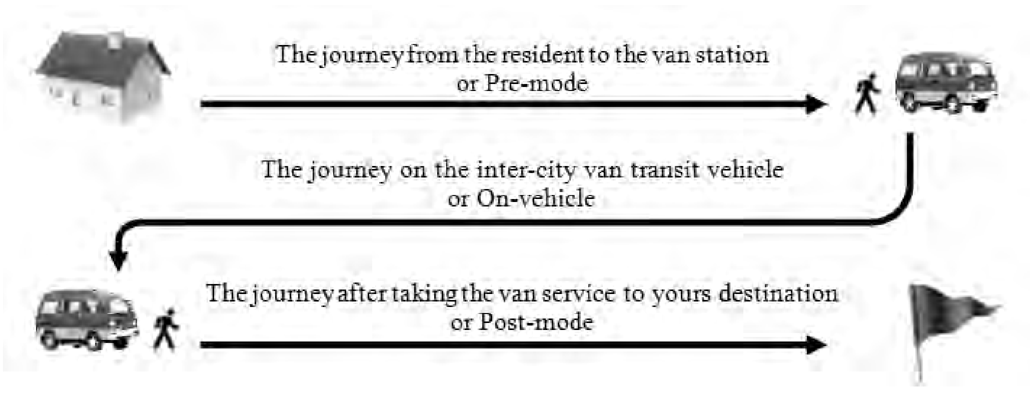
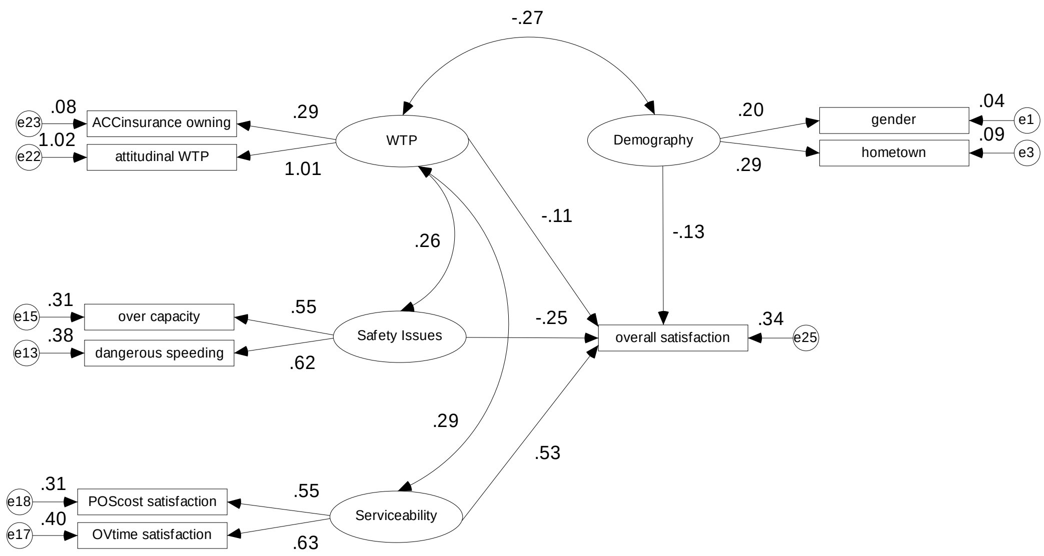


Figure 4: The journey characteristic of inter-city van transit

5.1 Short-distance traveling model

CFA test for short-distance observed variables was fine. Only some of them were removed to satisfy the model fit. Regarding to follow the result of

CFA, SEM model was developed by the grouping results on each category. By cut-off basic strategy, an adjustment provided the outcome only influenced factors under the primary assumption. Figure 5 shows the result of SEM model which all significance measurement values were all appropriate.



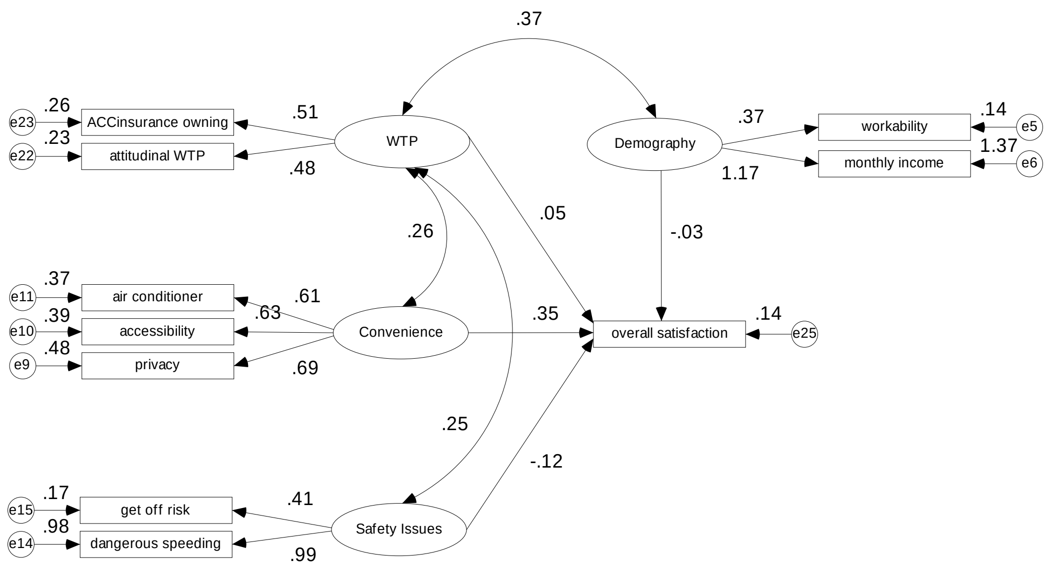
Chi-square = 16.251, df = 21, p = .755, CMIN/df = .774
RMSEA = .000, CFI = 1.000, GFI = .992, AGFI = .983

Figure 5: The SEM model of short-distance inter-city van transit

From the figure, WTP of short-distance inter-city van transit passengers accorded with other latent variables with the same rate (absolute values). However, riskier services and higher serviceability can force passengers to have more WTP (anticipated to support their life and improve the service). Therefore, female and provincial passengers may have lower WTP. Nevertheless, WTP did not inversely relate enough to believe that higher WTP passengers will attempt to avoid the van service (that indicate only by overall satisfaction of the service). Demographic variables also acted in the same way. Only serviceability and safety issues can obviously influence passengers to think about using the van service. Firstly, passengers will consider serviceability at the major factor to pick the inter-city van transit for traveling. Then unsafe condition will be the secondary factor to care about. Therefore, a better van service can catch higher demand of passengers while a riskier van service might make passengers to avoid the service.

5.2 Long-distance traveling model

For long-distance inter-city van transit, CFA test of observed variables reached the significant level of model fit requirement by factor elimination. Thus, SEM model was developed by the grouping results on each category following the result of CFA. After adjustment, the proper SEM model contented with the variables under the primary assumption and structure. Figure 6 displays the final SEM model of this scope.



Chi-square = 38.220, df = 29, p = .118, CMIN/df = 1.318
RMSEA = .027, CFI = .981, GFI = .983, AGFI = .967

Figure 6: The SEM model of long-distance inter-city van transit

The figure above shows the result that WTP had the direct relation with demographic characteristics. Therefore, passenger who is workable or gain higher monthly income might respect higher WTP. While riskier services and higher serviceability can force passengers to have more WTP (anticipated to support their life and improve the service). However, the impacts of WTP and demographic characteristics to the service usage were considerably low. For a longer distance service, first thing that passengers look forward was convenience. The loading factor of this latent variable 0.35 that was the highest among the other. Therefore, passengers will be more satisfied with a better convenient inter-city van. Oppositely, the minor influence which can affect passengers to avoid the service was the unsafe condition. This latent variable can mainly indicate by dangerous speeding behavior (observed variable) which gained the loading factor value of 0.99 to the factor of safety issues. Moreover, bad get-off condition (which can make passengers get the accident by stopping not close to stations or footpath) affected to safety issues only 40% of speeding behavior.

6. CONCLUSIONS

According to the results, inter-city van transit passengers are the persons who need the extreme advantages to deal with the time frame and comfort problems. However, they neglect the most importance factor in transportation, the safety. Even though the traveling is short or long, they prioritize the factor of safety as secondary. Thus, the possible reason is they can accept the risk that they will receive. Therefore, they can probably take the service as long as they can accept to dangerous speeding behavior, risk of getting off from the service vehicle and carrying passengers more than the capacity of van. There is a attitudinal differentiation between 2 formats of travel distance. Hence, short-distance traveling requires time control and inter-city van transit that can reach the transfer points which passenger can continue the journey with the cheaper transport mode. Therefore, serviceability of the van service should be reserved or improved to attract passengers. On the other hand, long-distance inter-city van transit should focus on convenience deeply. Passengers should be treated as they can feel like they are sitting in their private car. Moreover, accessibility is the factor to be considered. Passengers will be satisfied when they can reach the service easier. Lastly, for longer traveling, passenger's endurance is limited. Thus, air conditioner inside the service vehicles should work properly to make passengers feel relax and comfort.

7. RECOMMENDATIONS

Passengers of inter-city van do not consider safety as a first priority until they got an involvement of crash accident. Indeed, this group of inter-city transit user usually concentrates to how quick and convenient they can get. Thus, the idea of using passive countermeasure is more appropriate. The better approach is to educate the public to wake up on safety. Passengers should reach an effective service which they can feel it is safer than before. By avoidance of use and resistance from the public, service providers have to improve their service to satisfy a need of passengers. The another countermeasure can be implemented by using encouragement of inter-city transit safety. Making the service providers believe that inter-city van transit can be provided in higher quality and safety standard with subsidization from the government such as taxation reduction. Alternatively, the money from charity foundation can help to improve the service as well (because there is not any effort from passengers to pay the aid).

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BASIC RESEARCH FOR QUANTITATIVE ANALYSIS OF OIL-CONTAMINATED SOIL PURIFICATION BY MICROORGANISMS

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ABSTRACT

Recently, environmental damages are becoming serious in countries all over the world. This sometimes directly affects our health. It is necessary to estimate the environmental risk quantitatively and to establish the technology for purification of contaminated materials. Especially the necessity of purification technology of oil is growing, considering the trend of excluding fossil fuel. In this research, for the quantitative evaluation of the remediation of oil contamination, basic study was conducted.

A technique of "bioremediation" which purifies contaminated soil by the function of microorganisms is getting attentions. Bioremediation studies in the laboratory as well as in the field have been carried out so far, but quantitative evaluation of decomposing process of the oil contamination is still the least understood. A package of numerical analysis called BioDuCOM was developed by Ishida (2003) to simulate decomposition of organic wastes by aerobic microorganisms. In order to upgrade this BioDuCOM, basic element tests have been conducted.

In the element tests, temperature, soil type and water content were changed to examine a rate of oil concentration in soil. As a result, change in oil concentration was strongly influenced by volatilization rather than biodegradation. And also the temperature changes affected a lot.

***Keywords**: bioremediation, microorganisms, quantitative analysis, contaminated soil by light oil, GC-MS.*

1. INTRODUCTION

Nowadays, soil pollution is becoming serious in all over the world. It is difficult to identify and solve this problem, because underground situation can not be directly observed.

Even when the same term of soil pollution is used, there are various forms of it and of course the way to solve this problem is different by each case. Although solidification, insolubilization, chemical oxidation and physical method like incineration and excavation are often used as the way to purify soil pollution, recently "bioremediation" which utilize the action of microorganisms to decompose the polluted matters gathers attention. Advantages of this bioremediation are to be low-cost, environmentally-friendly and wide-range in application.

In Japan, the number of oil factories and gas stations are annually shrinking owing to decrement of dependence on fossil fuel energy and low profitability resulted from furious price wars. These facilities cause their underground soil polluted and it leads the risk of health hazard.

In this study, in order to invent the tool which can analyze quantitatively the process of purifying oil contaminated soil, the purpose is to clarify the reaction mechanism of oil purification by obtaining the data in elemental experiments. In past research,”BioDuCOM” was invented which can analyze quantitatively the process of composting. Therefore the final purpose is to add the model of oil-polluted soil purification to the BioDuCOM.

2. PAST RESARCH

2.1 Bioremediation

Bioremediation is defined as an environmental remediation technique which remediates polluted soil and underground water to its original state by living things activities and classified roughly into in-situ bioremediation which treats on the polluted spot and ex-situ bioremediation which uses reactors or piles up polluted soil in the place. These construction ways are selected considering construction period, pollution range, pollution concentration and pollution depth. Moreover, processing technology are chosen considering attribute of pollution matter, ground property in the place and surrounding environment.

As oil is originally derived from nature, it includes some components which are easily biodegraded. It is said that in biodegrading oil, to decompose in aerobic state is more efficient than in anaerobic state. And heavy oil and crude oil cannot be eliminated completely by only biodegradation. It is said because soil in Japan includes oil-degrading microorganism, there is no need to select bioaugmentation which is the construction way to introduce bacteria from outside that can decompose pollution matter when they are very few. Therefore in Japan, in-situ bioremediation or upgraded one to attach nutrition to activate microorganism is often applied.

2.2 BioDuCOM

Ishida et al. (1999) developed DuCOM to analyze corrosion and deterioration of concrete by thermo-hygro physics and Nattakorn et al. (2003) upgraded it to BioDuCOM dealing with organic matters. In past research, optimizing system in compost processing on a large scale was succeeded by using BioDuCOM.

During biological decomposition of substrate, a number of processes takes place simultaneously in the physical, chemical and biological domains within the compost matrix. In order to model all these primary phenomena, BioDuCOM integrates heat, moisture, oxygen and microbe system and gives optimum solution such as amount of reactant decomposition and oxygen consumption.

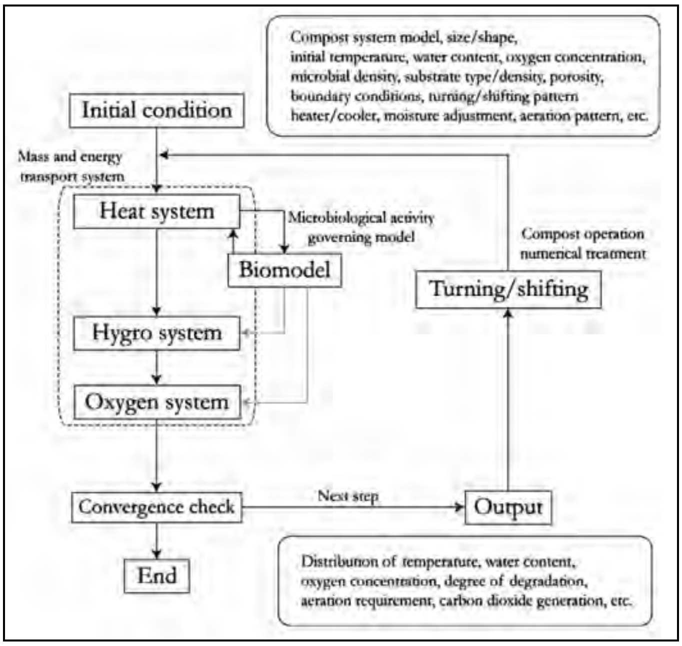

Figure 1: Flowchart of BioDuCOM system framework

2.3 Reaction mechanism of microorganism growth

Cell density, X, changes according to specified growth environment determined by the mass and energy transport models in Figure 1. Growth of microorganism is assumed to follow the batch growth scheme Michael et al. (2003). Cell density in the exponential (growth) and death phases change exponentially, while there is no net change in cell population during the lag and stationary phases. The first-order rate equation for growth in the growth scheme can be expressed by the following equation:

$$\frac{dX}{dt} = \alpha\mu X - \beta\mu_a X \tag{1}$$

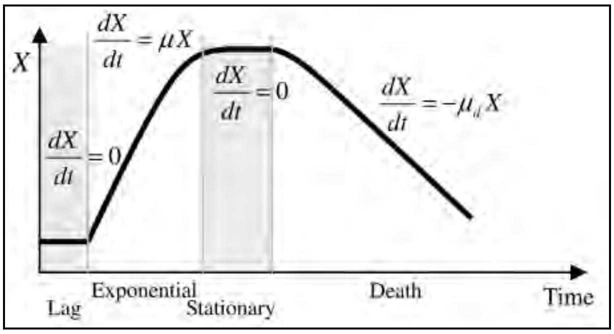

Figure 2: Typical growth curve for batch growth

The growth equation contains two terms: a growth term (the first term on the right-hand side) and a death term (the second term). X represents the cell density per unit compost volume, kg/m^3. μ is an environment-dependent specific growth rate and s^{-1}. μ_d, the equivalent death rate, s^{-1}, is assumed to be constant under whole process. Two numerical parameters, α and β, are introduced to numerically control both terms on the right-hand side of the growth equation. Both parameters possess either value of unity or zero at the corresponding growth phase. This gives the advantage of freedom in defining the growth phase based on changing environmental conditions. In lag and stationary phases, α and β are both zero; in exponential phase only a is unity; in death phase only b is unity. It is assumed that the growth phase changes from exponential phase to stationary phase when substrate, S, is completely degraded.

Many important factors influence the composting process; some of them have been identified as playing major roles in controlling microbial growth: temperature, availability of water, oxygen concentration, substrate concentration, and inhibitors. Based on these five factors, environment-dependent growth rate can be expressed by the following equation in multiplication form:

$$\mu = \mu_T(T) \cdot f_{O_2}(O_2) \cdot f_{H_2O}(\theta) \cdot f_S(S) \cdot f_I(I) \qquad (2)$$

where μ is the environment-dependent specific growth rate, s^{-1}, μ_T(T) the temperature-dependent maximum specific growth rate, s^{-1}, f(O_2) the oxygen reduction factor (-), f_{H2O} the water availability-reduction factor (-), f(S) the substrate-reduction factor (-), f(I) the inhibitor reduction factor (-), T the temperature, K, θ the volumetric water content, m^3/m^3, O_2 the gaseous oxygen concentration, m^3/m^3, S the substrate concentration, kg/m^3 and I the inhibitor concentration, kg/m^3. Eq. (22) consists of multipliers, which indicates that each parameter has a direct influence on the growth rate. As any parameter approaches zero, the total growth rate will be affected.

3. EXPERIMENT

3.1 Outline

Objective of the experiments was to measure how much oil in polluted soil could be biodegraded. Soil samples polluted by light oil were prepared. Type of soil, temperature, and water content of the samples were changed. These samples were put on constant-temperature and constant-humidity chamber for a month, after that those of light oil concentration were measured by test method of total petroleum hydrocarbon (TPH) with mass spectrograph. To know how much light oil was decomposed by microorganism activity, sterilized samples by autoclave were also monitored.

3.2 Preparation for experiment

Soil types used were loam soil collected in Tokyo University and Seed developed at collaborative company Vioce. Seed included many oil-degrading microorganisms and nutrients such as nitrogen and phosphate which were used to activate microorganisms. Samples were made by combining these two types of soil. Sterilized and not sterilized samples were prepared for each pattern. Sterilization was conducted in 120°C for 20 minutes by autoclave. Sample patterns are given in Table 1. Oil concentration in all samples was adjusted to 6000mg/kg.

Table 1: Sample patterns

Sample name	Sorts of soil	Temperature Humidity	Water content	Sterilized
LA	Loam (Seed 10%)	40°C	30%	No
LAS		90%		Yes
LAT20	Loam (Seed 10%)	20°C	30%	No
LAST20		60%		Yes
LAW50	Loam (Seed 10%)	40°C	50%	No
LASW50		90%		Yes
SeA	Only Seed	40°C	30%	No
SeAS		90%		Yes

3.3 Measuring oil concentration

Light oil concentration in soil sample was measured by test method of TPH in accordance with the oil concentration countermeasure guideline specified by Ministry of the Environment. TPH is an abbreviation of “Total Petroleum Hydrocarbon”. After extracting oil content in soil with carbon bisulfide, the extracted sample was separated by boiling point with non-polar column of a mass spectrograph GC-MS. Then, of the normal paraffin in acquired chromatogram, comparing the total peak area of all components in the boiling range between C6 and C28 to that of ASTM standard light oil in same condition, TPH concentration could be calculated.

4. RESULT AND DISCUSSION

4.1 Experiment results

Observed decrement of light oil concentration for 32 days is shown in Figure 3.

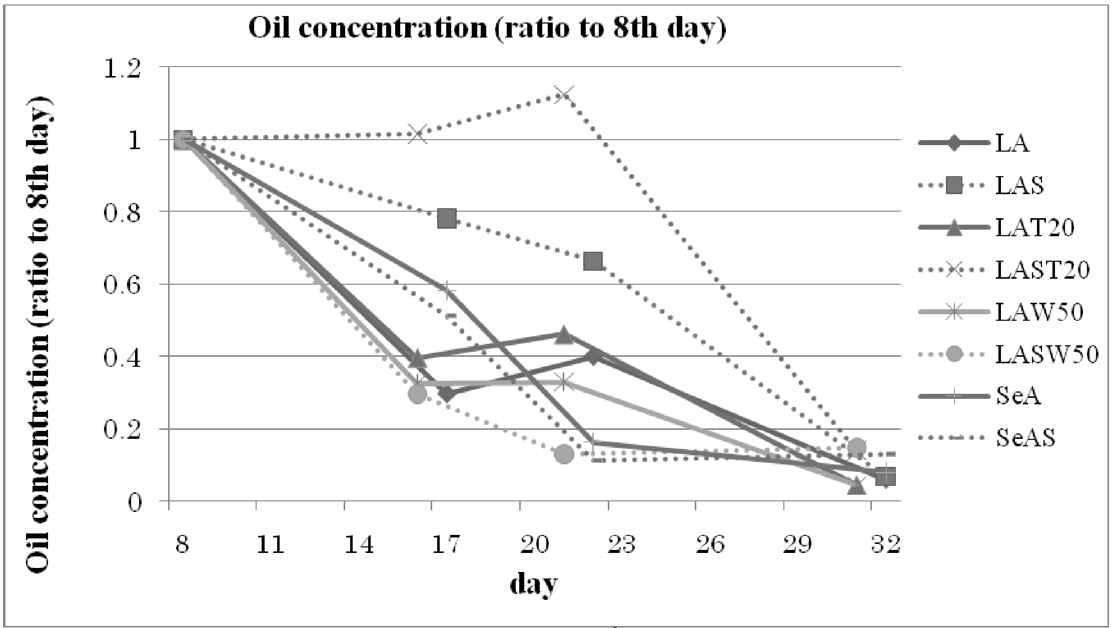

Figure 3: Oil concentration (ratio to 8^{th} day) of all samples

The vertical axis is oil concentration ratio to 8th day which is normalized. The reason which the ratio to 8th day is adapted is that in first week of this experiment the influence of volatilization is more exceeding than biodegradation therefore it was considered the first week was not useful for examining biodegradation of oil. The horizontal axis is elapsed day. The dotted lines are for sterilized samples and solid lines are for samples without sterilization. The oil concentration decrement of sterilized sample is because of volatilization and the difference between dotted line and solid line can be regarded as decrement by biodegradation.

It can be found in Figure 3 that all oil components, even sterilized ones, almost disappeared. This explains that the influence of volatilization strongly works. This is because light oil is the substance likely to be affected by volatilization, in addition to that the experiment apparatus was intended to ensure breathability therefore surface area faced to air was large and volatilization influence became large.

4.1.1 Influence of water content (Comparison between LA and LAW50)

Compared between LAW and LAW50, it could be found that biodegradation progress in 30% water content, although it didn't progress in 50%. According to past research on composting, the optimum water content is around 100%, there was a large divergence between them. It is considered that this is because the optimum water content of oil-degrading microorganism is lower than that of composting microorganism. If water in soil is higher than the optimum water content, the void in soil is filled with water, then there is a decrease in the oxygen supply to microorganism and their activity is lost. However this hypothesis has not been verified on oil-degrading microorganism, this is a future problem.

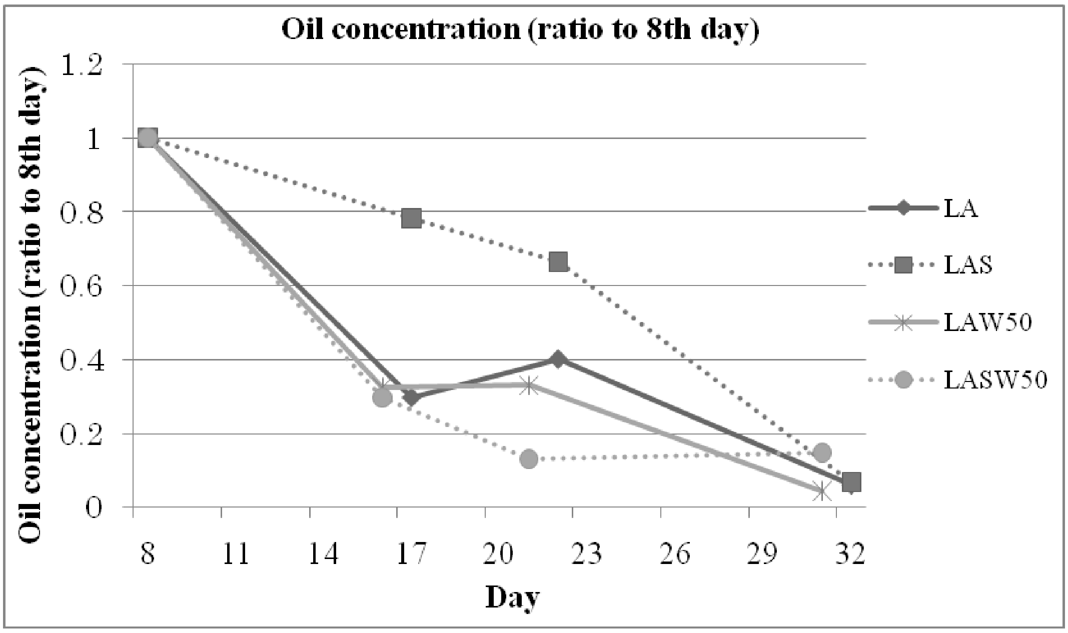

Figure 4: Oil concentration (ratio to 8th day) of LA and LAW50

4.1.2 Influence of soil type (Comparison between LA and SeA)

Compared between SeA and SeAS, the sterilized sample SeAS decomposed oil component more than not sterilized sample SeA, the reaction of biodegradation couldn't be found. It is considered that this is because SeA was composed of only seed composting, therefore excessive nutrients were included in SeA soil. N atoms invested as nutrients exist as ammonia, this ammonia easily becomes ammonia gas along increment of temperature, soil drying and so on. Ammonia gas is known as substance preventing reaction of microorganism and this phenomena is called gas injury in like agriculture sector. Table 2 shows concentration of N and P atom in LA and SeA mixed as nutrients. LA contained only 10% seed composting, on the other hand SeA was composed of only seed composting.

Table 2: N and P atom used as nutrients in LA and SeA

	N (mg/kg)	**P (mg/kg)**
LA	1800	1400
SeA	12800	10100

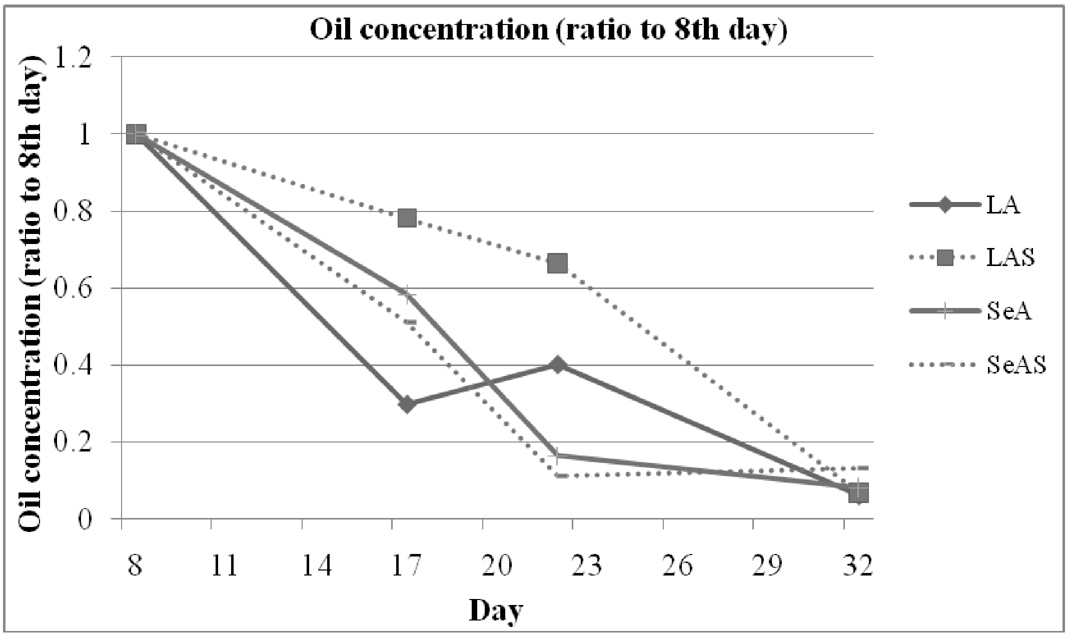

Figure 5: Oil concentration (ratio to 8th day) of LA and SeA

4.1.3 Influence of temperature (Comparison between LA and LAT20)

In regard to LA and LAT20 whose temperature was changed from 40°C of LA to 20°C, the difference by biodegradation was clearly observed. It can be read from Figure 6 that the amount of biodegradation of LAT20 is larger than LA. This result means that oil-degrading microorganism is more active in 20°C than 40°C and coincides with past research which explains the optimum temperature of oil-degrading microorganism is generally around 20°C to 30°C.

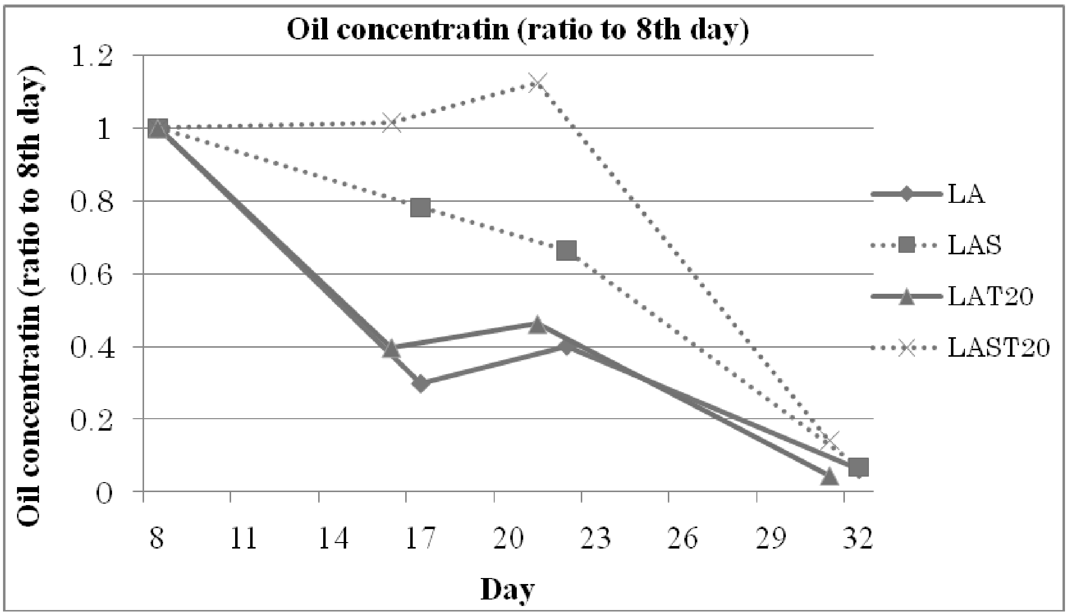

Figure 6: Oil concentration (ratio to 8th day) of LA and LAT20

4.2 Proposing a new model of BioDuCOM

4.2.1 Physical behavior

Based on these experiment results, a new model about purification of oil polluted soil was proposed. Previously mentioned, BioDuCOM expressed the process of composting by microorganisms with integration of heat, oxygen and water system. However, oil decomposition couldn't be analyzed with this model as it was, because influence of volatilization which occurred independently of biodegradation was not considered in this model. And also, it is considered that real scale pollution has light and shade of oil unlike this sample which was made uniform concentration, therefore advection and diffusion owing to this uneven concentration have to be considered. Hence a new framework is proposed in the following fig by adding past framework to physical behavior system such as volatilization, advection and diffusion.

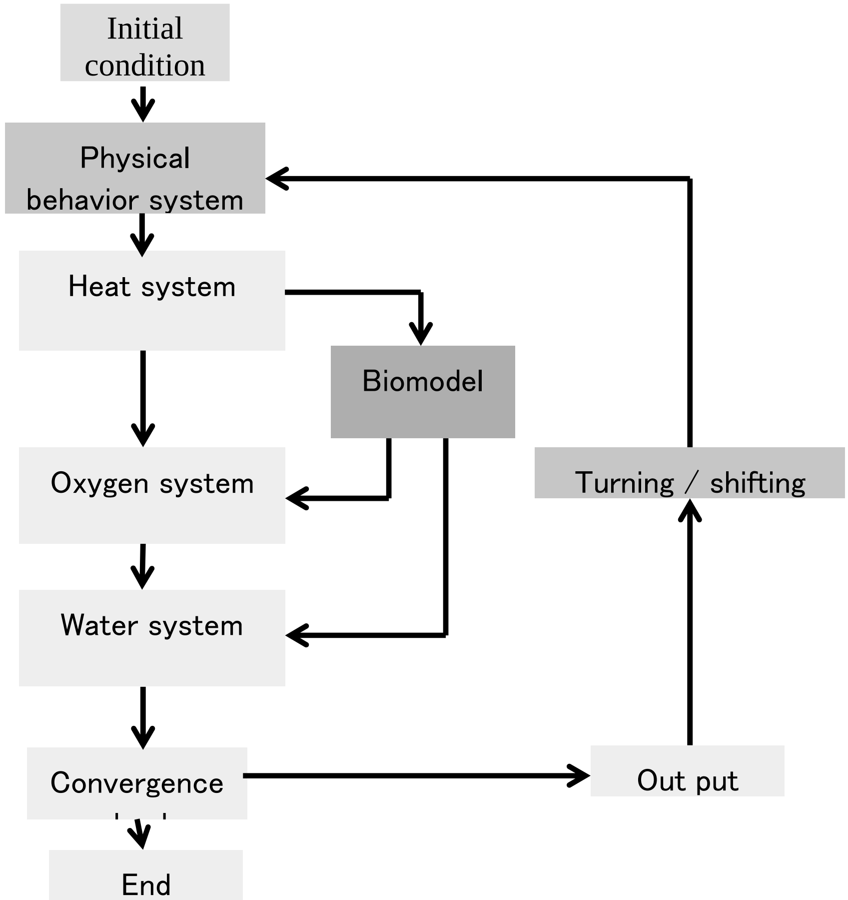

Figure 7: Proposed new framework of BioDuCOM considering physical behavior

4.2.2 Parameter of water content and temperature

Water content and temperature contribute to the function of microorganism growth, μ. Each model is expressed as following expressions.

