5th JOINT STUDENT SEMINAR on CIVIL INFRASTRUCTURE

August 20-21, 2012

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

5th Joint Student Seminar on Civil Infrastructure

20-21 August 2012
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

Hokkaido University

Chulalongkorn University

Myongji University, Korea
and

Chonnam National University

Edited by

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

Organization Teams

Prof. Worsak Kanok-Nukulchai (AIT, Thailand)
Dr. Pennung Warnitchai (AIT, Thailand)
Dr. Kunnawee Kanipong (AIT, Thailand)
Dr. Masahiko Nagai (AIT, Thailand)
Dr. Mukand Singh Babel (AIT, Thailand)
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Dr. Withit Pansuk (Chulalongkorn U, Thailand)

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Dr. Henry Michael (Hokkaido U, Japan)

Dr. Hyunmyung Kim (Myongji U, Korea)
Prof. Yongtaek Lim (Chonnam National U, Korea)
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5th JOINT STUDENT SEMINAR ON CIVIL INFRASTRUCTURE

August 2012

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 1st, 2nd 3rd, 4th and joint student seminar in July 2008, July 2009, July 2010 and August 2011, respectively, and following this success the "5th Joint Student Seminar on Civil Infrastructures" was held on 20th -21st August, 2012.

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 69, consisting of 2 faculties and 69 students from Hokkaido University, Chonnam National University, MyongJi University , Chulanongkorn University, The University of Tokyo and Asian Institute of Technology.

On the first day, we had a presentation session, having 2 faculties' lectures and 16 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 2 students.

1. Mr. Yoshiyuki Takano from University of Tokyo, Japan
2. Ms. Sung-Hi An from MyongJi University, Korea

On the second day, we had a field visit to the traveling along the a cruise along the legendary Chao Phraya River, Bangkok, Thailand, and some canals on the Thon Buri side (investigating the riverside area affected by the 2010 floods and observe the life of riverside communities along with of the Chao Phraya River); visit Vimanmek Mansion, Wat Arun (The Royal Temple of Dawn) and Ananda Samakhom Throne Hall.

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, Michael Henry and Withit Pansuk

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Opening ceremony (Dr. Akiyuki Kawasaki)

Dr. Michael Henry

Dr. Punchet Thammarat

Ms. Maria Bernadet Karina Dewi

Mr. Bhawat Chaichannawatik

Ms. Yuriko Yamamoto

Mr. Ashik Rajbhandari

Mr. Yoshiyuki Takano

Mr. Cheol Park

Ms. Rieko Kojima

Mr. Ratthaphong Meesit

Mr. Shohei Ikeda

Ms. Kulapramote Prathumchai

Mr. Alene Biruk Adane

Ms. Sung-Hi An

Mr. Taito Miura

Mr. Pong-in Intarit

Ms. Rina Goto

Mr. Bhawat Chaichannawatik

Chairperson (Dr. Masahiko Nagai)

Chairperson (Dr. Hyunmyung Kim)

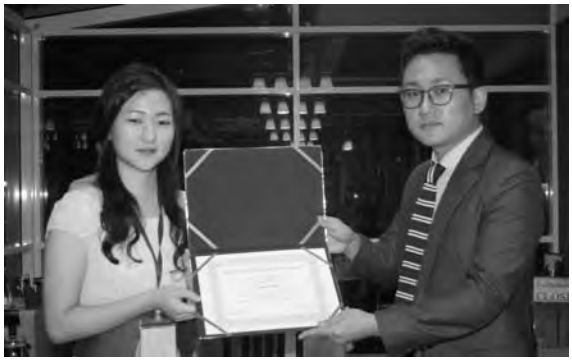
Review comment (Prof. Hiroshi Yokota)

Closing ceremony (Dr. Kunnawee Kanitpong)

During Meeting

During Seminar

During Welcome Dinner



Excellent Presenter Mr. Yoshiyuki Takano

Excellent Presenter Ms. Sung-Hi An


Phra Pinklao Bridge and cross over the river


constructing a flood wall with concrete beams and slabs


flood wall under construction


mold after flood damage

Seminar: Group Photo at Chulalongkorn University (Morning)

Seminar: Group Photo at SaSa International House (Afternoon)

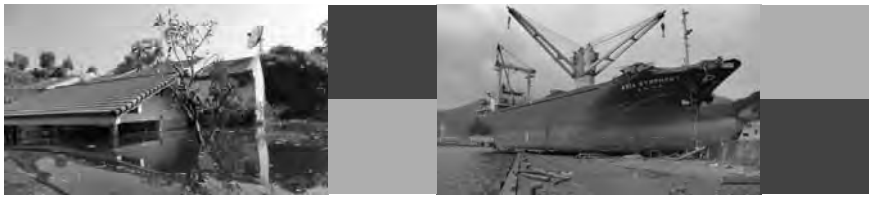
Field Trip: Group Photo at Vimanmek Mansion

Field Trip: Group Photo at Ananda Samakhom Throne Hall

Invited Lectures

INFORMATION COLLECTION AND NEEDS AFTER DISASTERS: LESSONS FROM THE 2011 TOHOKU EARTHQUAKE AND 2011 THAI FLOOD

Michael Henry
Division of Field Engineering for the Environment
Faculty of Engineering, Hokkaido University
mwhenry@eng.hokudai.ac.jp



Information collection and needs after disasters: Lessons from the 2011 Tohoku Earthquake and 2011 Thai Flood

Michael Henry
Division of Field Engineering for the Environment
Faculty of Engineering, Hokkaido University
Akiyuki Kawasaki & Kimiro Meguro
International Center for Urban Safety Engineering (ICUS)
Institute of Industrial Science, The University of Tokyo

Presentation contents

Disaster information
The role of information in disaster situations

2011 Tohoku Earthquake
In-depth multi-dimensional analysis results

2011 Thai Flood
General overview of basic analysis results

Improving information dissemination
For future disaster preparation & response

Information seeking and mass media

After disasters, people seek information to remain informed and to make decisions regarding their post-disaster action

Mass media: transmitters of official information

Phase	Role
Preparedness	Provide factual information about hazards and preparation
Response / Recovery	Focus attention on the affected areas to help community recovery
Mitigation	Disaster information provider to help raise awareness for future events

4

Growth of social media

Localized coverage is useful for building social connections and providing emotional support in the wake of a disaster

Growth of information and communication technologies (e.g. the Internet, social media) has enabled people to connect and participate in information seeking and providing together

However...

The integration of social media and related technologies with official disaster response activities for supporting distribution of critical information is still on-going

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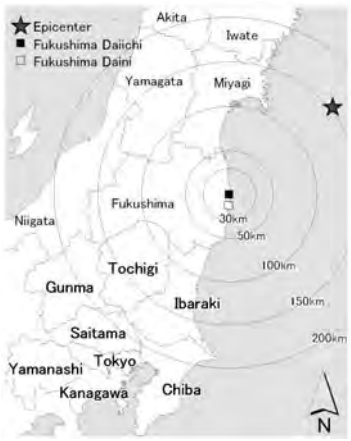
2011 Tohoku Earthquake

Disaster overview



At 14:46 on March 11th, 2011, a magnitude 9.0 earthquake struck off the Pacific coast of Tohoku

Triple disaster:

Earthquake
Tsunami
Nuclear crisis/meltdown

News of the disaster was immediately delivered around the world

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Conflicting and confusing information

After the earthquake and during the Fukushima nuclear crisis…

Domestic media ← **Large information disparity** → Overseas media

Examples: differences in the reported urgency, conflicting information

Large numbers of foreigners relocated to other parts of Japan or left the country entirely, spawning the term "flyjin"

"Flyjin"
A play on the Japanese word used for foreigners, "gaijin," to mock those who fled Japan

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Information and support for foreigners

Effects of foreigners' evacuation on socio-economic activities in Japan:

Relocation/closure of embassies	Implications for policy and foreign diplomacy
Relocation/closure of business functions Evacuation of foreign laborers	Negative impact on economic activities
Evacuation of foreign students	Confusion and loss of productivity in research and academic institutes
Avoidance of Japan by travelers Cancellation/postponement of conferences and exhibitions	Decrease in tourism sales and hotel industries

After the Great Hanshin-Awaji Earthquake of 1995, the problem of disaster assistance to foreigners was raised but received little attention

Considering progress of globalization, disaster response and information dissemination to foreigners who travel and reside in disaster-affected countries is a pressing issue

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Survey on disaster information - Japan

How did people in Japan collect information after the earthquake?

What sources did people trust when faced with a variety of information from both domestic and overseas source?

Did differences in nationality, language ability or other factors affect information collection behavior and post-disaster action?

What should be done to improve the dissemination of disaster information in the future?

Conducted a survey on disaster information collection after the 2011 Tohoku Earthquake

Objectives

- Clarify the disaster information gathering behavior and information-related difficulties of people in the Kanto region of Japan
- Develop proposals for improving disaster information dissemination after future disasters considering the needs of a diverse population

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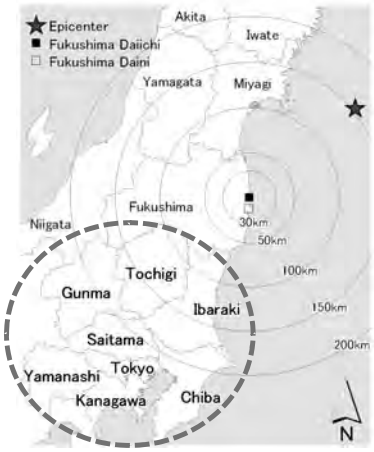
Why the Kanto region?



The Kanto region includes Tokyo, the capital and political, financial, and entertainment center of Japan

Home to 42 million Japanese and 1 million foreigners as of 2009 – making it one of the densest population centers in the world

Unlike the Tohoku region, daily life in the Kanto region was largely undisrupted in the aftermath of the earthquake and people had access to their normal channels of information

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Survey contents & distribution

Data were collected using an online survey prepared in nine languages
(Japanese, English, Chinese, Korean, Portuguese, Nepalese, French, Thai, & Vietnamese)

Survey contents

Information collection	❖ Most- & least-trusted information sources ❖ Media & language for information acquisition ❖ Information importance over time after the disaster
Information difficulties	❖ Unavailable, unclear & difficult to understand information ❖ Reasons for information-related difficulties ❖ Media & language for clarifying information difficulties
Post-disaster action	❖ Leave Japan, relocate in Japan, or remain in Kanto ❖ Reason for and timing of post-disaster action ❖ Usefulness of disaster information for decision making
Demographics	❖ Nationality, age, gender, occupation, etc.

The survey was distributed using two methods:
1) Social and professional contacts of the investigators
2) Direct requests for cooperation to various entities

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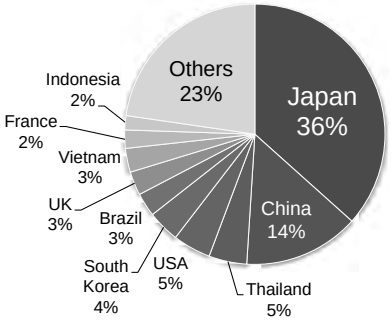
Respondent characteristics (i)

1357 respondents from **74** countries



Others…
- ❖ Nepal
- ❖ Australia
- ❖ The Philippines
- ❖ Sri Lanka
- ❖ Canada
- ❖ Italy
- ❖ Switzerland
- ❖ Germany
- ❖ Malaysia
- ❖ Pakistan

…and 54 more with less than 10 respondents per country

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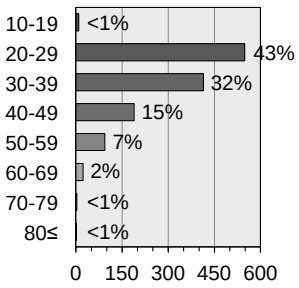
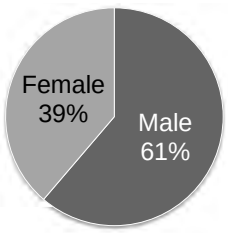
Respondent characteristics (ii)

Age



Gender



(Note: some respondents chose not to answer these questions)

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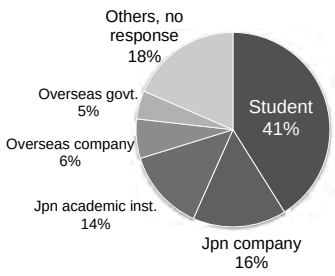
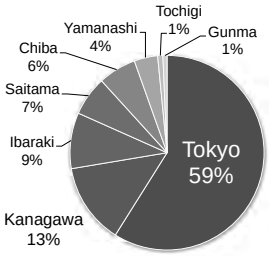
Respondent characteristics (iii)

Occupation



Area of residence



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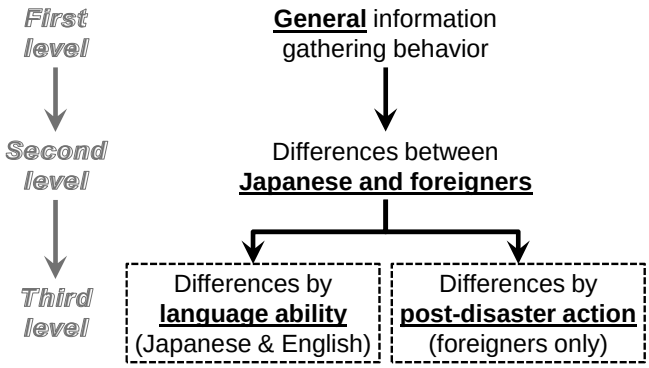
Analysis flow



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Analysis by language ability

Disaster information collection and problems may be affected not just by ***nationality*** but also ***language ability***

Extracted 922 respondents from total sample based on language ability and analyzed their information gathering behavior

Japanese proficiency \ English proficiency	Native	Advanced	Intermediate	Basic	None
Native	**JPN+ENG** F:198, J: 76		F:74 J:135	**JPN only** F:42, J:236	
Advanced					
Intermediate	F:152		F:57, J:1	F:30, J:1	
Basic	**ENG only** F:215		F:56	**Neither** F:9, J:1	
None					

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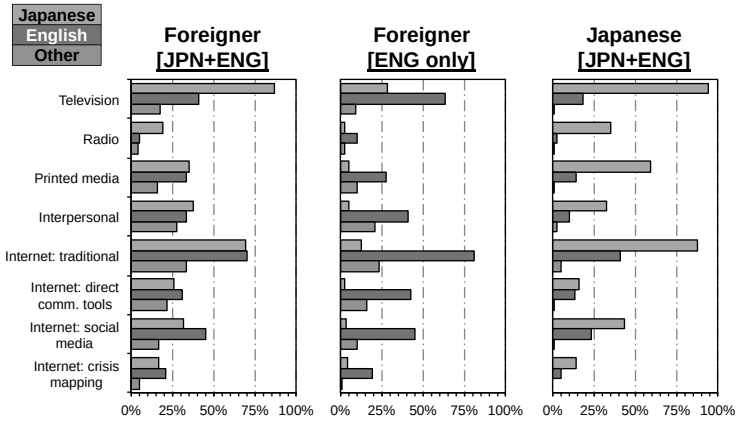
Utilized media and language (i)

Analysis by language ability



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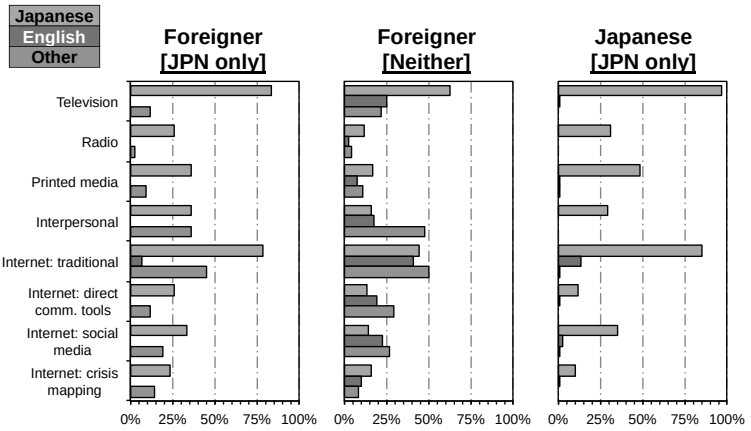
Utilized media and language (ii)

Analysis by language ability



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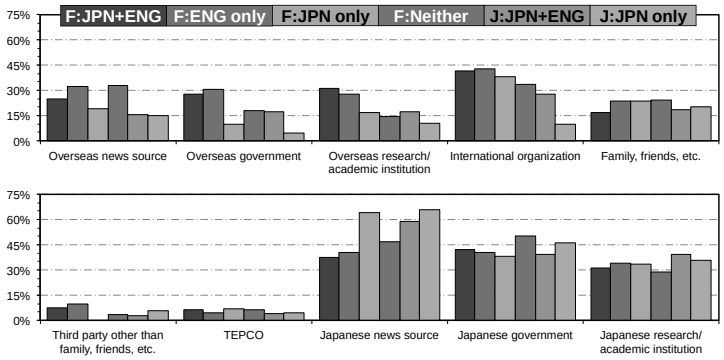
Reliability of information sources (i)

Analysis by language ability

Most-trusted sources



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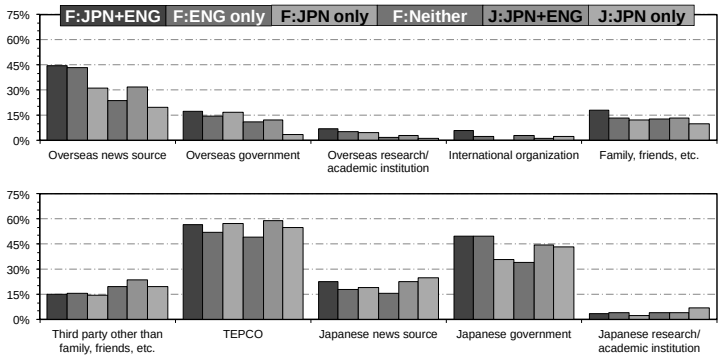
Reliability of information sources (ii)

Analysis by language ability

Least-trusted sources



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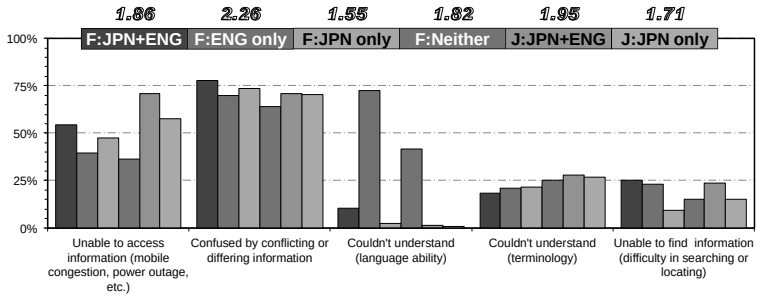
Reasons for information difficulties

Analysis by language ability

Average no. reasons per respondent



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Discussion points on language ability (i)

Dissemination of disaster information to foreigners in English

Foreigners [ENG] trusted similar sources as Foreigners [JPN+ENG], even though they primarily accessed English-language media only

Hypothesis: information provided by domestic sources in Japanese was disseminated to foreigners in English

Identified three means by analyzing open response section:

1) **NHK (Japan Broadcasting Corporation) news broadcasts**
   Provided English translations during TV broadcasts and press conferences; increased availability of English news programs
2) **Social media**
   Used for collecting or finding domestic information which was translated into English via third parties; examples include "Fukushima Reactor Feed" on Facebook or individual blogs
3) **Automatic translation of Japanese text via web browser**

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Discussion points on language ability (ii)

Reliance of foreigners skilled in English on overseas sources

Why did Foreigners [ENG] and Foreigners [JPN+ENG] both place higher trust in overseas sources and higher distrust in domestic sources?

- Discomfort or anxiety caused by the gap between the actual situation in Japan and the urgent or sensational reports from overseas
- Distrust in Japanese government and TEPCO due to lack of govt. involvement or intervention at Fukushima and lack of transparent publishing of information
- Shortage of reliable English information from public institutions

Opinions on domestic sources:

- Passive attitude towards information disclosure to the public
- Repetitious, meaningless, and ambiguous information
- Disappointment in govt. response to nuclear power plant crisis

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Discussion points on language ability (iii)

Reliance of foreigners skilled in Japanese on domestic sources

Foreigners [JPN only] mainly used Japanese media or their own language (excluding English), but rarely used English; this group had a high reliance on domestic sources versus overseas overseas sources

This group collected overseas information in their own language, in which the urgency of the crisis may have been different than domestic

Usage of non-Japanese, non-English information sources

Foreigners [Neither] had higher trust in overseas news sources than other groups, which may have been in their native language

Although NHK and other sources translated information to English, similar activities may not have been performed in other languages, so this group placed higher emphasis on non-English language media

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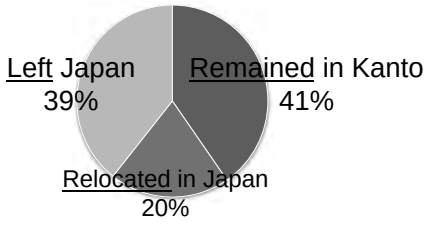
Analysis by post-disaster action

What factors affected post-disaster action (**leaving Japan entirely, relocating from the Kanto region, or remaining in Kanto**)?

Focused on the 860 foreign respondents, as the post-disaster relocation issue was much more pronounced for this group



(Note: in our sample, roughly 90% of Japanese respondents chose to remain in the Kanto region)

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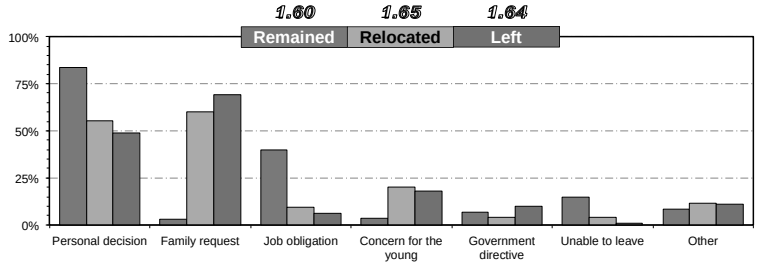
Post-disaster decision making (i)

Analysis by post-disaster action

Reason for post-disaster action

Average no. reasons per respondent



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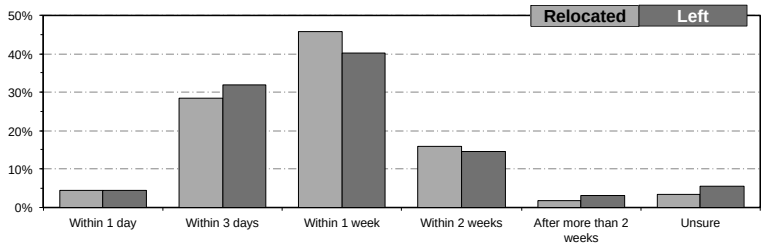
Post-disaster decision making (ii)

Analysis by post-disaster action

Timing of post-disaster action



(Note: only for respondents who chose to relocate within Japan or leave Japan entirely)

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Post-disaster decision making (iii)

Analysis by post-disaster action

Usefulness of disaster information for decision making

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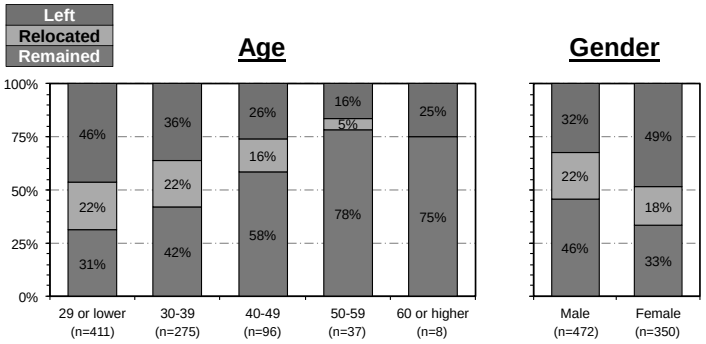
Demographics (i)

Analysis by post-disaster action



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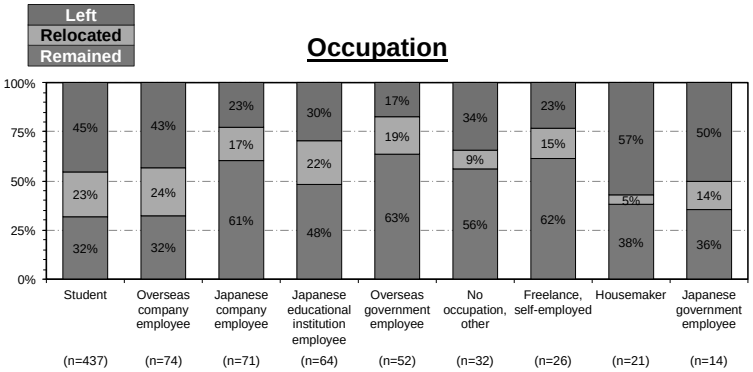
Demographics (ii)

Analysis by post-disaster action



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Discussion points on post-disaster action

Factors related to post-disaster decision to relocate or leave Japan

Rapid and effective dissemination of information after the disaster is important, as more than 80% of foreigners made their decision to leave or relocate within 1 week after the earthquake and more people who remained found disaster information to be very useful for their decision than those who relocated or left

Rapid and accurate dissemination overseas is also important as family request was the biggest reason cited for leaving; students were particularly affected by the family request

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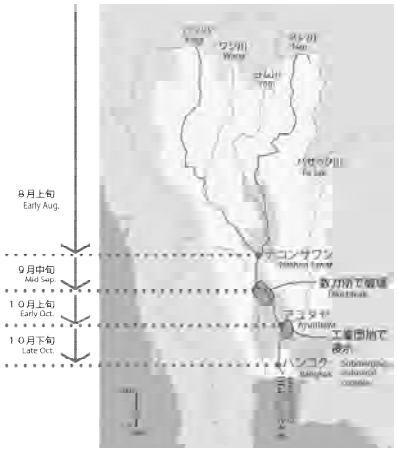
2011 Thai Flood

Disaster overview (i)



June – Sept. 2011
Precipitation in the Indochina Peninsula was 1.2 to 1.8 times higher than average

through early Oct. 2011
Heavy rainfall over the Chao Phraya River Basin

August
Landslides and flash floods in the northern region

Early October
Floodwaters submerged Ayutthaya area

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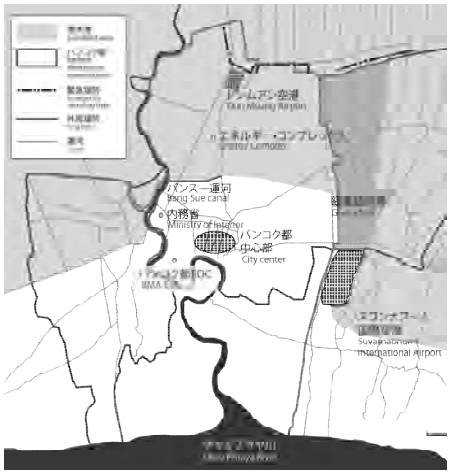
Disaster overview (ii)



End of Oct. 2011
Two flows of floodwater reached the northern part of Bangkok & flooding of Don Muang Airport

Mid-Nov. 2011
Floodwaters halted at Bang Sue Canal and flooding of Bangkok city center prevented

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Survey on disaster information - Thailand

Due to the slow flood progress and ambiguity of the flood progress and levels, people encountered difficulties in determining the risk to themselves and their families and property

How to improve information dissemination considering differing disaster situations?

Conducted a survey on disaster information collection after the 2011 Thai flood

Objectives

- Clarify the disaster information gathering behavior and information-related difficulties of people in Thailand
- Develop proposals for improving disaster information dissemination after future disasters
- Examine differences between different disaster events

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Survey contents & distribution

Data were collected using a survey prepared in three languages
(Thai, Japanese, & English)

Survey contents

Flooding	❖ Situation of flooding and decision to evacuate or not
Information collection	❖ Most- & least-trusted information sources ❖ Media & language for information acquisition ❖ Information importance over time after the disaster
Information difficulties	❖ Unavailable, unclear & difficult to understand information ❖ Reasons for information-related difficulties ❖ Media & language for clarifying information difficulties ❖ Awareness of support and evacuation systems
Demographics	❖ Nationality, age, gender, occupation, etc.

The survey was distributed using two methods:
1) Online survey (requests for cooperation via email)
2) Ground survey (direct requests to respondents)

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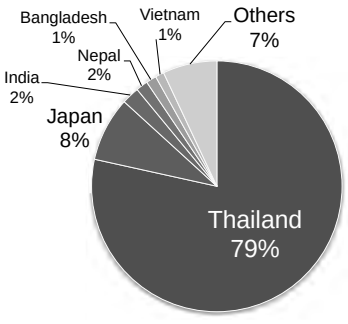
Respondent characteristics (i)

975 respondents from **29** countries



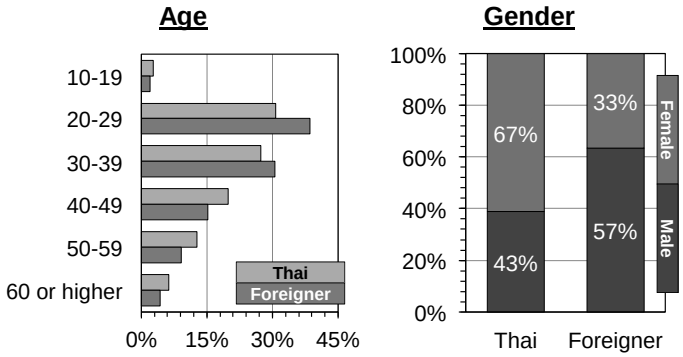
Others...

- Pakistan
- The Philippines
- Myanmar (Burma)
- Indonesia
- Malaysia
- Cambodia
- France
- Sri Lanka
- UK
- USA

...and 13 more with two respondents or less per country

38

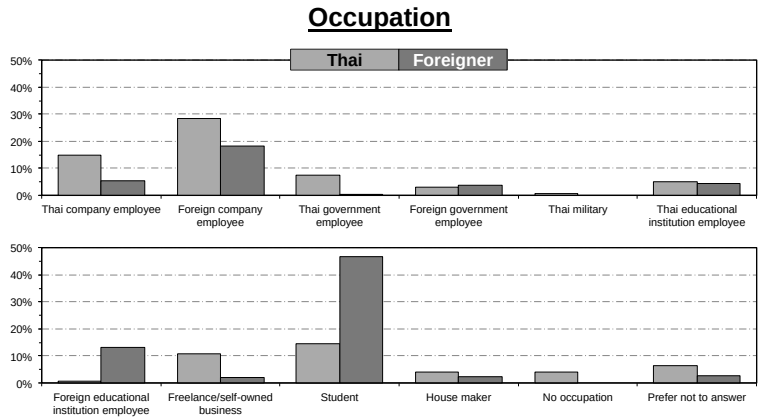
Respondent characteristics (ii)



(Note: some respondents chose not to answer these questions)

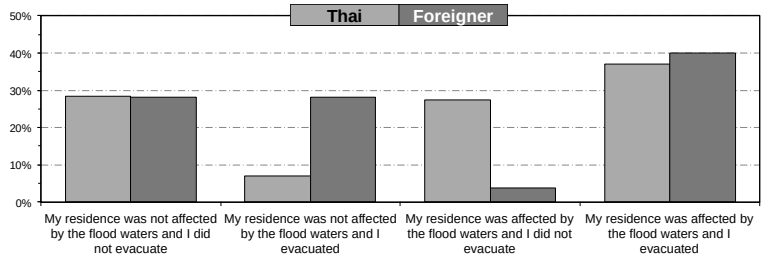
39

Respondent characteristics (iii)



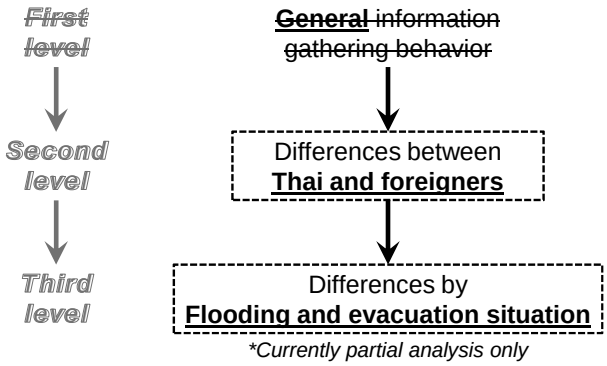
40

Respondent characteristics (iv)



41

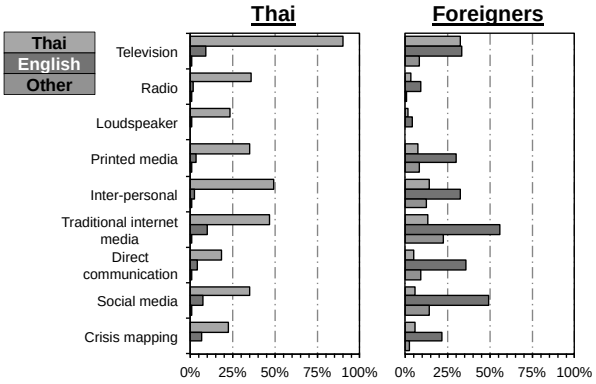
Analysis flow



42

Utilized media and language

Analysis by nationality

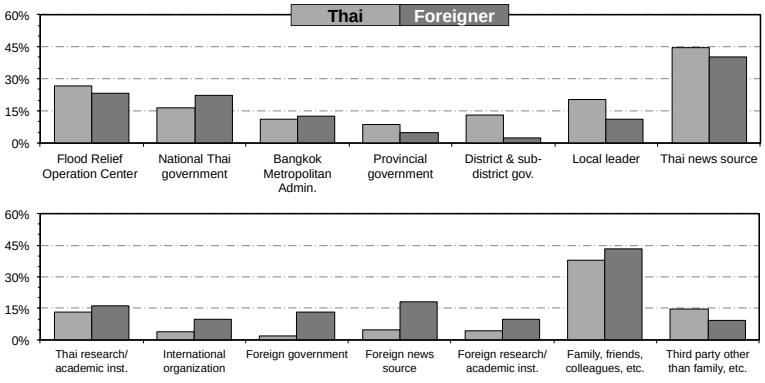


43

Reliability of information sources (i)

Analysis by nationality

Most-trusted sources

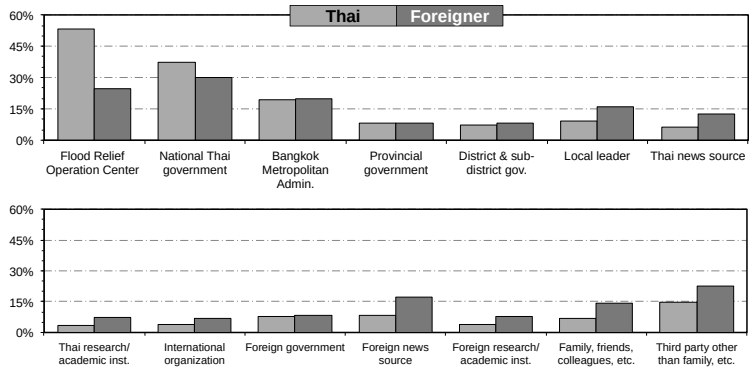


44

Reliability of information sources (ii)

Analysis by nationality

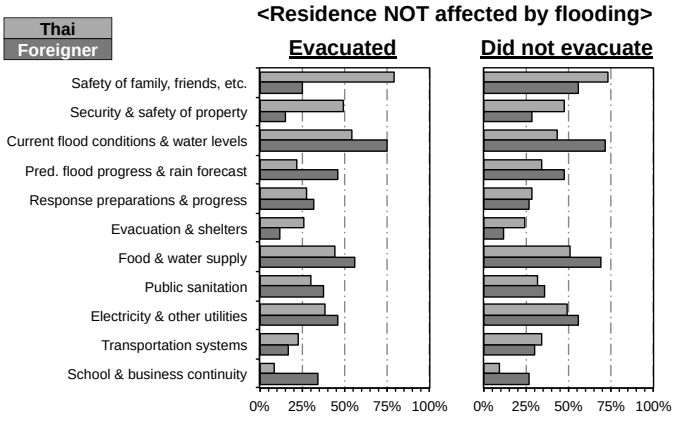
Least-trusted sources



45

Important info for decision-making (i)

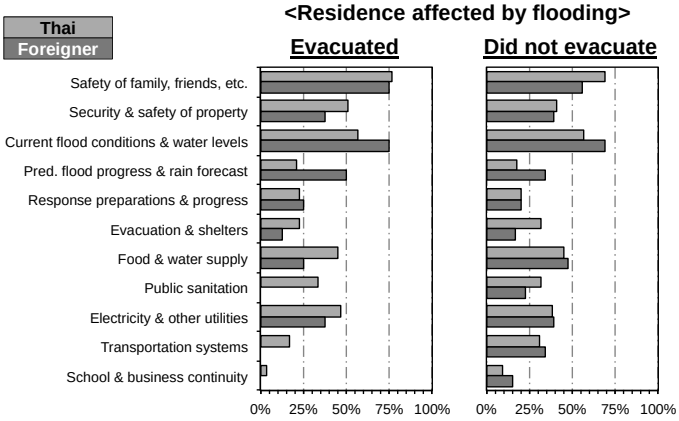
Analysis by nationality & flooding/evacuation situation



46

Important info for decision-making (ii)

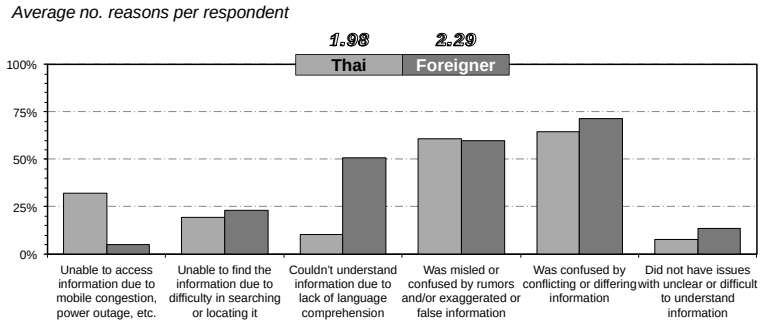
Analysis by nationality & flooding/evacuation situation