Water content function $f_{H2O}(\theta)$:

$$f_{H_2O}(\theta) = \begin{cases} \dfrac{1}{1+\left(K_\theta\left(\theta_{opt}-\theta\right)\right)^{n}}, \left(0 \le \theta \le \theta_{opt}\right) \\ \dfrac{\theta_{max}-\theta}{\theta_{max}-\theta}, \left(\theta_{opt} \le \theta \le \theta_{max}\right) \\ 0.0, (else) \end{cases} \tag{3}$$

where
θ_{min}: minimum water content
θ_{max}: maximum water content
θ_{opt}: optimum water content
K_θ, n: parameter

Temperature function $f_T(T)$:

$$f_T(T) = \left[A_T \cdot e^{-\frac{E_1}{RT}}\right]\left[1 + K_T \cdot e^{-\frac{E_2}{RT}}\right]^{-1} \tag{4}$$

where
T: absolute temperature
R: gas constant
A_T: exponential function item
E_1: microorganism activation item
E_2: microorganism unactivation item
K_T: coefficient

It is proposed that the parameters in these expressions are changed to satisfy the observed results in conducted experiments without changing the formation of expressions in themselves. Specifically, the parameters in water content function and temperature function are modified so that biodegradation proceed more rapidly in 50% water content and 20°C temperature than 30% and 40°C. In future, the consistency of these model have to be confirmed by accumulated accurate data and analytical verifications.

5. CONCLUSION

In order to construct a new model that can analyze the process of biodegradation in oil-contaminated soil and to accumulate enough data for constructing it, elemental experiments were conducted. In these experiments, type of soil, water content and temperature were changed as parameters in each sample, and amount of biodegradation was examined. As a result, it was found that the optimum water content and temperature of oil-degrading microorganism was different from those of composting microorganism in past research. Therefore the modification of past BioDuCOM model had to be considered, the parameters of water system and temperature system in BioDuCOM were revised and the necessity of new model related to physical behavior such as volatilization, advection and diffusion was recognized and proposed. In the future, the validity of these modifications and propositions has to be verified.

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MODELING OF OVEN-DRIED MORTAR AFTER FIRE EXPOSURE BY RIGID BODY SPRING MODEL (RBSM)

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ABSTRACT

Concrete is one of the most popular construction materials because it has many benefits in construction duration; however, it also has many cons in use at the same time especially for a severe fire deterioration. Nowadays, fire accidents often occur easily in all over the world included Thailand and almost of structural concrete under fire incidents were diminished the overall performance, i.e. the mechanical properties caused by a decomposition of underlying chemical compound of material strength and change of physical properties.

A series of experiment is conducted on macroscopic specimens in burning process conforming to ASTM E119, then, they are cut in order to investigate the attenuation of chemical properties on less than 0.15 mm diameter of powder samples, physical properties on 5 mm cube and mesoscopic samples for mechanical properties. The test data of the deteriorated oven – dried mortar in term of the material model are compared with the numerical simulation concerned the effect of this incident on mechanical properties due to a chemical – physical relation for describing the damages occurred.

Based on the results of the current study, the proposed numerical simulation can be used to assess the changes of material model as a function of the residual chemical compound in whole samples after high temperature treatment.

***Keywords**: fire exposure, deterioration, rigid body spring model, RBSM, mortar*

1. INTRODUCTION

Although a conventional concrete consisting of mortar and aggregate phase has its own soundness behavior such as strength, permeability, fire – resistance etc. depending on designated specifications that would be deteriorated by various factors in severe conditions; generally, fire accident brings the extremely serious deterioration to concrete structure. The properties of this binder are, therefore, chemically disturbed. Since the binding ability upon cementitious material is diminished under fire exposure, any deterioration may easily occur throughout developed space which was formed after fire exposure. Besides its chemical properties, the pore structure and material strength of damaged mortar is also one of the fundamental properties that should be considered for post – high temperature treatment condition. In addition, conventional methods for clarifying the fire deterioration on mortar are inadequate and do not allow to define the actual causes of changes in basic properties; therefore, to obtain the better understanding, the chemo – physical and physical – mechanical relations are strongly needed for evaluating a post – fire material performance.

In this study, one mix proportion of mortar conforming to JIS R5201 – Physical testing method for cement was used. At the age of 28 days old, all of dried prismatic specimens (50 x 400 x 20 and 50 x 400 x 40 mm^3) were stored in a sealed box until test to keep constant moisture content and additional damages in samples for both before and after subjecting to high temperature. Three series of specimens consisting of control specimens, 60 and 120 minutes were exposed to fire with unsealed condition and heating process is conforming to the standard temperature – time curve of ASTM E119; maximum temperature for an hour of exposure is 927 °C and another case is 1010 °C. Then, the burnt samples were cut to for the evaluation of mechanical properties. At given period, Thermal Gravimetric/Differential Thermal Analyzer (TG/DTA) and Heavy Liquid Separation and Methanol – Salicylic acid techniques are conducted on powder sample in order to obtain the content of calcium hydroxide and calcium silicate hydrate which has an influence on physical characteristic. Porosity is experimentally examined by Archimedean approach and Porosimetric analysis on 5 x 5 x 5 mm^3 cubic samples. Furthermore, the residual mechanical properties are determined, and then how the variation of content of chemical compounds affects physical and mechanical properties of damaged mortar are discussed.

2. EXPERIMENTAL RESULTS

In this paper, the investigation was aimed at clarifying effect of cement hydrated production decomposition on physical and mechanical properties of fire deteriorated oven – dried mortar. The results contribute to the understanding the chemo – physical and physical – mechanical properties change under elevated temperature.

2.1 Determination of Calcium Silicate Hydrate (CSH)

CSH is the most important chemical compound of cement hydration products because it contributes structural strength of material. During fire accidents, CSH still exists up until temperature of 560 °C (Gai F. P. et al., 2006). Based on the hydration of cement powder, hydration products were generated and expanded to the free space (Raymond A. C. et al., 1999), it is logical that the pore connectivity was diminished. Therefore, if the decomposition process of hydrated products occurs, pore – structure must be disturbed.

The CSH content was measured by Heavy Liquid Separation and Methanol – Salicylic acid technique. In this study, the specific gravity of heavy liquid solution was set to be 2.30. The percent CSH in whole sample is shown in Figure 1.

It can be found that the CSH content obviously diminished after 60 minutes of exposure. However, no significant difference between 60 and 120 minutes of exposure time was observed. The reason is because CSH was substantially decomposed after 60 minutes under elevated temperature (Gai F. P. et al., 2006).

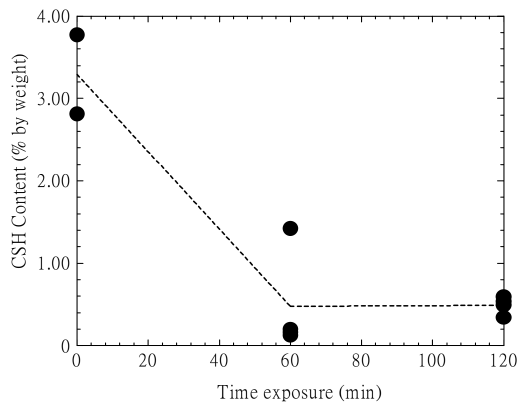

Figure 1: Amount of CSH in whole sample by weight percentage

2.2 Determination of Calcium Hydroxide (CH)

CH, one of major cement hydrate, is known as passivation layer of steel reinforcement in reinforced concrete structure; therefore, its decomposition may affect the durability of reinforced concrete. After exposed to elevated temperature, CH started to decompose and formed new carbonate chemical compound. TG/DTA technique was used to determine CH content in which chemical reaction expressed in Eq. (1) during the test. For the dissociation of CH, chemical compounds, lime and water, were newly formed.

$$Ca(OH)_2 \rightarrow CaO + H_2O \tag{1}$$

According to the law of conservation of mass, the amount of CH can be determined from the evaporated mass of water. However, the decomposition of CH is not so significant on strength loss compared with both invisible and visible cracks due to expansion and shrinkage of new compound during the formation process (Wei M. L., et al., 1996); therefore, in this study, the effect of residual content of CH on other properties was negligible.

2.3 Porosity assessment by Archimedean techniques

Mortar samples were dried at 105 °C for 24 – hour and made a saturated condition by soaking in water for 24 – hour, measured a weight at each condition. The result is shown in Table 1.

2.4 Porosimetric analysis by mercury intrusion porosimetry (MIP)

MIP is one of the most popular techniques which can determine porosity and pores size distribution of porous material based on threshold pressure and pore diameter relation. Owing to its own limitations, in continuous system, if larger pores can be filled by mercury through small pore necks only, MIP may not provide the actual results.

Once as hydration reaction proceeds, the pore space becomes entirely filled and let the isolated pore occurred. Because the pressure introduced to sample during the test can collapse the pore walls to the isolated one (Raymond A. C. et al., 1999), it can be said that one obtained from MIP technique is closer to actual porosity value than other methods.

As exposing to fire incidents, pore space might be developed again. Generally, the cumulative volume of mercury intruded must be plotted with respect to pore diameter in order to know the integrated volume of pore per gram of freeze – dried samples. The result is shown in Figure 2.

It can be observed that the total volume of mercury intruded which represent the total pore volume for deteriorated samples is greater than a control specimen. As shown in Table 1, the Archimedean’s porosity is less than those of MIP since the applied pressure did break the blockages through the existing isolated pore.

Figure 3 shows the relationships between pore diameter and volume of mercury intruded at any pore size. The pore diameter at characteristic peak for deteriorated specimens is larger than a control one because of the decomposition of chemical compounds after fire exposure. In addition, two characteristics peaks were observed in burnt samples. One possibility of these occurrences is to crush on hydrated products which impede the intrusion path; therefore, the neck size at a given peak may not correspond to the pore diameter.

To focus on deteriorated samples, two peaks are clearly appeared for after 60 minutes of exposure while there is only one peak for another set of samples. It can be explained that the surface and the blockages were almost broken for 120 minutes of exposure because of deterioration. Furthermore, due to the variability of material strength after fire exposure, pressure at the second peak is reasonable to say that can be varied by size of pore necks or thickness of framework.

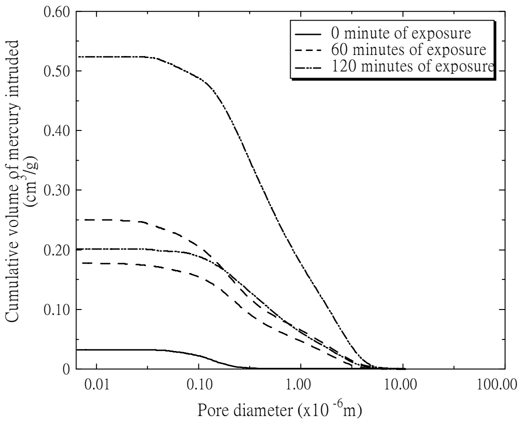

Figure 2: Cumulative volume of mercury intruded into samples

Table 1: Comparison of porosity value between Archimedean and MIP techniques

Time exposure (min)	**Porosity (Archimedean) (cm^3/g)**	**Total pore volume (MIP) (cm^3/g)**
0	0.0307	0.0321
60	0.1824	0.2136
120	0.2062	0.3622

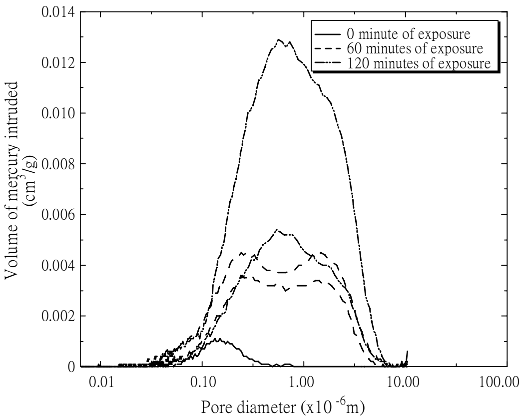

Figure 3: Differential curve of mercury intruded into samples

Since an unpredictable crack phenomenon during the test, the total pore volume sometime represents the porosity value including broken pore walls to a distinct network. Therefore, a porosity value from Archimedean technique may be preferable way for deteriorated samples.

2.5 3 – point mesoscopic bending test

A 3 – point bending test with roller support at both ends was conducted on the notched mesoscopic beam with dimension of 10 x 20 x 90 mm^3. Three LVDTs were set at both ends and mid – span for gathering the load – deflection curve without support settlements.

Figure 4 shows the tendency of reduction in flexural strength. It can be roughly seen that flexural strength would be diminished with the increment of exposure time; however, the results were divided into two groups. The shaded spots represent the test results whose specimens failed at artificial crack when applying point load at mid – span. The flexural strength was significantly reduced in the range between 0 and 60 minutes of exposure but there was a slightly recovery in the range between 60 and 120 minutes of exposure. The reason is fire deteriorations in mortar samples were extremely random in nature. Sometimes, the tested specimens were probably made from the zone without major cracks of burnt original samples; however, the difference between the results of two different time exposure were not so significant and the modulus of rupture for all damaged mortar samples were less than the value of control group. Another spots represent the residual flexural strength whose location of failure was unpredictable due to the behavior of fire damages. Although the reduction in flexural strength was obviously observed with an increment of time exposure as same as the shaded spots, the residual flexural strength in this group was so small compared with another group. One possibility to explain this kind of situation is, a severe damaged zone might be chosen to be testing specimens.

2.6 Calculated shear strength

The shear strength has been experimentally examined; however, the testing results were inclined to be a compressive strength due to inappropriate size of specimen and the limitation of maximum capacity of testing machine. Therefore, the preferable way to estimate the shear strength is to be calculated from their own actual flexural strength by numerical equation proposed by Japanese researchers as shown in Eq. (2).

$$\tau_{\max} = 1.083 f_b + 1.11 \tag{2}$$

Where $\tau_{\max}$ = shear strength (N/mm^2)

f_b = flexural strength (N/mm^2)

Miura T. and Sato Y. have proposed this linear equation to predict shear strength from tested flexural strength which was suitable for non – damaged and damaged mortar samples. Therefore, it may be more suitable way for predicting the shear strength of both control and fire – damaged samples. The results were shown in Figure 5.

Because the shear strength was calculated from its own flexural strength, the reduction tendency was same as flexural strength results. Although the reduction in shear strength was obviously observed with an increment of time exposure as same as the shaded spots, the residual shear strength in this group was so small compared with another group.

3. RELATIONSHIPS BETWEEN MATERIAL PROPERTIES

3.1.1 Chemical – Physical relation

With respect to two different time exposure, The proposed chemical – physical relation can be used to predict the porosity using residual content of CSH. Figure 6 shows relationships between porosity and CSH. The regression lines are obtained for different exposure times.

Since the volatilization of CSH was initiated at 560 °C, the non – evaporable water was gradually escaped out so a cohesive force between CSH layers was demolished. The porosity in samples exposed to higher temperature is greater than the lower one because in case of high temperature the molecular structure of CSH might be substantially destroyed. With respect to the increment of maximum temperature from 60 to 120 minutes during fire exposure, pore – structure coarsening was intensified because of the CSH decomposition phenomenon.

Actually, the content of CH for each fire condition was experimentally tested. However, a mechanism for the rehydration of CH may be able to happen but it is so complicated and not easy to expect because of the uncertainty of rehydration process (Wei M. L., et al., 1996). One possibility of this relationship is to say that the rehydration for post - fire samples; therefore, the pore space may be refilled by new formation of CH. In this study, the changed porosity was assumed to be affected by only the variation of CSH.

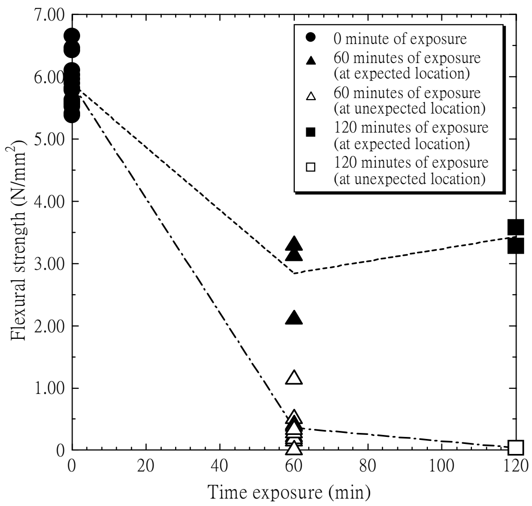

Figure 4: Reduction in flexural strength for post – fire samples

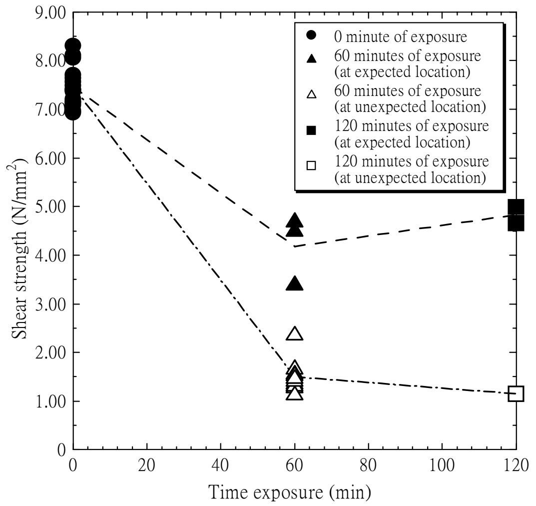

Figure 5: Reduction in shear strength for post – fire samples

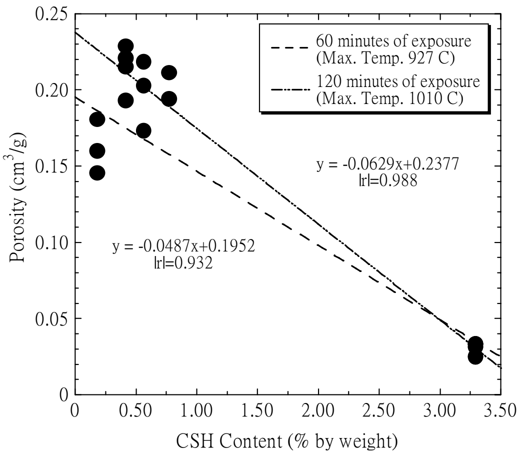

Figure 6: Relationship between CSH and porosity

3.1.2 Physical – Mechanical relation

As mentioned above, a porosity of mortar sample was estimated by the residual CSH in sample. Also, mechanical properties would be diminished by the influence of variation of porosity value (Omer A., 2007, Chang Y. F., et al., 2006, Chi S. P., et al., 2001, Djaknoun S., et al., 2012); therefore, the relationship between porosity against mechanical properties must be concerned in order to better understand the actual behavior of both non – damaged and fire – damaged mortar.

Regarding two different time of subjecting exposure in this study, the residual flexural strength has been interpreted in terms of its porosity predicted by the retained amount of CSH in sample after deterioration. The regression lines in Figure 7 were obtained for different exposure times and maximum temperature in furnace.

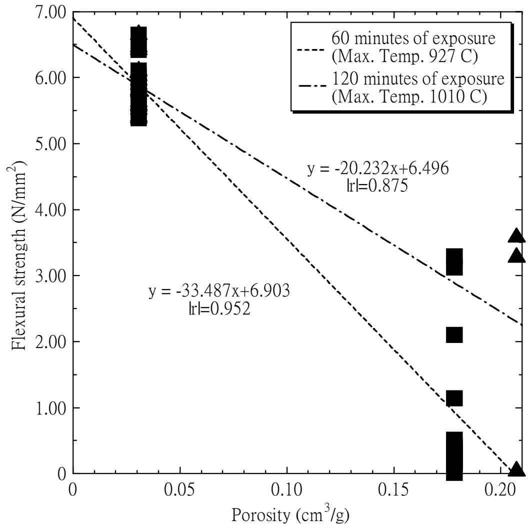

Figure 7: Effect of porosity on the flexural strength

Also, shear strength was calculated from its own flexural strength as expressed in Eq. (2). Therefore, the regression lines of shear strength must have the same tendency as the relationship between porosity and flexural strength.

Since the changes in porosity after subjected to high temperature treatment up to the target temperature, mesoscopic flexural and shear strength has been diminished due to the decomposition of strength compounds and Van der Waal forces between CSH layers. Figure 7 and Figure 8 show the influence of porosity on the residual strength in which a higher maximum temperature has a higher strength. In fact, mortar samples with same porosity value should have the same material strength; however, it was probably recovered depending on several factors such as rehydration process, post – fire cooling regimes or atmospheric humidity (Wei M. L., et al., 1996, Chi S. P., et al., 2001).

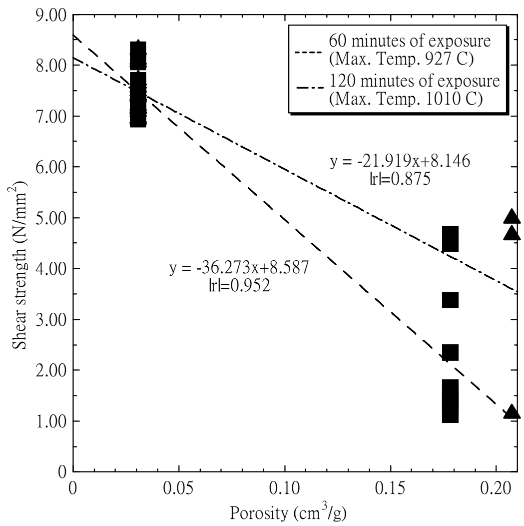

Figure 8: Effect of porosity on the shear strength

4. FULL – SCALE SIMULATION

Until now, all the test results were done on mesoscopic samples but, in practical, the performance of structural concrete was evaluated in full – scale structure. Therefore, the purpose of this task is to compare only the maximum load of actual 3 – point bending test in macro scale with the simulation result using the mesoscopic experimental data. In this study, the 60 minutes post – fire specimen was simulated compared with the actual experimental result at macroscopic sample.
The dimension of full – scale sample used in model construction was shown in Table 2 together with material properties in mesoscopic level. In analysis, the process was suddenly stopped at descending branch around 70 percent of peak load. The comparison of actual and simulation data was shown in Figure 9.

Table 2: Material information used in simulation

Time exposure (min)	Dimension			CSH (%W/W)		CH (%W/W)	
	Height (mm)	Length (mm)	Thickness (mm)	Ini.	Temp.	Ini.	Temp.
60	23.8	400.0	46.9	3.2931	0.4776	3.8513	1.9698

Despite there was some defect made non – smooth graph in damaged sample during the test, both the load – deflection shape and maximum load were almost the same with considering the diminishing of material properties and residual chemical compounds in sample after subjected to fire exposure. In addition, another possibility to explain a small difference between experimental data and simulation is the size effect. Material properties of small and macro specimens may not be exactly the same because the overall performance of full – scale structure is probably influenced by several factors. Based on the results of the current study, it can be said that RBSM can be used to predict the maximum applied load for 3 – point macroscopic bending test accurately with material properties in meso – scale and considering the effect of chemical compounds content in whole sample; however, the simulation of tensile softening branch need to be modified in the future prospects.

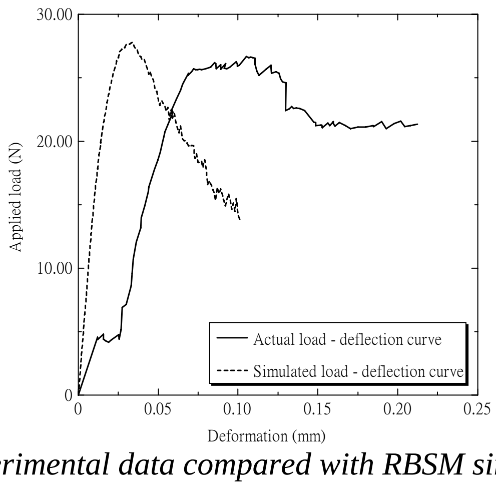

Figure 9: Experimental data compared with RBSM simulation for 60 minutes after fire

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CURRENT SITUATION ABOUT RECONSTRUCTION OF HAKOZAKI PENINSULA AFTER THE GREAT EAST JAPAN EARTHQUAKE

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ABSTRACT

It has been 2 years since the Great East Japan Earthquake occurred, and detailed reconstruction planning is ongoing in every area affected by tsunami. Kamaishi City, Iwate Prefecture, where severely damaged in the disaster, is also in such situation. Especially we focused on Hakozaki Peninsula in the north part of the city, which consists of 8 villages and majority of the people gain their livelihood by fishery. After the earthquake, some of the local people started thinking about reconstruction of their own village. As including external experts in urban planning, they came to consider about the future of all over the peninsula to be sustainable area and established a new NPO.

In discussion with the local government on planning of each village, the concerns incline to be present and narrow ranged matters. However, it is also necessary to consider and cope with the facing problems since before the disaster such as aging society and population declining from long-term, wide-areal and comprehensive viewpoint. From this point, this paper analyzes the current situation and problems in reconstruction of Hakozaki Peninsula.

***Keywords**: reconstruction, Kamaishi City, Hakozaki Peninsula, community participation, sustainable, problems.*

1. BACKGROUND OF KAMAISHI CITY BEFORE THE DISASTER

1.1 History

Kamaishi city is located on the south-eastern part of Iwate Prefecture, along the coastal line towards Pacific Ocean, with total area of 441.43 square kilometres. Kamaishi city was well known as a city of fisheries and iron. In 1857, Nambu Domain constructed Ohashi blast furnace at Kamaishi as the first western-style blast furnace in Japan. Then in 1934, the Meiji Government established Nippon Steel, when the city population at that time reached 40,388 people. At the same time, roads and railways were developed, and the role of Kamaishi Port became significant.

1.2 Population change

Population of Kamaishi City once reached around 100,000 in 1960's, but now it is 39,574 (Statistics Bureau, 2010). Figure 1 shows the population trend in Kamaishi City, DID (Densely Inhabited District) population, and the number of household, with the data obtained from National Census. The population from 2010 until 2040 was estimated. From this graph, it can be assumed that great amount of reducing population number will occur in the future. The decreasing number of people can be seen on the general population, also in the urbanized area. On the other hand, the household declining rate is smaller compared to population declining. Figure 2 explains about the population composition in range of age and sex. It expresses the state of declining birth rate and aging population.

1.3 Industry

The situation of industry in Kamaishi City is declining. In 2007, output of primary industry accounted for 3.8% of total, secondary industry 33.3%, and tertiary industry 67.6% (Kamaishi City, 2011). The number of employees had decreased by about 30% from 1990 to 2010. Particularly, the declining of primary industry was significant; it has been halved in 20 years. Agriculture has decreased about 65% among others (Statistics Bureau, 1990 and 2010). In fishery industry, although the amount of catch of fish have not decreased so much, output of money has been declining, especially in 10 years from 2000 until 2009 (Kamaishi City, 2011).

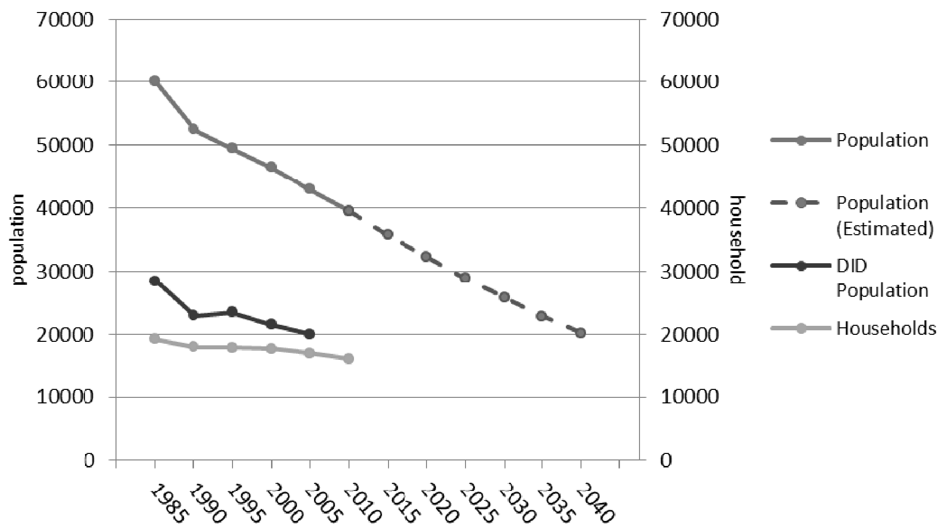

Figure 1: Changes in population and households of Kamaishi (Derived from National Census, 1985, 1990, 2000, 2005 and 2010)

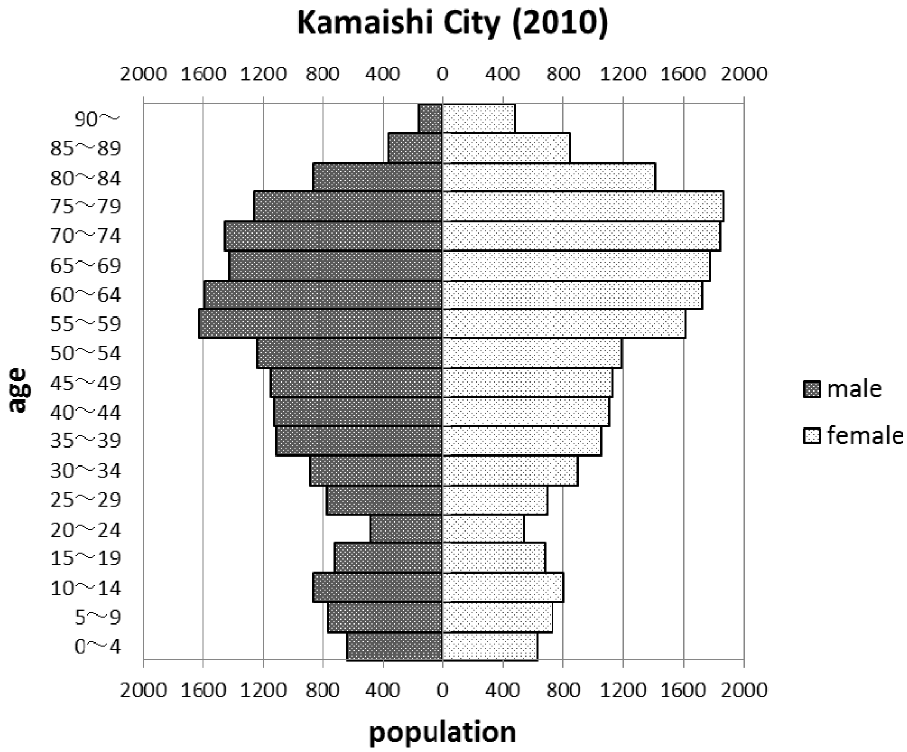

Figure 2: Population pyramid of Kamaishi City in 2010 (Derived from National Census, 2010)

2. DAMAGE ON GREAT EAST JAPAN EARTHQUAKE

Kamaishi City suffered great tsunamis recorded in 1896, 1933, 1960 and the last in 2011. During the Great East Japan Earthquake in March 11th, 2011, by the highest wave of tsunami reaching 10.1m at Kamaishi harbor, Kamaishi City suffered the total number fatalities 885 people, missing 176 people, evacuees to other area 9,883 people, and evacuees inside the city 633 people (Kamaishi, 2011). The number of dead and missing people of Kamaishi City was the third largest amount in Iwate Prefecture, after Rikuzentakata and Otsuchi Town. The number of totally collapsed buildings are 2,954, highly destroyed 396, partially destroyed 291, and damaged 907 (Kamaishi City, 2011).

3. CURRENT SITUATION

Location of the refugee has been closed by October 8th 2011, and 3,164 houses of temporary housing were constructed by August 5th 2011, which were located in 50 sites in Kamaishi City (Iwate Prefecture, 2012). Currently, people who lost their own houses mainly by the tsunami are living in the temporary housing which are scatteredly located inside the city and other housing outside the city.

The amount of proceeded debris in the disaster was estimated as 82 tons in Kamaishi City, and it is planned to be removed from the affected region by March, 2013, and completely processed by March, 2014 (Kamaishi City, Pacific Consultants, 2011). By April 2012, debris removal reached 50%, and the process rate was 3% (23,000t).

4. RECONSTRUCTION

4.1 Reconstruction plan of the municipality of Kamaishi City

In September, 2011, the Basic Principles of Reconstruction made by the municipality was enacted, which consists of basic principles and rough timetable of the reconstruction process from the beginning. Then in December, 2011, the Basic Reconstruction Plan (Figure 3) was established through asking opinions from the representatives of the citizens. On the other hands, detailed landscape plan and land use plan haven't been decided yet. They will be decided after consultation with communities and now they are under discussion in July, 2013 (Figure 4).

4.2 Present situation of the area and people related to reconstruction

Sets of interviews had been done in the settlement of Ryoishi and Shirahama by NPO (Non-Profit Organization) CeMI (Crisis & Environmental Management Policy Institute) and Kato Takaaki Laboratory in October and December 2011. This was aimed to know the real range of the choices of livelihood rehabilitation of each household, and consequently the potential range of recovery of the communities. The interviews were subjected to 20 household who had moved to temporary housing. From this interview, the following facts were revealed; Fist, affected people strongly feels anxiety from the uncertainty of the future of their lives. This may leads to the people moving out who want permanent housing and job in the early stage of reconstruction. Second, some people don't put the first priority on hard measures against tsunami in their villages. This means consideration about the balance of usage of money on hard measures and other amenities. Third, there are many people who can't recover their living on their own because of economic conditions. Thus support for such people is needed to be considered to realize their reasonable living and sustainability of the region.

Also, to stem the declining town is as important as ensuring citizens to live in. The basic city planning reconstruction of Kamaishi City was organized and intended to meets the needs of various kinds of stakeholders in the city. However, it was not transparent enough in assuring the opinion of the representative organization and citizens, including the details of the residential area plan and disaster prevention measures. Therefore it should be considered that the awareness of residents plays role to achieve satisfaction on all stakeholders.

4.3 Community Participation

After the disaster, community participation across Hakozaki Peninsula on the north part of the city has been active and the organization for discussion and activities for recovery of the area including 8 villages has been established. June 2011 was the start of this movement involving 4 villages together, mainly held by a fisherman in Ryoishi with support from CeMI. After that, they came to have leaders meeting almost every month across the 8 villages. Community members and CeMI has been working together for the reconstruction process, such as discussing reconstruction plan of their own village and get advices from planners including Kato associate professor. In March 2012, a new NPO was established, which was named O-Hakozaki Shimin Kaigi (Community Association of Hakozaki Peninsula) and it consists of community members, CeMI members, and planners.

The O-Hakozaki Shimin Kaigi's activities are participated by four working groups, starting August 2012. The Working Group 1 manages community recovery for future, including physical, social, and human factors; Working Group 2 involves economic, creating job opportunity and new industry related to the fisheries; Working Group 3 focuses on human capacity building such as disaster mitigation and response; and Working Group 4 focuses on economic factors, based on the resources of this area, and market the products and value addition.