47

Reasons for information difficulties

Analysis by nationality

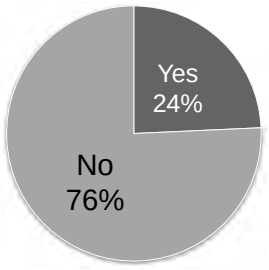


48

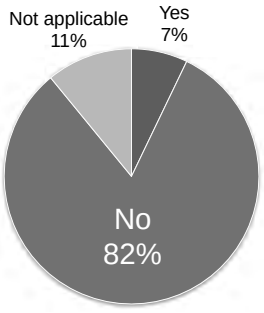
Disaster support for foreigners

Analysis by nationality

Aware of Thai PBS English news program on flood



Aware of foreigner flood evacuation center in Bangkok



(Note: these responses are for foreigners only)

49

Discussion points (i)

Differences in flooding and evacuation situation

A higher percentage of foreigners chose to evacuate even though their homes were not affected by flooding, and their decision was based on the current flood level conditions and water levels and food and water supply

A higher percentage of Thai, however, chose to remain at their homes even though they were affected by floods, and their decision was based on the safety of family and friends and the current flood level conditions and water levels

While both groups similarly trusted Thai news sources and family, friends, colleagues, etc., Thai distrusted the Flood Relief Operation Center (FROC) much more than foreigners

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Discussion points (ii)

Lack of awareness of disaster support for foreigners

Foreigners were generally unaware of the various support systems that were in place for them, such as English-language news programs and foreigner-specific evacuation centers

Foreigners also had difficulty acquiring disaster information due to language comprehension issues, so it may have been difficult for them to find out that these systems existed

Furthermore, although most foreigners primarily used English-language media, they used Thai and English TV roughly equally, which may have contributed to conflicting messages

Need to continue with further analyses to better understand the disaster information-related difficulties

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Improving information dissemination

Towards improving dissemination (i)

Considering the observed issues after the 2011 Tohoku Earthquake

1) **Providing official information in English**
   Foreigners could obtain Japanese information through both unofficial and official translations, but unofficial (third party or automated) translations may have introduced bias into the information; official information in English can provide an important source for both individuals and for foreign media and lead to more reliable information dissemination overseas
2) **Provision of information in clear Japanese**
   Various platforms were used to translate Japanese information into English (and most likely other languages as well); therefore, if Japanese information can be delivered frequently and clearly on a website, even those unskilled in Japanese may be able to obtain the core message

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Towards improving dissemination (ii)

3) **Need for institution to aggregate & disseminate information**
Japanese research/academic institutes were highly trusted and could actively provide information both within and outside Japan, such as via secondary publishing of reliable, translated information to the web

4) **Provision of local information by strengthening the connection between TV and the internet**
Both foreigners and Japanese used TV as their primary mode for gathering disaster information, but it's difficult to deliver localized information necessary for daily life; strengthening connection between TV and internet could bridge this gap

5) **Provision foreign language programs combining media**
Local radios contributed to gathering and disseminating local information in disaster-affected areas without TV; open time schedule could incorporate foreign language information as well

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Towards improving dissemination (iii)

6) **Improve the reliability of the Japanese government as a source**
Foreigners' evaluation of Japan's ability to manage a crisis was quite severe; delivering information which foreigners can use for concrete action, reducing unclear or non-specific expressions, and increasing transparency are possible steps for improving the government's reliability as an information source

Considering the observed issues after the 2011 Thai Flood

7) **Raise awareness of disaster support systems for foreigners**
Foreigners appeared to be unaware of various systems intended to provide them with information and to support their decision making or evacuation; reasons for this need to be investigated in further analyses in order to propose how to raise awareness

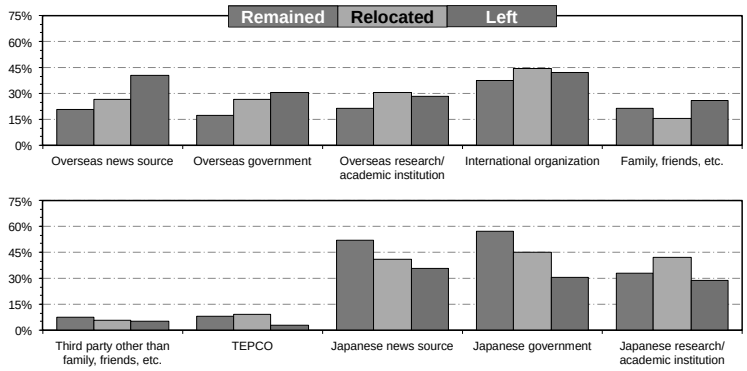
55

Thanks for your attention

Reliability of information sources (i)

Analysis by post-disaster action

Most-trusted sources

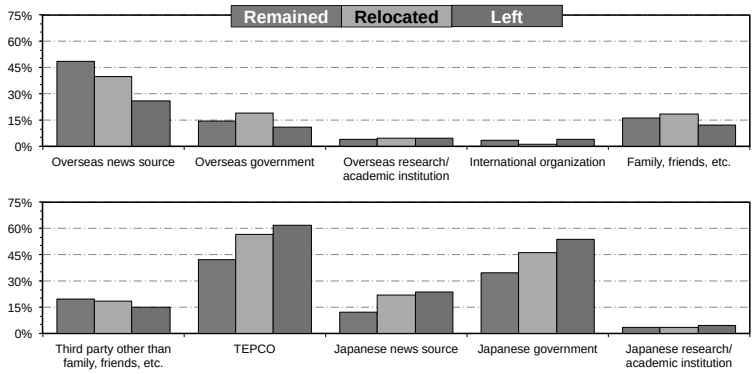


57

Reliability of information sources (ii)

Analysis by post-disaster action

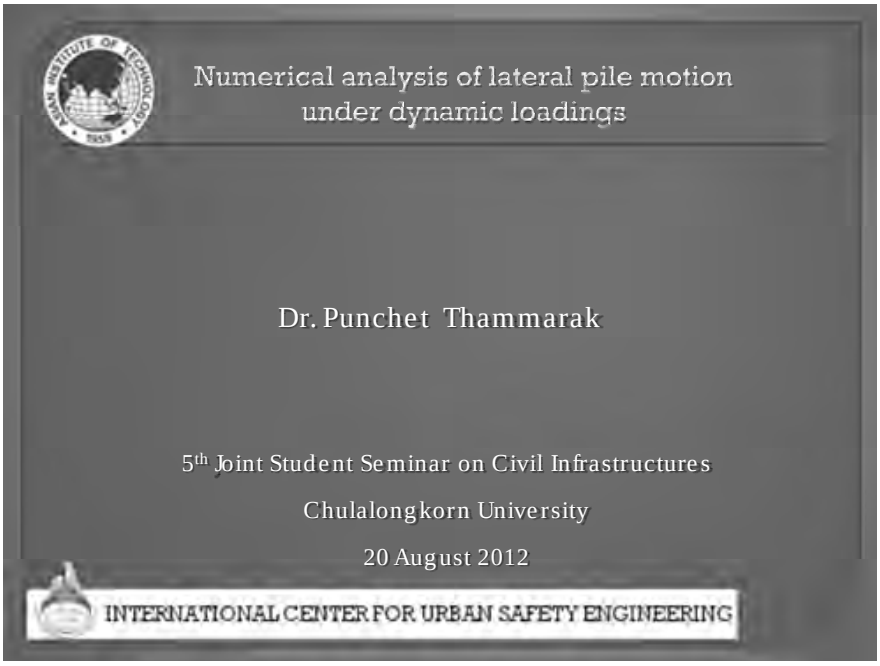
Least-trusted sources

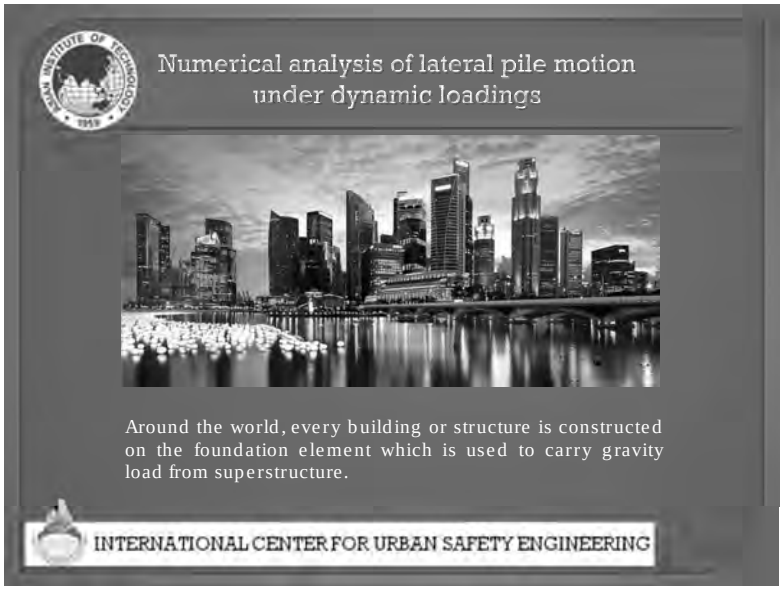


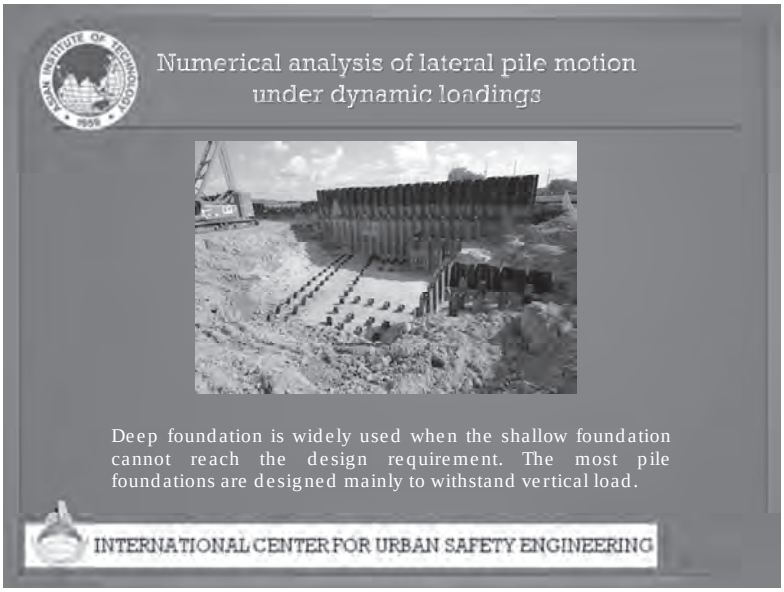
58

NUMERICAL ANALYSIS OF LATERAL PILE MOTION UNDER DYNAMIC LOADINGS

Punchet Thammarak
School of Engineering & Technology, Asian Institute of Technology,
P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand
punchet.thammarak@gmail.com






Numerical analysis of lateral pile motion
under dynamic loadings
Deep foundation is widely used when the shallow foundation cannot reach the design requirement. The most pile foundations are designed mainly to withstand vertical load.
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Numerical analysis of lateral pile motion
under dynamic loadings
In real condition, structures might experience lateral loads from many events such as wind, wave, earthquake, machines vibration, etc.
The effects of lateral load in structure design must be considered.
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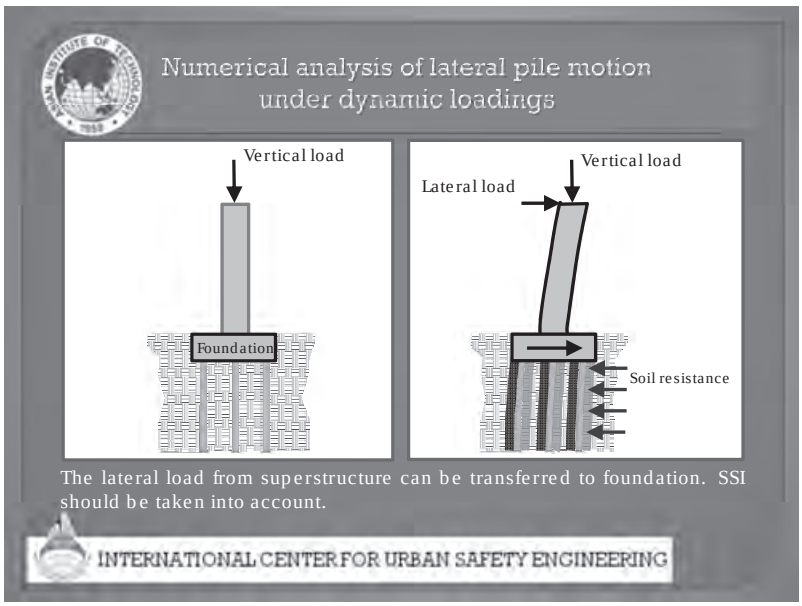
Numerical analysis of lateral pile motion
under dynamic loadings
Vertical load
Foundation
Vertical load
Lateral load
Soil resistance
The lateral load from superstructure can be transferred to foundation. SSI should be taken into account.
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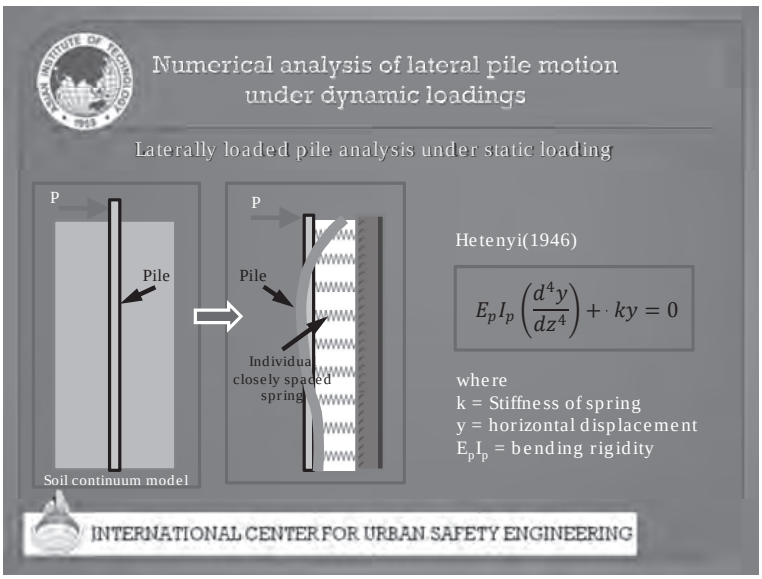
Numerical analysis of lateral pile motion under dynamic loadings
Laterally loaded pile analysis under static loading
P
Pile
Soil continuum model
P
Pile
Individual closely spaced spring
Hetenyi(1946)
$E_p I_p \left(\frac{d^4y}{dz^4}\right) + \cdot ky = 0$
where
k = Stiffness of spring
y = horizontal displacement
$E_p I_p$ = bending rigidity
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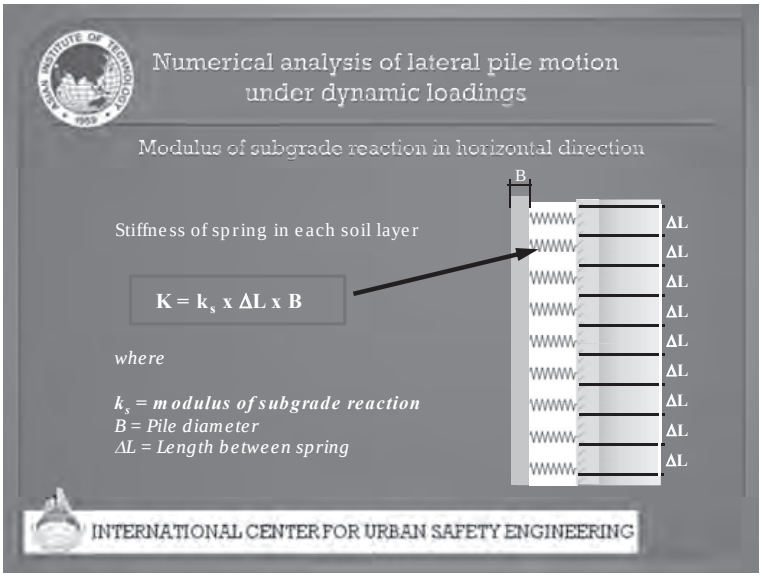
Numerical analysis of lateral pile motion under dynamic loadings
Modulus of subgrade reaction in horizontal direction
Stiffness of spring in each soil layer
$K = k_s \times \Delta L \times B$
where
k_s = modulus of subgrade reaction
B = Pile diameter
ΔL = Length between spring
B
ΔL
ΔL
ΔL
ΔL
ΔL
ΔL
ΔL
ΔL
ΔL
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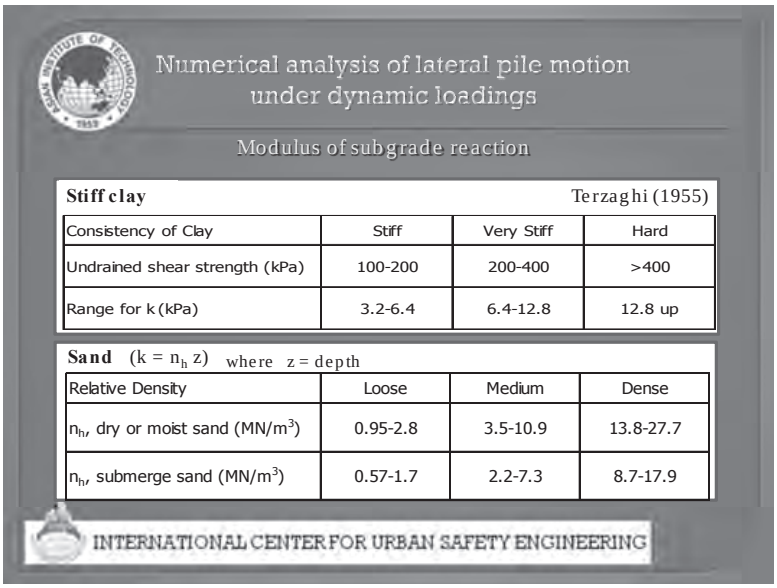
Numerical analysis of lateral pile motion under dynamic loadings
Modulus of subgrade reaction
Stiff clay
Terzaghi (1955)
Consistency of Clay | Stiff | Very Stiff | Hard
Undrained shear strength (kPa) | 100-200 | 200-400 | >400
Range for k (kPa) | 3.2-6.4 | 6.4-12.8 | 12.8 up
Sand ($k = n_h z$) where z = depth
Relative Density | Loose | Medium | Dense
n_h, dry or moist sand (MN/m³) | 0.95-2.8 | 3.5-10.9 | 13.8-27.7
n_h, submerge sand (MN/m³) | 0.57-1.7 | 2.2-7.3 | 8.7-17.9
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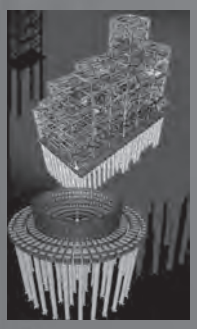
Numerical analysis of lateral pile motion under dynamic loadings

Lateral Pile Response Analyses under Dynamic Loading



There are several methods used to determine lateral pile response under dynamic loading

- Winkler soil model using springs and dashpots. The properties depends on definition of soil stiffness and geometric damping
- Analytical solution for pile-soil system idealized by soil layer system
- Analytical solution of laterally loaded pile embedded in soil continuum

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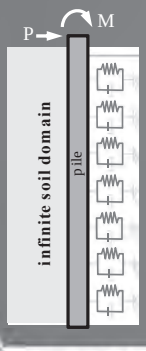
Numerical analysis of lateral pile motion under dynamic loadings