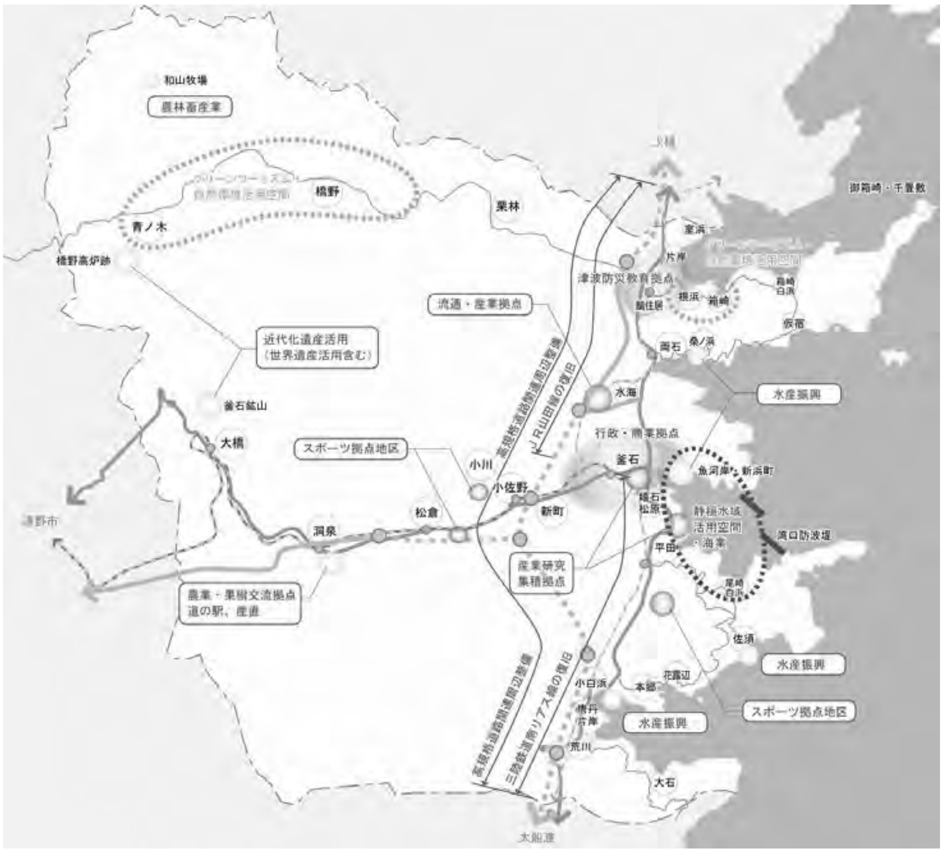

Figure 3: General plan of Kamaishi City in Basic Reconstruction Plan (Kamaishi City, 2011)

Figure 4: Draft of land use plan for one of the villages in Kamaishi City (Kamaishi City, 2012)

5. CHALLENGES AND PROBLEMS

During the reconstruction process, there are several challenges for all of the stakeholders. First, top-down planning strategies has been applied in this area since the very beginning of its history until before the Great East Japan Earthquake. But after this disaster, with the stream that expectation on regional decision and residents participation is much bigger than before, the municipality and the region itself should consider their reconstruction for themselves. For the reconstruction process, the citizens trust the municipality to develop and implement the plan. However, many of the municipalities in the affected area have little experience of making and implementation of regional planning including making agreement of residents, communities and various sectors. This can be applied to the community as well. Thus there needed enough time to think of their comprehensive and sustainable way of reconstruction of the region. Also, the planning system that includes municipality community and professionals such as planners should be made.

Second challenge is that there was not much chance for various people such as young people and women. Until now, the persons mainly taking part in the discussion are old men. In addition, the top person of the conventional organization has very strong influence that other members seem to have difficulty to state their opinions and take actions based on their ideas. The other difficulty is the community tends to have short-term view regarding their economic, social, and built environment situation, while the local government has a long-term view. The profile of community in the area is fishermen and fisheries industry, with their fishermen cooperative union which aimed for their working purpose.

The present condition of Japan as developed country needs a different approach for reconstruction than the previous disaster during developing period. Next challenge is the ageing society of the currently living population of Kamaishi City, also the declining economic condition. With majority of community leaders and most of the people are in the age of 70s years old. However, there is presence of young generation in Shirahama to support the reconstruction process. Second, the community members who are mainly elderly tend to stay in the previous place and/or city, and do not want to move to the other cities. Based on the interview, community has strong attachment to the area. The future of the cities ensuring the safety and sustainability issues in comprehensive way, and how to attract the people to stay in this area needs to be taken into account. It is also considered the formation of compact smaller town, to maintain the population and sustainability in the future.

6. CONCLUSION

Currently Kamaishi City and the other affected area in Japan are in the early phase of reconstruction from the Great East Japan Earthquake and Tsunami. Considering the past of Kamaishi City and the present situation of the ageing society, Kamaishi City has several challenges to face during the reconstruction process, especially related with the developed state of Japan and the currently applied planning system, also the character of community to adapt with the new situation.

Further study is to analyze the challenge of the reconstruction process, finding influencing factors, considering the needs of citizens, and consensus between all stakeholders, ensuring citizen involvement. Then, the analysis is aimed to find possible suggestion to achieve comprehensive reconstruction process.

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NEIGHBORING SEARCH PROCESS IN GENETIC ALGORITHM FOR TRAIN SCHEDULING PROBLEM

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ABSTRACT

One of the most important issues in railway planning is to optimizing a schedule. Delay is one of the key factors to optimize since decreasing in delay means lower cost to operator and less travel time for passenger. In this study, Genetic Algorithm combined with First-come First-served rule is proposed for a Train Scheduling Optimization Problem with variable departure time. The performance of conventional Genetic Algorithm process will be compared with Genetic Algorithm with Neighboring Search process. Optimization analysis was conducted on The Northern Section of State Railway of Thailand, on 22 segments with 12 trains. Within 1,000 generations, Neighboring Search process enhanced in Genetic Algorithm offered a 0 minutes delay which is a global optimum. However, without Neighboring Search, best solution of 3 minutes delay was reached within 1,000 generations. In conclusion, Neighboring Search process with smaller step with can improves Genetic Algorithm performance by avoiding a chance to miss an opportunity to convergence from larger step from crossover and mutation process in each generation.

***Keywords**: railways, optimization, train scheduling problem, Neighboring Search, Genetic Algorithm, delay, State Railway of Thailand*

1. INTRODUCTION

Timetable can be considered as one of the key factor to the railway system. In terms of scheduling, the management of trains can be consisting of the time of arrival and departure, from the depot or yards to a platform and including a crew scheduling. However, in term of operational timetable especially in a single track line, it is a principle of how to control the train between stations flawlessly by the time that train should be arrived and depart and which siding it should belong to.

Many factors have to be considered from the decision makers in order to create a timetable, e.g., number of passengers, their origin and destination, number of rolling stocks, available tracks and sidings, cost of operation and travel time. Obviously, the travel time can be one of the major factors which effected to other factors as well. For instance, apart from cost, passenger decision on mode choice is also depends on travel time. Too long travel time can force passenger to other train or other mode. In addition, travel time is also effect to the cost. Not only cost to railway operator from operation cost, less travel time can give more opportunity cost to the user as well. Thus, it is more convenience to develop the optimization algorithm to minimize travel time since it can be easily convert to other factor by simply multiply the cost factor or other factor to a given travel time. In single track railway, travel time consists of three main components, running time between station, dwell time in station and delay occurred from a waiting time. Delay is the only part which can be optimize since the other factors are the constant to the characteristics of railway network. Therefore, in this paper, delay will be minimized through the best meet-pass plan for a single-track line.

Study on train scheduling optimization was started by Szpigel (1973), who develop a linear programming model to determine the best overtaking and crossing positions in single track railways. Recent development on methodology and algorithm has been proposed extensively by many researcher but most of them still based on integer linear programing. Some researchers propose different methodology. For instance, Huisman et al.(2002) propose queqing network by queqing theory, Corman et al.(2010) propose taboo search for rerouting train. Also, some of artificial intelligent based search has been propose. Salim & Cai (1997) considering different other factors other than travel time based on genetic algorithm. Partical swarm also has been proposed by Ho et al.(2012) in terms of cost minimization for railway scheduling.

2. METHODOLOGY

In this study, Genetic Algorithm will be used to conduct a search algorithm to find the best departure time for each train. The departure time of each train is generated through Genetic Algorithm in each generation and allowed to be adjusted within a range of ±15 minutes from its actual departure time. Train operation in each conflict will be governed by a first-come first-served basis. Hence, only delay affected from departure time will be minimize in this study. Actual timetable including current departure time, travel time of each segment by each train was collected from State Railway of Thailand and will be used as inputs to the problem.

Performance comparison on conventional Genetic Algorithm and Genetic Algorithm with neighboring search will be analyzed in this study. Conventional Genetic Algorithm (Figure 1) is consisted of three general modules, namely, fitness selection, crossover and mutation which decoded in decimal. Proposed neighboring search module will be process after mutation module as shown in Figure 1.

Concept of neighboring search is derived from mutation process. However, unlike the mutation which mutated a chromosome into any value within a range, neighboring search tries to mutate a chromosome into nearby possible solution. In this case, if the chromosome was selected to be neighboring mutate from probability of neighboring mutate rate, the chromosome which is a departure time of each train will have a 50/50 chance to mutate +1 or -1 minute from its prior departure time as shown the comparison in Table 1.

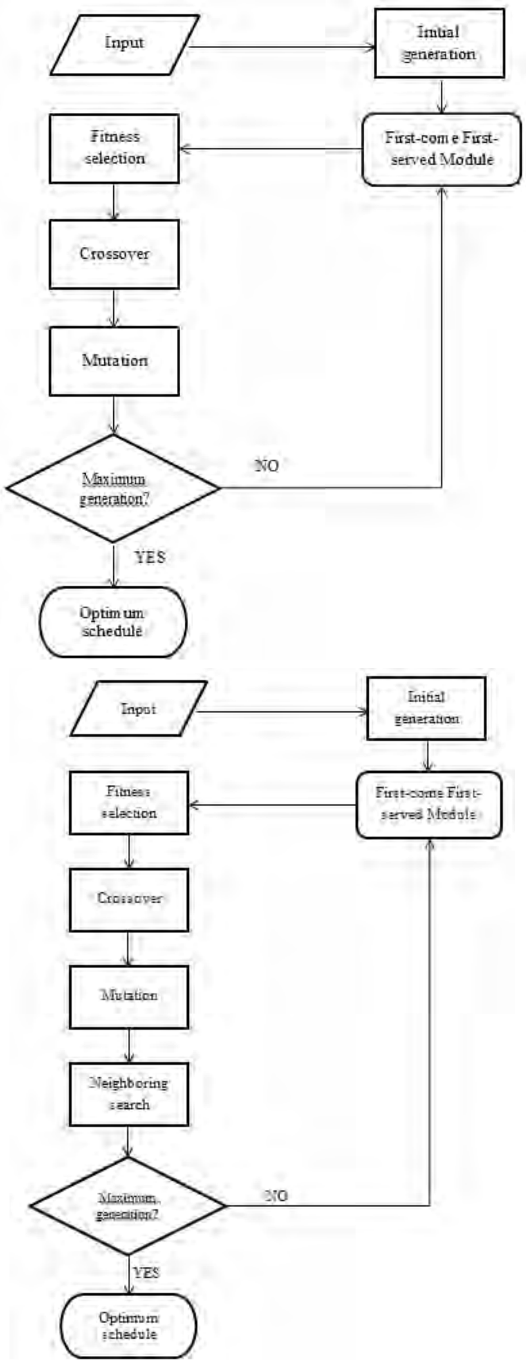

Figure 1: Flowchart of Conventional Genetic Algorithm (left) and Genetic Algorithm with Neighboring Search (right)

Table 1: Example of Conventional Mutation and Neighboring Search Mutation

➢ Suppose if departure time = 3:15 ➢ Allowable range of ±15 minutes	
Conventional Mutation	Neighboring Search Mutation
• Randomly change departure time within a range • Possible solution = 3:00 to 3:14, 3:16 to 3:30 • Probability of each solution; P = 1/30	• Randomly change departure time ±1 minute from its default value • Possible solution = 3:14 *or* 3:16 • Probability of each solution; P = 1/2

3. RESULT

Analysis was conducted on The Northern Section of State Railway of Thailand, from Phitsanulok Station to Chiang Mai Terminus with actual inputs of 22 segments with 12 trains and actual train schedule. Each iterations, Genetic Algorithm was set to execute at 1,000 generation. Within 10 iterations, conventional Genetic Algorithm could reach a minimum solution of 3 minutes. (Figure 2) However, with Neighboring Search, a global optimum solution of 0 minute could be reached 8 times from 10 iterations. (Figure 3) A comparison of the rate of convergence between two algorithms is shown in Figure 4. Difference of computational time between two algorithms is comparatively small and negligible.

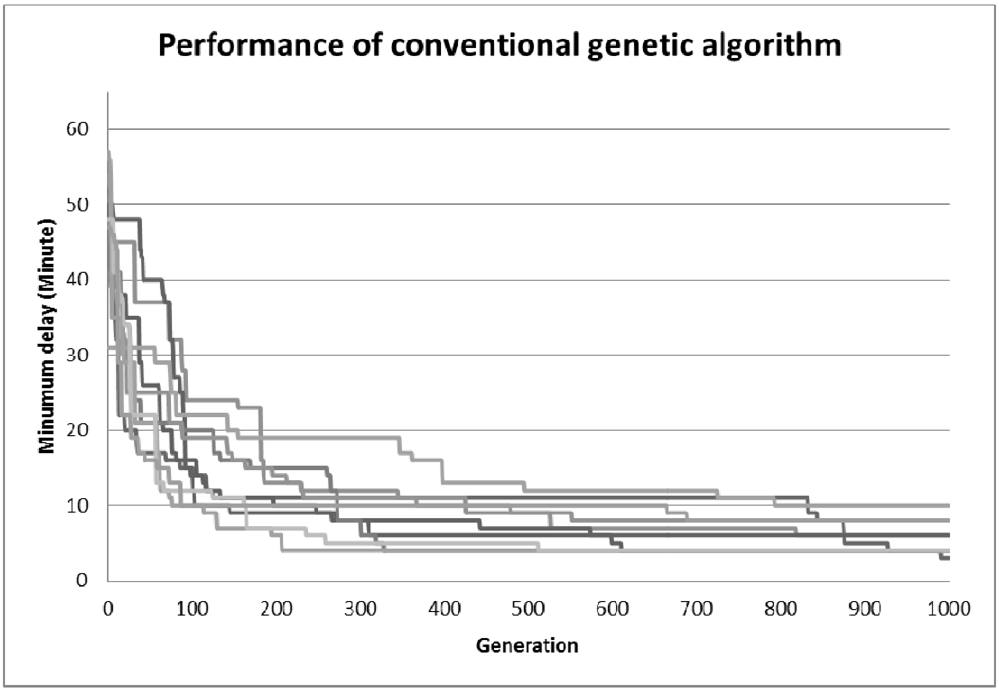

Figure 2: Performance of conventional Genetic Algorithm

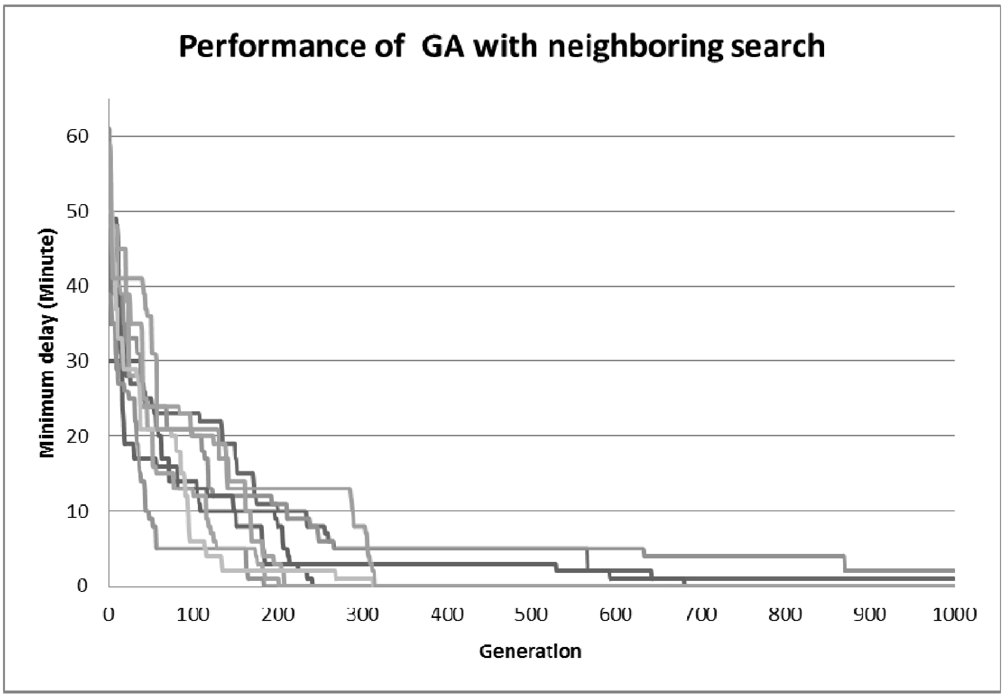

Figure 3: Performance of Genetic Algorithm with Neighboring Search process

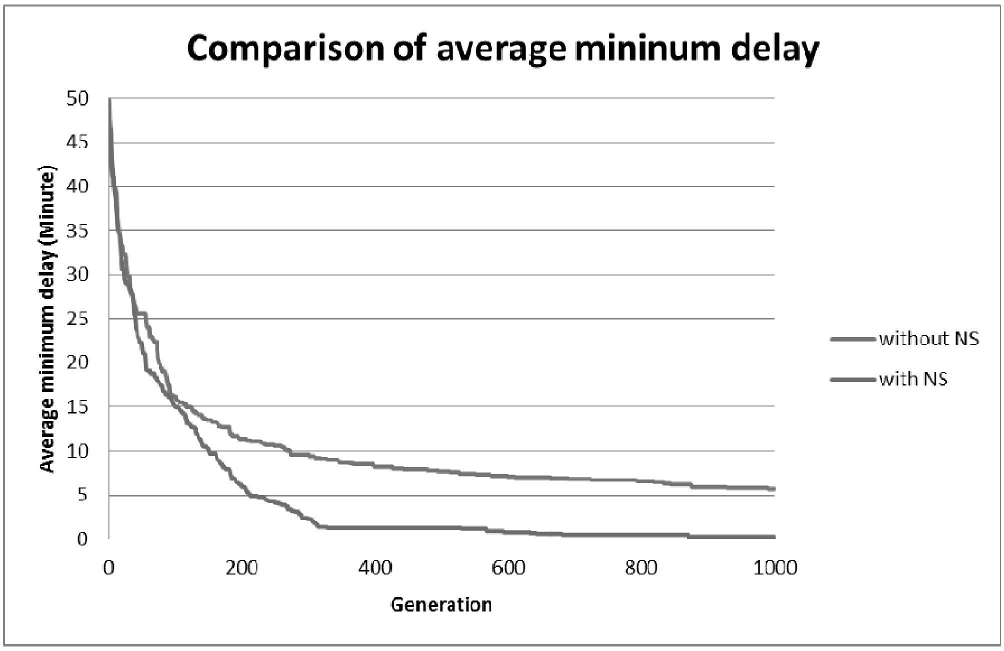

Figure 4: Comparison of average performance between two algorithms

4. CONCLUSION

It is proven from the result that Genetic Algorithm with Neighboring Search Process can reach better solution within a given constrain. The strength of Neighboring Search comes from a smaller step in each mutation. In a conventional mutation, each mutation has a main objective to jump pass a boundary of local optimum curve. Nevertheless, each jump might be too big and miss an opportunity to reach an optimum solution. By adding neighboring search process next to mutation process, after each big jump, a small step is conducted to search nearby solution for a better solution. This smaller step is proven to be a crucial step to find an optimum solution.

Neighboring Search is specially design for a Genetic Algorithm with decimal encoded. In mutation process, range of possible solution in decimal encoded maybe too wide for randomly selected process. Therefore, Neighboring Search Mutation is added in Genetic Algorithm to fill this gap. When a solution is already near situated near an optimum solution, little step from Neighboring Search gives an advantage to find nearby optimum point. In contrary, mutation process has a larger range to mutate so there is lower probability to find an optimum point. However, departure time result might be difficult to be implemented because departure time usually assign in 5 or 10 minutes interval.

As mentioned, this study analyze the performance of Neighboring Search Process under a specific condition; decimal coded and applied for train scheduling problem. It is recommended to apply Neighboring Search Process in other type of problems or other Genetic Algorithm techniques to verify the performance of Neighboring Search Process in Genetic Algorithm.

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AN INVESTIGATION OF ROAD BRIDGE MAINTENANCE SYSTEM IN JAPAN IN DEVELOPED SOCIETY

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ABSTRACT

The road assets in Japan have peak of construction in high economic growth period around 1970s. At that time, constructing bridges as fast and as cheap as possible was all their interest and the maintenance was not considered enough. However, as it is called "America in ruins", many structures in the United States constructed in New Deal without maintenance were rapidly deteriorated and caused tragic accidents. After those, Japan started to establish a countermeasure to prevent to be "Japan in ruins."

This research investigates a current situation of road bridge management system in Japan and clarifies the problems to be solved in the developed society. Many road bridges must be efficiently updated in the near future, so Japanese government tries to investigate maintenance PDCA cycle. However, a research showed most managers had not even inspected bridges. Japanese central government decided to let all local governments inspect bridges they manage and make plans for maintaining them for long term by "preventive maintenance". After this policy, most managers have inspected all bridges and made their own manuals. It seems inefficient but Central government could not make unified data base and inspecting manual because of the decentralized government system. In this situation, managers in charge of local bridges are local government, which seldom have enough staff. A research shows that there are some towns in Kochi Prefecture that have many bridges constructed without considering maintenance deeply but have only one or two persons in charge of the bridges. Furthermore, they are not enough educated or experienced to inspect and diagnosis whether or not they should repair. For those governments, diagnosis is difficult and managing bridges is a burden. To solve this problem, many universities and other organs started researching to make reliable system for deterioration prediction. However, it is almost impossible because uncertainty and individual conditions are unavoidable factors.

***Keywords**: road bridge deterioration, maintenance, asset management, limit of deterioration prediction, policy*

1. INTRODUCTION

Many bridges in the United States constructed in New Deal felt down with loss of lives for inappropriate maintenance. From the accidents, we learned that there is huge economical loss once an accident happens with loss of lives.(Inoue, 2010) Japan has 157 thousands of bridges over 15m span and 700 thousands over 2m span, and no accidents that cause lives loss have fortunately happened yet, but number of deficient bridges is increasing every year. This is a problem of developed society which had a construction boom in high economic growth period. Developed society has the problem of aging society of people at the same time. Especially in local areas, the problem is serious. Even though local governments are having hard time with short of public finance and staffs, they have to manage the bridges they have. The number of national road is 50 thousands and that of bridges managed by prefecture is 100 thousand, and by municipality is 521 thousand. 77 percent of bridges are managed by local government. National government tries to support the local governments but it is limited because of decentralized government system. This research investigates a current situation of road bridge management system in Japan and clarifies the problems to be solved in the developed society.

2. THE NUMBER OF ROAD BRIDGES AND THEIR AGE IN JAPAN

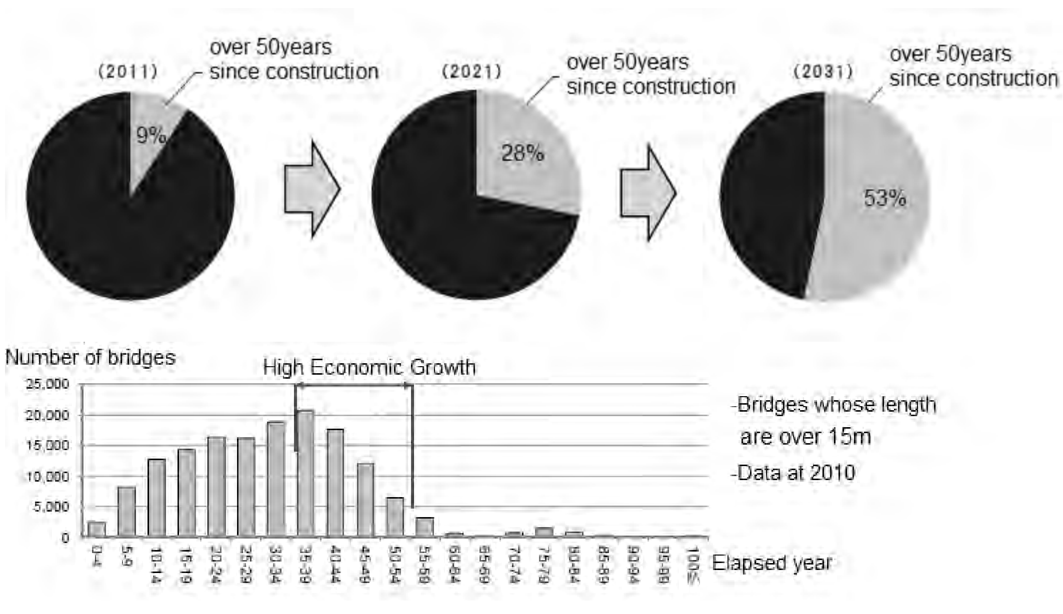
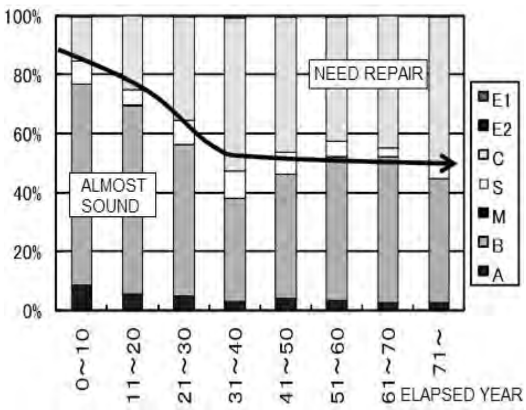


Figure 1: Number and the age of bridges in Japan (MLIT, 2010)

In 2031, the number of bridges whose age is more than 50 years will be over 50% of all the bridges.(Figure 1) There is no scientific support that bridges that are over 50 years old collapse, but the fact that around 50% of the bridges whose age is over around 50 years need maintenance can be reliable reason to say those bridges should be inspected and repaired if needed.(Figure 2) The reason why the ratio of deficient bridges does not increase after it achieves 50 years old is because seriously damaged bridges of those are already repaired. In japan, bridges whose age is more than 50 increase rapidly in a few decades although it is impossible to replace them at the same time in this condition of finance. To flatten the cost to the years, preventive maintenance which costs less should be started at present.



A: No damage or needless to repair
B: Need repair depends on the situation
C: Need repair immediately
E1: Need immediate action for structurally deficient
E2: Need immediate action for other reasons
M: Need maintenance service
S: Need detailed investigation

Figure 2: Percentage of dterioration level versus elapsed year (Tamakoshi, 2011)

3. CASES OF DEFICIENT

3.1 Kiso river bridge

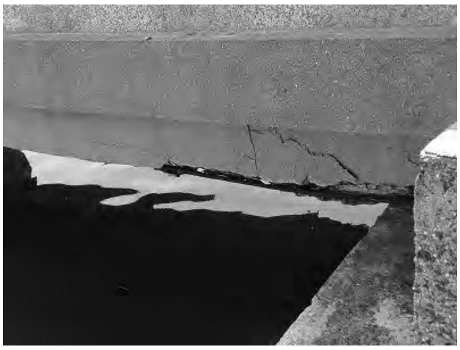
This is an example of national road damage. Kiso river bridge constructed in 1963 was seriously damaged at the connection between truss and girder. It was found when emergency investigation was taken for truss bridges in 2006. Until then, it was not found although it should be easily found if inspecting was taken. It was repaired right after the foundation and fortunately no accident happened.

Figure 3: Kiso River Bridge (Mie Prefecture)

3.2 Kanonji Gokuraku Bridge

This is an example of damaged bridge managed by local government. This bridge was constructed in 1933 and deteriorated seriously because of airborne chloride. Huge crack in pier would cause accident. Also, protective covering is too thin so that rod is exposed and rusted. This bridge need to be repaired or removed. Considering its traffic, removement is better choice, which is difficult to make consensus with neighbors for in terms of cultural heritage. For this reason, it is still available to use with limit of 4 ton.

Figure 4: Kanonji Gokuraku Bridge (Kanonji, Kagawa Prefecture)



4. MANAGEMENT SYSTEM OF NATIONAL GOVERNMENT

4.1 PDCA cycle

National government introduced maintenance cycle: inspection, diagnosis, maintenance and record. The cycle is going to be the third cycle. The national plan for inspection decides many points to inspect and diagnosis: 8 points for steel member, 8 for concrete member, and 16 for other and all of them have to be ranked from “a” for good to “e” for bad as shown in Figure 5. And this has to be done for each part of bridges, which takes a lot of work. Some parts that has to be inspected are shown in Figure 6. This is one of the reasons why national government could not let all local governments to use this inspection manual.

In asset management, the ideal cycle is inspection, prediction, assessment and maintenance. It is important to think individual bridges’ management and macro governance separately. The latter cycle cannot be applied for the individual management because deterioration prediction for each bridge is almost impossible although it would be the ideal. On the other hand, the cycle can be used for the macro governance to make a budget estimate. The prediction in this case is not deterioration prediction but that estimated by the number and age of bridges and cost statistically.

Damage of concrete member	Crack		a-e	Damage of steel member	Corrosion	Edge	a-e
	Leakage and free lime		a-e			Middle	a-e
	Detachment and rod exposure		a-e		Crack	Edge	a-e
	Falling out		a-e			Middle	a-e
	Damage of concrete stiffener		a-e		Loose and dropped bolt		a-e
	Floor crack	2 edge panels	a-e		Rupture	Edge	a-e
		Middle	a-e			Middle	a-e
	Concrete flaking		a-e		Anticorrosion deterioration		a-e
Other damage	Expansion gap abnormality		a-e	Common damage	Anchorage zone damage		a-e
	Rough road surface	Expansion joint	a-e		Color change, deterioration		a-e
		Others	a-e		Leakage and stagnant water		a-e
	Pavement damage		a-e		sound and vibration		a-e
	Bearing dysfunction		a-e		excessive deflection		a-e
	others		a-e		Deformation, deficit		a-e
					Pipe clogging by dirt		a-e
					Subsidence, movement, slope	Substructure	a-e
						Fulcrum	a-e
					scour		a-e

Figure 5: Inspection items (MLIT, 2004)

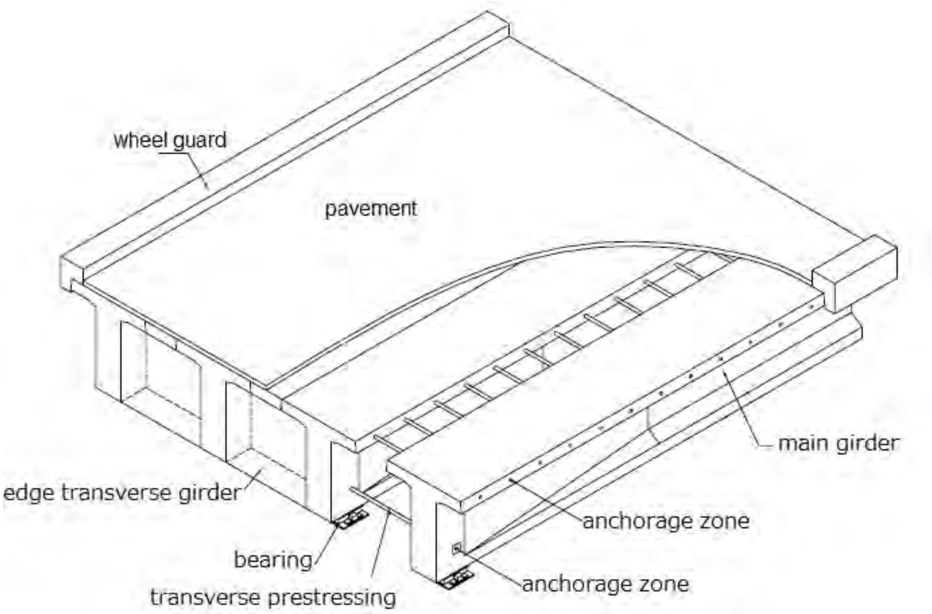


Figure 6.1: Name of parts of concrete bridge (NILIM, 2007)

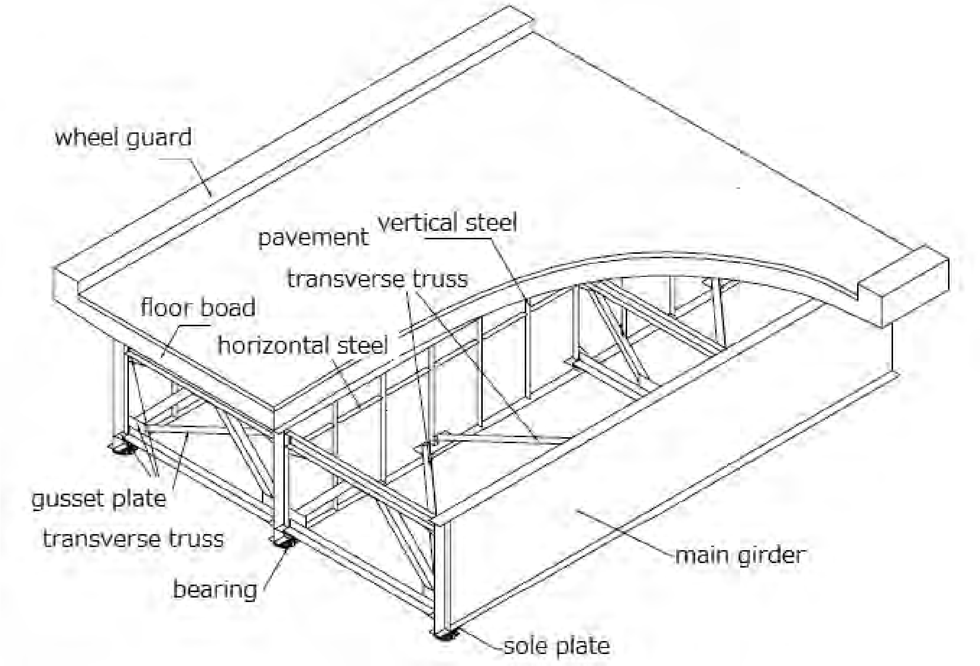


Figure 6.2: Name of parts of steel bridge (NILIM, 2007)

4.2 Deterioration prediction

For individual bridges, deterioration prediction is almost impossible because how the environment changes in the future cannot be predicted. Even if the environmental change can be expected, there are always unexpected errors in construction, so that still it is impossible to predict how exactly the bridge deteriorate. Prediction also has an avoidable wide variability. In the graph of Figure 7, grade of soundness is plotted versus elapsed year; from “a” for good to “e” for bad. Two approximate lines are somehow drowned but as can be seen in the figure, this is just an average and has a wide dispersion. This can be used for macro study for deciding budget but cannot be applied for individual bridges’ management. As stated above, central government majors the bridges deterioration by the index which is calculated by using many inspection data of the local parts. It may be possible to show the average deterioration of the bridges. However, the cause of collapse is caused by the local damage or failure; usually at the connection between truss and girder or around the shoe of the girder. Hence even if the total average assessment is not bad, it does not mean that the bridge is safe. For these reasons, precise deterioration prediction for individual bridge has a limit in field.