Beam on linear Winkler foundation with vibration disk stiffness



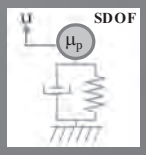
Equation of motion

$$\mu\frac{\partial^2 u(z,t)}{\partial t^2} + G(S_{u1} + iS_{u2})u(z,t) + E_p I_p \frac{\partial^4 u(z,t)}{\partial z^4} = 0$$

where

μ = pile mass per unit length

$E_p I_p$ = bending rigidity



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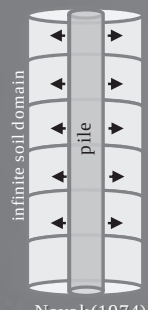
Numerical analysis of lateral pile motion under dynamic loadings

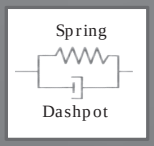
Application of vibration disk stiffness to laterally loaded pile

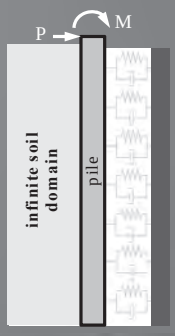


Novak(1974)

Vibrating disk stiffness

$$k = G_s(S_{u1} + iS_{u2})$$





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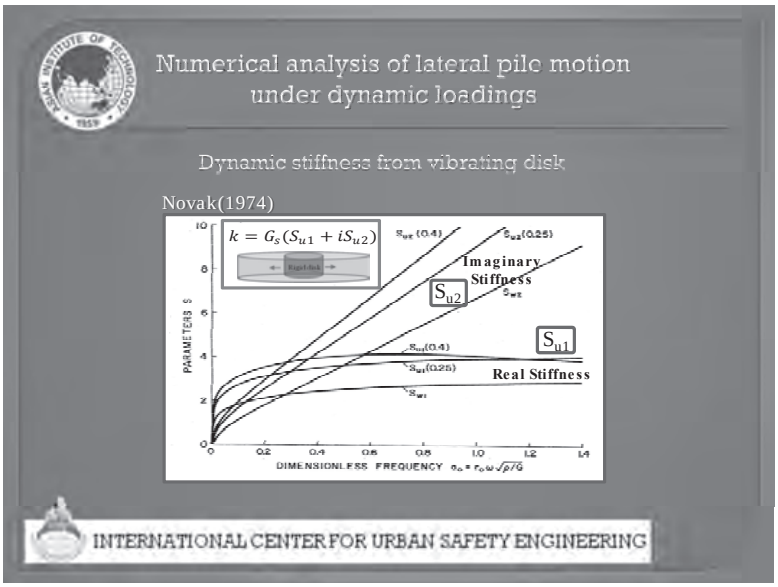
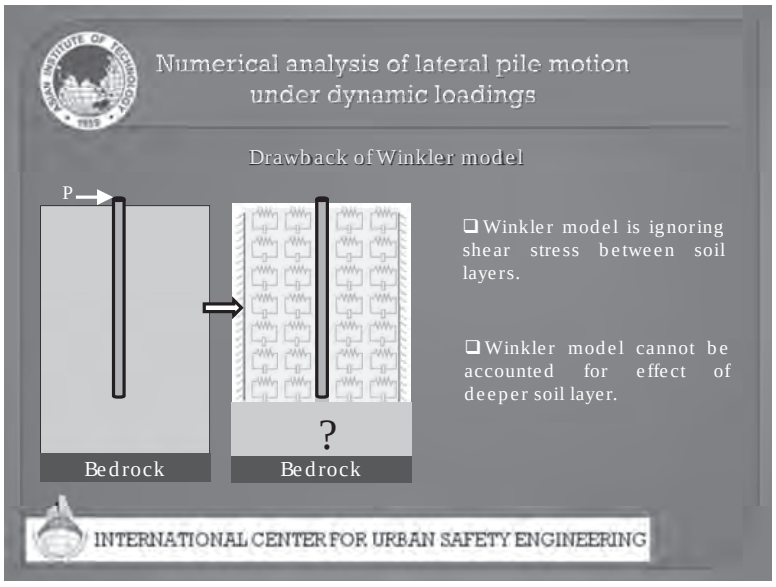

Numerical analysis of lateral pile motion under dynamic loadings
Dynamic stiffness from vibrating disk
Novak(1974)
$k = G_s(S_{u1} + iS_{u2})$
Imaginary Stiffness
S_{u2}
S_{u1}
Real Stiffness
PARAMETERS S
DIMENSIONLESS FREQUENCY
INTERNATIONAL CENTER FOR URBAN SAFETY ENGINEERING


Numerical analysis of lateral pile motion under dynamic loadings
Drawback of Winkler model
P
Bedrock
?
Bedrock
Winkler model is ignoring shear stress between soil layers.
Winkler model cannot be accounted for effect of deeper soil layer.
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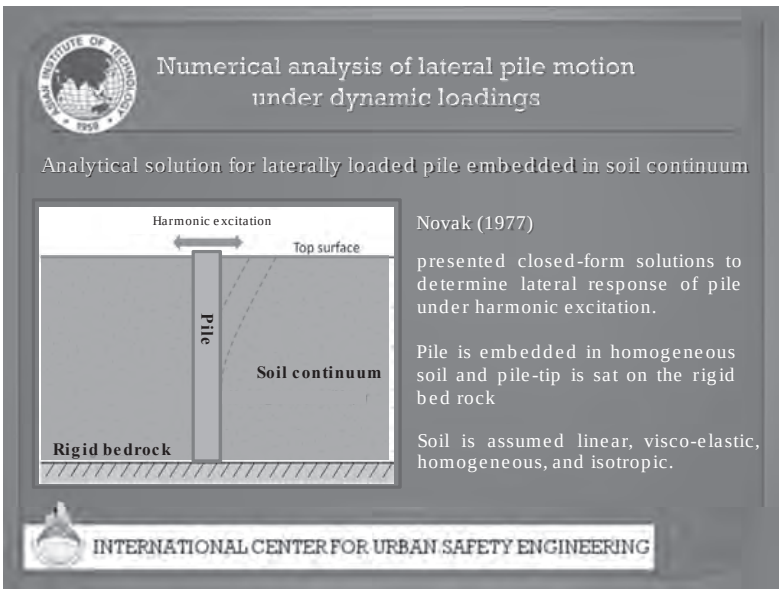
Numerical analysis of lateral pile motion under dynamic loadings
Analytical solution for laterally loaded pile embedded in soil continuum
Harmonic excitation
Top surface
Pile
Soil continuum
Rigid bedrock
Novak (1977)
presented closed-form solutions to determine lateral response of pile under harmonic excitation.
Pile is embedded in homogeneous soil and pile-tip is sat on the rigid bed rock
Soil is assumed linear, visco-elastic, homogeneous, and isotropic.
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Numerical analysis of lateral pile motion under dynamic loadings

The main studies of this research are as follows:

- Validation of natural frequency of soil from FEM with closed-form solution
- Study the response of laterally loaded pile due to the varying depth of underlying soil layer.
- Study the response of laterally loaded pile with varying stiffness and thickness of underlying soil layer
- Study the response of laterally loaded pile with constant soil thickness and varying length of pile

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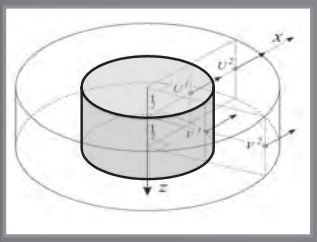
Numerical analysis of lateral pile motion under dynamic loadings

Reduced-Dimension model Continuum-ring element

Thammarak (2009)



- This model can present 3-D behavior by using 2-D model which can reduce drastically computational cost.
- The shear force between continuum ring element is taken into account.
- It is possible to develop this model to unbounded domain.
- This model has good efficiency to explain the deformation of surrounding soil in radial and tangential directions.

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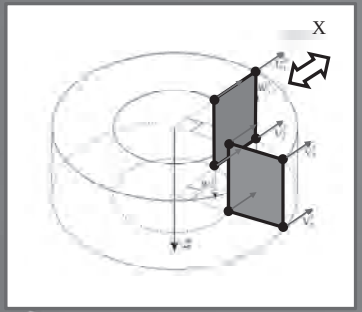
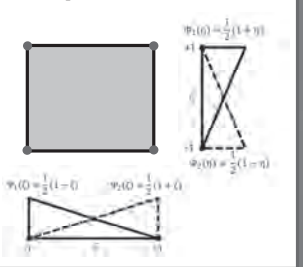
Numerical analysis of lateral pile motion under dynamic loadings

Continuum ring element (Thammarak ,2009)



Shape function



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Numerical analysis of lateral pile motion under dynamic loadings
New elastic continuum model (Thammarak , 2009)
pile
infinite soil domain
Transfering shear
Transfering shear
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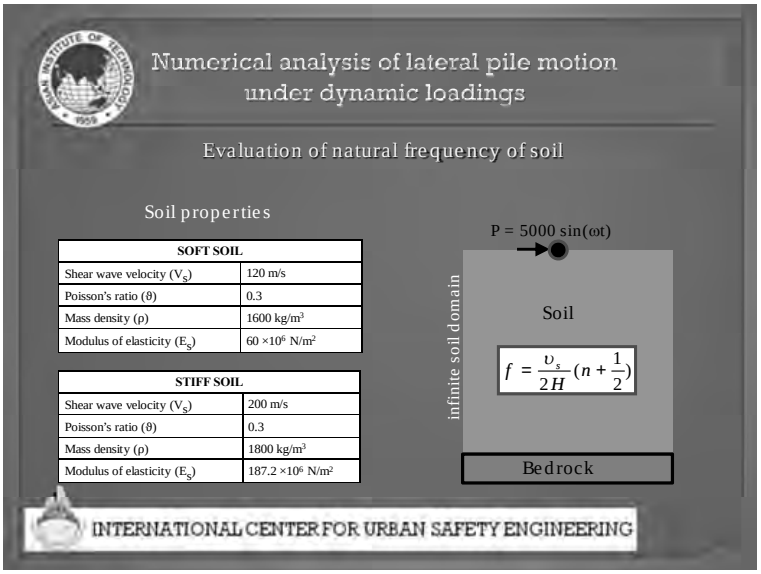
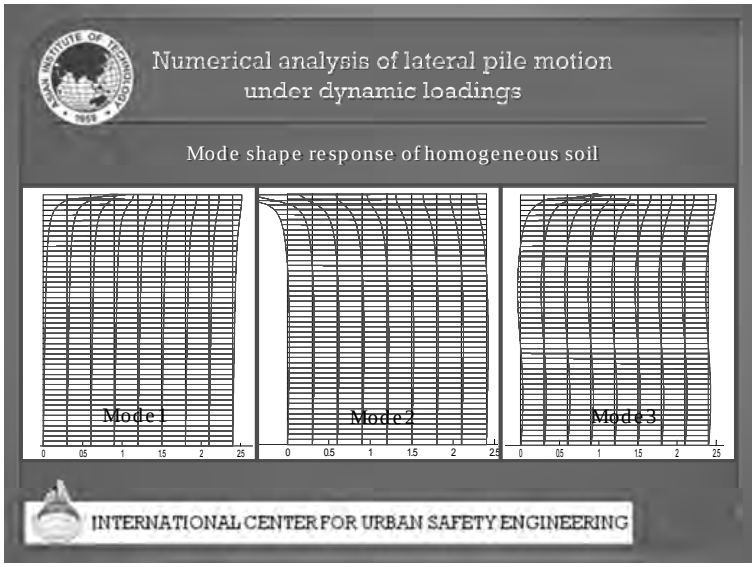
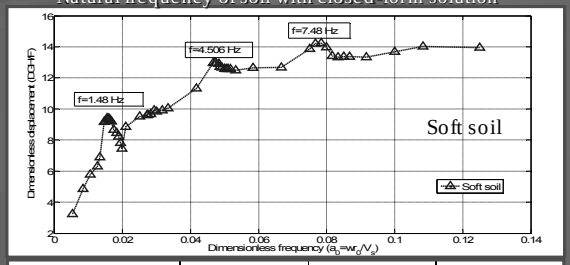

Numerical analysis of lateral pile motion under dynamic loadings
Evaluation of natural frequency of soil
Soil properties
SOFT SOIL
Shear wave velocity (V_s) 120 m/s
Poisson's ratio (ϑ) 0.3
Mass density (ρ) 1600 kg/m³
Modulus of elasticity (E_s) 60 ×10⁶ N/m²
STIFF SOIL
Shear wave velocity (V_s) 200 m/s
Poisson's ratio (ϑ) 0.3
Mass density (ρ) 1800 kg/m³
Modulus of elasticity (E_s) 187.2 ×10⁶ N/m²
P = 5000 sin(ωt)
infinite soil domain
Soil
$f = \frac{\upsilon_s}{2H}(n + \frac{1}{2})$
Bedrock
INTERNATIONAL CENTER FOR URBAN SAFETY ENGINEERING


Numerical analysis of lateral pile motion under dynamic loadings
Mode shape response of homogeneous soil
Mode 1
Mode 2
Mode 3
INTERNATIONAL CENTER FOR URBAN SAFETY ENGINEERING

Numerical analysis of lateral pile motion under dynamic loadings

Natural frequency of soil with closed-form solution



Natural Frequency	First Mode (Hz)	Second Mode (Hz)	Third Mode (Hz)
Closed-form solution	1.5	4.5	7.5
2D-3DOF model	1.480	4.506	7.484

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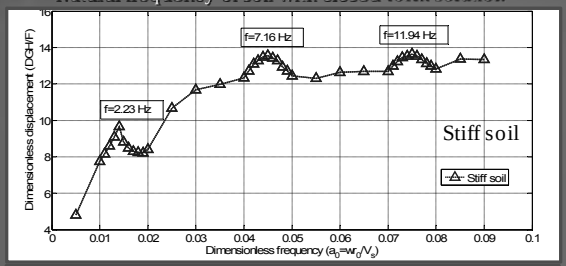
Numerical analysis of lateral pile motion under dynamic loadings

Natural frequency of soil with closed-form solution



Natural Frequency	First Mode (Hz)	Second Mode (Hz)	Third Mode (Hz)
Closed-form solution	2.5	7.5	12.5
2D-3DOF model	2.230	7.165	11.942

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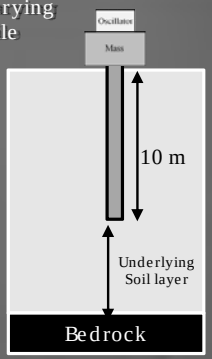
Numerical analysis of lateral pile motion under dynamic loadings

Response of laterally loaded pile due to the varying depth of underlying soil layer below the pile

Soil /pile properties

PILE	
Pile diameter	0.4 m
Poisson's ratio (ϑ)	0.2
Mass density (ρ)	2400 kg/m^3
Modulus of elasticity (E_p)	30 ×10^9 N/m^2

SOFT SOIL	
Shear wave velocity (V_s)	120 m/s
Poisson's ratio (ϑ)	0.3
Mass density (ρ)	1600 kg/m^3
Modulus of elasticity (E_s)	60 ×10^6 N/m^2



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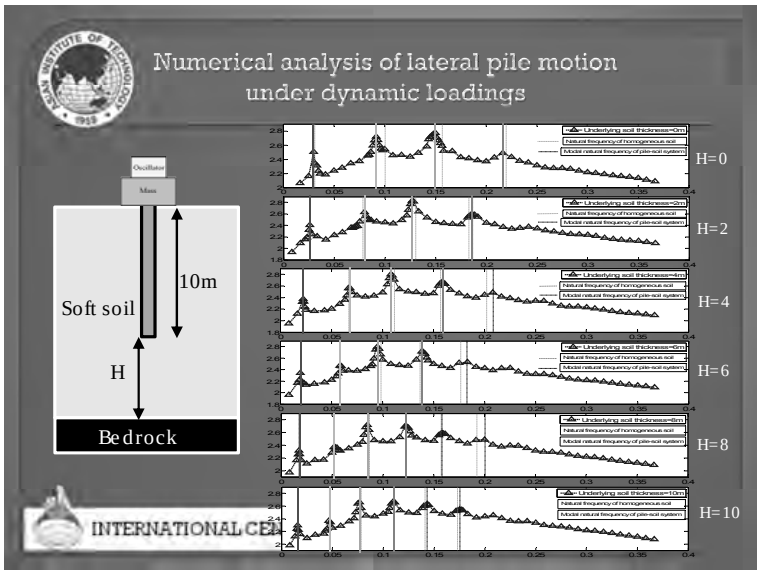
Numerical analysis of lateral pile motion
under dynamic loadings
Oscillator
Mass
Soft soil
10m
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Bedrock
H=0
H=2
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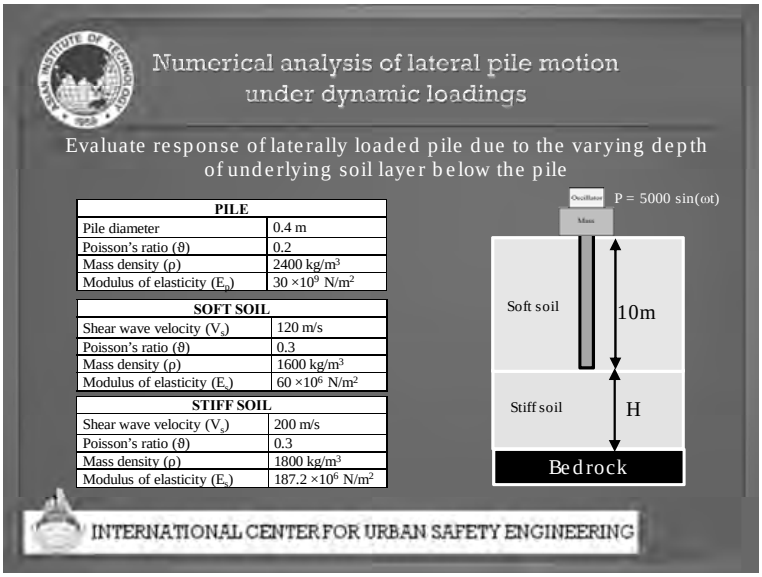
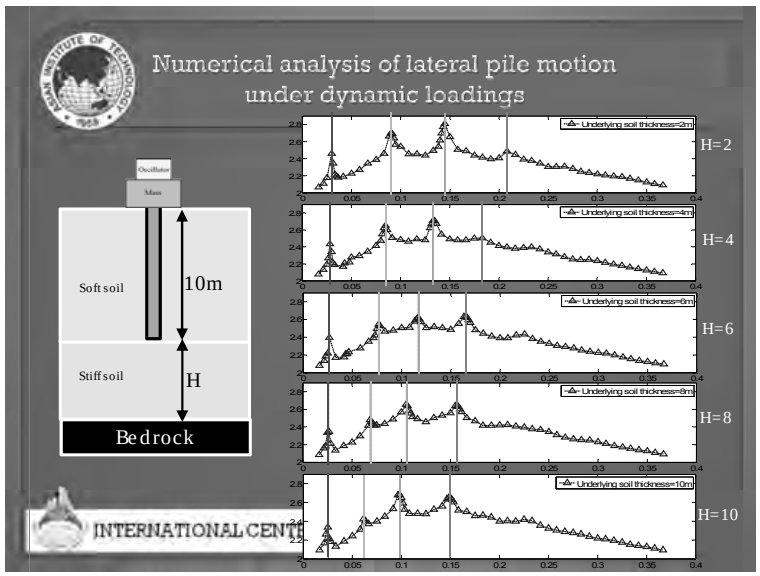
H=10
INTERNATIONAL CE