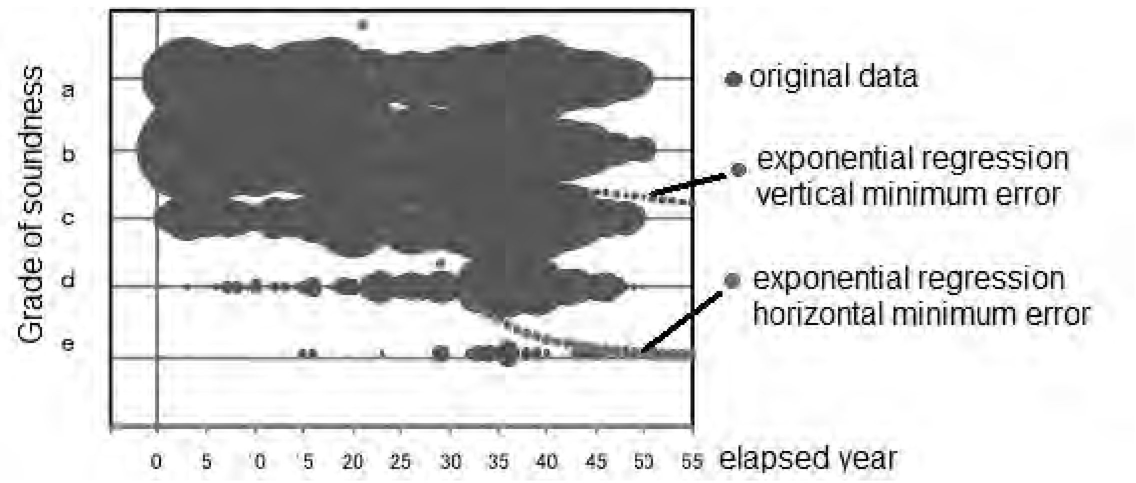


Figure 7: Unreliable deterioration prediction (Tamakoshi,2011)

5. LOCAL ROAD BRIDGE MANAGEMENT

5.1 Sustainable maintenance plan

A survey in 2007 showed that 90 percent of municipalities had not inspected their bridges after construction. Although local governments are short of budget and staff, they are in charge of managing their bridges. To let local governments manage their bridges efficiently, central government decided to support only if they inspect bridges and make their own plan to manage efficiently. It is inefficient that every government make their own ones but the central government could not make unified manual because Japanese governance system is decentralized and the central government is not the manager of those bridges in local area. After this policy, more than 95 percent of municipalities inspected their bridges and 81 percent of local governments made the plans by 2013(Figure 8).

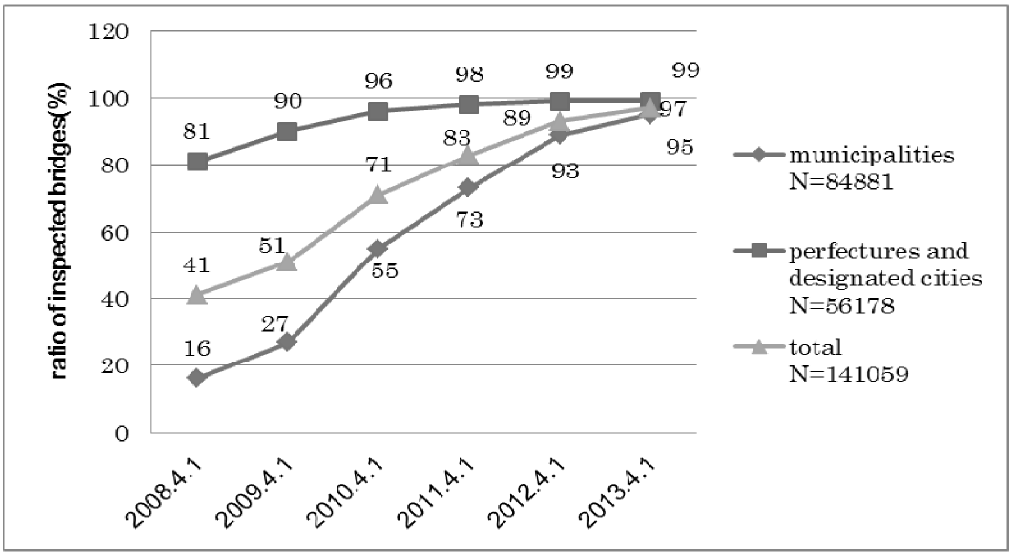
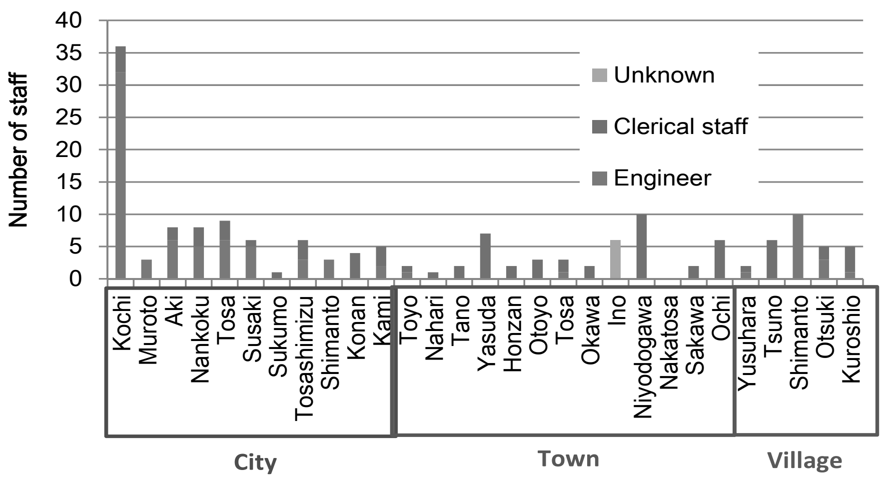


Figure 8: Change of percentage of inspected bridges (MLIT,2013)

5.2 Diagnosis

Thanks for the policy, “inspecting” of the PDCA cycle has been done in most local government. The next phase is diagnosis using their inspecting data. As it is shown in the research taken in Kochi prefecture, local governments have only a few staffs for management of bridges as shown in Figure 9 and it is not a rare case that they are not professional about bridges (Yabe, 2009). The upper graph in figure 9 shows the number of staffs in each municipality in Kochi. Kochi city which have 45 percent of population of Kochi prefecture (760 thousands) have many staffs compared to others. To think of the burden of the staffs, the lower graph shows the number of bridges to manage per staff. It is difficult for them to diagnose when and what kind of maintenance should be done and which bridge is the first priority. However, it is difficult to assign enough engineers to 1,742 municipalities. To improve the condition, municipalities should recognize their responsibility for last decision and ask advice for upper organization if they cannot diagnose. Those governments usually outsource management to consultants and ask advice for universities and other research institution who is supposed to be just advisers. Those organizations may have too much effect on the decision. Municipality governments should always make a last diagnosis with responsibility even though they do not have enough engineers. Being it difficult, they should ask prefecture government which have more educated engineers for support. If they also cannot diagnosis, they should ask regional development bureau. This system shown in Figure 10 makes the management efficient and solves the problem of short of engineers at local government.



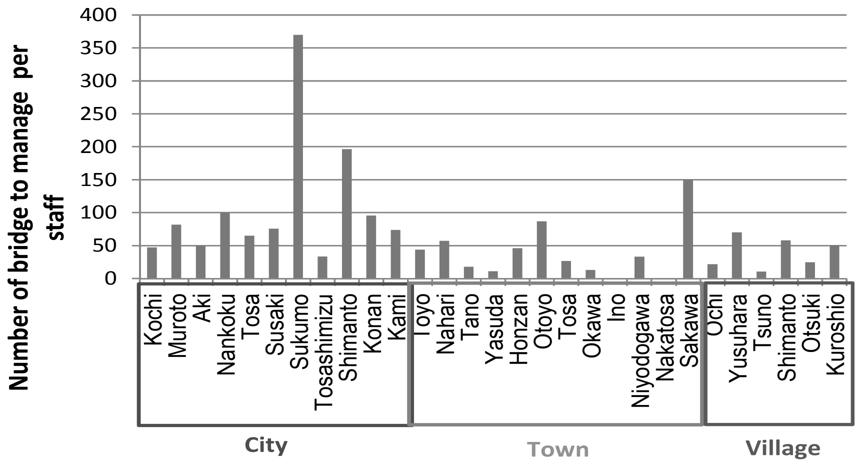


Figure 9: Situation of staffs in municipalities in Kochi

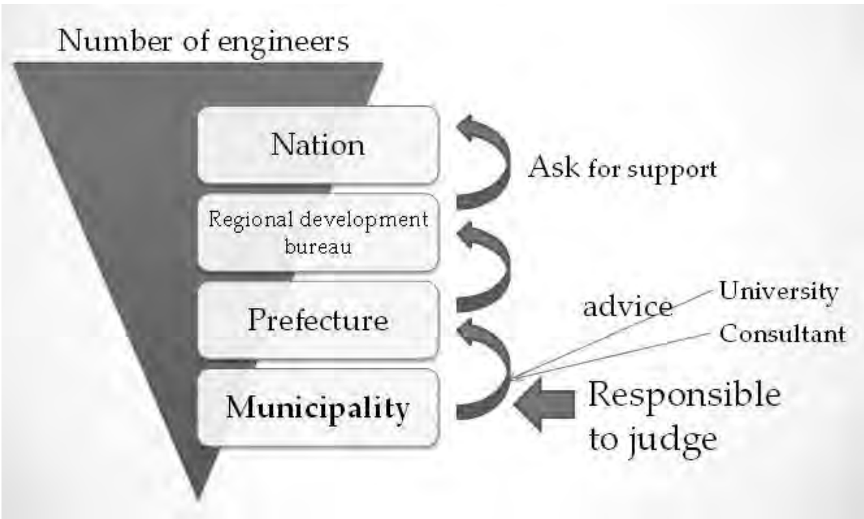


Figure 10: Ideal system of local management

5.3 Data base

To manage bridges efficiently through the nation, unified data base would be useful because any government is able to find other government's data of the same kind of bridge, and the central government can also let all governments to recall easier when some kind of bridge are figured out that those have deficient in shape . However, for the same reason as management manual, data base of each government is not unified. Central governmet is editing its own data base for lacal government to recorded their data. However, for the continuity of the data, it is difficult to let all local government to use the new database.

6. CONCLUSION

Even though it is difficult to predict exactly how bridges going to deteriorate, it is the fact that they deteriorate and early and efficient maintenance before accident happen is necessary. What is needed in the field is not an exact estimation but index that can be used to account for people and make budget. At the same time, making PDCA cycle work is important for efficient management especially for local governments that do not have enough budget and trained staffs.

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THE ROLE OF MUTUAL ASSISTANCE DURING DISASTER IN AGING SOCIETY

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ABSTRACT

For disaster reduction, it is important to consider balanced application of three types of countermeasures, which are self-support, mutual assistance, and public support. Vulnerable people such as pregnant women, small children, the aged, and the physically challenged are limited in their abilities to help themselves and rely more on help from others and public sectors compared to healthy people. Facing rapidly depopulation and aging society, effective countermeasure for vulnerable people is crucial in Japan as well as in other Asian countries where the similar situation will occur in the future.

During the time immediately after a hazard attacks, public support cannot be fully dependent thus mutual assistance becomes critical in providing support to vulnerable people. However the current disaster management plan by the Japanese government does not provide necessary information about mutual assistance.

In this research, the authors focus on the role of mutual assistance, based on the analysis of its characteristics and limitation, future adaptation plan of mutual assistance in the aging society is discussed.

***Keywords**: vulnerable people, mutual assistance*

1. INTRODUCTION

1.1 Significance of mutual assistance to reduce risks

For disaster reduction, it is important to consider balanced application of self-support, mutual assistance, and public support. In case of vulnerable people such as aged and disabled people, pregnant woman, children, foreigners and tourists, the role of mutual assistance and public supports will become more important comparing to the case of healthy people.

Japanese government had already recognized the necessity of mutual assistance to establish the system for helping vulnerable people and taken a number of countermeasures but many aged people and disabled people were killed in the 2011 great east Japan earthquake disaster.

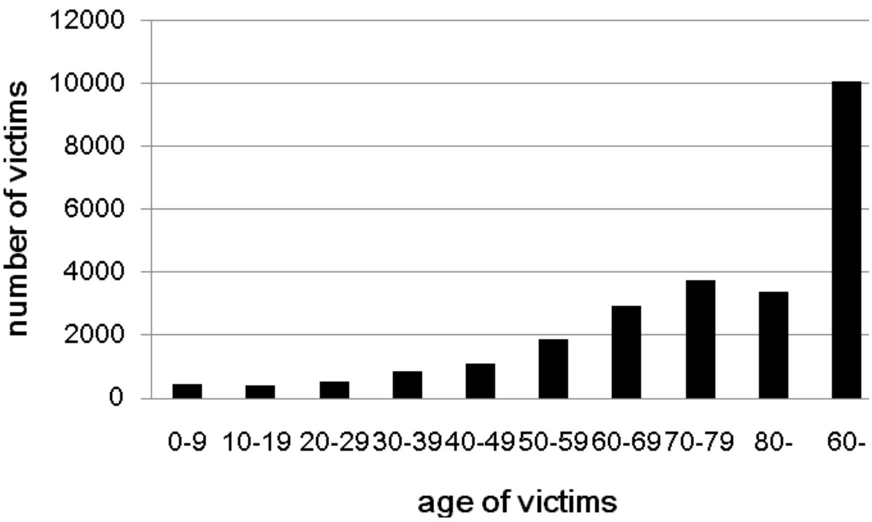

Figure 1: Age-specific victims of the 2011 great east Japan earthquake (from March 2011 to March 2012)

Figure 1 shows the number of age-specific victims due to the 2011 great east Japan earthquake, revealed by Cabinet office. “Victim” in the figure includes not only the dead person during disaster but also the victims who got killed by indirect effects of disasters. According to Figure 1, the number of the victims over 60 years old is as much as 10,085.

When aging society is increasing, ability of community to provide mutual assistance will decline. Therefore, it is necessary to build system of mutual assistance which is suitable to characteristics of aging community. In the following sections, we will introduce the situations surrounding of vulnerable people and the trends of recent countermeasures which expect to make use of mutual assistance in a community.

1.2 Situations surrounding vulnerable people and mutual assistance

Vulnerable people are defined as the people who have any kind of disability and need for others help during disasters. Because of disabilities or difficulties of avoiding dangers, difficulties in evacuation or living in the refugee shelters, and difficulty of recovering as fast as healthy people, these people need mutual help and assistance along with special care. (Japanese Red Cross Society, 2006)

Handicaps are different depending on each person, but the problems due to handicaps are classified in Table 1. These problems are the factors of serious bottlenecks in a disaster. Figure 2 shows the critical parameters in each phase and relationships between factors and disability problems.

Table 1: Problems of vulnerable people in disaster

Problems	Contents
Getting information	Difficulty in getting or understanding the information about disasters
Avoiding danger	Difficulty in defending oneself from dangers such as overturned furniture or stream of moving water
Delayed moving	Difficulty or delay in evacuating
Keeping health	Difficulty in keeping their lives without certain medicine , medical devices, and life support devices
Being adapted to changes	Difficulty in getting adapted to sudden changes of situation such as living in a shelter
Getting the high standards of housing	Difficulty in satisfying the housing standards which is higher than those of healthy people (e.g. impediment removal)
Economic disadvantage	Difficulty in getting high income due to handicaps

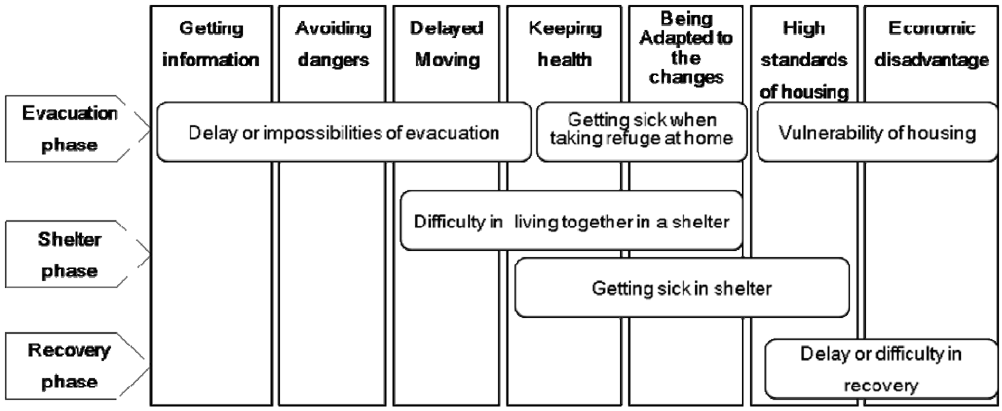

Figure 2: Relationships between disabilities and different phase of disabilities for vulnerable people in disaster

1.3 Recent countermeasures for vulnerable people in Japan

In order to solve above mentioned problems, many countermeasures have been considered and provided by public sectors. Especially, Japanese government started to put effort into evacuation supports after the 2004 Mid Niigata Prefecture Earthquake and a series of flood disasters in 2004, which caused the notable death of aged and handicapped people due to delay in evacuation.

The Japanese government revealed the guidelines of evacuation support for vulnerable people in March, 2005. Following 5 or 6 years, each local government started to prepare the vulnerable people list and some communities made efforts towards their trainings for evacuation supports.

Vulnerable people list contains personal information of vulnerable people such as their address and their needs in disaster, and list of people who need to be checked first during disaster for their safety confirmation. According to a survey by Japanese Cabinet Office from January to March in 2013, 32% of local governments didn't finish the preparation of the list. Even though the other 68% seem to have lists, only one third of them were registered by more than half of vulnerable people in the community. The reason of this seems the possible conflict with the personal information law, because of which the local governments gather information of only those people who want to register themselves in the list.

Few local governments have persuaded each person to register himself or herself in the list and getting his or her information, or shared the family registration information among the relevant institutions.

Japanese government also tried to prepare the evacuation places with special consideration of people disabilities. After the great east Japan earthquake in March 2011, it is said that the numbers of those evacuation places and nursing care stuffs were not enough when some of the nursing homes in the area were crowded. (Fujitsu Research Institute, 2012).

In conclusion, the countermeasures were already considered, but the actions taken by local governments were insufficient. The reasons can be considered as following three points.

First, the information of vulnerable people was not sufficient. However, this problem is now regarded as the very important issue and there is a big action to solve it. In 2013, the Disaster Measures Basic Act, which is the basic law of disaster management in Japan, has started to oblige local governments to make a vulnerable people list. This change will ease for local governments to gather information of vulnerable people.

Second is the limitation of evacuation supports for vulnerable people with mutual assistance in case of wide affected areas with shorter evacuation times.

Third is the lacking of supporting people. This problem was observed in many local governments. Some governments cannot find enough supporters for all vulnerable people, so that they prioritize them depending upon the degree of handicaps.

2. RESEARCH OBJECTIVES

To realize the mutual assistance for vulnerable people which should be accommodated in aging societies or communities, understanding the situation of vulnerable people is not enough. For this, assessing the potential capacity of community to support them will be required to make it possible to utilize the mutual assistance which can be applied in disasters. There are many researches on the quantification of coping capacity of the local community but they are not specialized in mutual assistance for vulnerable people.

Therefore, the purpose of this research is to propose a method for assessing potential capacity to support vulnerable people in disaster area with main focus on evaluation supports.

3. ASSESSMENT METHOD

3.1 Necessary characteristics of this method

In this section, the necessary characteristics of this assessment method are identified with referring the analysis of the existing methods used for evaluation of the coping capacity of the local communities in Japan (Nagamatsu, 2009).

1) We would like to show the components of disaster risk in order to describe the coping capacity. Disaster risk can be represented by the gap between coping capacity and the sum of hazard, exposure, and vulnerability. Hazard is just the external force as a factor of disaster occurrence. Exposure means how much our life is exposed to the disaster. Vulnerability contains both of the physical distribution of disaster and social distribution of vulnerable people. Vulnerable people such as the aged and the handicapped are included to social vulnerability. Whereas coping capacity is the ability of minimizing these risks. In Japan, the evaluation of vulnerability and that of coping capacity are often separately done, and there are few evaluation methods which combine both of them. Therefore, this research will aim to establish a evaluation method which can evaluate vulnerability and coping capacity together and can proposes required countermeasures.
2) The unit of each area should be defined. Current research mainly focuses on evacuation required in each unit based on the locations of shelters, such as, elementary school district or community center, etc.
3) The targets of evaluation factors in the community should be set. In this research, stakeholders who can have a relationship with vulnerable people are the targets, such as, neighborhoods, nursing care staff, district welfare commissioners, and volunteer fire department, etc.
4) It is necessary to consider the components of coping capacity. This is divided into risk awareness, exposed capacity, and latent capacity (Nagamatsu, 2009). Risk awareness is the factor of people awareness about the risk of the area. Exposed capacity is defined as the explicit degree of preparedness for reducing the risks. Latent capacity is the implicit ability of community capacities which is not intended to reduce the risks, but has a possibility to contribute to it. Some of recent researches have set a high valuation on the latent capacity. However, when support for vulnerable people is considered, the problem is disparity of the quality and quantity of care between normal times and in the disaster periods. Therefore, it is necessary to carefully evaluate latent capacity. In Addition, coping capacity will include the ability to support vulnerable people.

The characteristics of this method are summarized as follow.

1) There is a structure to produce the countermeasures.
2) The unit of evaluation area is based on the places of shelters.
3) Target includes the various stakeholders who have a relationship with vulnerable people.
4) Coping capacity should be considered based on how much support vulnerable people can receive.

In addition, simple representation of evaluation will be preferred.

3.2 Assessing flow

In this section, the image of assessing flow is introduced. It is necessary to consider three categories, which are characteristics of hazard, vulnerable people, and potential support ability. Hazard can be classified as the range of affecting area and the degree of urgency to evacuate. Table 2 shows the factors and the origin of data in order to evaluate the governing factors.

Table2: Factors of assessing

Category	Factor	Data
Hazard	Characteristics of the hazards(Earthquake, flood, landslide, etc)	Hazard map
Vulnerable people	Distribution of their living places	Statistics(GIS)
	The ratio of each kinds of vulnerable people	Statistics
Potential support ability	Distribution of young people's living place	Statistics
	Distribution of shelters	Statistics
	Unionization rate of voluntary organization for disaster prevention	Needs for getting data from field work

First, hazard map and the distribution of shelters are plotted on the map of whole area, mesh size is decided and each mesh is classified based upon the level of difficulty to evacuate. The levels are showed as the Table 3.

Table 3: Level of hazards

Level	Shelters	Hazard
4	Not available	High risk
3	Available	High risk
2	Not Available	Low risk
1	Available	Low risk

Second, in order to produce the index of ability to support, distribution of young people and vulnerable people are plotted. The index is produced on each mesh with considering several situations depending on time zone, days of the week, and seasons. The index is referred as following.

$$c(aV / bY) + d$$

where:

V: number of vulnerable people,
Y: number of abled people
a: self-help ability of vulnerable people
b: supporting ability of abled people
c: characteristics of disaster
d: other factors

In this research, abled people are defined as people who have no disability in normal time, and supporting ability of abled people is defined as any resource which contributes to evacuation supports, for example skills of nursing care, sign language, knowledge about certain disability, and availability of evacuation support devices like a car, etc.
After producing index, we can over view the distribution of ability to support vulnerable people. Then we can take countermeasures in order to reduce the disparity of ability to support vulnerable people.
The assessing flow is shown in the Figure 3.

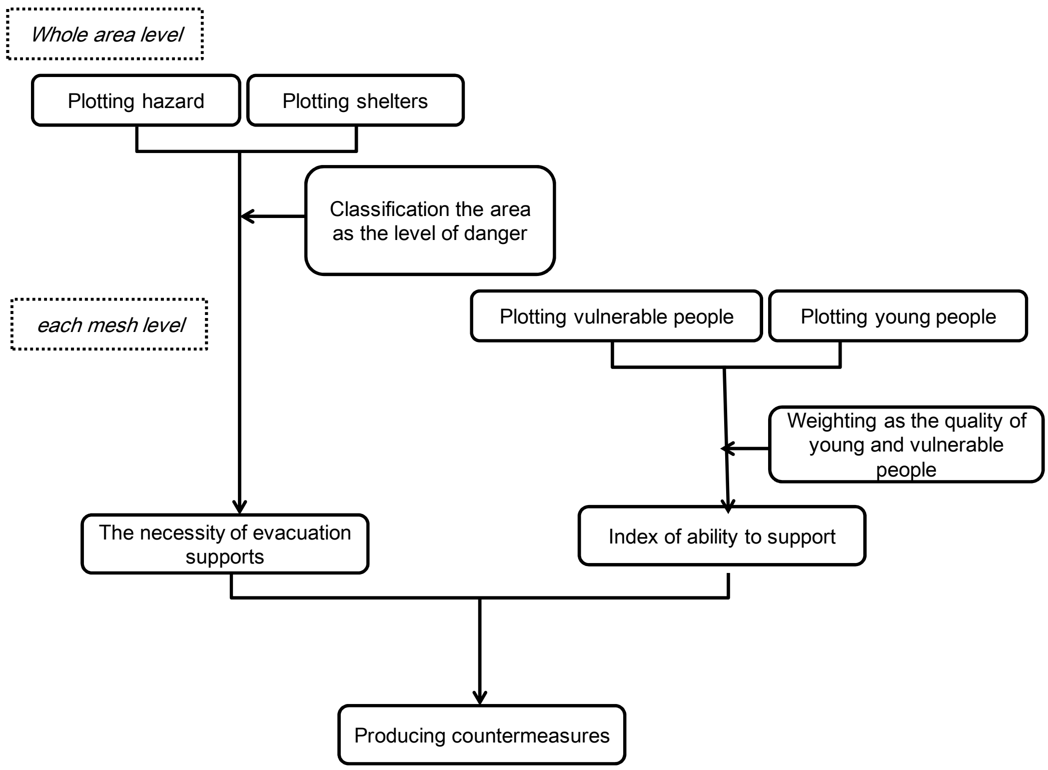

Figure 3: Assessing flow

3.3 Advantage of this method

In this section, we will explain about the advantage of representing the ability of community to support vulnerable people. First, it is easy to compare the ability of each community, so that we can identify which area is most dangerous and who should move to the safer area. Second, it can be analyzed how the ability to support vulnerable people will change as community will be aging in the future. Addition, assessing the ability itself may encourage the disaster prevention activities in the community or awareness of vulnerable people in the community.

This kind of index can be useful especially in rural area which is under severe aging and depopulation. Also, in Japan huge earthquakes are supposed to occur along the Nankai trough in near future, which will hit many rural areas. The assessment of capacity to evacuation support will be meaningful for these areas.

4. PROBLEMS AND FUTURE PLAN

In order to build the assessment method, basic survey is needed. The topics of survey can be as following.

- Types of vulnerable people e.g. which are easy or difficult to help.
- What is the difference between the care-skilled people and no-skilled people in order to help vulnerable people
- Categorizing the characteristics of the community
- Categorizing the countermeasures based on public support, mutual assistance, and self-support.

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THE CALIBRATION OF ROAD NETWORK TRAVEL TIME FUNCTION IN KOREA : THE ISSUES AND SOLUTIONS

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ABSTRACT

The purpose of this research is to improve reliability of the calibration of road network Travel Time Function(TTF) in Korea with a new calibration methodology and using cutting-edge data. In this perspective, there are four research issues; 1) old calibration techniques, 2) data problems, 3) traffic assignment problems and 4) fixed value of TTF's parameters. We are provided with basic data like origin-destination(OD) traffic volume, network and observed traffic counts from The Korea Transport Institute Data Base(KTDB) and cutting-edge data like Toll Collection System OD(TCS OD) and Car Navigation Data(Navi-data) from Korea Highway Corporation Data Base(KHCDB) and MN-Soft, respectively.

The validation criterion for the network calibration is that the link volume error is within ±30%. In addition we developed new calibration model based Harmony Search(HS) to estimate a set of parameter values of TTF. Also, traffic volume consistency verification method and observed traffic volume filtering method are developed to improve accuracy of observed data.

Finally, we conduct an analysis how much the level of calibration index improved based on the result of this research and suggest future direction of research.

***Keywords**: travel time function, BPR function, car navigation data, harmony search, intra-zonal trip, network calibration*

1. INTRODUCTION

A current road network is used to expect feasibility and demand of various transportation policies or infrastructure construction enterprises. Accordingly, reproducing accurate road network is very important because these Social Overhead Capital(SOC) Projects generally has greater social impact and large scale. In order to construct status road network accurately, estimation of Travel Time Function(TTF)'s parameters is one of the most important elements. However, the problem is that the difference between two kinds of link traffic volumes observed and estimated by established TTF is so big that reliability of calibration is not enough.

Therefore, the purpose of this research was to improve reliability of the calibration of road network TTF and calibrate TTF's parameters by developing new calibration methodology and using cutting-edge data. We investigated the reasons decreasing reliability of calibration and the methods to improve existing calibration system and finally we suggested new coefficient of TTF's parameters as both range and value.

2. DATA AND METHODOLOGY FOR CALIBRATION

2.1 Travel Time Function

TTF is the monotonically increasing function to traffic volume. It is used in traffic assignment model and can represent congested traffic flow condition when traffic demand exceeds road capacity. For examples, Wardrop function, Bureau of Public Roads(BPR) function, Conical function, and Irwin, Dodd and Von-Cube function are typical. From among these, BPR function is the most commonly used TTF; it is used in Korea; and it is expressed as follows (formula 1):

$$t = t_0\left\{ 1 + \alpha \cdot (X/C)^{\beta} \right\} \tag{1}$$

The variable of BPR function is traffic volume(X) and travel time(t). There are four parameters, t_0, C, α, β and each parameter's explanation is in the Table 1.

Table 1: Parameters of BPR function

Parameters	Explanations
t_0	Free flow travel time; determined by field investigation
C	Capacity of the road; determined by capacity analysis
α	Coefficient; estimated by calibration or traffic assignment model
β	

First two parameters, t_0 and C, are determined by field data because these are not related to sensitivity between X/C and travel time. On the other hands, other parameters, α and β, are estimated by calibration or traffic assignment model because these affect function's shape for whole region of

X/C. Especially, α and β have information reflected the physical condition of road. As a result, each parameter of BPR function has different effective area for function's shape according to X/C (Figure 1).

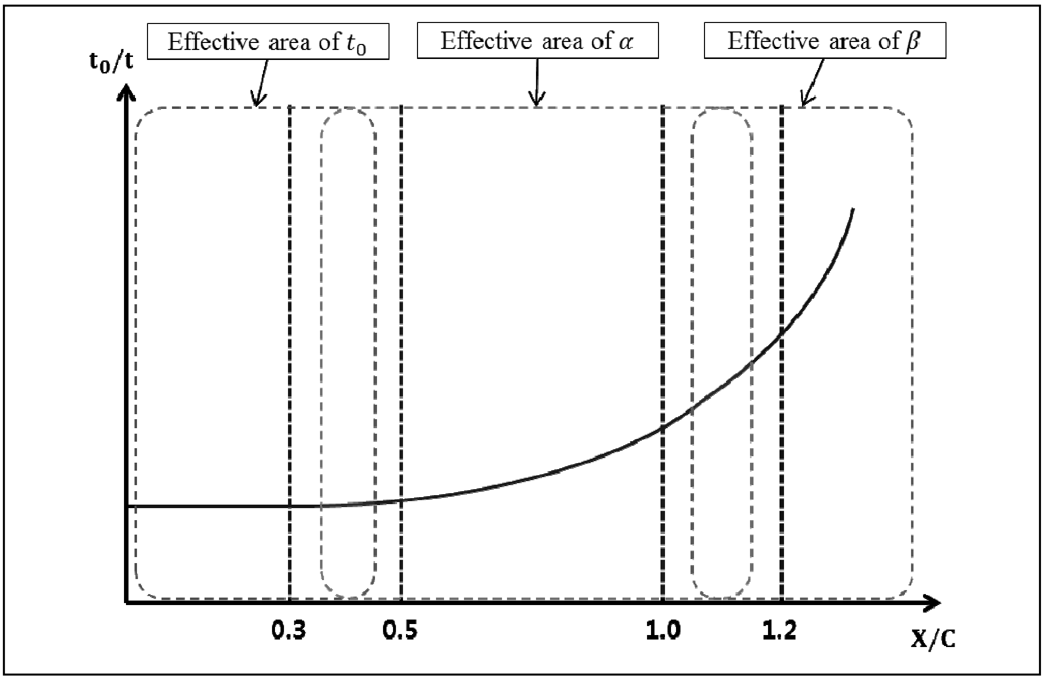

Figure 1: Effective area of BPR's Parameters

2.2 Network and Data

KTDB road network consists of 248 zones, 107,844 nodes and 68,613 links except for centroid-connectors and ramps. In Korea, all roads are classified into the 16 levels according to attributes such as road type, the number of lanes and density of intersection, also each level of road has different TTF's parameters.

Table 2: Criteria for classification of TTF's level

Level of TTF	Type	Lane	# of intersection in 1km	Level of TTF	Type	Lane	# of intersection in 1km
1	Highway	< 3	No intersection	9	Arterial	1	0.7 – 1.0
2		≥ 3		10		≥ 2	
3	Urban Highway	< 3		11		1	1.0 – 2.0
4		≥ 3		12		≥ 2	
5	Arterial	1	0 – 0.3	13		1	2.0 – 4.0
6		≥ 2		14		≥ 2	
7		1	0.3 – 0.7	15		1	≥ 4.0
8		≥ 2		16		≥ 2	

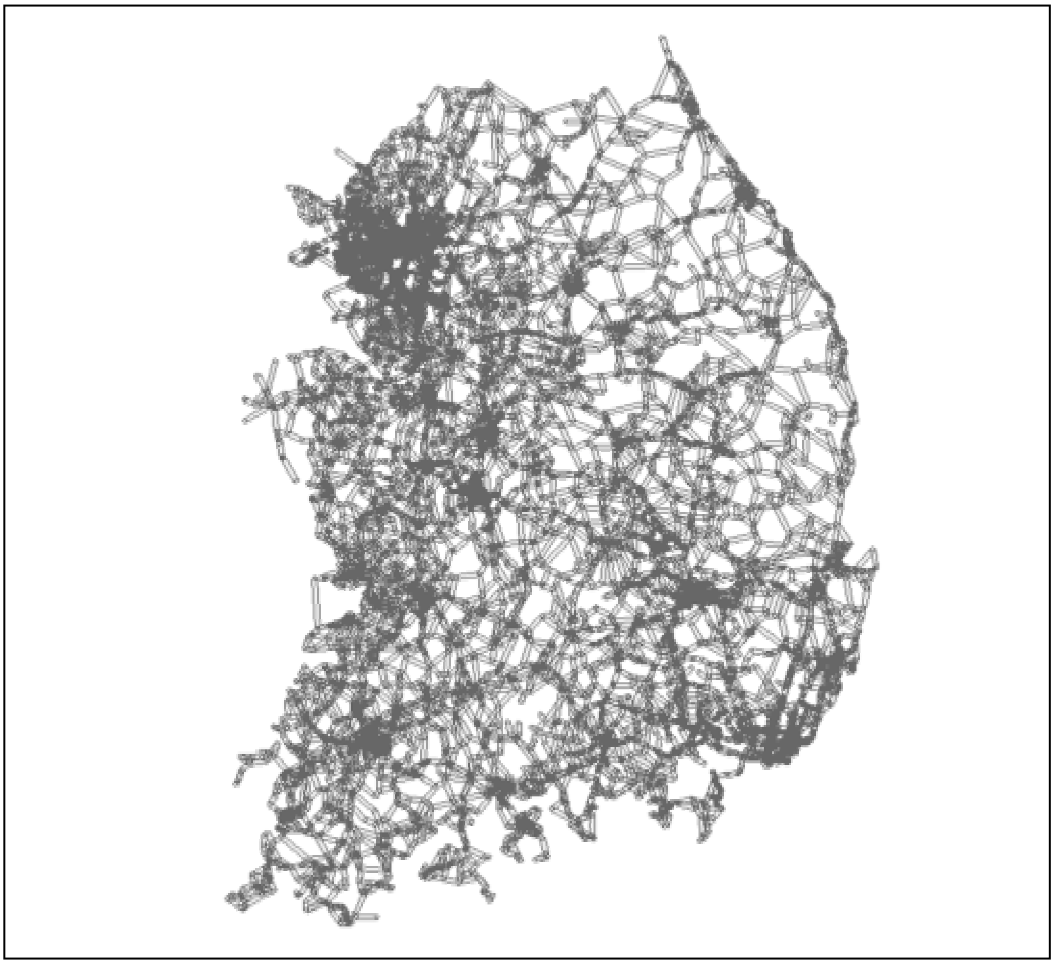

Figure 2: KTDB road network of Korea

To calibrate road network TTF, Origin-Destination(OD) traffic volume and observed link traffic volume are needed. These data are provided from KTDB. The number of OD pairs is 61,256 and the data is classified into 5 types of vehicle. Also, observed link traffic volume is counted at 6,818 places by detectors or investigation and it is classified into 12 types of vehicle.

In Korea, cutting-edge data, Toll Collection System OD(TCS OD) and Car Navigation Data(Navi-data), has currently received a lot of attention in field of transportation. Especially, Navi-data could be usefully applied to verification of zone-network compatibility and many other analyses by processing variously like intrazonal trip rate, the number of passing OD pairs, average travel distance of passing car and OD traffic volume sharing ratio of link.

2.3 Calibration Criteria

The current calibration criteria of road network is that the error between observed traffic volume and estimated traffic volume of each link is inner ±30%, and if this criteria is satisfied, it means TTF explain present trip pattern well. However, even if observed traffic volume of link is reproduced by TTF well, travel time is not reproduced well on many links. Therefore it needs to do analysis about reasons and solutions of this problem.

3. RESEARCH ISSUES

In case of arterials, the hit ratio within 30% range from the observed counts was 22.6% on average in 2011. This ratio is too low to be get reliability of TTF, thus, we suggested what decrease reliability of TTF as research issues.

3.1 Calibration Technique

To calibrate TTF's parameters which maximize the hit ratio, we have used Golden Section Method or Incremental Method before as calibration technique, however, these methods have high randomness problem that cannot find unique global solution. Accordingly, it needs to develop new calibration model based on global optimization method for reducing randomness in TTF calibration process.

Also, it needs to diversify calibration criteria like travel speed or time for detailed calibration of the road network. To apply new calibration criteria, the data related criteria must be databased, however, it is difficult to get basic data for applying new calibration criteria.

3.2 Data Problems

The data used for calibrating road network has a problem itself that the data doesn't guarantee its accuracy, because OD traffic volume is not observed data but estimated and observed traffic volume has counting error from detector. For solving these data problems, therefore, it needs to use high accuracy data or find solution correcting data logically.

3.3 Traffic Assignment Problems

Zone system is one of the most effective elements to reliability of calibration, nevertheless, traffic assignment based zone system has fundamental problem. In zone based traffic assignment, OD traffic volume is only valid when generating zone is different to arriving zone. It is defined as interzonal trip. In contrast, when generating zone is same with arriving zone, its OD traffic volume is not existed in estimated traffic volume but observed volume. It is defined as intrazonal trip (Figure 3).

Intrazonal trip is main cause of under estimated traffic volume and it affects critical impact to reliability of calibration. To mitigate this impact from this problem, it needs to separate zone system more detailed or reflect intrazonal trip to traffic assignment.

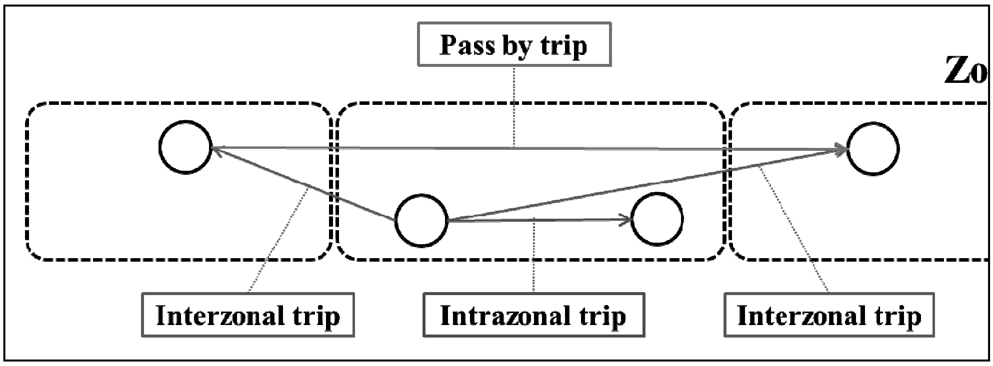

Figure 3: Definition of interzonal trip and intrazonal trip

The above problems are collectively defined as zone-network compatibility problem. There are two cases of non-compatibility (Figure 4), and the road network of Korea corresponds to case 1.

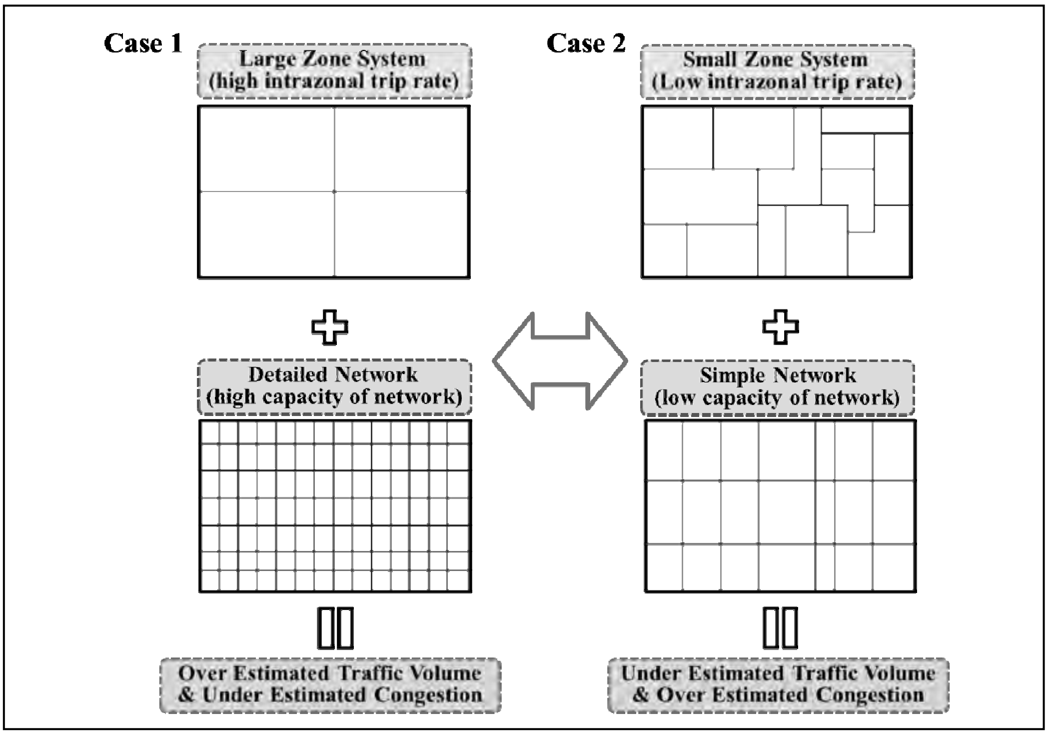

Figure 4: Cases of zone-network non-compatibility

Conventional zone system has another fundamental problem that generating and arriving trip are only assigned by centroid connectors. It makes overestimated traffic volume on some observed links which connected directly with connectors. For solving this problem, it needs to exclude links connected directly with connectors from observed place or separate zone system more detailed in common with solution of non-compatibility. As a result, we could solve this problem by using Navi-data.

3.4 Range or Value of TTF's Parameters

The parameters of TTF have information related to the physical condition of road. However, it is impossible that all of each road is explained by fixed parameters, even though the levels of TTF are separated very detailed, because physical conditions of each road in a same level of TTF are different little by little according to spatial range. Therefore, it is needed to suggest the range of each parameter, then, analyst can use TTF flexibly.

4. SOLUTIONS

To solve the problems mentioned in research issues, we suggested two solutions. First was to improve previous calibration system by applying Harmony Search(HS); it is a kind of global optimization method; and calibrate new TTF's parameters. Second was to use cutting-edge data; TCS OD and Navi-data; for correcting observed traffic volume and analyzing basic reliability of network by verifying network compatibility. As a result, we could improve reliability of road network TTF from these solutions.

4.1 Improvement of Calibration System

The TTF estimation problem was formulated as a Bi-level optimization problem because it has structure which iterates traffic assignment and adjusting coefficient to optimize objective function. TTF parameter estimation has the plural combinations of optimum solutions; accordingly it needs to apply global searching optimization method. To solve this convex problem, TTF calibration algorithm based HS was developed by Kim et. al.(2012).

HS is a phenomenon-mimicking inspired by the improvisation process of musicians proposed by Geem(2001). In the HS algorithm, each musician (= decision variable) plays (= generates) a note (= a value) for finding a best harmony (= global optimum) all together. HS is similar to Genetic Algorithm(GA), however, HS may overcome the drawback of GA's building block theory which works well only if the relationship among variables in a chromosome is carefully considered. It iterates process to find new solutions by combinating parts of superior solutions randomly. Based on above concepts, optimization problem for TTF calibration was configured as follows (formula 2):

$$Min \ \sum_{a \in A}(1-\gamma) \cdot \frac{|x_a - \overline{x_a}|}{\overline{x_a}} + \gamma \cdot \sum_{b \in B} \frac{|v_b - \overline{v_b}|}{\overline{v_b}} \qquad a \in A, b \in B \tag{2}$$

In formula, A and B is the set of links existed observed traffic and travel time respectively, and γ is the coefficient which define relative weights between traffic volume and travel time of error. Also, x_a is traffic

volume of link a, v_b is travel time of link b, and, $\overline{x_a}$ and $\overline{v_b}$ is observed traffic volume and travel time each.
Using HS TTF calibration algorithm developed by Kim Hyun-myung in 2011, we did estimation of TTF's parameter. Finally we could find plural combinations of optimum solutions with solving the local solution in previous Golden Section Method or Incremental Method.

4.2 Cutting-edge Data

4.2.1 TCS OD

To guarantee accuracy of network calibration, high accuracy data and new calibration criteria are needed, so we did highway separated calibration.

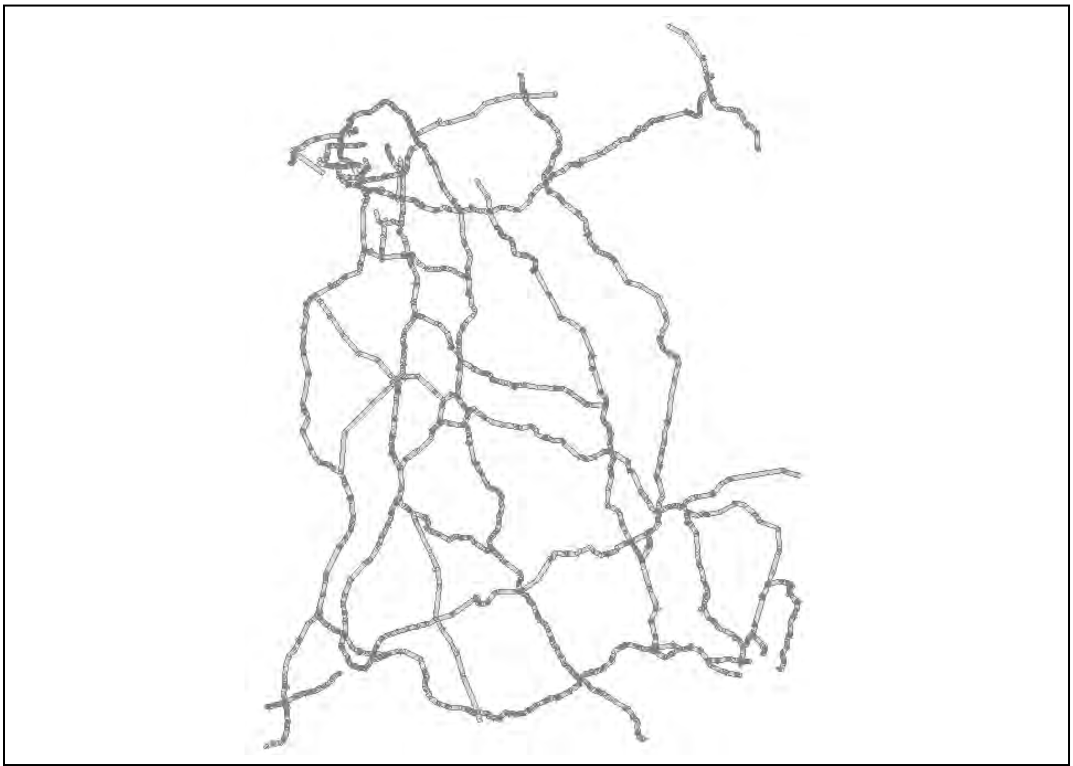

Figure 5: Network for highway separated calibration

In Korea, almost of highway operates closed toll, thus the TCS OD from toll to toll could be get by inflow and outflow count at each toll. TCS OD is more accurate than KTDB OD from zone to zone because it is not sample data. As a result, we could estimate more reliable parameters of TTF1 and TTF2 by applying highway separated calibration with TCS OD. Additionally, we could apply new calibration criteria, travel time, because highway acquires link data not only traffic volume but also travel time.

Also, we developed axis consistency verification method based the law of conservation of traffic volume to correct observed traffic. The definition of the axis consistency is that the sum of each traffic volume of upstream and downstream must be same (Figure 6). Consequently, it was possible to correct observed traffic volume within allowable error rate by calculating error rate between upstream and downstream traffic volume.

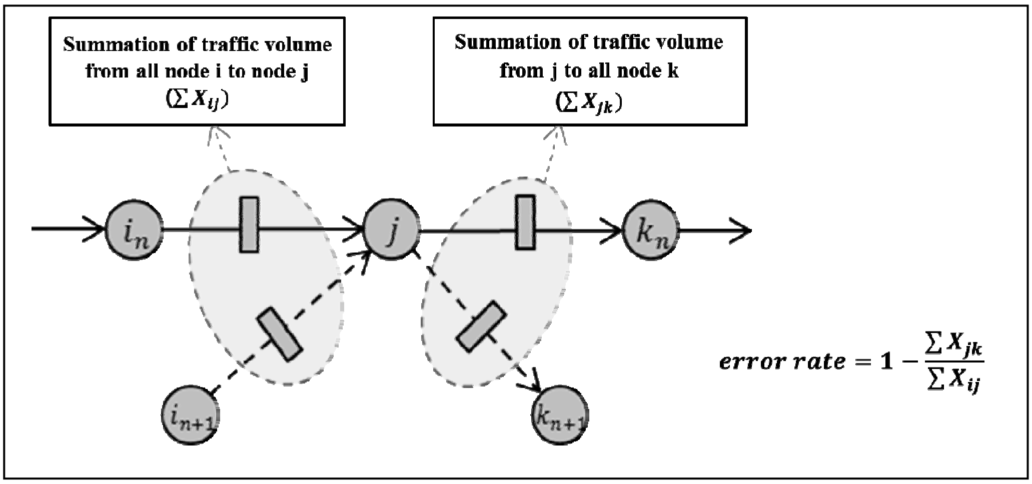

Figure 6: Definition of the axis consistency

In this research, first, we did highway separated calibration by using TCS OD; we calibrated TTF1 and TTF2, then we did KTDB network calibration as the parameters of TTF1 and TTF2 are fixed.

4.2.2 Car Navigation Data

Navi-data are very important and high usable in this research. The number of links which the Navi-data are acquired is 33,179, and it is 48.4% of links of KTDB network. By using Navi-data providing detailed start point, end point and path of the cars, we could calculate intrazonal trip rate, the number of passing OD pairs, average travel distance of passing car and OD traffic volume sharing ratio of each link.

The intrazonal trip rate was especially very valuable data because the intrazonal trips do not simulated by traffic assignment. In general, a half of observed traffic counts are intrazonal trip currently. (Table 2).

Table 2: Under estimated rate of arterials (%)

Underestimated Rate	Arterials	TTF 5&6	TTF 7&8	TTF 9&10	TTF 11&12	TTF 13&14	TTF 15&16
-30% ~ -50%	10.2	6.1	9.5	10.0	14.0	12.5	25.0
-50% ~ -70%	9.9	6.9	10.1	9.1	10.5	16.2	21.2
-70% ~ -100%	16.1	14.0	15.6	17.6	15.9	22.1	17.3
-100%	17.5	23.5	19.5	14.8	14.1	5.9	13.5
Total	53.7	50.5	54.7	51.5	54.5	56.7	77.0

With other calculated results including intrazonal trip rate, we could do link network compatibility evaluation and priority analysis for verifying basic reliability of KTDB road network. For example, compatibility of each link is judged to be as high as intrazonal trip rate is low, the number of passing OD pairs is various and average travel distance of passing car is long.

Also, we could verify zone-connector problem by using OD traffic volume sharing ratio of each link. This result explains overestimated traffic volume of observed links which connected directly with connector and give judgment about appropriacy of current zone system.

5. RSEULTS

5.1 Analysis Results Using Navi-Data

As a result of calculating intrazonal trip rate, average of each TTF's rate is about 10% and 30~50% in case of highways and arterials. Namely, intrazonal trip rate of arterial is much higher than highways. Also it is showed patterns as lower as the road has low level of TTF; the density of intersection is high; and the number of lane is many (Figure 7). Consequently this result solved underestimated traffic volume problem, referenced (Table 2), of arterials for network calibration.

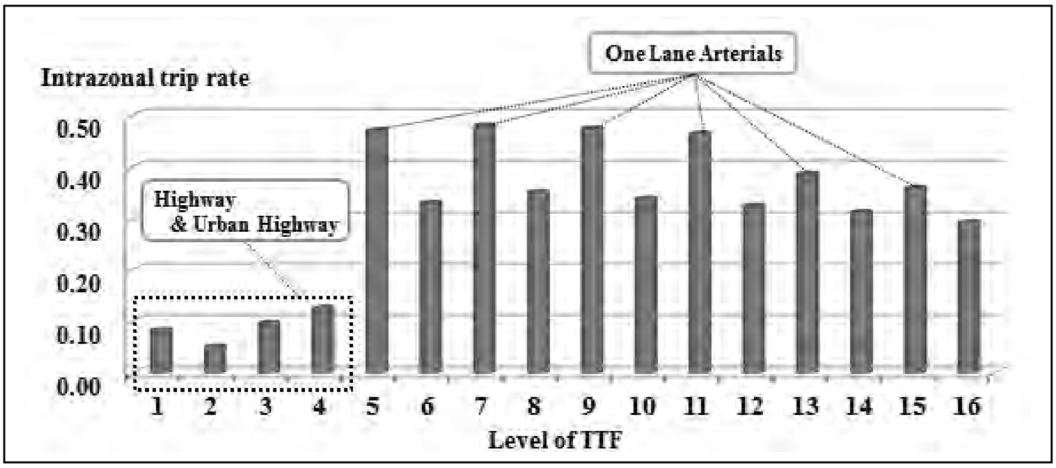

Figure 7: Analysis results of intrazonal trip rate

From intrazonal trip rate, the number of passing OD pairs and average travel distance of passing car of each link, we analyzed zone-network compatibility. As a result of analysis, we understood the facts that there may be included in some links which not appropriate for traffic assignment based current zone system and the compatibility of urban road is lower than local road relatively (Figure 8).

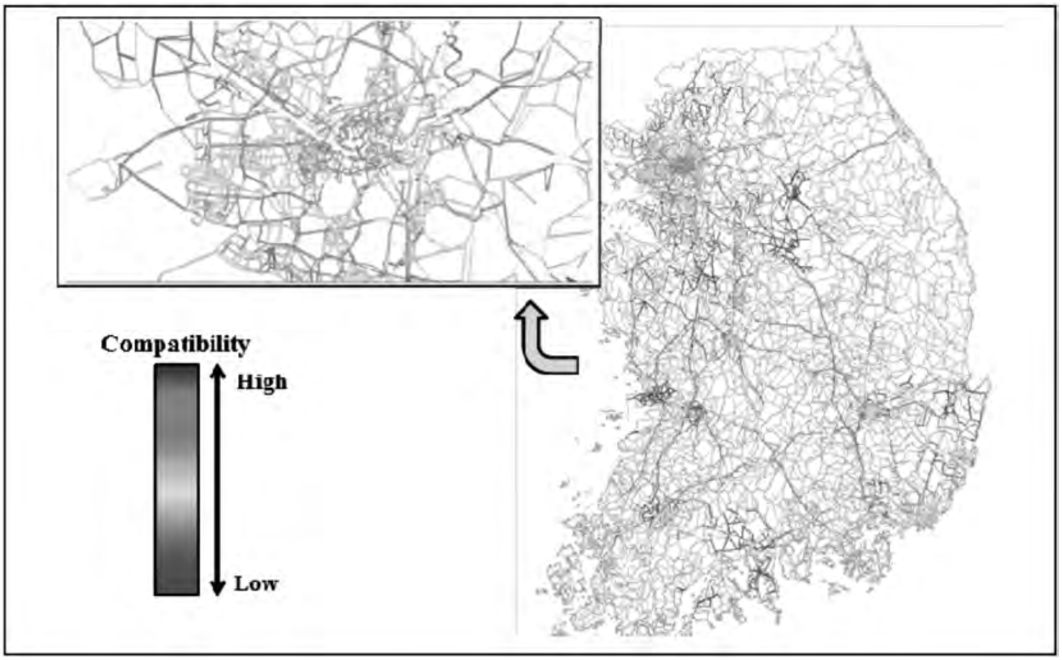

Figure 8: Compatibility analysis by car navigation data

Additionally, we verified zone-connector problem by using OD traffic volume sharing ratio. For example, figure 9 is analysis result of generating OD sharing ratio. In figure, actual generated OD traffic volume of links connected directly with connectors is about only 21% in a whole zone. It namely means that 79% of generated OD traffic in a whole zone can't be explained by connectors for traffic assignment. This problem cases overestimated traffic volume of observed links which connected directly with connector. For mitigate this impact of problem, we could add more connectors, but it is not fundamental solution, because it is impossible to set assigned OD traffic volume of each connectors.

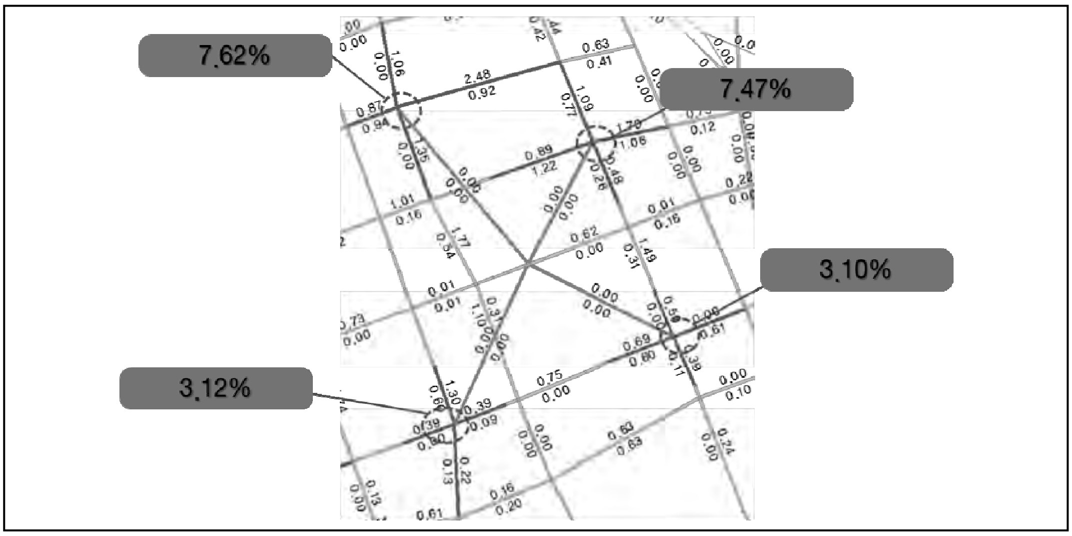

Figure 9: The example of zone-connector problem

5. 2 Calibration Results

As a result of comparison analysis between previous highway calibration and current high way separated calibration, the hit ratio of TTF1 and TTF2 was improved 22.6% and 11.6%, respectively (Table 3). From the result, accordingly, it was proved to appropriate for highway separated calibration which use more accurate TCS OD than KTDB OD and parameters estimated by HS.

Table 3: The result of highway separated calibration (traffic volume)

Traffic Volume	TTF 1 (%)			TTF 2 (%)		
	Before	After	Change	Before	After	Change
200% ~	0.5	0.0	-0.5	2.4	0.0	-2.4
100% ~ 200%	4.7	0.0	-4.7	5.3	1.0	-4.3
75% ~ 100%	7.5	0.9	-6.6	2.4	0.0	-2.4
50% ~ 75%	6.0	1.1	-4.9	3.5	0.5	-3.0
30% ~ 50%	11.3	5.2	-6.1	5.6	7.7	2.1
15% ~ 30%	12.8	16.0	3.2	9.1	11.1	2.0
0% ~ 15%	15.2	23.1	7.9	14.5	15.5	1.0
-15% ~ 0%	18.5	26.5	8.0	26.0	30.9	4.9
-30% ~ -15%	13.5	17.0	3.5	18.6	22.2	3.6
-50% ~ -30%	6.5	7.8	1.3	7.4	9.7	2.3
-75% ~ --50%	2.9	2.2	-0.7	0.6	1.4	0.8
-100% ~ -75%	0.3	0.0	-0.3	3.5	0.0	-3.5
~ -100%	0.3	0.0	-0.3	1.2	0.0	-1.2
±30%	**60.0**	**82.6**	**22.6**	**68.1**	**79.7**	**11.6**
±50%	**77.8**	**95.6**	**17.8**	**81.1**	**97.1**	**16.0**

In case of travel time, we verified it by using difference between observed and estimated travel time, because it has never used as calibration criteria, so it is impossible to compare with precious result (Figure 10). In figure, the dispersion of two values is similar to shape of 45 degrees; consequently it is justified to be high reproduced rate for travel time.

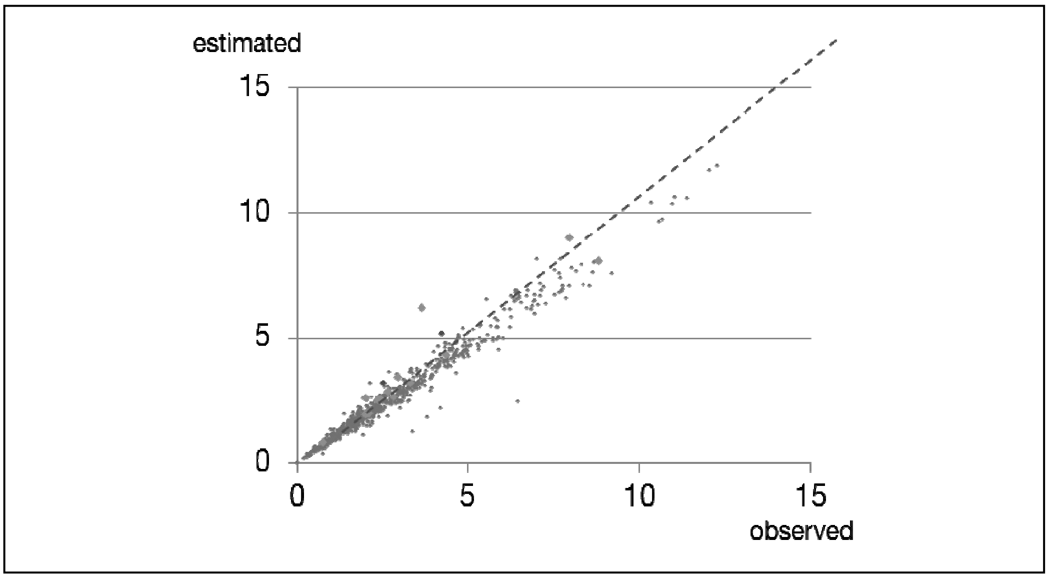

Figure 10: The result of highway separated calibration (travel time)

Next, we did comparison analysis between previous and this highway calibration for KTDB network as the parameters of TTF1 and TTF2 from highway separated calibration were fixed. In result, the hit ratio of TTF1 and TTF2 was worsened -2.8% and -3.8%, respectively (Table 4); however, TTF2 is improved as much as 3.4% within 50% range, so this is not serious problem. Also, TTF1 showed an overestimated tendency and TTF2 contrarily did an underestimated it.

The overestimation problem of TTF1 is caused by some particular highways which included in TTF1, but different from physical conditions of road. Therefore it needs to be defined new TTF hierachy to separate these highways.

Table 4: The result of KTDB network calibration (highway)

Traffic Volume	TTF 1 (%)			TTF 2 (%)		
	Before	After	Change	Before	After	Change
200% ~	0.5	0.7	0.2	2.4	0.0	-2.4
100% ~ 200%	4.7	5.5	0.8	5.3	2.8	-2.5
75% ~ 100%	7.5	9.8	2.3	2.4	0.8	-1.5
50% ~ 75%	6.0	9.8	3.8	3.5	3.4	-0.2
30% ~ 50%	11.3	9.5	-1.9	5.6	10.1	4.5
15% ~ 30%	12.8	13.4	0.6	9.1	8.4	-0.7
0% ~ 15%	15.2	15.5	0.2	14.5	12.4	-2.1
-15% ~ 0%	18.5	17.4	-1.1	26.0	19.7	-6.3
-30% ~ -15%	13.5	11.0	-2.5	18.6	23.9	5.3
-50% ~ -30%	6.5	5.3	-1.2	7.4	10.1	2.7
-75% ~ --50%	2.9	2.1	-0.9	0.6	3.7	3.1
-100% ~ -75%	0.3	0.2	-0.2	3.5	3.7	0.1
~ -100%	0.3	0.0	-0.3	1.2	1.1	-0.1
±30%	60.0	57.2	-2.8	68.1	64.3	-3.8
±50%	77.8	72.0	-5.8	81.1	84.6	3.4

In addition, we analyzed result of KTDB network calibration of arterial. In case of arterial, the hit ratio within 30% range from the observed counts was 25.4%, so it was improved as much as 2.8% compared with previous result. In general, the high TTF roads (TTF5~10) tend to be overestimated and low TTF roads (TTF11~16) do to be underestimated (Table 5).

Table 5: The result of KTDB network calibration (arterial)

Traffic Volume	Total	TTF 5	TTF 6	TTF 7	TTF 8	TTF 9	TTF 10	TTF 11	TTF 12	TTF 13	TTF 14	TTF 15	TTF 16
200% ~	11.4	15.5	17.5	10.7	14.2	6.5	17.8	4.9	11.6	13.4	7.9	17.1	7.7
100% ~ 200%	11	13.9	9.6	11.8	13.5	9.7	10.3	8.3	9	4.2	9.2	2.9	10.8
75% ~ 100%	4.5	4.2	7	5.4	3.5	3.4	4.3	3.3	5.7	1.7	5.4	2.9	4.6
50% ~ 75%	6.8	6.6	7.9	6.2	9.2	4.9	9.2	4.7	8.2	6.7	9.2	2.9	1.5
30% ~ 50%	5	3.6	7.9	4.2	7.1	3.7	7.4	4.7	6.4	1.7	5.7	0	9.2
15% ~ 30%	4.3	2.7	1.8	3	5.3	3.5	7.1	4.9	7.1	4.2	4.4	5.7	7.7
0% ~ 15%	5.4	3.7	2.7	3	8.7	5.2	7.1	7.3	7.8	5	7.9	5.7	4.5
-15% ~ 0%	6.5	3.6	10.6	4.6	7.9	7.6	7.4	7.6	8	5.9	11.6	5.8	10.8
-30% ~ -15%	9.2	9	7	7.9	7.3	10.6	6.3	15.1	9.7	11.7	8.2	14.3	9.3
-50% ~ -30%	14	9.7	16.7	13.8	10	21.5	10	19.1	14	15.1	11.1	14.3	29.2
-75% ~ --50%	10	13.7	4.4	11.6	7.8	8.1	8	8.2	6.4	16	12.3	20	3.1
-100% ~ -75%	11.8	13.7	7	17.7	5.2	15.3	4.9	12	6.1	14.3	7	8.6	1.5
~ -100%	0.1	0.1	0	0.1	0.2	0.2	0	0	0	0	0	0	0
±30%	25.4	19	21.9	18.5	29.4	26.8	28.1	34.8	32.6	26.9	32.3	31.4	32.3
±50%	44.3	32.3	46.5	36.5	46.5	52	45.6	58.6	53	43.7	49.1	45.7	70.8

The overestimation problem of high TTF roads was judged to be caused by zone-connector problem because many high TTF roads are connected by connectors directly. On the other hand, the underestimation problem of low TTF roads is judged to be caused by high intrazonal trip rate.

In general, we could solve underestimation problem in whole network by applying intrazonal trip rate to calibration system though there are still many underestimated links. Also, if we solve the problems of TTF5 and TTF7 which satisfy the two lowest hit ratio, it is expected to improve reliability of calibration for whole KTDB network.