Numerical analysis of lateral pile motion
under dynamic loadings
Evaluate response of laterally loaded pile due to the varying depth
of underlying soil layer below the pile
PILE
Pile diameter 0.4 m
Poisson's ratio (ϑ) 0.2
Mass density (ρ) 2400 kg/m³
Modulus of elasticity (Ep) 30 ×10⁹ N/m²
SOFT SOIL
Shear wave velocity (Vs) 120 m/s
Poisson's ratio (ϑ) 0.3
Mass density (ρ) 1600 kg/m³
Modulus of elasticity (Es) 60 ×10⁶ N/m²
STIFF SOIL
Shear wave velocity (Vs) 200 m/s
Poisson's ratio (ϑ) 0.3
Mass density (ρ) 1800 kg/m³
Modulus of elasticity (Es) 187.2 ×10⁶ N/m²
P = 5000 sin(ωt)
Oscillator
Mass
Soft soil
10m
Stiff soil
H
Bedrock
INTERNATIONAL CENTER FOR URBAN SAFETY ENGINEERING


Numerical analysis of lateral pile motion
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Oscillator
Mass
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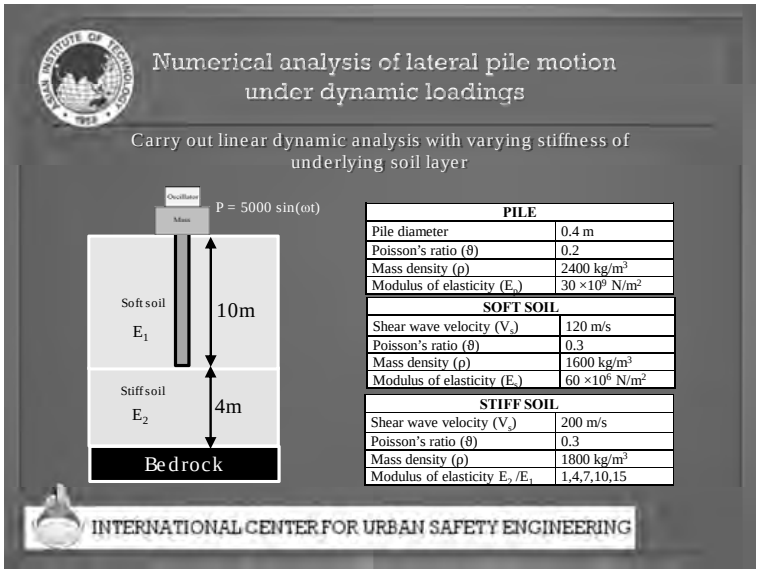

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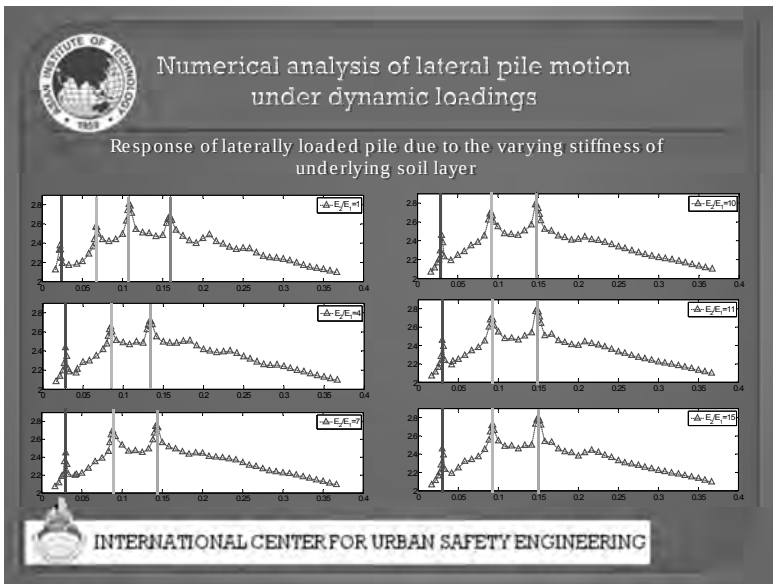
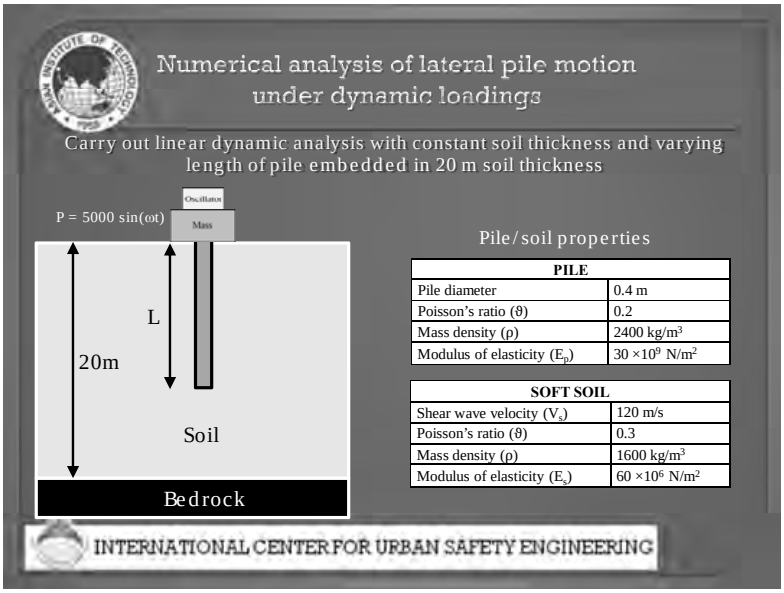
STIFF SOIL	
Shear wave velocity (V_s)	200 m/s
Poisson's ratio (ϑ)	0.3
Mass density (ρ)	1800 kg/m^3
Modulus of elasticity E_2 /E_1	1,4,7,10,15





Pile/soil properties

PILE	
Pile diameter	0.4 m
Poisson's ratio (ϑ)	0.2
Mass density (ρ)	2400 kg/m^3
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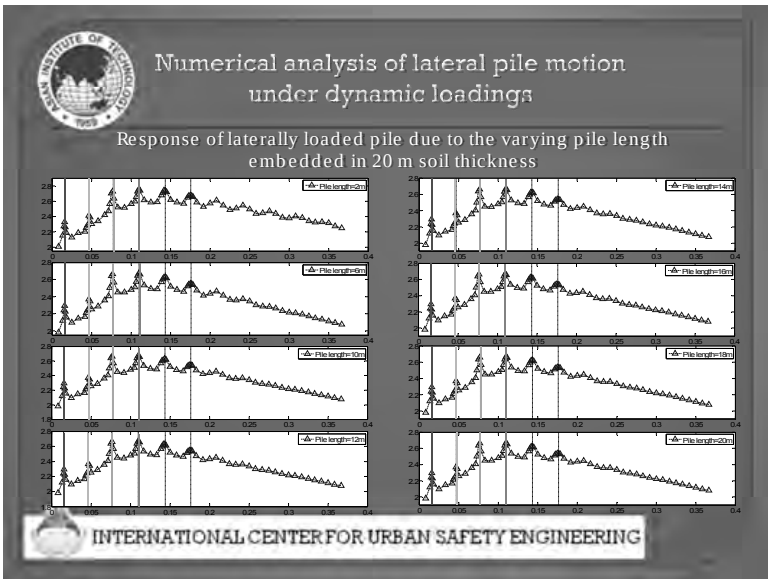

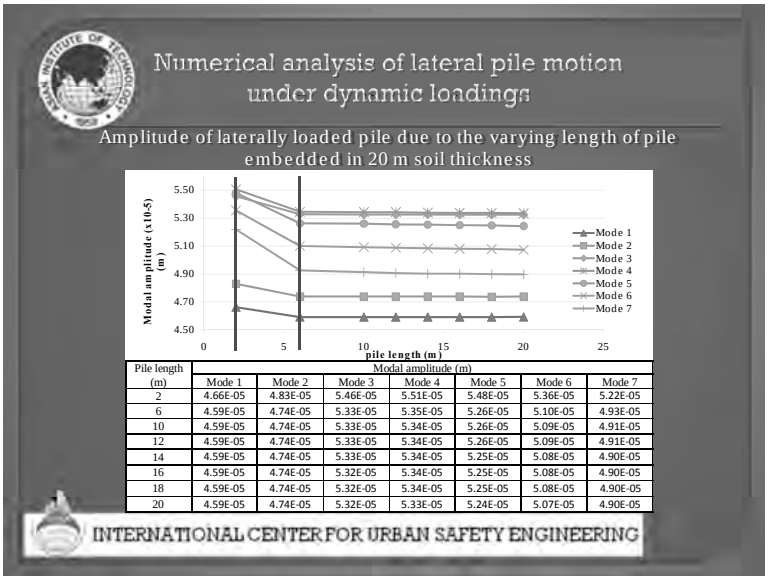

Pile length (m)	Modal amplitude (m)						
	Mode 1	Mode 2	Mode 3	Mode 4	Mode 5	Mode 6	Mode 7
2	4.66E-05	4.83E-05	5.46E-05	5.51E-05	5.48E-05	5.36E-05	5.22E-05
6	4.59E-05	4.74E-05	5.33E-05	5.35E-05	5.26E-05	5.10E-05	4.93E-05
10	4.59E-05	4.74E-05	5.33E-05	5.34E-05	5.26E-05	5.09E-05	4.91E-05
12	4.59E-05	4.74E-05	5.33E-05	5.34E-05	5.26E-05	5.09E-05	4.91E-05
14	4.59E-05	4.74E-05	5.33E-05	5.34E-05	5.25E-05	5.08E-05	4.90E-05
16	4.59E-05	4.74E-05	5.32E-05	5.34E-05	5.25E-05	5.08E-05	4.90E-05
18	4.59E-05	4.74E-05	5.32E-05	5.34E-05	5.25E-05	5.08E-05	4.90E-05
20	4.59E-05	4.74E-05	5.32E-05	5.33E-05	5.24E-05	5.07E-05	4.90E-05

Student Presentations

RECONSTRUCTION OF KAMAISHI CITY AFTER THE 2011 TOHOKU EARTHQUAKE AND TSUNAMI

Maria Bernadet Karina DEWI[1], Sae SHIKITA[2], Takaaki KATO[3]
[1] Graduate Student, ICUS, IIS, The University of Tokyo, Japan
dewi@iis.u-tokyo.ac.jp
[2] Undergraduate Student, ICUS, IIS, The University of Tokyo, Japan
sahe@vega.ocn.ne.jp
[3] Associate Professor, ICUS, IIS, The University of Tokyo, Japan
kato-t@iis.u-tokyo.ac.jp

ABSTRACT

Hakozaki Peninsula, Kamaishi City, consists of 8 villages, located alongside the coastal area of Iwate Prefecture. During the 2011 Tohoku earthquake and tsunami, the casualties were 1,061 death and missing, 2,954 completely destroyed houses, and 687 partially destroyed houses. Currently, the population lives on the temporary houses which are scattered located. This city faces a very significant problem as the other cities in the Tohoku affected area, such as declining society, also the other problems.

The background of Kamaishi City, including the population data, economic and governance system was the resource that ever existed in Kamaishi city and the resource should be considered. And after the 2011 Tohoku earthquake occurred, the process of reconstruction since then until present time with the involved stakeholders from the national government, to the municipality level, community, NPO, and the others has been going on progress. This paper aims to analyze the current situation of the recovery state, the community activities for reconstruction, and finding the relation between each activities, then problems found between the process and involved stakeholders.

Keywords*: reconstruction, Kamaishi city, Hakozaki Peninsula, community participation, challenge*

1. BACKGROUND – THE SITUATION OF KAMAISHI CITY BEFORE THE DISASTER

Kamaishi city is located on the southeastern part of Iwate Prefecture, along the coastal line towards Pacific Ocean, with total area of 441.43 square kilometers. 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.

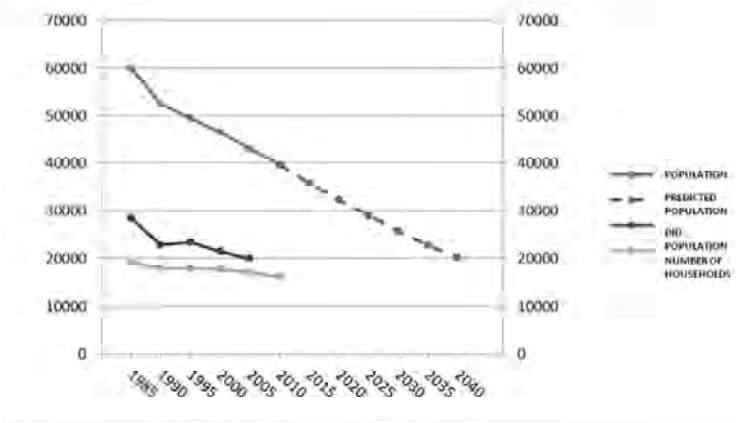

Figure 1: Changes in population and the number of households of Kamaishi (Source: National Census)

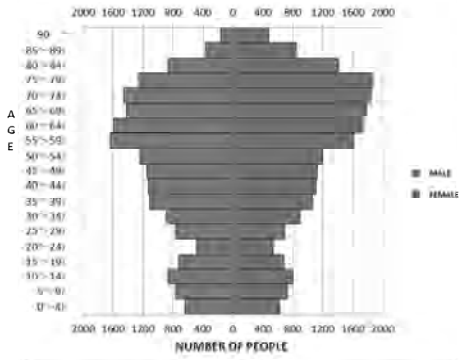

Figure 2: Population pyramid of Kamaishi City in 2010 (Source: National Census)

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 was estimated from 2010 until 2040. 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, is in the state of declining birth rate and aging population, with the majority population between the age of 55 until 79.

The situation of industry in Kamaishi City in 2007 was decreasing, primary industry became 3.8%, secondary industry 33.3%, and tertiary industry 67.6%. Number of employees had been declining about 30% from 1990 until 2010. Particularly, the declining of primary industry was significant, halved in 20 years. Agriculture has decreased about 65% among others. The amount of catch of fish have not decreased so much, but the sum

of money of fishery industry has been declining, especially in 10 years from 2000 until 2009.

2. CASUALTIES AND DAMAGE ON GREAT EAST JAPAN EARTHQUAKE AND TSUNAMI

Kamaishi City suffered great tsunamis recorded in 1896, 1933, 1960 and the last in 2011. By the highest wave of tsunami reaching 10.1 m at Kamaishi harbor during Great East Japan Earthquake and Tsunami in March 11th, 2011, Kamaishi City suffered in 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.

3. CURRENT SITUATION

Location of the refugee has been closed by October 8th, 2011, and temporary housing number was 3,164 which had been completed by August 5th, 2011, and located in 50 sites. Debris removal by April 2012 was 50% in the estimated number of 762,000t, and the process rate of 3% (23,000t). Currently population are living in the temporary housing which is scatteredly located.

4. RECONSTRUCTION

4.1. AUTHORIZED RECONSTRUCTION PLAN BY THE GOVERNMENT

In September 2011, the Basic Policy for Reconstruction has been enacted, consists of policy and timetable of the Reconstruction Plan from the beginning. Then in December 2011, the Basic Reconstruction Plan (Figure 3). However, the detailed landscape plan and land use will be decided after consultation with communities (Figure 4).

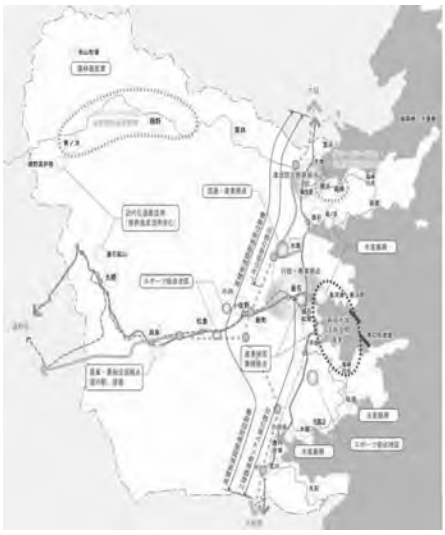

Figure 3: The ideal image of the city in Basic Reconstruction Plan (Source: Kamaishi, 2011)

Figure 4: Draft of land use plan for the central area (Source: Kamaishi, 2012)

4.2. COMMUNITY PARTICIPATION

Sets of interviews had been done in the settlement of Ryoishi and Shirahama, to know the condition and expectation of the communities for their reconstruction process. The interviews were subjected to people who had moved to temporary housing, the reconstruction target area, especially who left the town right after the earthquake. 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 meets the needs of stakeholders. 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.

Community participation across Hakozaki Peninsula has becoming more effective and the community bond between districts has becoming stronger. June 2011 was the start of this movement by involving the 4 villages together, mainly held by fisherman in Ryoishi Village with support from NPO (Non-Profit Organization) CeMI (Crisis & Environment Management Policy Institute). Community members and NPOs had been working together for the reconstruction process, such as discussing the reconstruction plan. Then in October 2011, activity was held in Katagishi Village, aimed to raise awareness and encouraging the residents participation. In March 2012, a new NPO was established, named O-Hakozaki Shimin Kaigi (Community Association of Hakozaki Peninsula) consist of community members, and professionals. The involved community is located in some villages such as: Ryouishi, Kuwanohama, Kariyado, Shirahama, Hakozaki, Nebama, Katagishi, and Murohama.

The O-Hakozaki Shimin Kaigi's activitiesare 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.

5. DISCUSSION

Challenges and problems

During the reconstruction process, there are several challenges for all of the stakeholders. One positive condition is that community quite adaptable to the scatteredly location of temporary housing and form a new community in their new location.

Top-down planning strategies has been applied in this area since the very beginning. For the reconstruction process, the citizens trust government to develop and implement the plan. However there is a challenge of differentiation in the reconstruction division, which has no sufficient cohesion between all of the divisions. For example, the reconstruction is mainly focused on the physical aspects and with some consideration on the other aspects such as social and economic. However, such interlinked function is needed to have a comprehensive approach of reconstruction process, and to bridge the involved stakeholders. The possible solution is through citizen participation.

Second challenge is that there was not much chance for the community to participate and share their aspiration. The reconstruction plan and management was planned to have consensus building with community, and in the implementation of public hearing for the plan was held. The other difficulty is the community has 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, 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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http://reconstruction.go.jp. Data obtained on June 2012.Japan Non-Profit Organization . 2012. nonprofitjapan.home.jgc.org/npo/mpojp.html. Data obtained on June 2012

DEPARTURE-TIME CHOICE (DTC) BEHAVIOUR FOR INTER-CITY TRAVEL DURING A LONG-HOLIDAY IN BANGKOK, THAILAND

Bhawat CHAICHANNAWATIK
Doctoral student, Asian Institute of Technology, Thailand
bh_ch@hotmail.com

ABSTRACT

Time-of-day (TOD) or departure-time choice (DTC) becomes an interesting issue over two decades. Researchers have intensely focused on time-of-day or departure-time choice study, especially work days and weekend with a focus on long-holiday/intercity travel that has largely been ignored in previous studies. Based on Thailand evidences, the severe traffic congestion usually occurs along main routes from Bangkok Metropolitan Area (BMA) to other regions during every long-holiday. With a specific focus on traffic congestion occurred during the beginning of festivals, this paper discussed the characteristics of long-holiday intercity travel patterns during New Year 2012 in Bangkok, Thailand. 590 households were collected by interview and analyzed to provide more understanding of general characteristics of DTC behavior for intercity travel at the beginning of Bangkok long-holiday.

Keywords*: time of day, long-holiday, travel behavior, departure-time choice*

1. INTRODUCTION

Like all other capital cities in developing countries, Bangkok is the primate city of Thailand which has registered and non-registered populations of approximately 5.7 million and 2.3 million, respectively (Tangchonlatip, 2010). Large number of non-registered populations evidently demonstrates the domestic migration and resettlement of people who leave rural areas to find the better opportunities for jobs or/and education.

According to domestic migration and resettlement of people to Bangkok, it causes many urban transportation problems in the cities e.g., traffic congestion, and public transportation provisions, etc. Moreover, there is another consequence overlooked by transportation planners that frequently happen during every long-holiday (three-day weekend or more holidays). During such periods, inter-city travel demands to move out (at the beginning) and move into Bangkok (at the ending) generally take place along the main routes from Bangkok to other regions. When considering trip

purpose, people usually go for social (i.e., meeting friends/remote family) and recreational trips rather than work trips.

Based on Thailand evidences at the beginning of every long-holiday or festivals, the severity of traffic congestion usually occurs along main routes from Bangkok Metropolitan Area (BMA) to other cities. This repeatable problem causes many impacts such as fuel consumption, air pollution, and road accident. In 2007, Department of Disaster Prevention and Mitigation (DPM) reported average traffic volume on major highways from Bangkok to all regions during Songkran festivals in 2005 and 2006 were increased by 35 % and 23 % higher than normal period. Furthermore, average traffic volumes were up to 22% during New Year's Eve 2007.

In transportation planning views, there are some interesting issues from these occasional evidences such as long-distance travel demand forecasting, travel behaviors (i.e., frequency, location, mode, route, and departure time) and the special traffic management during festivals, etc. However, this research specifically focuses on the repeatable traffic congestion occurring at the beginning of the long-holiday. The phenomenon is contradictory with concept that traveler has a rational decision and select the suitable departure-time to avoid the congestion. Hence, this paper aims to study departure-time choice behavior for inter-city travel at the beginning of long-holiday for Bangkok Metropolitan Area (BMA), Thailand.

2. LITERATURE REVIEW

2.1 Study area overview

Bangkok is the primate city of Thailand with population of 8 million. In 2006, number of population registered in BMA is 21 times bigger than the Municipality of Nonthaburi that is the second biggest city and has population of approximately 200,000. Administratively, Bangkok consists of 50 municipal districts covering total area of 1568.737 km^2 and its population density is about 3,630 populations/ km^2. Moreover, Bangkok has been recorded as the first rank of the highest number of registered vehicles. According to the data from Department of Land Transport (DLT) (2011), amount of vehicle registered in Bangkok as of 30 September 2010 is 6,385,218 or about 22.65 % out of the total registered vehicles in Thailand. The highest proportion of vehicles in Bangkok is motorcycle (40%), following by sedan (37%), and van & pick up (15%).

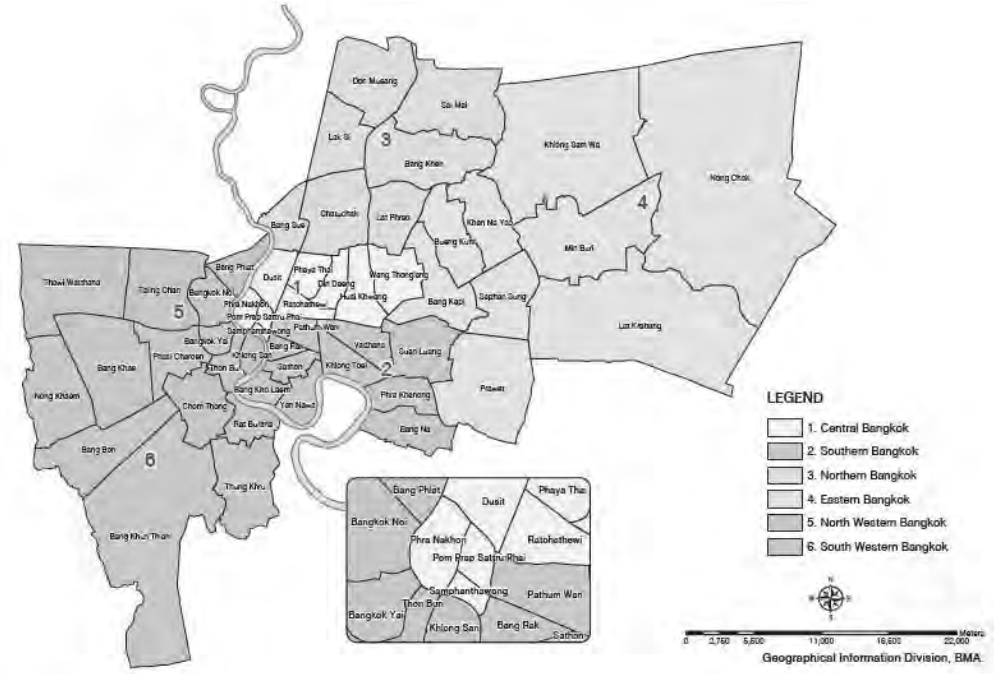

Figure 1: 50 municipal districts of Bangkok (SED, 2011)

2.2 Holidays

Thailand is well-known as festive kingdom celebrating numerous regional and national holidays. In 2011, the government declared 19 national holidays that most of them are adjoined with weekend days. Moreover, 5 of 19 were more 3 day breaks such as Songkran Festival (13-17 April), Royal Ploughing Ceremony Day (13-17 May), etc.

2.3 Traffic problems during festivals

In all festival, traffic congestion usually occurs along main routes among BMA and other regions. In 2007, Department of Disaster Prevention and Mitigation (DPM) reported average traffic volumes on major highways from Bangkok to all regions during Songkran festivals in 2005 and 2006 were up to 35% and 23% larger than the normal period. As well, it increases by 22% over the normal situation during New Year's Eve 2007. The dramatically increase in travel demand during festivals derived from road transport modal can lead to other impacts including loss of production time, GHG-emissions, waste energy consumption, and high risk of traffic accidents. According to the data of average number of accidents and fatalities during the festivals from 2007-2010 recorded by Road Safety Center, DPM (2011), there were 559 crashes per day and 52 deaths per day counted as about two times of the normal period.

a. an unsafe 2-level pick-up

b. an unsafe high occupancy vehicle

Figure 2: the general seen picture during festivals (DOH, 2007)

2.4 Policies/measures during festival

In every long holiday, government agencies have placed greater importance on traffic problems by setting a clear transportation operation and safety plan. Policies/measures can be classified into 2 groups as follows; 1) Traffic related policy on road accident prevention and reduction and providing adequate public transportation strategy and road safety strategies (DPM, 2011 and OTP, 2011) and 2) Tourism policy to promote domestic tourism.

3. METHODOLOGY

3.1 Literature reviews

Based on reviews, previous studies have developed many aspects on departure-time and time of day; however, most of them only focused on a short distance of urban travel which can be classified into 2 main groups; 1) urban-work related DTC such as Chin (1990), Zeid, A. et al. (2006) and Holyoak (2008), etc. and 2) urban-non-work DTC such as Bhat (1998), Steed and Bhat (2000), Okola (2003) and Yang, et al (2008), etc. In addition, there were few researches related to DTC for intercity or long-distance travel such as Jin (2007) and Jin, et al. (2009). However, they ignored the study of DTC behavior of long distance travel during holidays. Hence, this research fills up the gap which might result in a reduction of severity of traffic congestion especially at the beginning of festivals.

3.2 Data collection

In order to examine individual departure-time choice behavior of inter-city travel at the beginning of the long-holiday, it needs to find potential ways for collecting trip, personality and household structure information. The best way is to collect complete information, real time data or using travel diary data collection. However, it is not convenient to use these methods for longer data collection period (Madre et al., 2007 and Frei, 2008). Hence, this research proposes to use the most common method that is the home interview survey for the departure-time data collection.

Factors related to Departure-Time-Choice (DTC) study can be classified in to 3 main groups; 1) individual characteristics and preferences 2) household characteristics and 3) trip characteristics. All of DTC related factors have been reviewed for preparing questionnaire.

The data collection began on Saturday 7th January and finished on Sunday 26th February 2012. 875 households throughout 50 districts of BMA were interviewed in order to examine the actual travel information during New Year 2012 festival. However, only 590 data were qualified to use in data analysis.

3.3 Type of departure-time choice

In general, two peaks in a festival are more likely to be working days of the week which are the beginning and ending peak of festival. Typically, the beginning peak as the time that people moving out of the city to participate in activities can be separated into 2 periods. The first period usually occurs from evening to midnight of the last working day called as "Evening Peak: EVP" (18:00-24:00) and the second period begins from morning till noon of the starting date of the festival defined as "Morning Peak: MNP" (08:00-12:00).

Therefore, in this study, there are 3 off peak periods as follows;

1) Early depart (ED): the traveller chose the starting time before the beginning of evening peak,

2) Depart after evening peak (AEP): the traveller chose the departure-time between 00:01-07:59 a.m. on 31 Dec 2011, and

3) Lately depart (LD): the traveller chose to stay at home during peaks and departed after the ending of the morning peak to avoid traffic congestion.

Hence, the timescale of long-holiday will be roughly divided into 5 time spans: 1) before evening peaks (early depart; ED), 2) depart on 1st peak (depart at evening peak; DEP) 3) depart after evening peak; AEP), 4) depart on 2nd peak (depart at morning peak; DMP)), 5) after peaks (lately depart; LD).

4. RESULTS

4.1 General characteristics

General characteristics of 590 samples of people who made intercity travel during New Year festival 2012 are shown in Table 3.

Table 3 General characteristics of samples

Variable	Frequency analysis			
	Mean	**S.D.**	**Min**	**Max**
1. Individual and household socio-economics characteristics				
Age (yrs)	30.59	11.09	14.00	69.00
Income (Baht)	18,553.22	15,610.00	0.00	120,000.00
Number of holidays (day)	4.49	1.55	2.00	28.00
Household income	45,729.09	32,051.93	0.00	350,000.00
Household member	3.09	1.67	0.00	10.00
2. Trip characteristics				
Distance (km.)	356.89	252.40	29.00	1250.00
Travel cost per head (Baht)	495.49	536.97	22.50	3,000.00
Total travel time (min)	319.36	229.64	45.00	1,520.00
Departure date and time	30-Dec-2011, 21:16:58	1 day, 01:56 hrs.	19- Dec-2011, 20:00:00	07-Jan-2012, 08:30
No. of other passenger in trip (person)	1.37	1.41	0	8

4.1.1 Traveler characteristics

- Gender: samples mostly consisted of male travelers (51.5 %).
- Age: age range of 21-30 years old were counted for the highest percentage (48.8 %), following by 31-40 years old (19.8%) and less than 20 years old (13.4 %).
- Working status: most of samples are employee (37.1 %), following by study/unemployed (34.9%) and entrepreneur (15.3 %).
- Income: majority income were ranged between 5,000-10,000 Baht/month (28.8 %), following by 10,001-15,000 and 20,001-30,000 Baht/month (18.8% and 17.6 %), respectively.
- Household member: most of family contained 4 members (25.2 %), following by 3 members and 2 members (19.5% and 16.6 %), respectively.
- Full-time workers/students: 85.5% of household has full-time workers/students. It found that the household has 4 full-time workers/students, following by 2 and 3 full-time workers/students (24.1%, 22.3%, and 21.7 %), respectively.
- Household vehicle ownership: 58.3% of household owned at least one vehicle.
- Number of holidays in New Year 2012: Most of respondents have 4 connected days (68.9 %), following by 5 and 7 connected days (14.4% and 4.8 %), respectively.
- Beginning date of holidays: it mostly started on 31-Dec (74.2 %), following by 30-Dec, and 29-Dec (14.1% and 4.8 %), respectively.
- Ending date of holidays: Most of respondents came back on 3-Jan (83.2 percent), following by 2-Jan and 4-Jan (8.0% and 4.8 %), respectively.

4.1.2 Trip characteristics

- **Trip purpose:** most of respondents went travelling for leisure/recreation purpose (44.1 %), following by returning home and other (42.9% and 3.9 %), respectively.
- **Main mode:** most of respondents used passenger car (47.6 %), following by intercity bus and van (18.0% and 16.1 %), respectively.
- **Distance:** travel distance were mostly ranged between 101-200 km. (25.6 %), following by 201-400 and 601-800 km. (23.7% and 15.6 %), respectively.
- **Travel time:** most of respondents traveled between 2-4 hr. (33.2 %), following by less than 2 hr. and 4-6 hr. (19.3% and 17.6 %), respectively.
- **Number of transfer:** For public transportation users, majority of people transferred 3 times (37.3 %), following by 2 times and 4 times (36.9% and 12.7 %), respectively.
- **Travel cost:** most of respondents paid less than 200 Baht (38.3 %) following by 201-400 Baht and 401-600 Baht (24.7% and 11.9 %), respectively.
- **Children under 13 years old in trip:** 8.3 % of children under 13 years old were found.
- **Elderly appearance:** only 4.4 % of elderly people were found.
- **Number of other passengers in trip:** Most of people traveled alone (35.9 %), following by 1 passenger and 2 passengers (24.2% and 19.7 %), respectively.
- **Departure date:** most of people left Bangkok on 31-Dec (42.9 %), following by 30-Dec and 29-Dec (27.1 % and 10.17 %), respectively
- **Departure date and time:** 22.2 % of travellers chose to depart their home during 8:00-10:00 a.m. on 31/12/2011.

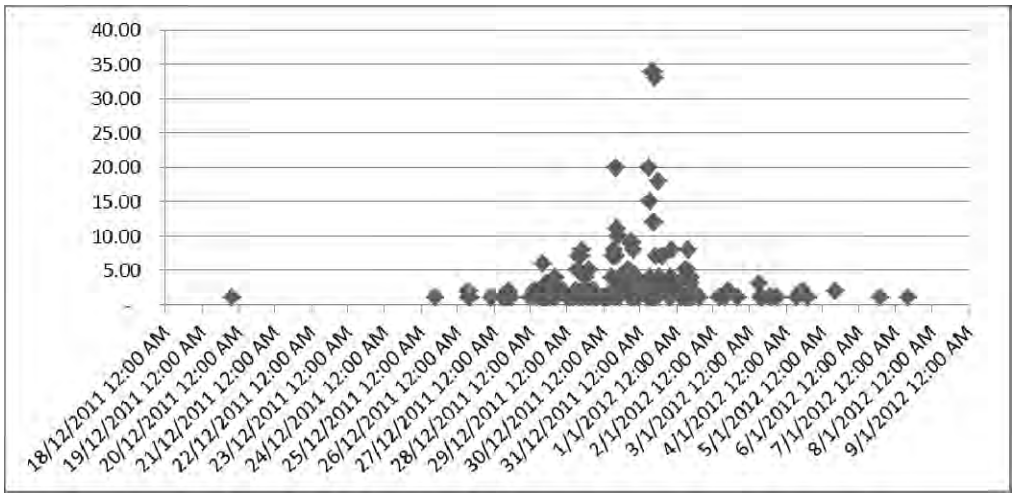

Figure 3: Departure date and time choice for intercity travel in New Year 2012

4.2 The relationship of socioeconomic characteristics on DTC

Overall results from crosstab analysis of relationship of socioeconomic characteristics on DTC for intercity travel behaviors in New Year 2012 can be described as follows:

- **Gender and DTC:** Both males and females chose to leave early (ED) (37.17% and 38.46 %), following by DMP and LD. Moreover, female travellers were likely to depart earlier and later than males do (F38.46/M37.17% and F18.88/M17.43 %).
- **Age and DTC:** Travelers "less than 30 years old" and "more than 60 years old" were likely to depart before peaks (ED); while 31-40 years old were more likely to depart at both peaks (DEP and DMP). For the 41-60 year old group, they preferred to depart after peaks (LD).
- **Income and DTC:** Almost all income groups chose to travel before the traffic jam (early depart: ED), except for a group with income of 15,001 to 20,000 baht that chose to depart on the morning peak (DMP) than other periods.
- **Occupation and DTC:** According to the results, the largest percentage of professional or academic group departed early (ED) (61.1 %), following by driver and engineering and production (50.0% and 50.0 %).
- **Number of full-time member in household and DTC:** The analysis results indicated that the increase in household members who are full-time workers/students (from 0, 1, 2, 3, 4, and more than 5 persons) would have an effect on increasing the percentage of early depart to avoid traffic congestion (from 28.4, 30.8, 32.3, 46.3, 46.3 and 50.0 %).
- **Household income and DTC:** All of HH income group chose to depart early (ED) except a group of 5001-15000 baht that mostly chose to depart in the morning peak (DMP).
- **Household car ownership and DTC:** Most of both groups who occupied car and have no private cars chose to depart early (ED) (35.5 and 41.1 %), following by depart in the morning peak: (DMP) (25.3 and 30.5 %). The results also indicated that the evening rush is minimum preference in both groups (10.2 and 3.7 percent).
- **Length of stay (days) and DTC:** The analysis results indicated that increase in length of stay from 1 to 4 days would have an effect on increasing the percentage of depart in the evening peak (0.0, 1.1, 7.51, and 15.0 percent, respectively).
- **Number of transfer and DTC:** For public transport, if the number of transfer increases by 1, 2, 3, and more than 4 times, the percentage of ED on the number of transferring will reduce from 62.1 to 26.7 %. On the other hand, the percentage of DMP on the number of transferring will increase from 10.3 to 36.7 %.
- **Number of other passengers in trip and DTC:** All of party sizes (Number of other passengers in trip) chose to depart early: ED (from 31.9 % to 50.0 %).

- **Trip purpose and DTC:** According to the results, the largest percentage of people who traveled with working purpose chose to depart early (ED) (47.6 %), following by returning home and leisure/recreation (41.1 and 35.4 %).
- **Travel time and DTC:** most of travelers in all travel time chose to depart early (ED), except for a group of 1-2 hrs that mostly chose to depart in the morning peak (DMP). For the longer travel time trip, majority of travelers chose to depart at the evening peaks (DEP).
- **Distance and DTC:** the analysis results indicated that the distance between 0-400 km tends to avoid departing in the evening peak. However it seems to be increase for the longer distance.
- **Travel distance and mode:** Passenger car is the most preference for all distance groups of intercity travel in NY 2012. For train, it was slightly increased in % within distance group of 601-800 km (10.9 %). For air travel, it was slightly increased in % within distance ranged from 201-400, 401-600, 601-800, 801-1000 km (0.7, 2.2, 19.6, and 33.3 %), respectively.
- **Trip purpose and mode:** For returning home group, intercity bus/van was found the most preference (47.4 %), following by passenger car and train (43.1 and 5.1 %), respectively. For leisure and recreational group, passenger car was found the most preference (72.7%), following by intercity bus/van and air (18.5 and 7.7 %)

5. CONCLUSION

Nowadays, humans travel more and longer due to the transportation technology advancement. The increase in travel demand for long distance during festivals leads to various transportation impacts especially traffic congestion. As Thailand evidence at the beginning of every long-holiday or festivals, the severity of traffic congestion usually occurs along main routes among Bangkok Metropolitan Area (BMA) and other regions. This repeatable problem causes adverse impacts such as fuel consumption, air pollution, and road accident.