Finally, we suggested the result of TTF parameters estimation as range and applied value for calibration (Table 6).

Table 6: The result of TTF's parameters

Type	Level of TTF	Range				Applied Value			
		v_0 (km/h)	C	α	β	v_0 (km/h)	C	α	β
Highway	**1**	110~130	1700~2100	0.25~0.65	1.80~3.50	101	1700	0.55	2.60
	2	110~125	1750~2150	0.30~0.70	1.50~3.20	121	1900	0.48	2.50
Urban Highway	**3**	95~105	1700~2000	0.35~0.75	1.60~3.40	98	1700	0.50	2.40
	4	90~100	1900~2200	0.40~0.80	1.40~3.10	92	1900	0.42	2.30
Arterial	**5**	70~90	680~1400	0.47~0.85	2.05~2.90	72	680	0.85	2.85
	6	90~105	1150~1550	0.50~0.70	2.00~2.50	90	1300	0.70	2.20
	7	70~85	650~1150	0.52~0.88	1.95~2.80	70	650	0.86	2.75
	8	85~100	1100~1500	0.55~0.75	1.90~2.40	86	1200	0.73	2.10
	9	65~85	630~1000	0.57~0.90	1.85~2.60	68	630	0.87	2.60
	10	83~100	930~1500	0.60~0.80	1.80~2.30	84	1100	0.76	2.00
	11	65~80	550~800	0.58~0.90	1.85~2.40	66	600	0.88	2.40
	12	80~95	780~1450	0.62~0.82	1.80~2.05	82	950	0.78	1.90
	13	65~75	400~600	0.60~0.90	1.75~2.30	65	580	0.89	2.25
	14	80~90	600~800	0.66~0.86	1.70~1.95	80	800	0.80	1.80
	15	60~70	350~500	0.67~0.90	1.65~2.20	62	550	0.89	2.15
	16	70~80	600~800	0.71~0.91	1.55~1.85	75	780	0.82	1.75

※ v_0 is related to t_0 ($v_0 = length/t_0$)

6. CONCLUSION

From this research, we improved reliability of the calibration of road network TTF by applying new calibration system; HS and highway separated calibration; and using cutting-edge data; TCS OD and Navi-data. Also we suggested new coefficient of TTF's parameters as both range and value.

As a result of calibration of road network TTF, the hit ratio of TTF1 and TTF2 was improved 22.6% and 11.6% respectively in highway separated calibration. In arterials of KTDB network calibration, the hit ratio was 25.4%, so it was improved 2.8% compared with previous result and generally underestimation problem was solved by applying intrazonal trip rate.

In addition, we suggested fundamental problems and future research direction of calibration system from network compatibility analysis and zone-connector verification by using Navi-data.

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STUDY ON EFFECT OF STREET BLOCKADES ON TRANSPORTATION OF SERIOUSLY-INJURED VICTIMS TO HOSPITALS-CASE STUDY OF EXPECTED TOKYO INLAND EARTHQUAKE

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ABSTRACT

Tokyo Metropolitan area has high risk of the Tokyo Inland Earthquake in the future. In case of the earthquake, disaster base hospitals have missions to accommodate seriously-injured victims and provide medical treatment for them. According to the lessons from past disasters, medical treatment within 72 hours after the disaster is essential to increase the possibility of saving the lives of victims. Rapid transportation of seriously-injured victims to disaster base hospitals and immediate medical treatment are very important to avoid their "Preventable Death".

In this research, effect of street blockades to transportation of seriously-injured victims to hospitals in case of the expected Tokyo Inland Earthquake was analyzed considering road network. The maximum transportable area where victims could be transported to some hospitals by car within certain time was identified using a software "ArcGIS Network Analyst". After the Kobe Earthquake in January 1995, road blockades due to the debris from collapsed buildings caused problem on medical transportation. This research simulated the effect of road blockades on maximum transportable area. As a result, almost all the areas in Tokyo Prefecture were accessible to disaster base hospitals within 10 minutes by car in normal situation. However, maximum transportable area drastically shrank when road blockades in case of disaster was considered. This analysis identified the areas where rapid transportation to the nearest disaster base hospitals was impossible in case of the earthquake. Increase in the number of disaster base hospitals or dispatch of medical treatment team with portable facilities such as DMAT (disaster medical assistance team) may be necessary in these areas.

Keywords: *Tokyo Inland Earthquake, seriously-injured victims, disaster base hospitals, transportation*

1. INTRODUCTION

It is believed that in the Tokyo Metropolitan Area, massive trench-type earthquakes with magnitudes of 8 or greater, such as the Great Kanto Earthquake (1923), will occur at intervals of 200-300 years. Additionally, it is presumed that several Tokyo Inland Earthquakes of magnitude 7 will occur prior to a magnitude 8 earthquake, and the imminent possibility in the first half of this century has been pointed out. Because of that, many types of Tokyo Inland Earthquakes are assumed by the cabinet office of Japanese government and Tokyo metropolitan government with various possible epicenters and the complicated mechanism of occurrence. According to the estimation of The Tokyo metropolitan government, the number of seriously-injured victims will be about 150 thousand in the earthquake with an epicenter in the northern part of Tokyo Bay (assumed scale of M7.3, 18p.m.). So, it is essential to provide the medical treatment within 72 hours after the disaster to increase the possibility of saving the lives of victims due to the lessons from past disasters. Rapid transportation of seriously-injured victims to disaster base hospitals and immediate medical treatment are very important to avoid their “Preventable Death”.

A disaster base hospital is responsible to accommodate seriously-injured victims whom the medical aid stations are not able to treat, based on the stations’ request (Tokyo metropolitan disaster base hospital installation management guidelines, 2003). In Tokyo metropolitan area, there are 70 disaster base hospitals and 182 emergency hospitals, with an average number of beds of 574 and 158. Figure 1 shows the distribution of seriously-injured victims based on the occurrence of the earthquake with an epicenter in the northern part of Tokyo Bay (assumed scale of M7.3, 18p.m.). The darker the color is, the higher the number of the seriously-injured victims is. The circles with black dots are the disaster base hospitals and the empty circles are the emergency hospitals, where the size of the circles shows the number of beds. According to this figure, the eastern part of the Tokyo metropolitan area has more seriously-injured victims but has fewer disaster base hospitals.

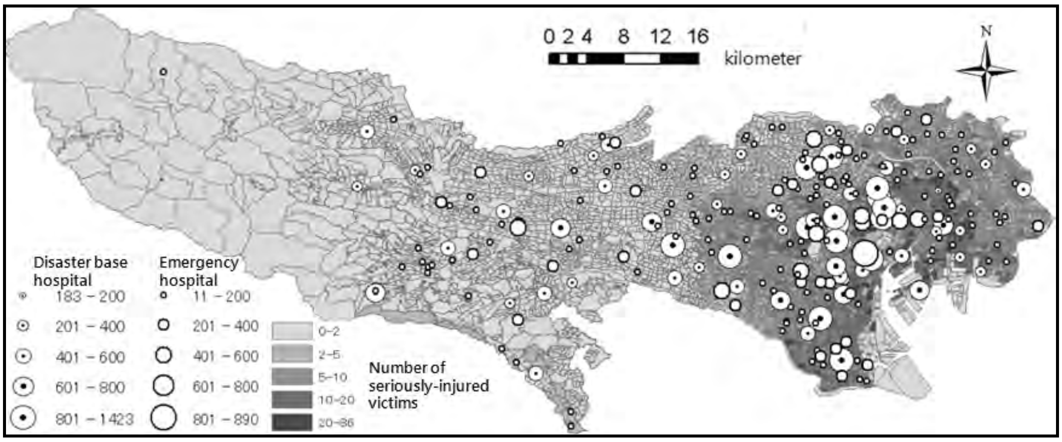

Figure 1: Distribution Map of Heavily-injured Victims and Hospitals in Tokyo

However, as Figure 2 shows, the eastern part of the Tokyo metropolitan area is the most severe part according to building collapse. The debris may cause serious street blockades and traffic jams which could impede the speed of medical treatment and decrease the possibility of saving the lives of victims.

Figure 2: Distribution of the Total Collapse of Buildings (Assumption by Tokyo Metropolitan Government)

There are mainly two previous researches on the seriously-injured victims transported to disaster base hospitals. Ohara (2008) estimated the number of seriously-injured victims transported to disaster base hospitals and emergency hospitals using an entropy model. However, the direct distance between the location of the injury and the hospital has been used in calculations instead of the road network. Maruyama (2010) analyzed the level of function loss of disaster base hospitals. Road network and decrease of the speed of transportation due to the street blockades based on the intensity of earthquake were considered. However, it still needs some more detailed calculations on the effect of street blockades.

Based on the background and previous researches, this paper aims to consider the road network and the effects of street blockades on transportation to identify the areas where rapid transportation to the nearest

disaster base hospitals are impossible in case of the expected Tokyo Inland Earthquake.
This kind of analysis would become a basis to provide a plan for increasing number of disaster base hospitals by strengthening existing emergency hospitals or the dispatch of medical treatment teams with portable facilities such as DMAT (disaster medical assistance team) in these areas.

2. METHDOLOGY

To identify the areas where rapid transportation to the nearest disaster base hospitals is impossible, “ArcGIS Network Analyst” is a useful tool. It can be used to identify the maximum transportable area up to which victims could be transported to a specific hospital by car or on foot within a certain time. This section describes the outline of methodology to analyze the traffic situation both in normal and disaster situations using “ArcGIS Network Analyst”.

2.1 Method of traffic simulation in normal situation

First, the hospital database has been made based on the list of disaster base hospitals in Tokyo metropolitan area. Next, the map, hospitals and road network (Table 1) of Tokyo metropolitan area were plotted on GIS. The maximum transportable areas have been identified for time distance of 5 and 10 minutes traveled by car, using “ArcGIS Network Analyst”. Figure 3 shows the maximum transportable areas within 5 minutes and Figure 4 shows the maximum transportable areas within 10 minutes. According to the Fire and Disaster Management Agency of Japan, the average time from the ambulance call to reach is about 10 minutes. Figure 4 shows the result that almost all the area in Tokyo Prefecture is accessible to disaster base hospitals within 10 minutes by car after an ambulance call.

<table>
<tr><td></td><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>0</td></tr>
<tr><td colspan="2">Code of Road Type</td><td>13m></td><td>13m-5.5m</td><td>5.5m-3m</td><td>3m<</td><td>Uninvestigated</td></tr>
<tr><td>National highway for high speed car</td><td>1</td><td colspan="2">80</td><td rowspan="2">20</td><td rowspan="2">10</td><td rowspan="9">2</td></tr>
<tr><td>Urban freeway</td><td>2</td><td colspan="2">60</td></tr>
<tr><td>General national highway (toll way)</td><td>3</td><td rowspan="7">30</td><td>20</td><td rowspan="5">12</td><td rowspan="5">7</td></tr>
<tr><td>Major local roads (prefectural road)</td><td>4</td><td rowspan="4">17</td></tr>
<tr><td>Major local roads (specified city road)</td><td>5</td></tr>
<tr><td>General prefectural roads</td><td>6</td></tr>
<tr><td>General city roads for specified city</td><td>7</td></tr>
<tr><td>Other roads</td><td>9</td><td rowspan="2">12</td><td rowspan="2">8</td><td rowspan="2">4</td></tr>
<tr><td>Uninvestigated</td><td>0</td></tr>
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Table 1: Velocity Table of Roads in Tokyo Metropolitan Area

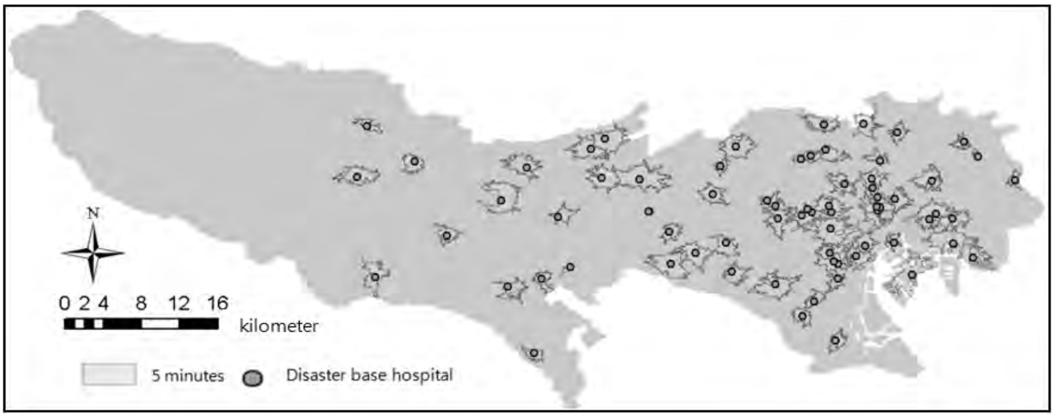

Figure 3: The Maximum Transportable Areas of Disaster Base Hospitals in 5 Minutes

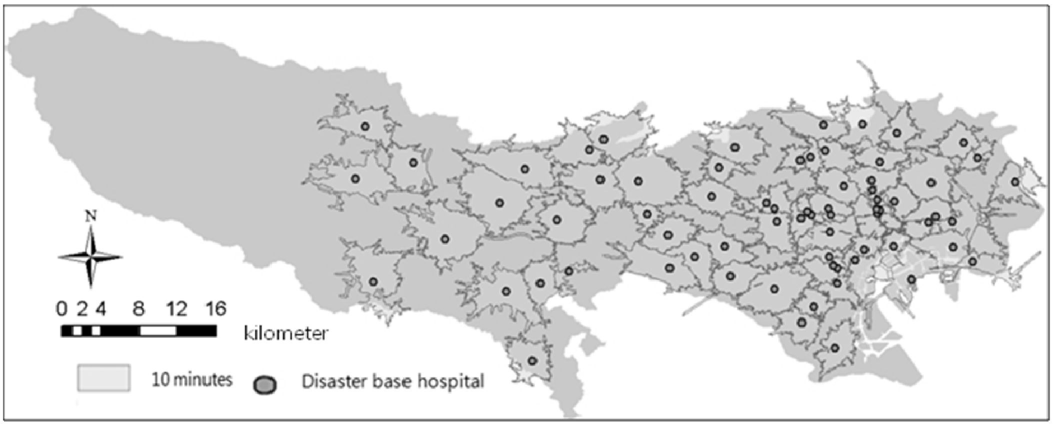

Figure 4: The Maximum Transportable Areas of Disaster Base Hospitals in 10 Minutes

2.2 Method of traffic simulation in disaster situation

The Method of traffic simulation in disaster situation is almost the same as that in normal situation except that the road network changes. Here, the effect of street blockades on transportation was considered. Figure 5 is the flow of method of traffic simulation in disaster situation.

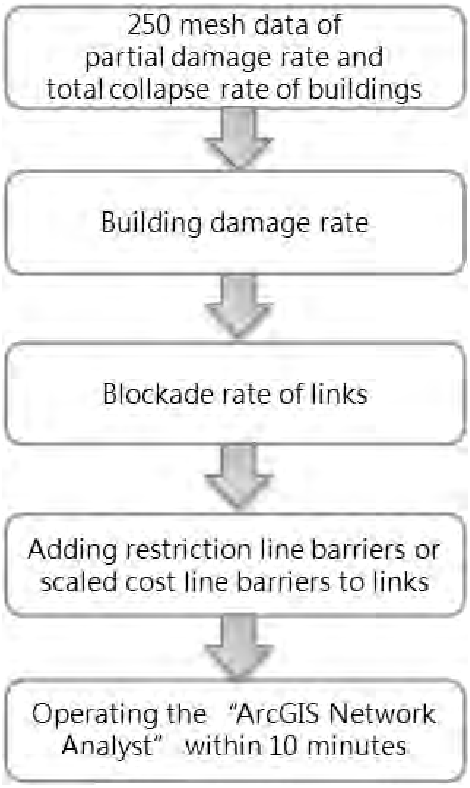

Figure 5: Flow of method of traffic simulation in disaster situation

At first, using the 250 mesh data of partial damage rate and total collapse rate of buildings, building damage rates have been calculated by the equation below.

Building Damage Rate = Total Collapse Rate + 1/2 Partial Damage Rate

Next, the blockade rates of the links were calculated using building damage rate. Ieda (1997) surveyed the relationship between building damage and blockade rates in the affected district in Kobe City after the 1995 Kobe Earthquake. Based on these survey results, two equations are currently proposed for calculating blockade rates of links; one is the equation used in the damage estimation of the Tokyo Inland Earthquake by Tokyo Metropolitan Government. The other is the equation used in the damage estimation of the Tokyo Inland Earthquake by the Cabinet Office of Japanese Government. The calculation using the former equation was defined as case 1 and the latter as case2. In Figure 6, these equations according to the width of the road are shown in red or green lines.

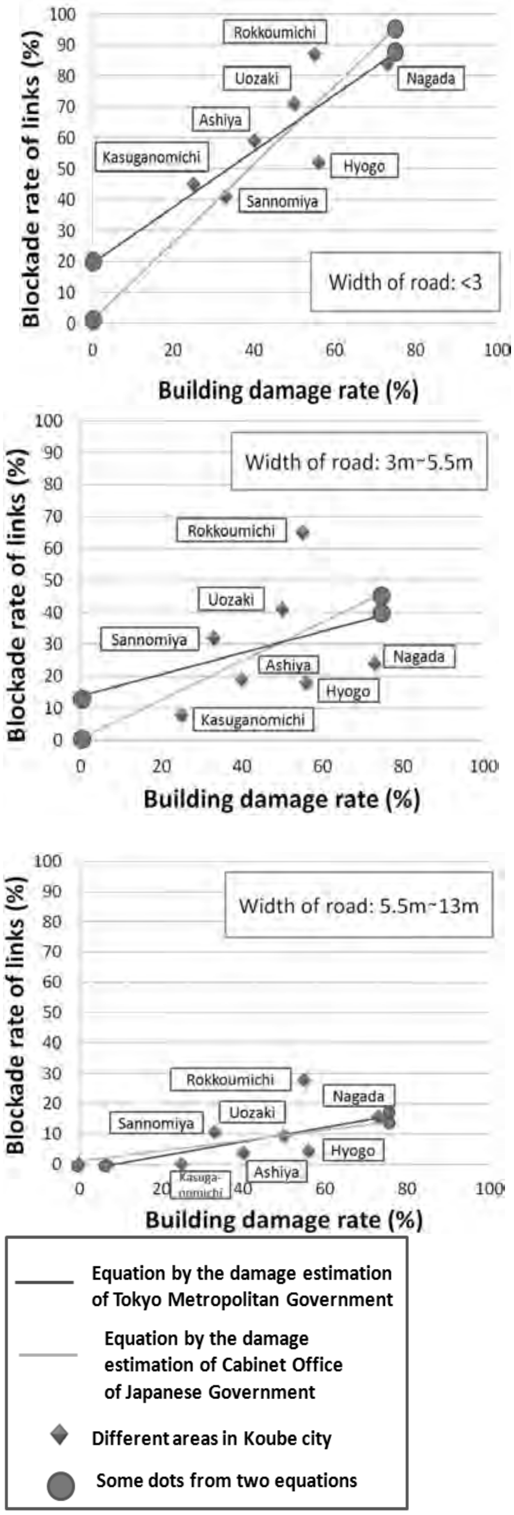

Figure 6: The relationship between building damage rate and blockade rate of links

Then, restriction line barriers (Figure 7) or scaled cost line barriers ((Figure 8) were added to links. Barriers are feature classes in network analysis layers that restrict or alter impedances of the underlying edges and junctions of the associated network dataset. There are two types of line barriers; one type is restriction line barrier that prohibits travel anywhere the barrier intersects the network, and the other type is scaled cost line barrier that doesn't restrict travel on the edges and junctions it covers; rather, it scales the cost of traversing the covered edges and junctions by a factor you specify. For example, a factor of 2 would mean it is expected to take twice as long as normal.

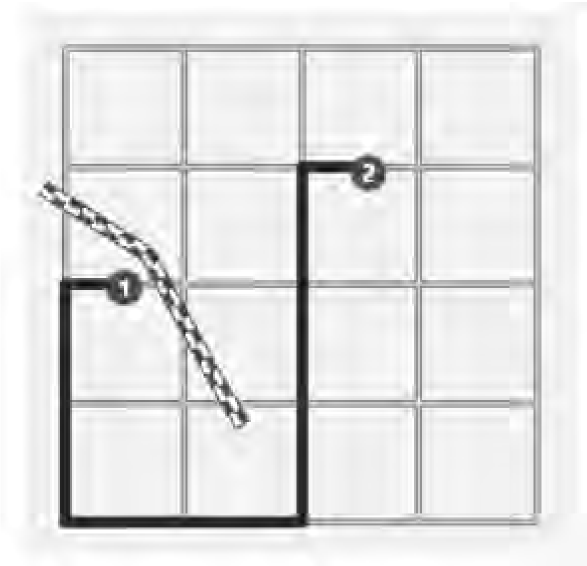

Figure 7: Restriction Line Barrier

Figure 8: Scaled Cost Line Barrier

According to Hagita (2009), in the case of Hanshin-Awaji Earthquake, the running speed of Route 2 of the Kobe city fell down from 25 km/h of rush hours in normal situation to less than 3km/h at the day of the occurrence. Because the running speed fell down to almost 1/10 of the normal situation, a factor of 10 was adapted as Scaled Cost Line Barriers as shown in Figure 9. Furthermore, according to Ieda's survey (1997), almost all the road users gave up using the blockade links or areas which had been blocked with 20% or more. Based on this, restriction line barriers were added to the links with 20% or more blockades as in Figure 9.

Last, by operating the "ArcGIS Network Analyst" within 10 minutes based on the changes of roads, the maximum transportable areas in disaster situation were identified.

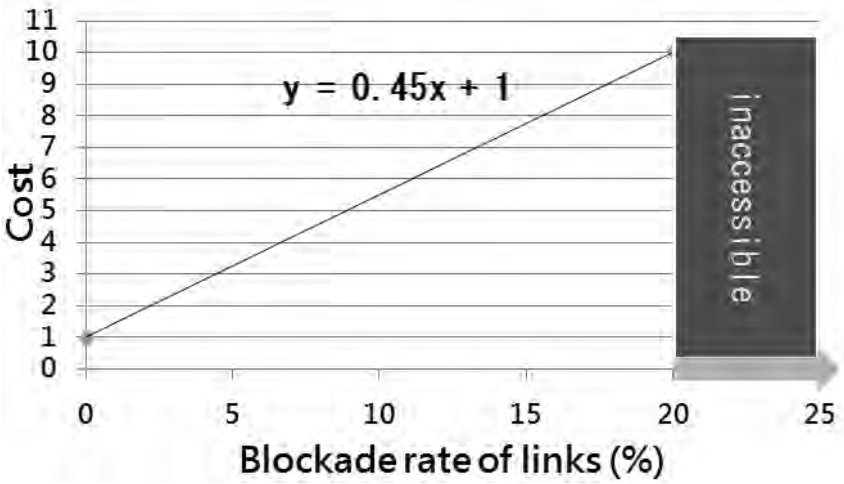

Figure 9: Relationship between Cost and Blockade Rate of Link

3. SIMULATION RESULTS

The results of inaccessible links of case 1 (Figure 10) and case 2 (Figure 11) show that most of the inaccessible links are in the eastern part of Tokyo and there were more inaccessible links of case 1, which led to two inaccessible hospitals and much shrank of maximum transportable areas (Figure 12) to the nearest hospitals compared with case 2 (Figure 13). One of the inaccessible hospitals is located at Katsushika district (Figure 14) and the other one is located at Arakawa district (Figure 15). Furthermore, compared with the normal situation, the maximum transportable areas also shrank seriously when road block in case of disaster was considered.

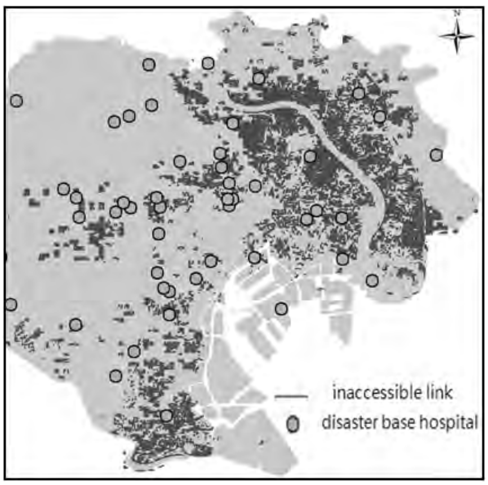

Figure 10: Inaccessible Links of Case 1

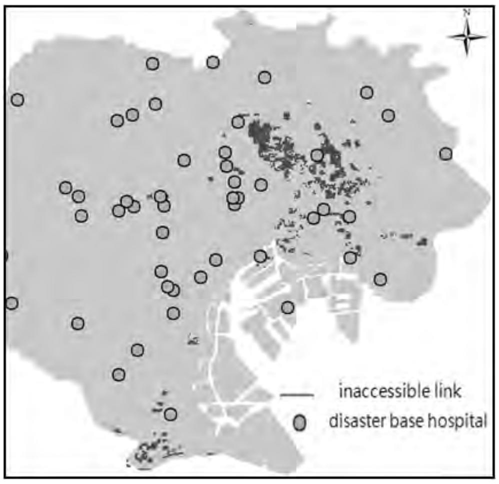

Figure11: Inaccessible Links of Case 2

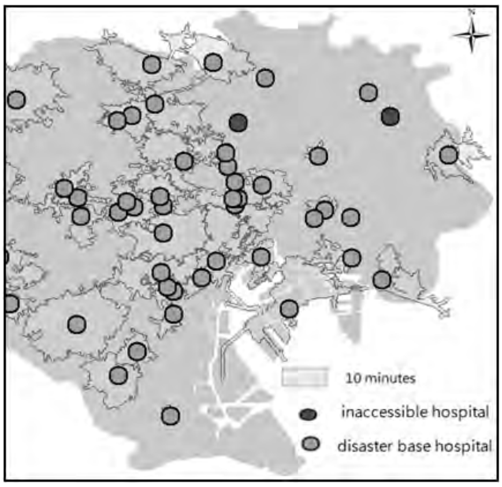

Figure12: Accessible Areas of Case 1

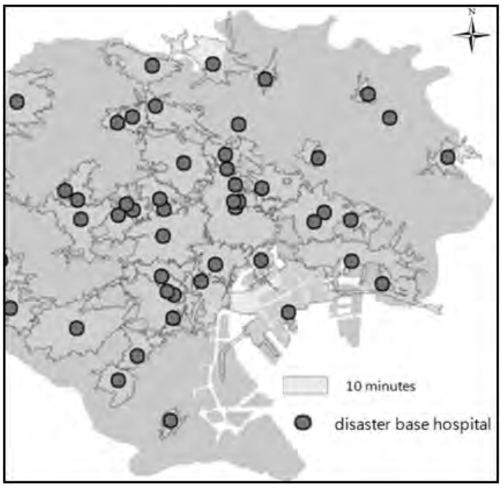

Figure13: Accessible Areas of Case 2

Figure14: Inaccessible Hospital at Katsushika District of Case 1

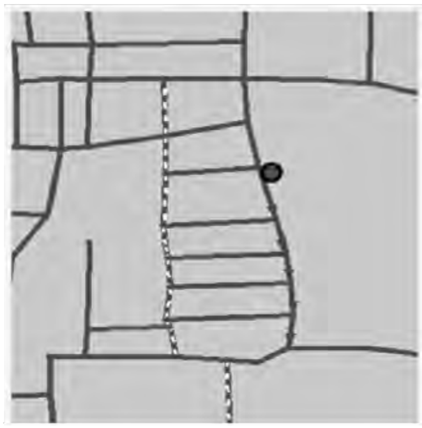

Figure 15: Inaccessible Hospital at Arakawa District of Case 1

4. CONCLUSION

This study simulated the effect of street blockades on transportation of seriously-injured victims to hospitals using “ArcGIS Network Analyst” in case of the expected Tokyo Inland Earthquake. The simulation results showed that almost all the areas in Tokyo Prefecture were accessible to disaster base hospitals within 10 minutes by car in normal situation. However, maximum transportable area drastically shrank when road block in case of disaster was considered. This analysis identified that the rapid transportation of the eastern part of Tokyo metropolitan area to the nearest disaster base hospitals would be impossible in case of the earthquake. A series of measures should be taken in those areas, such as increase in the number of disaster base hospitals by new construction or strengthening existing emergency hospitals, preparation for accommodating victims rapidly in the hospitals in surrounding areas with little damage, or dispatch of on-site medical treatment team with portable facilities such as DMAT (disaster medical assistance team).

As future studies, various scenarios should be considered such as expanding the maximum transportable areas to within 30 minutes or 1 hour or changing the parameters of scaled cost line barriers etc. Additionally, transportation to the hospitals on foot or to the existing emergency hospitals should also be considered in the next steps.

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A STUDY OF LOW COST GROUT FOR PRE PLACED AGGREGATE CONCRETE

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ABSTRACT

In this study, a high performance low-cost low-cement grout mix for Preplaced Aggregate Concreting is studied with different fly ash replacements to identify the effects of this pozzolanic material. Results show that replacement of fly ash at 20 to 30% improves the flow of grout at constant w/c and superplasticizer content. Compressive strengths of both grout and PA concrete mixtures have attained a similar early strength (24 h) even after fly ash replacement, attaining as high as 30MPa in 7 days for 20% fly ash replacement. Therefore, a low-cost cementitious grout for PA concrete can be a viable alternative to high cost commercial products.

1. INTRODUCTION

Preplaced Aggregate Concrete (PA concrete) is a concreting method where coarse aggregates are preplaced or packed into formworks first (as called Preplaced Aggregate) then high performance grouts that can penetrate into the aggregates filling up all voids are injected. Making a material that carries load and behaves in the same way as conventionally casted concrete. PA concrete is also termed in other literature as “Two-Stage Concreting Method”, implying that the method is casted in two steps, both being independent of each other. This method of casting is of great advantage to structural repair works where very difficult placement conditions and limited site access are encountered. In most repair works, damaged structures are already in service for quite some time, and access to repair site is mostly very limited and provides disturbance. PA concreting method is done without the need of very large mixer trucks, even on high volume concrete repair jobs. Formwork materials and coarse aggregates can be transported and installed way before actual grouting can take place, which can also be done by batches.

As a relatively old technique of concreting work, projects as early as 1937 for the rehabilitation of a tunnel in California has already made use of this method of concreting to save on cement costs. PA concrete, surprisingly, has very limited studies available, even ACI 304, the committee on PA concrete, has written that even on compressive strength alone of PA concrete, neither research nor performance data is available. This may be due to the patenting of the method which was granted in 1940.

In PA concreting work, it is obvious that the quality of the grout dictates the quality of the final concrete product. Since the grout injected holds the concrete together, it is therefore fundamental to understand and develop a high performance grout that is suitable for PA concrete. In order to reach the optimal mix of grout, the right combination of cement, pozzolans, and other additives that affect grout properties should be studied. Several researchers have studied and concluded that the use of a low-reactivity, fine grained material improves the necessary workability of cementitious materials (Erdogan 1997). Flow of grouts can also be improved by an increase in w/c ratio but at the expense of early strength and possible cause of bleeding, therefore superplasticizers essential to maintain this ratio low while attaining the grout fluidity required. Chemical admixtures have come a long way since the early days of PA concrete, becoming cheaper and more effective through research. The incorporation of superplasticizers however, its effects, proper dosages and reactions with other pozzolanic admixtures should be evaluated in the laboratory before actual field use. This study addresses the effects of fly ash replacement on superplasticized cementitious grout, since in PA concrete grout, it is essential to maximize flowability while minimizing grout cost. To maintain this balance, a low cementitious content grout $(200kg/m^3)$is used as the main proportion and fly ash replacements are done to maximize the flow of grouts without increasing cost.

2. EXPERIMENTAL

2.1. Materials

Specimens for testing mechanical and hardened properties of preplaced aggregate concrete is prepared using a binder proportion which incorporate different replacement levels of fly ash. Sand, water and super plasticizer dosages are held constant. Mix proportions and cost are shown in Table 1.

Table 1: Mix Proportion and Costs of Selected Mixtures

Mix Code	Cement (kg/m^3)	Fly Ash (kg/m^3)	Sand (kg/m^3)	Water (kg/m^3)	HRWR (l/m^3)	Cost (THB)
Control	200	0	200	80	4	1280
PFA10	180	20				1250
PFA20	160	40				1220
PFA30	140	60				1180
PFA40	120	80				1150

2.1.1 Cement and Pozzolanic Admixtures

An ordinary Portland Cement Type-1 (ASTM C150) and Fly ash sourced locally (ASTM Type-F) was used in all specimen preparation. Typical Chemical Compositions are shown in Table 2.

2.1.2 Chemical Admixtures

Superplasticizer used in the preparation of flowable grout, which is later injected into preplaced aggregate formwork, is a Napthalene Sulfonate Formaldehyde type admixture. It is classified in ASTM C494 as Type-F, High-range water reducing admixture. Delivered in a dark brown liquid with a solid content of 41%, a bulk density of 1.2 kg/l, and ph value of 7.5.

2.2. Mixing Procedure

A rotary drill with a plate type mixing head is used to agitate the mixtures prepared in 10L batches. In preplaced aggregate work, the quality and consistency of the grout used dictates the success in the casting operation. Therefore, in order to achieve a consistent grout for sampling and testing, a consistent method is used to prepare all mix proportions of grout, which is outlined below:

1. Binder proportions are dry mixed for 30s
2. Sand is added and dry mixed for another 30s.
3. Half of mixing water is introduced into the mixture while half is mixed with superplasticizer and introduced into the mix.
4. After all liquid is introduced; mixing is continued until a total time of 5 mins. is achieved starting from first contact with water.

All mixtures are done in a laboratory condition typical of an indoor site in tropical climates in South-East Asian region, with average daily temperatures of 30±5ºC and around 50% RH.

Table 2:Physical, chemical and mechanical properties of cementitious materials used in the study

Chemical Analysis (%)	*Cement*	*Fly Ash*
SiO_2	21	20-55
Al_2O_3	5.3	5-40
Fe_2O_3	3.3	1-15
CaO	66.6	7-20
MgO	1.1	0-5
SO_3	2.7	1.5-4
LOI	2.5	1
Insoluble Residue	0.1	
C_3S	60	
C_2S	15	
C_3A	8.5	
C_4AF	9.7	
Physical Properties		
Blaine Fineness (cm^2/g)	3350	2500
Autoclave Soundness (%)	0.02	
Initial Setting time	105 min.	
Final Setting time	135 min	
Compressive strength (MPa)	12, 19, 28 @ 3, 7 and 28 days	

2.3 Measurements

Grout properties are measured during the fresh state (max 10 mins. after first contact with water) and hardened state (>24 h after casting). All measurements are done in accordance with relevant ASTM standards and test methods including casting and sampling of concrete specimens of preplaced aggregate concrete.