This paper discusses the characteristics of long-holiday travel pattern especially for intercity travel during New Year 2012 in Bangkok, Thailand. 590 household interview surveys were analyzed to provide the understanding of general characteristics related to DTC behavior for intercity travel at the beginning of the long-holiday for Bangkok Metropolitan Area (BMA), Thailand. Based on this study, better suitable policies related to DTC behavior of intercity travel during long-holiday should be provided to reduce traffic congestion along main routes in the future.

6. DISCUSSION

Due to the severe flooding in some area of Bangkok occurred during October to December 2011. Hence, people feel uncomfortable to participate in the interview. Therefore, knock doors were not used for some reasons such as nobody at home in the time of interviewing, locked gate, only child/elderly at home, too busy to complete interviews, commuters not staying home. Because the nature of intercity travel in festival is a rare event, it is quite hard for researcher to find samples. Moreover, many cases gave information but they did not make an intercity travel during concerned period.

ACKNOWLEDGEMENT

Author gratefully acknowledges the financial support provided by Kasem Bundit University (KBU) for doctoral degree program study.

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STRUCTURAL PERFORMANCE ASSESSMENT OF DETERIORATED UNREINFORCED CONCRETE STRUCTURES

Yuriko YAMAMOTO[1] and Hiroshi YOKOTA[2]
[1] Graduate Student, Graduate School of Eng., Hokkaido University, Japan
yurincorhcp14@ec.hokudai.ac.jp
[2] Professor, Faculty of Eng., Hokkaido University, Japan

ABSTRACT

A lot of unreinforced concrete structures are found along the coastline in Japan. They were constructed during the high economic growth era in the 1970's. Since those structures have been reaching the design service life of 50 years, they are concerned about performance degradation and/or materials deterioration due to aging. However, there are few studies on performance degradation assessment and prediction of unreinforced concrete structures. In this study, to evaluate the deterioration degree, new criteria for deterioration assessment of unreinforced concrete structures are proposed based on load-carrying capacities in relation to a crack width.

Keywords*: unreinforced concrete, crack width, crack depth, criteria for deterioration*

1. INTRODUCTION

A lot of unreinforced concrete structures were constructed during the high economic growth era along the coastline in Japan. Since those structures have been reaching the original design service life of 50 years, it is necessary to implement intensive maintenance and/or even renewal in the near future. They may have damages due to ageing and materials deterioration, which subsequently degrades structural performance such as safety and serviceability. However, there are few studies on the performance assessment of deteriorated unreinforced concrete structures.

To evaluate the degree of deterioration of unreinforced concrete structures, the authors suggest the criteria of deterioration grading using a crack width in relation to structural performance. First, the correlation of crack width and crack depth has been investigated in existing structures. Then, deteriorated structures have been modeled and analyzed with the nonlinear finite element method. The deterioration of an unreinforced concrete structure has been expressed with an already existing crack having various widths and depths. Finally, criteria for deterioration assessment of unreinforced concrete structures are proposed

2. CRACK INVESTIGATION

Unreinforced concrete parapets of breakwaters in fishing ports are focused in crack investigation. Crack widths were measured with a crack gauge, while crack depths were measured by the impact elastic wave method. Ultrasonic pulse method is a popular method to measure the crack depth. However, it needs to smooth and grease concrete surface before application. Thus, the impact elastic wave method has been used in this study, because it is easy to apply on the site and is suitable to measure the depth of a deeper crack.

3. RELATIONSHIP BETWEEN CRACK WIDTH AND DEPTH

Thirty pairs of data on crack width and depth were obtained. Figure 1 shows the relationship between crack width and depth. It is confirmed that there may be a linear relationship between the crack width and depth. The correlation coefficient is 0.69; thus the crack width may be an explanatory parameter for estimating crack depth. Correlation equation 1 is shown in Figure 1 with the solid line. For standing the safe side, Equation 2 is proposed as the dashed line in Figure 1.

$$d = 135W \tag{1}$$

$$D = 200W \tag{2}$$

Where d and D are crack depths (mm) and W is crack width (mm).

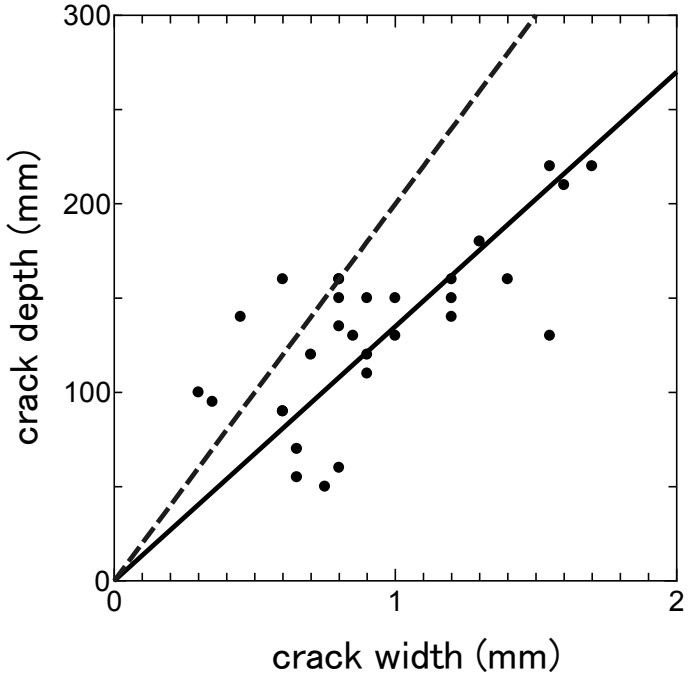

Figure 1: Crack width and depth

4. ANALYSIS ON STRUCTURAL PERFORMANCE

4.1 Analytical model

The crack in the parapet is modeled with Equation 2. The X-direction is the normal direction to the parapet while the Z-direction is the vertical direction. Structural performance of the parapet is analyzed by the nonlinear finite element method using software DIANA. Analytical models of the parapet are shown in Figure 2. An already existing crack is described by vertically inserting boundary elements at the center of the model. Developing cracks during analysis are described by smeared cracks. A uniformly distributed load is applied to the colored surface as shown in Figure 2. Fixed boundary conditions are provided at the bottom surface for horizontally loaded cases, and at the side surface for the vertically loaded case.

4.2 Results and discussion

The relationships between the width of an already existing crack due to deterioration etc. and normalized load-carrying capacity that is the ratio of maximum load applied of cracked model to that without a crack are shown in Figure 3. It is observed that an already existing crack of 1 mm wide or less brings very little capacity degradation. In case that the crack is 5 mm wide or more, the structural capacity is rather degraded. When the crack passes through the section of the parapet, the structural capacity is remarkably lost.

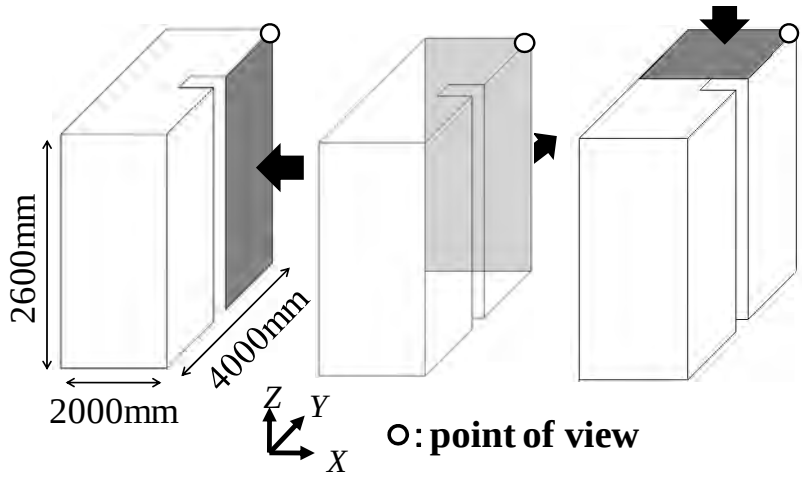

Figure 2: Analytical models

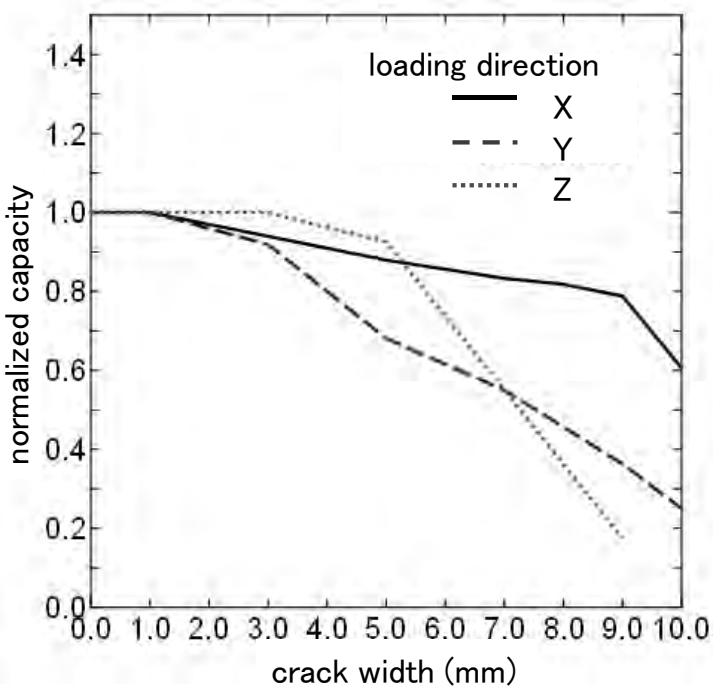

Figure 3: Crack width and normalized capacity

5. CRITERIA FOR DETERIORATION ASSESSMENT

5.1 Present criteria

The present criteria for deterioration assessment of unreinforced concrete parapet are summarized in Table 1. Grade *d* is a sound case while Grade *a* is a seriously deteriorated case. In practice, a crack of 10 mm wide or more seriously affects the structural performance. Thus, the present criteria may not be suitable to precisely grade the deterioration condition.

Table 1: Present criteria for deterioration assessment

Grade	Criteria for evaluation
d	Undamaged
c	Crack width is under 10 mm
b	Crack width is over 10 mm
a	Damages affecting the performance

5.2 New criteria for deterioration assessment

The relationships between crack width and the normalized capacity are shown in Figure 4. There is no capacity degradation when crack width is less than 1 mm, thus this case should be evaluated Grade *d*. A crack of around 7 mm wide, the normalized capacities with the application of Y and Z loads are decreased below 0.6. Thus, this case should be evaluated Grade *a*. In conclusion, the new criteria for deterioration assessment is proposed as summarized in Table 2.

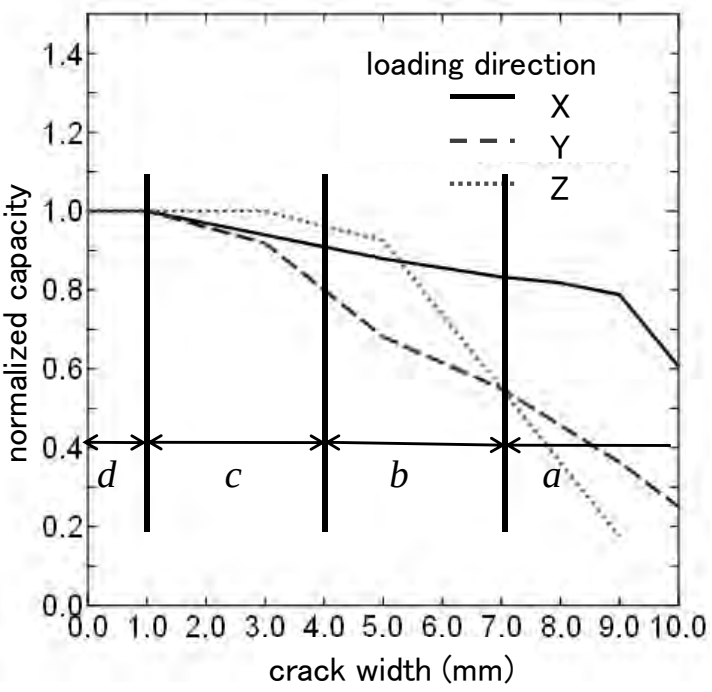

Figure 4: Crack width and evaluation

Table 2: New criteria for deterioration assessment

Grade	Criteria for evaluation	capacity
d	Undamaged or crack width is under 1 mm	100%
c	Crack width is 1-4 mm	Under 90%
b	Crack width is 4-7 mm	Under 80%
a	Crack width is over 7 mm or penetrating crack	Under 60%

6. CONCLUSIONS

The following conclusions are drawn in this study:

1) The correlation equation between crack width and depth is made clear.
2) The new criteria for deterioration assessment of unreinforced concrete structures are proposed.

ACKNOWLEDGMENTS

The authors would like to extend their appreciation to Dr Katsufumi Hashimoto, Assistant Professor and Mr Koichi Furuya, Graduate Student, Hokkaido University for their supports during the field survey and structural analysis.

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TOPIC-GEO MAPPING OF DISASTER INFORMATION USING ONTOLOGY

Ashik RAJBHANDARI[1], Masahiko NAGAI[2]
[1] Doctoral Student of Remote Sensing and Geographic Information Systems (RSGIS), School of Engineering,
Asian Insitute of Technology (AIT), Thailand
ashik.rajbhandari@gmail.com
[2] Associate Director, Geoinformatics Center (GIC),
Asian Institute of Technology (AIT), Thailand
nagaim01@gmail.com

ABSTRACT

In the recent times, there is a huge amount of data gathered about the Earth observation, not only from spatial information systems but also from new and more sophisticated data collection techniques. This scenario leads to challenges how to integrate geographic information of different forms from various domains along with the problem of heterogeneity. The other challenges include standardizing spatial syntax and formalizing spatial semantics.

With such excessive information, it is very difficult for the users to identify and extract the effective amount of information. Whereas, most of the information remains undiscovered without the integration of scientific and social Data and that the discovered information remains less interpretable for machines.

Therefore, this study is an initiative to design a robust system for assessing the social data from the available disaster related web portals [news, blogs, tweets, etc.] through text extraction processes and relating them with scientific data implementing ontology for the effective information retrieval and visualization.

Keywords*: topic-mapping, inter-operability, disaster, ontology, visualization*

1. INTRODUCTION

In the recent times, there is a huge amount of data gathered about the Earth observation, not only from spatial information systems, but also from new and more sophisticated data collection techniques. This scenario leads to challenges how to integrate geographic information of different forms from various domains along with the problem of heterogeneity. The other challenges include standardizing spatial syntax and formalizing spatial semantics.

Every time, the world is enriched with lots of information by many hundreds of news agencies, immediately before or after any disaster happened. Such information explaining about disaster is relayed in the form of articles or journals or publications (hard copy / word doc / pdf formats), web posts, media (pictures or videos), maps, charts, etc. Some important issues encountered in this scenario is, the audience may find it very time consuming to go through all those information one by one. It is even impossible for them to figure out at least single reliable information from a bunch of such big data. If there is only one centralized system to relaying all the proper information, it would be very beneficial for users that they can spend their time in other decision making tasks rather than spend hours only in searching related information from pools of many information sources. Therefore, there is a necessity of a system which not only encloses information from all possible data sources as one stop service but also standardizes them.

1.1 Semantic Interoperability

Another concerning point is how the system can be advanced in providing not just any ordinary information but the reliable and content related ones (Raubal, 2006). It should be effective in excluding the heterogeneity issues by achieving the semantic interoperability as semantic web in the form of collection of information called ontologies (Alesso and Smith, 2005) will be a key to drive the system. The heterogeneity can be explained as Semantic or Semiotics (Lieberman, 2007).

1.1.1 Semantic

It is defined for two or more than two names for the same thing.

Entity 1: "**earthquake**"
English (en) - earthquake
Japanese (jp) - 地震 (pronunciation: jishin)
Thai (th) - แผ่นดินไหว (pronunciation: P̄hæ̀ndinh̄i̦w)

1.1.2 Semiotics

It is defined for one name for two or more than two different things.
Entity 2: "**mustang**" - car name (Ford Mustang)
- location name (in the north-central part of Nepal)

For any two entities - "earthquake" and "mustang", a non-semantic based system will return all the information related to earthquake and mustang (both car name and location name for earthquake will be retrieved). In this case, it might be quite irrelevant from user's point of view to receive information of earthquake related to car name Mustang. However, if there is a semantic relation defined between earthquake and mustang, and then user

can retrieve information of earthquake related to Mustang as location name in Nepal.

Therefore, the compilation of disaster related information under single system to gain knowledge sharing is highly required. Considering this major requirement, this system has been proposed in the paper with the motivation to retrieve knowledge based disaster information to its users.

2. OBJECTIVES OF THE PROPOSED SYSTEM

In view of the aforementioned issues, the following objectives have been implemented in the proposed system:

1. Development of Ontology based on Critical Observation Parameters (COP) and Social Benefit Areas (SBA).
2. Identification and Integration of disaster related information based on developed ontology for Semantic Interoperability.
3. Standardization of information into common format type.
4. Visualization of information in the form of maps, highlights or onto-graph.

A conceptual design of the proposed system has been shown in the Figure 1.

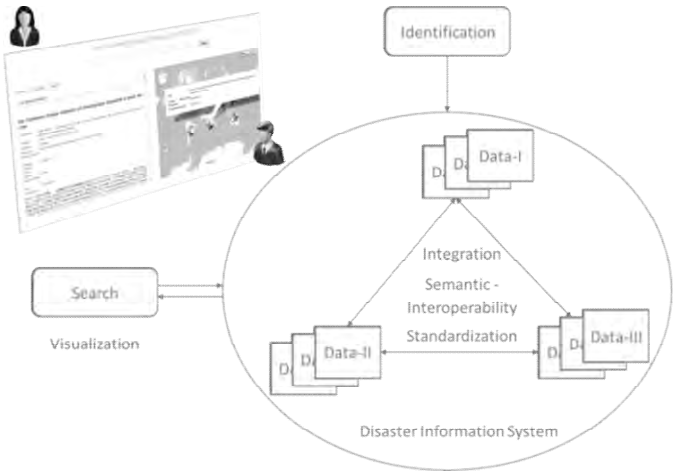

Figure 1: Conceptual design of the proposed system

3. DETAIL ARCHITECTURE OF THE PROPOSED SYSTEM

The system is categorized into five major functionalities as shown in Figure 2:

Ontology Development.
Identification and Extraction.
Ontology Update from Journals.
Indexed Database.
User Interface / Integrated Data View.