2.3.1 Fresh Properties

Spread flow and flow cone method (ASTM C949) tests were performed in each mixtures right after mixing and samples are collected for setting time and bleeding measurements which also includes samples of hardened properties testing of grout.

2.3.1.1 Spread Flow (Mini slump)

Spread flow test is an alternative method to measuring the spread flow of grout in which is related to the yield stress of the mixture when a viscometer is not available, which is also studied and suggested by several researchers (Felekoglu, 2006), (Flatt, Larosa, & Roussel, 2005) and (Nepomuceno, Oliveira, & Lopes, 2011).

2.3.1.2 Flow Cone (ASTM C939)

The flow cone test method is an indicator of good flow of grouts for injection purposes. Used in this study to assess the time of efflux of each mixtures relating to the plastic viscosity of the grout samples. The apparatus is a modified Marsh cone test which is standardized by ASTM (Fig 1)that consists of a cone funnel with a 12mm diameter outlet pipe where a 1,725 ml of grout will exit through and the time until all the grout has been discharged is recorded as the efflux time of the grout.

Figure 1: ASTM C939 Flow Cone

2.3.1.3 Bleeding Test (ASTM C940)

Bleeding as it is termed is the appearance of bleed water at the surface of the grout, which is an important indication of grout properties in concrete repair applications because it affects the bond performance of the repair material to the substrate concrete. In this study a bleeding test from ASTM C940 is used to measure the relative bleeding of the pastes, in which an 800ml of grout is poured into a cylinder and measuring the bleed water that shows after 3 hours, which is then divided by the total volume to get the percentage of bleeding.

2.3.1.4 Setting Time (ASTM C953)

In concrete repair works, the time span a concrete mix is workable depends on the time of setting of the material, which is measured in this study from ASTM C953, which defines the initial setting as the time the grout is already starting to stiffen and pouring/injecting will not be possible and the final setting of the grout as the time the grout has already stiffened.

2.3.1.5 Injection Test

Injection tests are done in order to test the penetrability of grout to preplaced aggregate forms and to visualize the ability of the grout to resist segregation even after experiencing pressure. In this study, grouts are injected into 50x100x100mm moulds with preplaced aggregates of about 15% voids. Schematics of the test is illustrated in Figure 2.

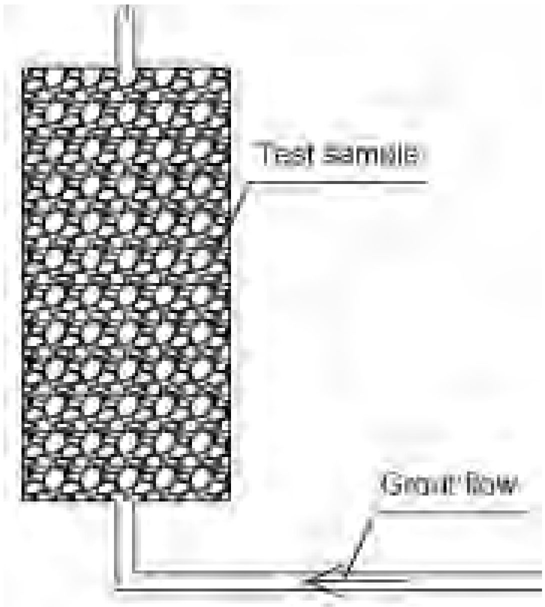


Figure 2: Schematics of Injection tests to simulate PA Concrete casting

2.3.2 Hardened Properties

2.3.2.1 Grout Compressive Strength (ASTM C942)

Preliminary testing of compressive strengths of preplaced aggregate concrete is done by sampling and testing 50x50x50mm cubic samples as shown in Fig 3. This is to evaluate the compressive strength of grout for initial selection of mixes and quality control of grouts as it is one of the main sources of strength of the PA concrete which holds the aggregates together.

Figure 3: High Performance PA grout sample preparation

2.3.2.2 Concrete Compressive Strength

In an attempt to study the relationship between the strength of grout and the actual concrete strength using the preplaced aggregate method, a value more suitable for the actual designing of structures to be repaired, concrete cubes (150x150x150mm) are prepared simulating the actual concrete casting procedure of a preplaced aggregate concrete, Fig 4 shows moulds preplaced with coarse aggregate to be pumped with grout, after pumping and demoulding. These samples are later on de-moulded after 24 hours of curing then tested for 1 day strength, and the rest water cured (100%RH) for 3 days and 7 days evaluation of compressive strength. A 2000 KN Universal Testing Machine calibrated independently in accordance with Japanese, European and American standards is used as the compression force testing equipment.

Figure 4:Compressive Strength specimen preparation through pumping

2.3.2.3 Drying Shrinkage of Preplaced Aggregate

In repairing concrete structures, especially when cementitious materials are used for repairing, drying shrinkage of the material whether the material will last long without cracking which can affect the durability, strength and protection of the utilities and reinforcements within the repaired member. Casting method is likewise simulated as that of PA concrete casting in the field as shown in Fig 5. A linear shrinkage measurement is done in accordance with the specified procedure outlined in ASTM C157 with first length measurement starting at 24h after casting, then every day for the next seven days while cured on water.

Figure 5: Shrinkage Specimen preparation using PA method

3. TEST RESULTS AND DISCUSSION

3.1 Fluidity and viscous flow of grouts with low cement and fly ash replacement

Grouting work in preplaced aggregate concreting method is evidently one of the most important characteristic of the work, also mentioned previously, it dictates the success and failure of the job. An optimum grout during its fresh state should be cohesive enough without segregation while stationary with very fluid or free flowing when moving (Collepardi, 1998). Quality of the grout, as several researchers have also mentioned, depends on a large number of parameters like mixing (Nguyen, Remond, & Gallias, 2011), mineral content (Svermova, Sonebi, & Bartos, 2003), pozzolanic content (Mirza, Mirza, Roy, & Saleh, 2002),w/c ratio, environmental conditions (A., Henriques, & Cidade, 2010), mixing time, mixing process, superplasticizer addition (Huang, 2001) and so on. Clearly, there is still a lot to understand regarding the flow of fluid grouts. In light of this, starting with a conclusion from Huang that Fluidity of cement-fly ash grout is greatly enhanced by the use of a superplasticizer, but when an excessive dosage is incorporated, segregation and bleeding will occur and adversely affect the supposedly performance and engineering properties of the mixtures. This is why, researches like the present one are important in detecting the proper dosage in a given concrete mixtures and their interaction on pozzolanic materials such as fly ash addition. Fig 6 shows the effect of flyash on the efflux time of grout mixtures with superplasticizer dosage and water to powder ratio held constant. It can be seen from the graph that flyash replacement can reduce the flow of grout mixtures which are evident from 30 to 40% replacement when superplasticizer dosage is at 2% by weight of binder, higher replacement than this will cause an excessive bleeding and segregation of the grout mixture and were discarded. This phenomenon is explained by French researchers (Morin, Tenoudji, Feylessoufi, & Richard, 2001) that when superplasticizers are dosed to the extreme, a large amount of repulsive forces are introduced into the surface of particles, which in turn causes seggragation, and in this case, since the dosage is held at constant it can be hypothesized that due to the finer particles of fly ash, a higher replacement of ash can mean a higher surface area that electrostatic repulsive forces can adhere to, therefore segregation occurs at higher replacement levels of fly ash. Separating heavier sand particles and disrupting flow of grout.

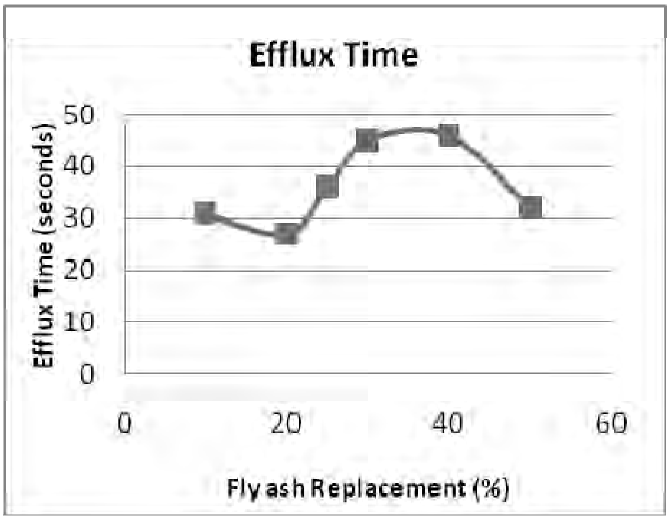


Figure 6:Efflux time with different fly ash replacement levels

3.2 Mini Slump Cone spread with respect to fly ash content of mixtures

In this section a discussion on the results measured by using the mini slump flow method of measuring the relative yield stress of each cement grouts mixed. Results are shown in Fig 7 . The final spread diameter in relation to the yield stress and viscosity of the grout is studied upon byBouvet et. al., which can be attributed to the spread because when the cone is lifted up, the yield stress of the paste is exceeded by the normal stress exerted by the available weight above it, but after a certain amount of spread, weight gets lesser and to an extent where the local shear in the grout is already equal to the yield stress to which the grout stops flow. As suggested by several researchers, (Bouvet, Ghorbel, & Bennacer, 2010) that a slump flow of 300mm to 400mm approximately corresponds to a very low value of yield stress approaching that of a Newtonian fluid when in transit. Results in this study has shown that the influence of fly ash on the slump flow of mixtures are only noticeable at replacement intervals of 30 to 40%, this may be attributed to the spherical shape of the fly ash particles thus the lubricating effect on the mixtures and the high replacement of fly ash particles on the mixture, extensive literature review on fly ash can also be found in (Coo, 2011).

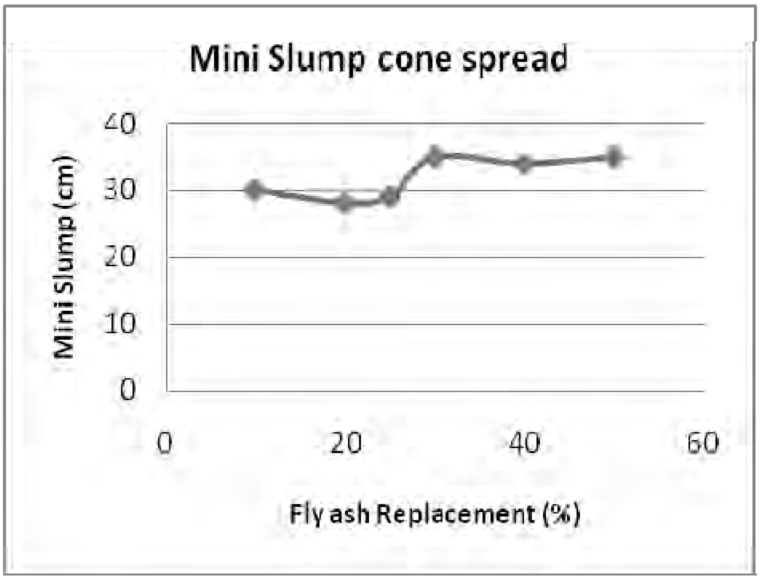


Figure 7: Mini slump cone spread of PA grout

3.3 Bleeding (ASTM C940)

The test is done to check the excess water that seeps out of the grout when mixing is done, bleeding on the concrete surface means that there is a substantial excess of free water and may adversely affect the engineering qualities of the grout. All mixtures tested in this study did not show any bleeding, partly due to the low w/c used and the use of fly ash which requires a greater amount of water from the higher total surface area than cement. But it is good to note that (Toumbakari, 2002) has concluded that bleeding on grouts are allowable up to 5% without adverse effects. Therefore, fly ash replacement on low cement content grout mixtures up to 40% replacement will not be susceptible to bleeding.

3.4 Pumpability

The objective of this study is to determine stability of the mix while under pressure from pumping that will eventually be used in making a preplaced aggregate concrete, it is therefore substantial that the grout mixtures should be pumpable while fresh and will remain stable without segregation even after the end of pumping. This is shown in Fig 8, a typical pumping on a transparent prismatic formwork with coarse aggregates preplaced. After pumping, the excess grout coming out of the exhaust on top is evaluated for signs of segregation while pumping (water coming out first), and later the forms are opened while still wet to check for honeycombing. No grout mixtures done in this experiment has shown any segregation and honeycombing, as expected, due to the fluid consistency of the grout shown using the flow cone test, slump spread and bleeding tests done as shown from previously done tests. It can therefore be concluded that flow cone test and slump spread test results are good workability indicators but resulting values should only be taken as a guide, because even with flow cone results of around 50 seconds, PA grout mixtures can still be hand pumped (0.3 MPa pressure) without any problem, 1/10 of the pressure commonly used in the field (3MPa) as mentioned in ACI 301

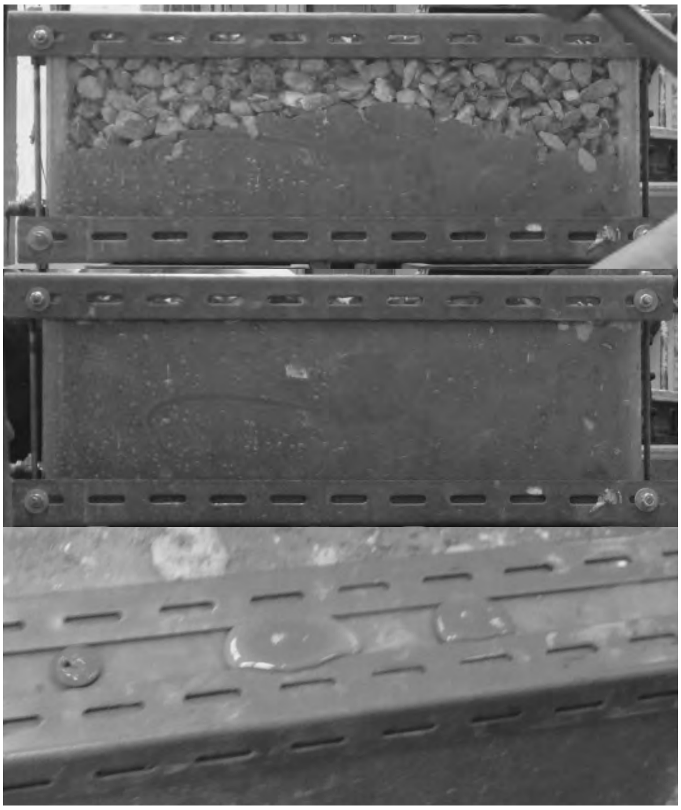


Figure 8: Pumping of PA grout

3.5 Setting Time

Directly related to the allowable time the grout is allowed to stay after first contact with water is the setting time of the mix, and in the field, this measurement is essential in order to estimate the duration grout remains workable and allowed to be pumped. Setting time is affected by factors such as water and cement content of mixes and whether a pozzolanic admixture is added, and also the incorporation of a superplasticizer. In this study, a low cement content and the incorporation of a pozzolanic admixtures to which the cement will not experience a premature set due to the low heat of hydration. Results are shown in Figure 9, 10FA to 40FA on the left side of the graph are grout mixtures done in this study for Preplaced aggregate concrete use, while on the right side, an SCC grout researched previously for high volume repair applications (coo 2011) . It can be seen from the graph that cement content alone can produce a significant decrease in setting time of mixtures, even at high replacement levels of fly ash. But in a general sense, a 4 hour working time is well suited enough for field application, the lowest setting time recorded.

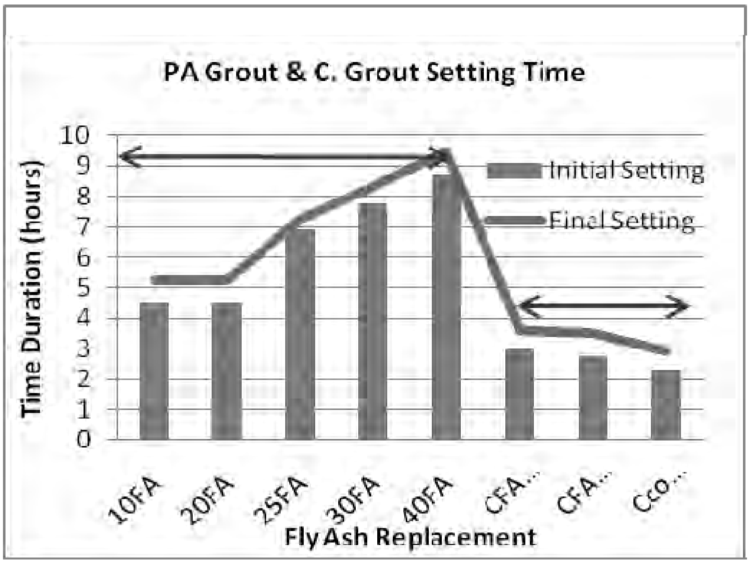


Figure 9:Setting time measurement of PA grout in comparison to conventional fly ash concrete

3.6 Compressive Strength of Grout and Concrete: A comparison

Compressive strength of grout is done as an initial study to identify mixtures that has the highest compressive strength in terms of fly ash replacement. As shown in Fig 10, a high early strength can be achieved with all the grout mixtures tested, except those of 50% and 60% fly ash replacement, one of the reason is that due to the low starting cement content of the mixture, a replacement of fly ash at very high degrees will cause a significant decrease of cement content and could induce retardation of the mixture. Nevertheless, grouts with replacement levels of 10-40% has shown an excellent grout compressive strength which can be utilized in preplaced aggregate grouting work.

Concrete compressive strength on the other hand as casted by pumping the same grout as mentioned above has resulted in a significant decrease (half) in compressive strength, with the same trend for all replacement levels of fly ash as shown in Fig 11. Trends like these are already expected since the strength of the coarse aggregates should be factored into, but a trend of almost always twice the strength of concrete produced is the strength of the grout injected is a new find.

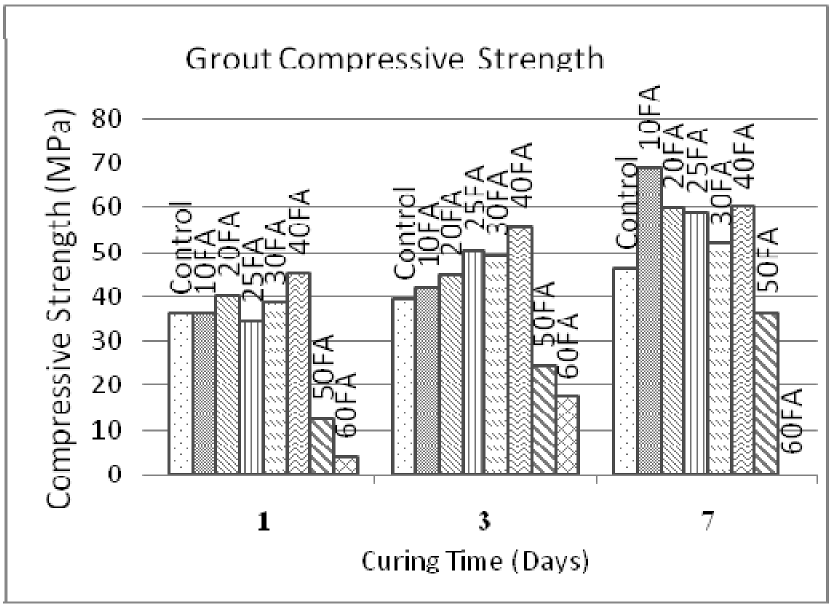
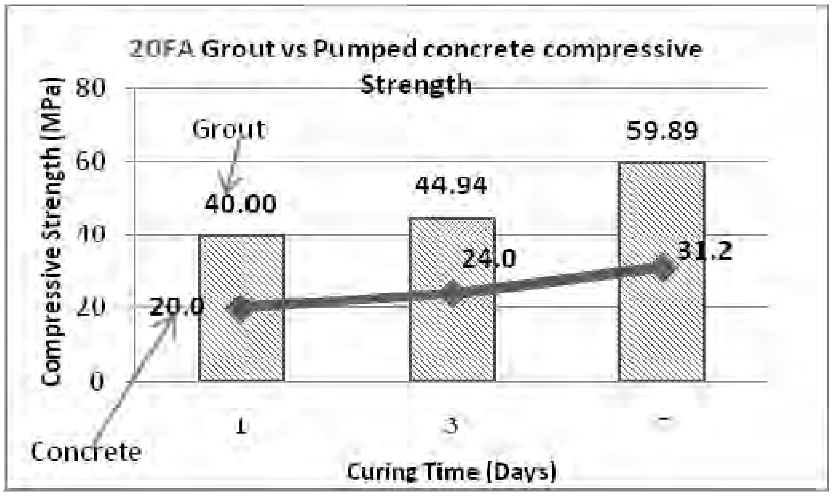
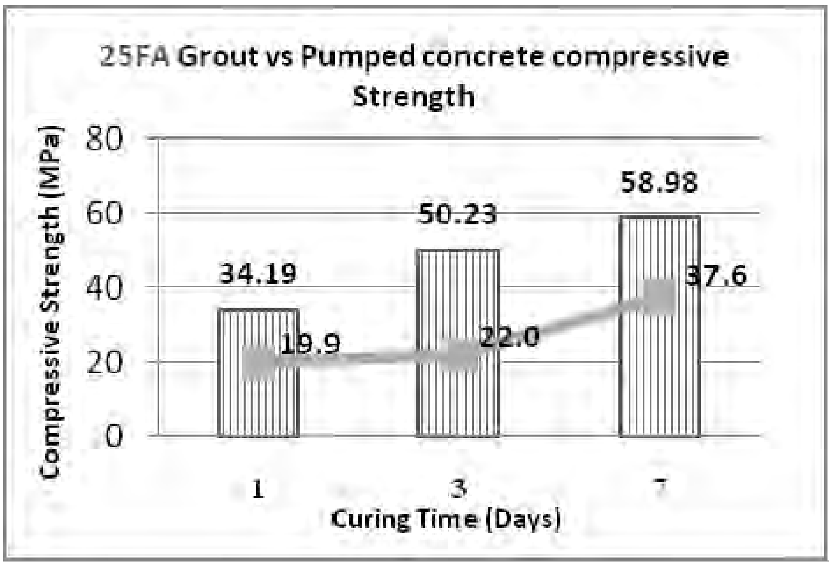


Figure 10: Grout Compressive Strength





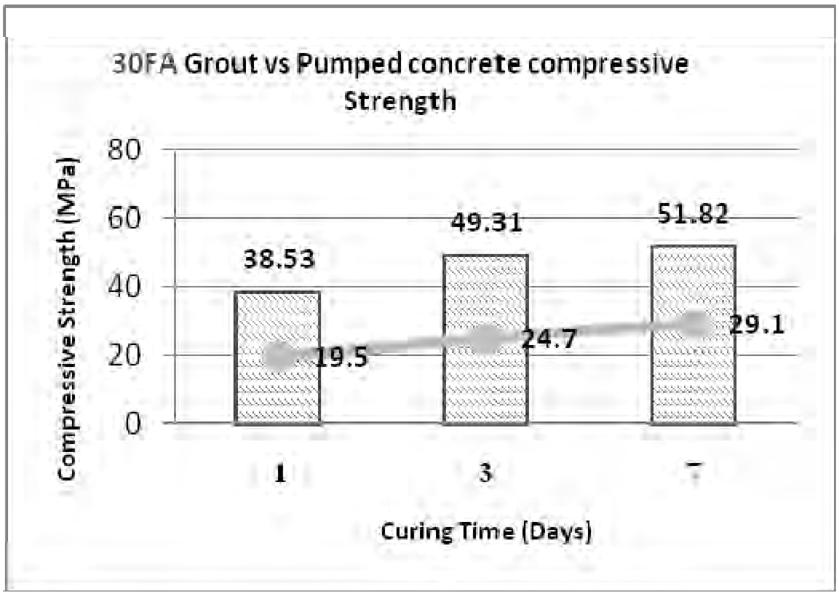


Figure 11: Comparisons of grout strength and concrete compressive strength by pumping

3.7 Preplaced aggregate casting method: Poured and Pumped

Two methods of casting is done to determine the influence of casting method in PA concrete. One is pumping the grout into preplaced aggregates and another pouring from top. Figure 12 shows the results obtained, P from the mix proportion indicates pumped sample and numerals indicate fly ash replacement. Negligible differences are noticed in compressive strengths of concrete. This indicates that as long as formworks are fully filled with grout, the same hardened concrete properties can be assumed in the same grout mixture whether grout has experienced pressure from pumping or poured and allowed to consolidate by gravity.

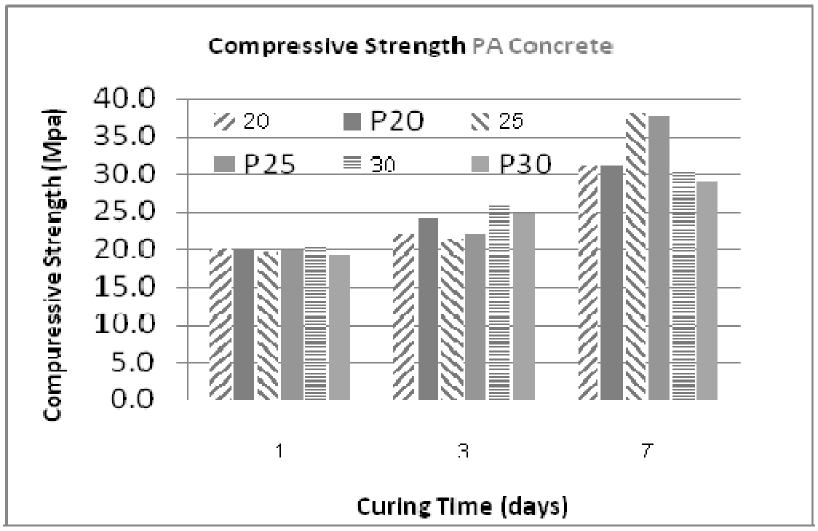


Figure 12: Compressive Strength of concrete: comparison with pumping and poured

4. SUMMARY AND CONCLUSIONS

In this research, a high performance grout with several fly ash replacements for preplaced aggregate concrete injection is studied under its fresh and hardened properties. Only binder proportions are replaced with fly ash, other factors such as superplasticizer addition and water-cementitious materials ratio are held constant. Several conclusions can be drawn from the results:

4.1 Fly ash replacements from 30% to 40% of grout mixtures resulted in an increase in fluidity of the grout mixtures using the flow cone test.

4.2 A 20% increase in slump spread of grouts with fly ash replacement level of 30% to 40%. This indicates a correlation between the flow cone testing method and the slump spread method, more study is recommended for further understanding.

4.3 With the use of a low cement, low w/c with sand and fly ash replacement on grout mixtures, bleeding can be minimized or avoided entirely.

4.4 Pumpability of grout mixtures can be visually evaluated by the proposed method of preplaced aggregate concreting simulation done in this study. The ability of the grout to fill coarse aggregate voids can be visually detected and segregation can be seen on the overflow vent of the transparent formwork.

4.5 Sensible setting times are achieved by fly ash replacement of PA grout.

4.6 Compressive strengths of grouts can be used to estimate the strength of actual PA concrete for preliminary study, but casting of pumped specimens are still recommended.

A low-cost low-cement and high performance cementitious grout for PA concrete application can be achieved by replacing cement by 20 to 40% of fly ash

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A STUDY ON STRATEGY FOR EFFECTIVE DISASTER INFORMATION DIS SEMINATION : CASE STUDY IN THAILAND

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ABSTRACT

Information Dissemination is considered as one of the most important tools to disaster risk reduction; yet, if poorly managed, it can pose hindrances to disaster mitigation process. This paper examines disaster information dissemination system in Thailand. It intends to investigate how disaster-related information was disseminated during Thailand's most extensive inundation in 2011; and, attempts to draw recommendations. During the flood, the Thai government tried to establishment disaster information communication with the people. However, its attempt was not successful. As a result, this led to frustration of a majority of Thai people and, in turn, triggered a momentum of information flow in various forms and means of informal communication. In the latter part of this report strategies for effective disaster information dissemination are also proposed.

Keywords*: disaster information dissemination, Thailand flooding 2011.*

1. INTRODUCTION

In July 2011, Thailand was hit severely by the build-up of waters brought by a 25% increase in average season rainfall. The inundation later spread through provinces of the Northern, North-Eastern and Central Thailand along the Mekhong and the Choa Phraya river basins and became the country's most extensive inundation in 70 years. The flood claimed more than 600 lives; and the World Bank (2011) estimated economic losses were at 45.7 billion USS. Due to the exorbitant lost, there were a number of evidence pointing that Thailand was unable to deliver effective disaster information to the people, which led to poor management of the flood and an urgency to develop a comprehensive framework to manage disaster.

(Larnard and Sandman, 2011; Coben, 2011; Reuters, 2011; Bangkok Post, 2013).

Flood risk communication studies have been carried out extensively in the US and Europe as one of the most important tools to disaster risk reduction. (Cole T.W. and Fellows K.L, 2008; Tinker T.L. and Galloway, Jr. E.G., 2009; Bradford and O'Sullivan, 2011) In case of Thailand, however, there is a limited number of studies carried out in terms of flood disaster information dissemination during the worst flood in 2011. Therefore, this paper intends to investigate how disaster-related information was disseminated during Thailand's most extensive inundation in 2011. It focuses on disaster information dissemination in Thailand; and, attempts to draw recommendations. In this study, strategies for effective disaster information dissemination are also proposed.

2. THAILAND'S 2011 FLOOD DISASTER INFORMATION DISSEMINATION

To investigate disaster information dissemination during the 2011 flood, this report employs documentary research methodology and breaks lines of communication during Thailand's 2011 inundation into 2 periods using October 8, 2011, as the breakpoint because October 8, 2011, was when the Prime Minister of Thailand ordered a setup of Flood Relief Operations Centre (FROC) as the "one stop service" for flood-related matters including information and warning dissemination. The 2 periods comprises (1) Thailand's disaster information dissemination before October 8, 2011, and (2) Thailand's disaster information dissemination after October 8, 2011.

2.1 Thailand's disaster information dissemination before October 8, 2011

According to the National Disaster Prevention and Mitigation Plan B.E. 2553-2557 (2010-2014), Thailand's latest disaster prevention and mitigation scheme, general requirements have been introduced for effective disaster information dissemination. The following government agencies responsible for disaster information dissemination have to make notifications.

- Thai Metrological Department (TMD) and National Disaster Warning Center (NDWC) are responsible for close surveillances and warning at national level.
- Department of Disaster Prevention and Mitigation (DPM) receives warning information from TMD and NDWC and some relevant agencies and further disseminates warning information to the provincial government.
- Provincial government is responsible for the watch-out and dissemination of warning information at provincial level.
- District office is responsible for surveillance and dissemination of warning information at district level.

- Civil Defense Volunteer and warning information dissemination network are responsible for surveillance and dissemination of warning information at community level.

2.2 Thailand's disaster information dissemination after October 8, 2011

On October 8, 2011, the Prime Minister of Thailand set up the Flood Relief Operations Centre (FROC) in an effort to solve floods in a coherent and comprehensive manner. One of FROC main duties was to be the center of flood-related information to send out important information to people such as situation evaluation and warning. The Justice Minister was appointed to take charge FROC along with the Interior Ministry's Deputy Permanent Secretary. The Science and Technology Minister was put in charge of operations. The Transport Minister managed FROC's information and public relations. Governors of local entities were to follow FROC's orders in managing the floods in their respective localities and encouraged to set up provincial versions of FROC. The armed forces as well as other governmental agencies were to take orders from the Prime Minister's Office. Later in October 20, 2011, the Prime Minister invoked Section 31 of the 2007 (B.E. 2550) Disaster Prevention and Mitigation Act which gave the prime minister a single control to all officials.

In the setup day, FROC was assigned as the focal point to disseminate disaster information to people. Apart from regular announcement through mass media, FROC opted to send information through SMS text messages. It appointed the National Broadcasting and Telecommunications Commission (NBTC) to look after the task. NBTC summoned ad hoc cooperation with the 3 major mobile phone network carriers in Thailand, namely AIS, DTAC, and TRUE.

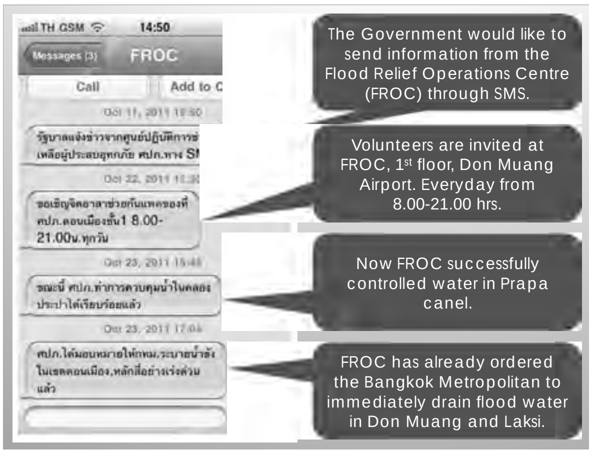

Table 1: The 4 SMS sent by FROC

Unfortunately, FROC did not mount a united front in its management of the floods crisis and lost its credibility. (Chinchit, 2011) The FROC's chief often gave contradictory statements to the media, issued a false sense of confidence to the public and, most importantly, delivered irrelevant information that people did not really need. (Thairath, 2011) Its first SMS was released on October 11, 2011 and the last one was reported to be received on the October 23, 2011. Altogether, it was reported in Thairath newspaper (2011) that there were 4 messages sent by FROC and the people were not satisfied with the content of them because they did not serve the purpose of early warning and evacuation. Figure 1 shows the 4 messages with translation. On October 24, 2011, FROC officially announced that it had stopped sending SMS to the people by giving the reasons that “sending information via SMS messages is limited to 70 alphabets. The limitation would cause messages confusing and subjected to people’s interpretation.”

Matichon Newspaper (2011) reported that Assumption University’s ABAC Poll Research Centre surveyed 415 people living in Bangkok and adjacent provinces in October 2011 regarding FROC’s credibility. The survey revealed that nearly 90 percent of the respondents said they were confused by announcements from FROC. 87% said they did not trust information from FROC and 86% said FROC did not provide clear information as to whether their homes would be flooded. They gave average score of 3.36 out of 10.

Now FROC still exists but appears to be inactive under the Ministry of Natural Resources and Environment.

3. THAI GOVERNMENT AGENCIES RELATED TO FLOOD DISASTER DISSEMINATION

Apart from the aforementioned agencies, there are also a number of government agencies that routinely take part in disseminating flood information in Thailand. Some send warning and useful information directly to the people while some are in charge of information gathering, monitoring as well as issuing warning and useful information to concerned agencies. This part of the paper attempts to gather relevant agencies that disseminate disaster information particularly flood-related information to the people. Through an observation, there are 10 following agencies related to flood information dissemination in Thailand. Ones marked with w have warning systems.

1. Thai Meteorological Department (TMD) w
2. National Disaster Warning Centre (NDWC) w
3. Department of Disaster Prevention and Mitigation (DPM) w
4. Department of Mineral Resource (DMR) w
5. Department of Water Resources (DWR) w
6. Department of National Park, Wildlife and Plant Conservation (DNP) w
7. Royal Irrigation Department (RID) w
8. Hydro and Agro Informatics Institute (HAII)
9. Electricity Generating Authority of Thailand (EGAT) w
10. Bangkok Metropolitan Administration

All 10 agencies have established their own means to communicate with the people mostly through websites and some have certain system that issues warning to (1) concerned agencies and (2) areas or people that might be at risk. Table 1 shows agencies that have warning systems, while Table 2 shows agencies that have monitoring function. To mention some, DPM and DMR have established a network of trained volunteers that can disseminate disaster information to the local people and collect information from the at-risk sites to send back to central authorities. DWR has developed early warning systems in local areas where sound alarm can be triggered after detecting dangerous level of rainfall.

Table 1 : Agencies that have warning systems

	Agencies	Content of Information	Means of Communication
Issuing warnings to relevant agencies	Thai Meteorological Department (TMD)	Weather Forecast to DPM	SMS
	Department of Disaster Prevention and Mitigation (DPM)	Flood-related and disaster information received from relevant agencies	Disaster warning notice, SMS
	Department of Mineral Resources (DMR)	Water, Flood, Geo-hazard and landslide information	Disaster warning notice & SMS
	Royal Irrigation Department (RID)	River Water & Rainfall Information, Medium- and Large-sized Reservoir Water Level	Through various channels
	Electricity Generating Authority of Thailand (EGAT)	Dam Water Level by Telemetering System to RID and DPM	Warning system
Issuing warning to people	Thai Meteorological Department (TMD)	Weather Forecast	Mass media
	National disaster warning center (NDWC)	Flood-related and disaster information received from relevant agencies	Mass media, Mobile Phone Application (iOS & Android)
	Department of Disaster Prevention and Mitigation (DPM)	Flood-related and disaster information received from relevant agencies	Mass media, Mr.Warning*
	Department of Mineral Resources (DMR)	Issuance of Warning regarding Geo-hazard and landslide	Mass Media, SMS & Volunteer Network (13,857 volunteers in 39 provinces)
	Department of Water Resources (DWR)	Early Warning System for Flood and Landslide (in 1,587 at-risk villages)	Early Warning station at risk areas
	Department of National Park, Wildlife and Plant Conservation (DNP)	Forest flood and rainfall information (comprising 1,034 rainfall gauge stations)	Warning system

*Mr.Warning is a network of trained community coordinators who give warning to people as well as monitor and send useful information back to central authorities.

Table 2 : Monitoring Agencies

Agencies	Content of Information	Means of Communication
Thai Meteorological Department (TMD)	Rainfall Statistics, Weather Map and Forecast, Meteorological Satellite Picture, Dam Water Level Data Analysis, Meteorological Information, Storm Tracking	Website
National disaster warning center (NDWC)	Flood-related & other disasters information	Website
Department of Disaster Prevention and Mitigation (DPM)	Flood-related & other disasters information	Website
Department of Mineral Resources (DMR)	Flood, Water, Geo-hazard and landslide information	Website
Department of Water Resources (DWR)	Water Level Monitoring by CCTV (27 sites), Water Situation Report, Flood and Water Information through	Website

Table 2 : Monitoring Agencies

Agencies	Content of Information	Means of Communication
	Mekhala Centre for Water Crisis	
Department of National Park, Wildlife and Plant Conservation (DNP)	Rainfall Monitoring Stations in National Conservation Parks (1,034 stations)	Website
Royal Irrigation Department (RID)	River Water & Rainfall Information, Medium- and Large-sized Reservoir Water Level	Website
Hydro and Agro Informatics Institute (HAII)	Information on Rainfall and storm by Mini Telemetering System/Satellite/Radar	Website
Electricity Generating Authority of Thailand (EGAT)	Dam Water Level by Telemetering System	Website
Bangkok Metropolitan Administration	Rainfall Information by radar, Water drainage monitor by Telemetering	Website

4. FLOOD-RELATED INFORMAL COMMUNICATION

Since the government's attempt to deliver flood information to the people was not successful, frustration of a majority of Thai people was developed and, in turn, triggered a momentum of information in various forms and means of informal communication. One of the most popular channels that Thai people opted for getting information was through the Internet and social networks such as Facebook, Twitter, YouTube, and Weblog. There were statistics showing a sharp increase in messages shared through Twitter during flood disaster in Thailand from 1.5 million messages a day in normal time to about 2.2 million messages a day during the flood (Bangkok Biz, 2011).

Informal communication during the flood can be grouped into 3 following categories with some examples.

Category I Communication that have already existed before the flood but its function changed.

- Seub Nakhasathien, YouTube channel, normally served the purpose of promoting forest conservation. During the flood, Sasin Chalermlarp, Secretariat-General of the foundation, used the channel to broadcast his flood analysis. The number of accumulative viewers reached almost a million. The most popular VDO reached 450,000 viewers.
- Muang Ake community used its existing platform such as website and Facebook page to communicate with its inhabitants within the community during flood crisis. Its original function was to share general and administrative information.

Category II Communication that was created for flood purpose but now inactive

- Roosuflood (know and beat the flood) is a YouTube channel that have anime VDO concerning how to fight the flood. Some VDO reached more than 300,000 views. The last activity was May 2012.

- ThaiFightFlood, ThailandFlood2011 and NamKunHaiReepBok (when water rises, we tell) are Facebook account that updated news regarding flood. Their last activities were October and September 2012.

Category III Communication that was created for flood purpose and have functioned up till now.

- www.thaiflood.com and its Facebook and Twitter account were lunched during flood in 2010 and now continues to broadcast flood-related information. Now it has over 70,000 likes.
- Volunteers watchdog for Bangkok flood (in Thai) is Facebook account that created during the flood and still posts flood information.

Though social media has proven to be a popular and effective tool for sharing information, it can hinder response efforts especially when the information is incorrect, malicious, outdated, and inaccurate. In some cases, the location of the hazard or threat was inaccurately reported, or some requests for help were retransmitted repeatedly even after victims were rescued.

5. RECOMMENDATIONS FOR DISASTER INFORMATION DISSEMINATION IN THAILAND

The 2011 flood has led to the necessity that the government established a comprehensive framework for better management of flood disaster in the future. As a result, on 13 February 2012, the government issued the Regulations of the Office of the Prime Minister to improve flood and water prevention and mitigation by integrating work plans of relevant agencies and establishing a central unit that gives command on water management. This directed to the establishment of the Office of the National Water and Flood Management Policy (NWFMP), run by the National Water and Flood Management Policy Committee, chaired by the Prime Minister, with the hope to make comprehensive national water and flood management policy.

However, information communication and dissemination is one of the essential aspect determining whether or not Thailand is to achieve water and flood management. Some hindrances can pose threat to the credibility and the government might not be able to achieve what it has hoped for. To avoid repeating the 2011 flood’s history, the following recommendations are proposed.

- So far, there have been 2 government agencies whose main duties ought to be the centre of flood-related information in times of crisis. The 2 agencies are NDWC and FROC. As a result, there is still possibility that Thai people will be confused on which agencies they are to listen to. Choosing one and terminating the other are recommended to create true single command and avoid redundancy and confusion.
- NDWC should be chosen because it has already established since

2005. Though NDWC was set up to respond to Tsunami, its original function covers every disaster that might occur in Thailand.

- The government should set up a risk communication unit under either NDWC or FROC as a focal point to communicate between the government and the people and an establishment of trustworthy communication should start from today on.
- Existing facilities concerning disaster information dissemination should be employed to better cater the warning system. Also, it is encouraged that the government would use as many and various channels as possible to deliver message to the people since the people are not homogenous and can be categorized in various groups like the handicapped and flood-inexperienced.
- Since FROC's messages were reported that they were irrelevant information that people did not really need. The content of messages during flood disaster should focus on reporting current situation, issuing warning when needed, and informing of an evacuation when necessary.
- The government should also focus on the prevention and preparation. Disaster education and preparation should be continuous even though there is no coming disaster. Since behavioural changes are more likely if they are self-motivated, rather than imposed, developing a raising awareness of current flood information sources such as websites, brochures and flood information campaigns offers potential for empowering individuals and communities to mitigate flood risk in an appropriate manner. Means of promoting information sources includes dissemination through mass media and circulation by post or through recognised access points such as train station, council officers, and libraries.

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Student Report

REPORT FROM STUDENT PARTICIPATION ON 6th JOINT STUDENT SEMINAR ON CIVIL INFRASTRUCTURE

DATE: August 6-7, 2013

The 6th Joint Student Seminar on Civil Infrastructure was a combined programme of an in-house seminar and a field trip. This year, the seminar was held at Dipak C. Jain Room, SASA International House, Chulalongkorn University, on August 6th, 2013. It consisted of 5 main parts; opening remarks, invited speakers, student presentations, closing remarks and an award-presenting banquet. On the following day, August 7th, 2013, the participants went on a field trip of visiting places of cultural and engineering significance. The trip started at Hua Lamphong's construction site where a tunnel of the new MRT Blue Line was being excavated, then, Hua Lamphong train station - Thailand's central hub of the train system. In the afternoon, the participants visited cultural sites as such Kao Sarn Road, Kalayanamitra Temple and Bowonniwet Temple.

Participants of the 6th Joint Student Seminar on Civil Infrastructure

PRESENTATION SESSION

OPENING REMARKS

Dr. Akiyuki Kawasaki, Asian Institute of Technology (AIT), gave opening remarks, signifying the commencement of the 6th Joint Student Seminar on Civil Infrastructures. He first expressed his sincere gratitude for the committee members for their tremendous support to the administration of the seminar, offering his special thanks to Dr. Hyunmyung Kim, Dr. Kunnawee Kanitpong and Dr. Withit Pansuk. He then mentioned the objectives of the seminar, which are to experience an international seminar, to improve presentation skills in English, to share research information and to build friendship. He wrapped up his opening remarks by encouraging the students to actively contribute to the seminar as it could widen their horizons.

INVITED SPEAKERS

Two distinguished speakers were invited to deliver presentations. Dr. Jeong Whon Yu, Ajou University, Korea, talked on the topic “Big Data and Transportation Information Platform in Korea”. The term “Big Data” is referred to as a collection of data that is so large and complex that it becomes unmanageable if they are dealt with traditional data processing applications. Information platform in Korea was also presented.

The other speaker was Mr. Kunakorn Pragthong, a representative of Hilti (Thailand) Ltd. He delivered a presentation on the topic “Understanding Post-Installed Anchor Systems & Code Design Requirements”, which gave the audience an introduction to anchor systems. His talk demonstrated that chemical anchors can be a practical alternative, or better in some cases, to mechanical anchor. Yet, it is very important for an engineer to choose the right type of anchor for the optimal result.

STUDENT PRESENTATIONS

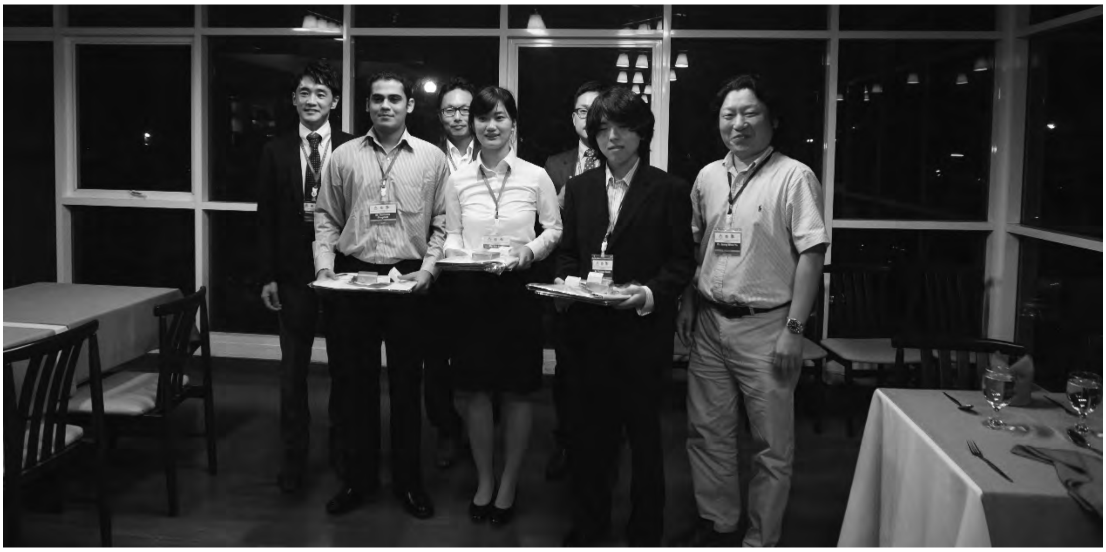
Twenty students from AIT (Thailand), Chulalongkorn University (Thailand), the University of Tokyo (Japan), Myong Ji University (Korea), and Seoul National University of Science and Technology (Korea), gave presentations and participated in an exchange of ideas. Topics of presentations were grouped into 3 parts, chaired by Dr. Akiyuki Kawasaki, AIT, Dr. Kunnawee Kanitpong, AIT, and Dr. Sung Bong Chung, Seoul National University of Science and Technology, respectively.

CLOSING REMARKS

Dr. Kunnawee Kanitpong, AIT, delivered significant reviews, comments and closing remarks of the 6th Joint Student Seminar on Civil Infrastructure. She stressed that all the participants’ performance surpassed expectations and it was a really good opportunity to give presentations and exchange ideas in an international environment. She also recommended us to attend more seminars both student or professional seminars. Last, she wished all the participants success and good luck in study in the future.

AWARD-PRESENTING BANQUET

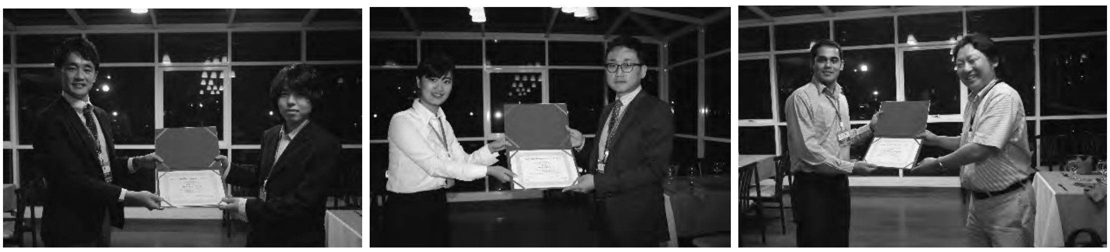
In the evening of August 6th, 2013, a dinner banquet was held as a platform for the participants to further exchange ideas and develop networks. Three excellent presenters were also awarded at the banquet. The excellent presenters were chosen according to criteria such as research quality, oral presentation, and enquiry-answering. Another criterion was added this year, which was "contribution during Q&A session". Judges consisted of lecturers, invited speakers, and chairpersons.



The students awarded "Excellent Presenters" with the panel of judges

One of the judges' remarks was that "this year the quality of research was very high. There were 6 presenters that earned high scores and judges had a very difficult time to choose only 3 excellent presenters." The following students were awarded "Excellent Presenters". Order does not signify rank of scores.

1. Mr. Tsubasa Sasaki, University of Tokyo (The impact of flow velocity on microbial precipitation of calcium carbonate among soil)
2. Ms. Fei Jiang, University of Tokyo (Study on effect of street blockages on transportation of seriously-injured victims to hospitals : case study of expected Tokyo inland earthquake)
3. Mr. Seemanta Bhagabati, AIT (Comparison of benefits for political boundary and natural boundary from hydropower development in the Mekong)



Excellent Presenters 2013: (left to right) Mr. Tsubasa Sasaki, Ms. Fei Jiang and Mr. Seemanta Bhagabati

FIELD TRIP

On August 7th, 2013, participants went on a field trip to visit places of engineering and cultural significance.

HUA LAMPHONG CONSTRUCTION SITE VISIT

Hua Lamphong is the area where Bangkok's main railway and the construction site of the new MRT Blue Line (Subway) are situated. The field trip started at the construction site of the new subway blue line, officially named as Metropolitan Rapid Transit (MRT) Chaloem Ratchamongkhon Line. The project was aimed to complete within 4 years. So far, it has been in a process of excavating the main tunnel. With help from Japan, the project uses Tunnel Boring Machine (TBM) to make a tunnel of about 2.8 kilometres in length. We were granted an opportunity to go down the tunnel and see the real TBM. Down in the tunnel, safety is the first priority.

(left to right) inside the briefing room, the entrance of the tunnel

(left to right) inside the tunnel, the mouth of the TBM

After that, we went to Hua Lamphong train station, officially named Krungthep station. The station was opened on June 25th, 1916, after six years' construction. The site of the railway station was previously the national railway's maintenance centre, which was moved to Makkasan in June 1910.

(left to right) Hua Lamphong or Krungthep Station, a locomotive awaiting for its journey, participants inside the station

CULTURAL SITE VISIT

In the afternoon, we visited cultural sites of Bangkok including 3 temples and Khao Sarn Road. Kalayanamitr Temple, Sraket Temple & Golden Mountain, and Bowonniwet Temple were the temples we explored and they were unique for their significance. Kalayanamitr Temple has the biggest braze Buddha’s image in Bangkok and was built for the King Rama III. Sraket Temple & Golden Mountain has a beautiful golden pagoda situated on the top of a mountain. With 500-step staircase, the top of the mountain provided a picturesque view of Bangkok. Bowonniwet Temple contains a number of Chino-Portuguese and Victorian buildings.

At Kalayanamitr Temple : (left to right) Kalayanamitr Temple from across the river, students shaking sticks in a bamboo cylinder to read their fortunes, the giant brass bell believed to bring good luck to the person who rings it

At Sraket Temple & Golden Mountain : (left to right) students starting climbing up to the Golden Mountain, Bangkok from the top of the Golden Mountain, the golden pagoda

Inside Bowonniwet Temple

Khao Sarn Road comes from the word "*Khaosan*" which can be translated as "milled rice", a reminder that in former times the street was a major Bangkok rice market. Now, Khaosan Road has developed into “Backpacker’s heaven”.

What was special about this trip was that we had a chance to experience different modes of transportations, which were “river bus” and “canal bus”. Both were established as an alternative to avoid road congestion during rush hours of Bangkok. The river bus took us across the Chao Phraya River in about 5 minutes and the cannel bus made the journey from the outer ring of Bangkok to the inner city fast and interesting.

(left to right) Khaosarn Road, a pier of the river bus, inside the cannel bus

Impressions from the Student Participants

This is my second time to attend the Joint Student Seminar on Civil Infrastructures. I was very excited, because I could meet wonderful friends from different countries! This seminar not only gave me a valuable chance to present my research in front of an international audience but also provided me an occasion to further widen my perspectives on civil infrastructures and services. I had a great moment with students, researchers and professors by sharing the knowledge. It was a precious experience to me and thanks ICUS for giving us this opportunity **(by Sung-Hi An)**

I was very glad that I had a chance to participate in this seminar since it gave a variety of invaluable experiences – traveling around Bangkok and seeing what was going on in Thailand, getting to know what kind of research the students from overseas were engaged in, to name a few. Although I was proud of getting myself the presentation award, I believe that there were many other presenters who provided more fascinating talks in a very skilful and effective way. So, I learned a lot from them and felt that it would help me change for the better as a presenter. Finally, I would like to offer my sincere gratitude for everyone who put forth effort to make the seminar successful, and who helped the whole trip to Thailand become this valuable and memorable. Thank you all. **(by Tsubasa Sasaki)**

The 6th Joint Student Seminar on Civil Infrastructures was a great platform for amateur researcher students to present their work in an international environment. It was a great pleasure to attend the seminar again this year, as I attended it last year as well. It was a wonderful experience for me as I made new friends from a wide variety of fields and countries, and got to know about the parallel researches going on. I really enjoyed the seminar as well as the field trip. I am really honored to receive the excellent presenter award, my first such award in an international audience. I would like to express my sincere thanks to all the participants who shared their work, judges for their valuable comments and feedbacks as well as to the organizing committee who made this event a great success. I am looking forward to attend it next year.
(by Seemanta Sharma Bhagabati)

The 6th Joint Student Seminar on civil Infrastructure has given me a wonderful experience. This was my first time to make a presentation in front of foreign students and researchers. So, I was a little uneasy at first. However, it was a precious experience to receive advice about my research and to discuss it with students and professors from other universities. I was motivated by students' presentation and their researches, and enjoyed talking with students. I really appreciated this opportunity of joining the seminar. From now on, I will do my best in advancing research and improving my English communication skills. **(by Noriko Okamura)**

I spent very good days and had a wonderful experience at the 6th Joint Student Seminar on Civil Infrastructure. This seminar was my first experience of going abroad and making a presentation at an international platform. Not only did I learn how to improve my English and presentation skill, I also had a chance to be exposed to different cultures. As the program went on, I realized that the seminar had given me valuable attributes. At first, I found that making and English presentation was a very hard task, but I was able to develop confidence gradually. In the future, I will surely use my experience earned from this seminar to benefit my future research. **(by Ryoichiro Hoshino)**

I was very glad to have an opportunity to take part in the 6th Joint Student Seminar on Civil Infrastructures. Through the conference, we have shared and gained a lot of new knowledge and experiences. The judges and speakers from different fields of research created the multidisciplinary atmosphere for the seminar. As for me, this was my first time to listen about concrete technology but it was very interesting and attention-grabbing. In my point of view, all of my fellows were well-prepared and some had excellent presentation. From them, I have learnt more about presentation, question and answer skills. The questions and comments from judges and audience will help me improve my research work. In addition, this was a change for international students exchange culture and expand friendship network. Although there was only 2 days, we had many good memories together, especially in the field work in Bangkok. I really enjoyed the field work and deeply impressed by the harmony between modernization and tradition in Bangkok. **(by Dang Anh Nguyet)**

The 6th Joint Student Seminar on Civil Infrastructure was very exciting and gave me a wonderful experience. The seminar gave me the first opportunity to make a presentation in a foreign country. This was also the first time for me to travel abroad. Before the seminar, I was very strained over travel arrangement and presentation in a foreign country; but, after the seminar, I think I would want to do it again. I have learned a lot of things from the seminar and I would like to make use of the experience for my future research. **(by Shunya Kimura)**

The 6th Student Seminar was a good experience for me. This was my first time to give a presentation in English. I was nervous because you knew my English level is low. My lately interest is railroad operation in Japan. So I wanted to talk to Japanese student. But I wasn't given opportunity because I thought my English level. I think it's lucky for me to ask my presentation by somebody and chair. Frankly I didn't understand about half presentation because my major is transportation investment and planning. But I got many major's information through talking to somebody else; civil engineering, urban planning, chemistry, tools, foreign culture and so on. The seminar gave me an opportunity to think about the importance and necessity of infrastructure and learning English, and I would like to attend this seminar next year.

P.S. Thanks to my professor for let me attend this seminar. Also, thanks to Dr. Akiyuki Kawasaki for the answer "otsukaresamadesita" and I want to meet and talking about Japan's infrastructure(railroad) if I go to Tokyo.

(By Baekkyu Namkung)

It was a wonderful experience for me to join the 6th Joint Student Seminar on Civil Infrastructure. I have never had an experience of making a presentation on my research in front of students from other countries before, but this seminar gave me such opportunity. Not only did I aim to use better English but also make my presentation understood to the audience. Also I had an enjoyable time taking with students from other countries during lunch and dinner. This seminar had helped improve my English skill, so that I can make any presentation fearlessly than before. I want to research more deeply and make a presentation in English in front of people from different countries. **(by Aya Fujikawa)**

It was a very good opportunity to me for joining this seminar. With the objectives to encourage students and researchers to practice their presentations and share their studies, all of participants were got the new experience and also the new knowledge. The benefits did not only relate to my specific field of study, but also covered to all the fields of civil infrastructures. I have got new friends as well. They are very impressing to me both their friendliness and brilliance. Their hard working studies had been proved to their abilities beside their tolerance. I have appreciated them. Moreover, I also want to express my thankful to the organizer team, the seminar will not be successful without them. **(by Tharadol Punlop)**

The 6th Joint Student Seminar on Civil Infrastructure was my first opportunity that I had taken part in an academic seminar. It was a very nice experience for me and I enjoyed myself very much. Since participants were from many different countries and they had different backgrounds, it was very interesting to get to know each other and exchange opinions. Also, the seminar had added an international aspect to my research and ways of thinking. I am convinced that this opportunity had given motivation for my research in the future. Moreover, the field trip further created a space where we could exchange views deeply with counterparts that were not acquainted. Please allow me to extend my thankfulness to everyone taking part in this seminar. **(by Shunya Suzuki)**

This is my 2nd time to attend this joint student seminar. Last year I attended as an audience in the 5th joint student seminar, I thought it was useful seminar for the non-native English speaker to practice how to make a presentation and discussion in English speaking environment. After one year passed, I have attended this seminar again as a speaker. However, it was not only good chance for practicing the presentation skill, but it was also a very good chance to have a new friendship with all participants. We made a useful discussion and gave some comments to other speakers at time of presentation and talked about casual things like shopping, sight-seeing in Thailand. It will be one of my unforgettable memories. **(by Onnicha Rongviriyapanich)**

I fortunately had experienced giving presentation in English before, but in this seminar, thanks to its warm atmosphere, I could join the discussion much more interactively by making and answering questions. Especially, I was glad to have had questions from 3 professors from Korea and students, in which I could get important viewpoints. It will benefit every country if we internationally cooperate and exchange experience and knowledge about recovery after disasters. Also, I really enjoyed the field trip with students from civil engineering. Since it was my first trip to Thailand, the temples in Ayutthaya and townscape in Bangkok impressed me very much. It was pleasure to catch a glimpse of Thai history and culture. At last, I am grateful to everyone who supported and took part in this seminar. **(by Sae Shikita)**

The Joint Student Seminar on Civil Infrastructures provided me a very great chance to a variety of new research related to civil works. It is such a pleasant time for me to listen to the new topic which some of them were never been heard before in my working experience. However, due to a large number of participants, it may be little bit exhausted to join the seminar from 8am to 6pm and since many participants have not enough time for their sightseeing around Bangkok. Therefore, my suggestion is, should the seminar be divided in two days? I'm looking forward to join this seminar again. **(by Jetpan Wetwitooait)**

It was a great experience to join the 6th Joint Student Seminar on Civil Infrastructure. All of the presentations made by invited speakers and students were very interesting and had a lot to learn. As a bachelor course student, it was the first time for me to make a presentation on my research. I was frustrated by my inability to answer the questions raised from the floor; at the sam time, it gave a great motivation to make my better research and presentation. My sincere thankfulness is to all of you who gave me this wonderful opportunity. **(by Nakashima Mari)**

This seminar was very exciting because it was the first time to introduce my own research to students from foreign universities. Having fruitful discussion and receiving comments from students and professors were a precious experience to me. Also, exchanging viewpoints with students during coffee breaks, lunch and dinner was enjoyable. The time I spent during the seminar had motivated me to improve my research, English, and presentation skill. The accommodations and seminar arrangement were so good that there was no need to worry even though you had never been abroad. Finally, I would like to show my appreciation to professor, secretary, seniors, and staffs both at the seminar and in the laboratory for giving me this chance and helping me for everything. **(by Nao Sasaki)**

The 6th Joint Student Seminar on Civil Infrastructures gave me opportunity to speak presentation in front of foreign students. Last year, I attended this 5th seminar as an audience. That time, I was worried about presentation in English. However, I got new and valuable experience from this seminar and it was meaningful that we met each other who are studying in same field. Also, I was sorry to participate in field trip together due to my personal reason. Next year I will probably join this seminar again. I hope that I will speak more advanced presentation and make relationship with all students.**(by Choong-shik Lee)**

I would like to offer my sincere gratitude to all organizers of this seminar and those who helped me during the field trip in Thailand. At first, I was little worried since it was my first time to present in English in an international environment. However, I made it and gained confidence after this seminar. It not only provided us an opportunity to present our research in English and communicate with students from other different fields, but also gave us a chance to gain friendship. I really learned a lot from this seminar and I will use this experience to my further study and keep contact with friends gained from t his seminar in the future. **(by Fei Jiang)**

It is such a great opportunity to present my work and listen to what others are working on and the progress of researches in civil infrastructures, especially by students like me. This may be the second time I've joined this seminar but indeed a lot has changed since my last attendance. Just two years have passed but the quality of work and enthusiasm of presenters has evolved into much greater depts. It has always been exciting and a good opportunity to practice and brush up on my presentation skills, but more importantly, on making my presentation as simple as possible while still including all the important details. Finally, I would like to extend my sincere gratitude to the organizing committee and to the attendees for the excellent seminar and friendships fostered. **(by Michael Coo)**

When I realized that I was granted an opportunity to participate in the 6th Joint Student Seminar on Civil Infrastructure in Bangkok, I was a bit worried because my academic background was different. However, the experience I had from the seminar was somewhat valuable and memorable. For the student presentation session, I have learnt new genre of expertise and interesting researches. Most importantly, I have met new friends from Japan, Thailand and Korea. This network of friendship, I trust, will be very useful for us as an informal platform to exchange ideas and useful information in the future. For the field trip, I was very impressed by the construction site visit. The real TBM machine looked more majestic than the image I saw on documentary channel, If I had not participated in this program, I would not have had a chance like this. My thankfulness is not enough to express how I felt and I do hope that this program will continue as it gives priceless opportunities for students. **(by Niwat Apichartbutra)**

6th Joint Student Seminar on Civil Infrastructure

Venue: Sasa International House (Room: Dipak C. Jain), Chulalongkorn University
Date: 6 August 2013

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Time	Topic	Name of speaker
08.00-08.30	Registration	-
08.30-08.40	Opening remarks	Dr. Akiyuki Kawasaki, AIT
08.40-09.00	Group photo & Coffee break	
Invited Lectures (chair: Dr. Hyunmyung Kim, Myong Ji University)		
09.30-10.15	Big Data and Transportation Information Platform in Korea	Dr. Jeong Whon Yu Ajou University
10.15-11.00	Understanding Post-Installed Anchor Systems & Code Design Requirements	Mr. Kunakorn Pragthong Hilti (Thailand) Ltd
Student Presentation 1 (chairs: Dr. Akiyuki Kawasaki, AIT)		
11.00-11.15	Car Navigation Data Analysis for Transportation Planning	Ms. Sung-Hi An Myong Ji University
11.15-11.30	The impact of flow velocity on microbial precipitation of calcium carbonate among soil	Mr. Tsubasa Sasaki University of Tokyo
11.30-11.45	Comparison of benefits for Political boundary and Natural boundary from Hydropower development in the Mekong	Mr. Seemanta Bhagabati AIT
11.45-12.00	Evaluating thermal comfort in city life and its relation to socio-economic activities	Ms. Noriko Okamura University of Tokyo
Lunch		
Student Presentation 2 (chairs: Dr. Kunnawee Kanitpong, AIT)		
13.00-13.15	Development of real wind turbine blade vibration measurement technique by 3D motion analysis software	Mr. Ryoichiro Hoshino University of Tokyo
13.15-13.30	Forest carbon estimation using the combination of LiDAR data and high resolution imagery in Ludikhola Watershed, Nepal	Ms. Dang Anh Nguyet AIT
13.30-13.45	Three-dimensional simulation of flow of fresh concrete in multi-dimensional steel bar arrangement by MPS	Mr. Shunya Kimura University of Tokyo
13.45-14.00	Application of Risk Management to forecasting Transportation Demand	Mr. Baekkyu Namkung Seoul National University of Science and Technology
14.00-14.15	Characterization of Air Quality in Global Mega-Cities by Remote Sensing and Inventory Data	Ms. Aya Fujikawa University of Tokyo
14.15-14.30	Structural equation models regarding to inter-city van transit in Thailand: A case stuy of difference of travel distance	Mr. Tharadol Punlop AIT
14.30-14.45	Basic research for quantitative analysis of oil-contaminated soil purification by microorganisms	Mr. Shunya Suzuki University of Tokyo
14.45-15.00	Modeling of oven-dried mortar after fire exposure by Rigid Body Spring Model (RBSM)	Ms. Onnicha Rongviriyapanich Chulalongkorn University
Coffee Break		

6th Joint Student Seminar on Civil Infrastructure

Venue: Sasa International House (Room: Dipak C. Jain), Chulalongkorn University
Date: 6 August 2013

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Student Presentation 3 (chairs: Dr. Sung Bong Chung, Seoul National University of Science and Technology)		
15:30-15:45	Current Situation about Reconstruction of Hakozaki Peninsula after the Great East Japan Earthquake	Ms. Sae Shikita University of Tokyo
15.45-16.00	Neighboring Search Process in Genetic Algorithm for Train Scheduling Problem	Mr. Jetpan Wetwitooait AIT
16.00-16.15	An investigation of road bridge maintenance system in Japan in developed society	Ms. Nakashima Mari University of Tokyo
16.15-16.30	The role of mutual assistance during disaster in the aging society	Ms. Nao Sasaki University of Tokyo
16.30-16.45	The Calibration of Road Network Travel Time Function in Korea : The Issues and Solutions	Mr. Choong-Shik Lee Myong Ji University
16.45-17.00	Study on Effect of Street Blockades on Transportation of Seriously-Injured Victims to Hospitals-Case Study of Expected Tokyo Inland Earthquake	Ms. Fei Jiang University of Tokyo
17.00-17.15	A study of low cost grout for Preplaced Aggregate Concrete	Mr. Michael Coo AIT
17.15-17.30	A Study on Strategy for Effective Disaster Information Dissemination: Case Study in Thailand	Mr. Niwat Apichartbutra University of Tokyo
17.30-17.45	Review comment Closing remarks	
18.00	Dinner at Sasa International House, Presentation Award Excellence Presenter Ceremony	

Thai 6 speakers (AIT 5, Chula 1)
Korea 3 speakers (Myong Ji University. 2, Seoul National University of Science and Technology 1)
Japan 11 speakers (University of Tokyo 11)
Total no. 20 speakers

***10 minute presentation and 5 minute discussion**

6th Joint Student Seminar on Civil Infrastructure

Field trip Program

Date: 7 August 2013

Time	**Descriptions**
08.00	Meeting at lobby of the Sasa International House
09.30 -11.00	- Visit Construction site of new MRT Blue Line (Underground) at Hua Lampong http://www.mrta-blueline.com/
11.30-12.00	- Hua Lamphong Railway Station http://en.wikipedia.org/wiki/Hua_Lamphong_Railway_Station - Wat Kalayanimit http://www.encyclopediathai.org/sunthai/rkosin31.htm
Lunch	
12.30-16.00	- Kao Sarn Road http://en.wikipedia.org/wiki/Khaosan_Road - Wat Ratchanadda http://bangkokforvisitors.com/ratanakosin/loha-prasat/
16.00	Departing from Wat Ratchanadda
17.00	Returning to Sasa International House
18.00	Transfer to the airport

For the field trip information:

- Dress : polite , not sandal shoe, not t-shirt (Visit Construction site)
- Proper dresses should be worn, no shorts, no dresses showing bare shoulders (Visit Temple)

Expected No. (Bus)

	No. of Student	No. of Faculty
Japan	11	-
Thai	2	Organizing team 2
Korea	-	-
Total	13	4

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