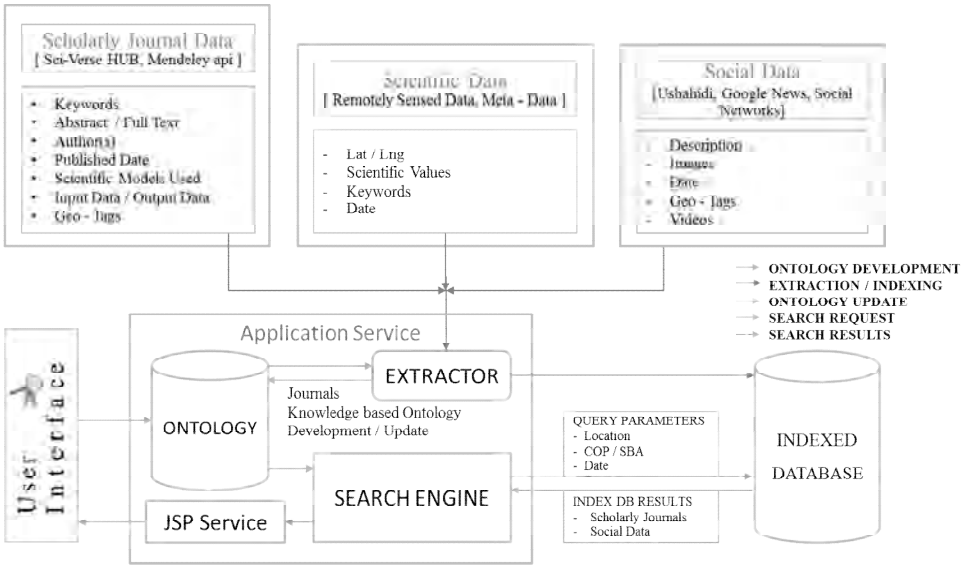

Figure 2: Detail Architecture of the Proposed System

3.1 Ontology Development

Ontology with concepts based on Critical Observation Parameters and Social Benefit Areas have been designed as defined in the standard results of the Group on Earth Observations (GEO), an intergovernmental organization, in GEO Task US-09-01a as shown in Table 1.

Table 1: The 25 highest-ranked Earth observations listed according to the score in the Cross-SBA analysis.

Earth Observation Parameter	GEO Societal Benefits Areas*							
	Agriculture	Climate	Disaster	Ecosystem	Energy	Health	Water	Weather
Precipitation								
Soil Moisture								
Surface Air Temperature								
Surface Wind Speed								
Land Cover								
Surface Humidity								
Vegetation Cover								
Surface Wind Direction								
Normalized Difference Vegetation Index								
Sea Surface Temperature								
Urbanization								
Vegetation Type								
Flood								

*The Biodiversity SBA did not produce a list of priority Earth observations.

Thus, the Cross-SBA analysis involved observations from only 8 SBAs.

the observation was included in the SBA's set of priorities
the observation was not included in the SBA's set of priorities

From Table 1, it is obvious that only “Ecosystems” and “Health” SBAs are commonly included in both of the “Sea Surface Temperature” and “Urbanization” COPs, while rest of the other remaining SBAs are not common to each. It can be said that all the SBAs are not necessarily included to each COPs. Each COP can have one or more, or all of the SBAs included to it. Based on these relations of COPs and SBAs, ontology is developed as shown by onto-graph in Figure 3.

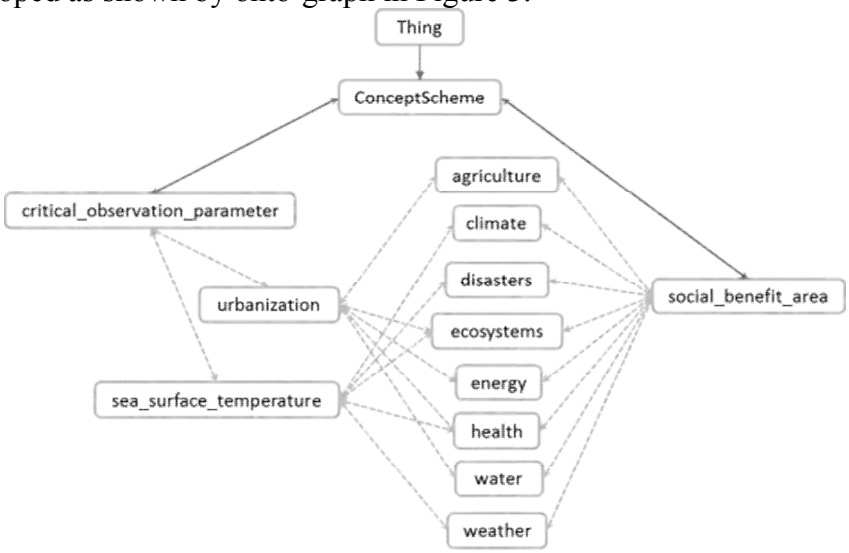

Figure 3: Onto-Graph of “Sea Surface Temperature”, “Urbanization” with SBAs

3.2 Identification and Extraction

The relevant disaster information is initially identified by concept tagging from developed system ontology. The identified information is then extracted via web as scientific, social, and journal data. The response format of data is acquired in XML, JSON or HTML, which are retrieved using various Reader APIs. At the same time, additional entity information is retrieved from Alchemy API as well. The retrieved information are of types: geo-tags, keywords, date, scientific values, graphs, maps, title, author(s), abstract, full text, input data, output data, scientific models, descriptions, videos, images, etc.

3.3 Indexed Database

The extracted information is finally indexed into Apache Solr index categorized based on web sources i.e. scientific, journal and social indexes for future search.

3.4 Ontology Update from Journals

The information extracted for journals such as title, scientific models, input-output data types implemented in its methodology are further related with COPs and SBAs. Such categorized journals for each COP and/or SBA are once again used to develop knowledge based ontology of journals. In every journal information extraction, the ontology is updated as shown by onto-graph in the Figure 5.

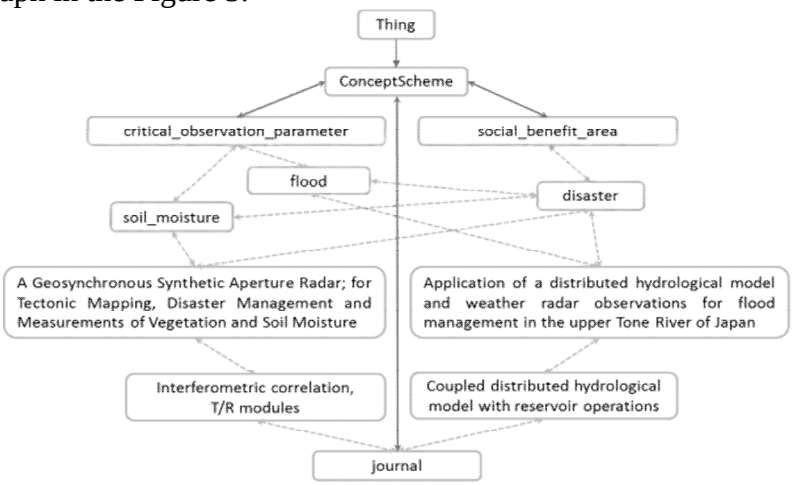

Figure 4: Ontological Diagram of COP, SBA and Journals

Figure 4 basically gives an idea of relationship of any journal associated to one or more COPs in relation with one or more SBAs.

3.5 User Interface / Integrated Data View

All the above functionalities are based on system's recursive backend processes. In order to meet the objectives of the proposed system to provide users with sufficient and relevant disaster related information, a user interface supported by application service is a promising requirement. It receives user's any query requests, and responses the results from the index based on developed ontology as shown in Figure 5, Figure 6 and Figure 7.

Figure 5: Integrated Data View on Google Map

Figure 6: Integrated Data View of Search Results

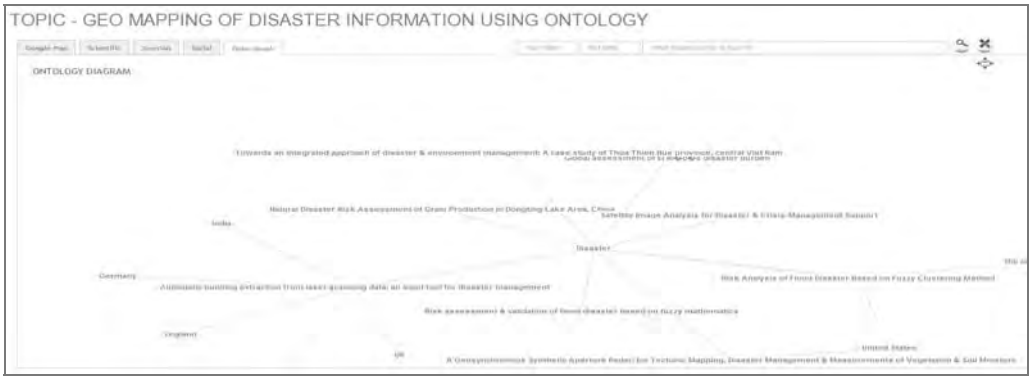

Figure 7: User Interface showing Onto - Graph View.

4. DATA USED

Based on vast forms of disaster information availability and retrieval methods, data has been classified into three sections as the following:

1. Metadata of Scientific Data
2. Journal Data
3. Social Data

4.1 Metadata of Scientific data

Information derived from empirical and measurable evidences, observation results based on specific principles of reasoning for analysis and reuse are considered as scientific data. The scientific data provided by Data Integration and Analysis System (DIAS), one of GEOSS (Global Earth Observation System of Systems) activities in Japan, are implemented in the proposed system. Data provided are, scientific measured values, geo-images, maps, and other metadata forms. DIAS is a Japanese national key project with missions to archive earth environmental data and analyses global phenomenon through combining and processing observation data, numerical model outputs, and socio-economic data provided from the fields of climate, water cycle, ecosystem, ocean, biodiversity and agriculture and share earth observation data, knowledge among different disciplines.

4.2 Journal data

Several online library systems acting as one-stop-web service providing scholarly journals such as Google Scholar, Mendeley API, SciVerse-HUB, etc. Extracted information from journals as title, full text, keywords, metadata, scientific models, and input-output data are maintained into ontology relating with COP and SBA.

4.3 Social data

A social data is basically a theoretical concept beneficial in the social sciences to study associations between individuals, parties, groups, organizations, or even entire-societies as social units. The interaction of social entries has been easier with the availability of many social sites in the internet such as Facebook, Ushahidi platform, BBC News, etc. At the same time, the proposed system particularly extracts the information related to disaster from the only official web pages in RSS News Feed.

5. RESULTS AND ANALYSIS

The categorization of overall extracted information under each index standardizes the scientific, social and journal data into common format as Apache Solr xml schema format. The search result analysis was performed in two ways – with and without the implementation of ontology. Query giving more number of search are classified as “Diverging Search Results and search results giving more précised number of search results are classified as “Converging Search Results” after implementing ontology as shown in Table 2.

Table 2: Search Results Analysis

Search Result Analysis							
Query Text	Scientific Data		Journal Data		Social Data		Search Result Type
	Without Ontology	With Ontology	Without Ontology	With Ontology	Without Ontology	With Ontology	
disaster	2	5	13	23	308	325	Diverging Search Results
flood	11	4	17	18	345	420	Diverging Search Results
agriculture	11	14	24	30	3	3	Diverging Search Results
agriculture OR cover	32	11	57	24	11	3	Converging Search Results

5.1 Analysis - I: Diverging Search Results

The search query for term “disaster” returned 2 docs for scientific, 13 docs for journal, and 308 docs for social data without implementing ontology because of only single term “disaster” in their full text. Whereas, the same query request returned 5 docs for scientific, 23 docs for journal, and 325 docs for social data after implementing ontology. It can be seen that search query after implementing ontology returned more number of documents i.e. diverging search results.
The journal titled “A Geosynchronous Synthetic Aperture Radar; for Tectonic Mapping, Disaster Management and Measurements of Vegetation and Soil Moisture” was returned implementing ontology but it was missing without implementing ontology. It is mentioned in its full text as “the near-real time mapping of surface changes caused by mudslides that depends upon soil moisture”. This document is returned as “mudslide” is a disaster form and there is a clear relation of “Soil Moisture” with “Disasters” included in Table 1.

5.2 Analysis – II: Converging Search Results

The search query for term “agriculture cover” returned 32 docs for scientific, 57 docs for journal, and 11 docs for social data without implementing ontology because of two terms “agriculture” or “cover” in their full text. Meanwhile, the same query returned 11 docs for scientific, 24 docs for journal, and 3 docs for social data implementing ontology. Thus, search query after implementing ontology returned concise number of docs i.e. converging search results.

The journal titled “Local and Remote Responses to Excessive Snow Mass over Eurasia Appearing in the Northern Spring and Summer Climate, A Study with the MRI” is not returned after implementing ontology, as the concept “agriculture” is related to only two concepts “land cover” and “vegetation cover”, without any association with “snow cover”, “cloud cover”, “snow cover extent”, “sea ice cover”, etc. Thus, docs including terms “agriculture” and “land cover” or “vegetation cover” are returned excluding docs with other terms for “cover”.

6. CONCLUSION

The retrieval of relevant information according to the users' requirement is an essential part of any system. Functions have been defined that operates over scientific, social and journal data in consideration to their interoperability. The following conclusions can be derived from the study:

1. The ontology developed for this system covers the concepts for 146 Critical Observation Parameters, 8 Social Benefit Areas and Journals.
2. The system is efficient in retrieval of more and more précised disaster information after every updates of the ontology.
3. The system works as one-stop service facilitating the user with maximum possible of data in text, media, maps, etc.
4. The system plays a prominent role in standardizing possibly scattered information in the web by bringing them under common index database.
5. The system also provides basic visualization of information to the user. The user can easily trace the information provided in the Google Map for any particular location or entities relation from Onto-graph.

In conclusion, the system works as knowledge based system acquiring the objectives of identification, integration, interoperability, standardization and visualization maintained under standard data format in distributed indexes.

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AN ANALYTICAL INVESTIGATION OF ANCHORAGE FAILURE OF RC CONFINED BY TRANSVERSE BAR BY 3D RBSM

Yoshiyuki TAKANO[1], Daisuke HAYASHI[2], Kohei NAGAI[3]
[1] Graduate Student, School of Engineering, The University of Tokyo, Japan
y-takano@iis.u-tokyo.ac.jp
[2] Project Researcher, IIS, The University of Tokyo, Japan
[3] Associate Professor, ICUS, IIS, The University of Tokyo, Japan

ABSTRACT

To study the bond performance and failure mechanisms between reinforcement and concrete around an anchorage zone in a structural element, two simulation cases of anchorage failure were carried out by three-dimensional Rigid Body Spring Model (RBSM). In the first case, simulation of uni-axially reinforced cylindrical specimen subjected to tension was made. Splitting crack failure could be simulated. Also strain distribution of pull-out reinforcements and pull-out behavior was predicted as well as experiment. Further simulations were also carried out to confirm the benefits of transverse reinforcement to enhance the anchorage of reinforcements. These simulations confirm this beneficial effect and show good agreement with experiment data in terms of anchorage capacity, crack patterns and failure modes. And also internal crack developments in simulation are shown from analysis.

Keywords*: RBSM, anchorage failure, crack development, transverse bar*

1. INTRODUCTION

Nowadays in Japan, seismic design code is becoming more stringent. To satisfy the stringent requirements, lager amounts of reinforcement must be placed, resulting in increased reinforcement congestion. This problem particularly occurs in beam-column joints, where reinforcements meet from many different directions.

As a result, it becomes difficult to ensure proper concrete compaction and hence poorer concrete quality may result. As one of these reasons, it is considered that the design procedure of anchorage is still defined by specifications. Thus, in order to develop the rational design procedure for anchorage, anchorage performance must be evaluated based on mechanical theory. However, it is difficult to clarify the anchorage performance on complicated bar arrangement like beam-column joint, and several bar-end

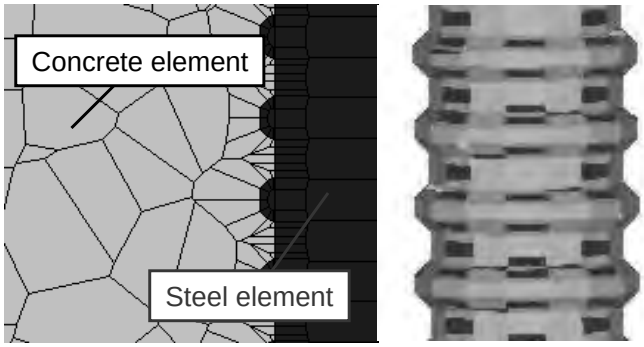
shapes. For this, authors considers that anchorage performance on anchorage in structural elements is possible to evaluate by using numerical simulation reflected the mechanical and material properties around reinforcement.

In this study, numerical simulations were carried out to investigate the anchorage performance by Rigid-Body Spring Model, which is a kind of discrete analysis. And anchorage failure on two types of bar arrangement was attempted to replicate. First case is a pull-out simulation of reinforcement embedded in thin cover cylindrical specimen. From this result, the reproducibility of pull-out behavior is confirmed by comparing to experiment result. Further, to investigate the effect of transverse bar on anchorage performance, pull-out simulations by varying the amount of transverse bar are carried out.

2. ANALYSIS METHOD AND MODEL

2.1 Analysis method

In this study, analysis is carried out by 3D RBSM approach, proposed by Kawai (1978). Two types of elements, namely concrete and steel elements, are used to define the geometry of a specimens embedded reinforcing bar. The concrete elements size is set smaller than the maximum aggregate size, while the steel element size is set according to geometric complexity of the reinforcing bar (Figure 1). Three springs (one normal direction and two shear directions) are assumed to connect each face of the elements. The properties of the springs are determined so as the elements, when combined together, enable accurate prediction of the response of laboratory-scale material test. In this study, simulation system developed by Nagai (2004) is used.



(a) Cross section of elements (b) 3D Rebar shape

Figure 1: Modeling of geometric rebar shape

2.2 Constitutive models

Two elements are used to represent the behavior of reinforced concrete:

(1) Steel element

The geometry of the steel elements is modeled in an accurate manner to properly account for the interlock between reinforcement and concrete. Figure 1 illustrates typical reinforcement geometry used in analysis.
The normal and shear springs used in the steel elements are assumed to be perfectly elastic. This simulation is not considered reinforcement yielding because the focus of these simulations is the reproduction of anchorage failure on several arrangements of reinforcements.

(2) Concrete element

The shape of concrete elements is determined by using the Voronoi diagrams, expect those nearby the steel elements which were constructed manually following the geometry of the steel elements. Random element generation is considered to reasonably replicate concrete fracture process.

The concrete constitutive models for the normal and shear spring are shown in Figure 2. The normal springs are assumed to behave elasticity both in compression and in tension. After reaching its strength in tension at f_t, the stress in the springs is assumed to decrease linearly to zero at the maximum crack width w_{max} (assumed to be 0.003mm, Figure 2(a)). The shear spring is assumed to behave in an elastic-plastic manner (Figure 2(b)), with a yield strength computed from Equation 1 (adopted from Muto et al.(2004), Figure 2(c)). Here, ϕ =37° .

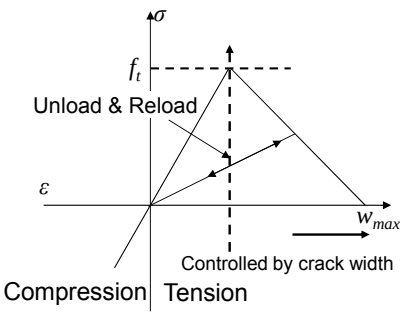
$$\tau = \begin{cases} c - \sigma tan\emptyset & (\sigma \geq 0.5 f_c) \\ c - 0.5 f_c tan\emptyset & (\sigma < 0.5 f_c) \end{cases} \quad (1)$$

$$c = f_t(1 + \tan\emptyset)$$

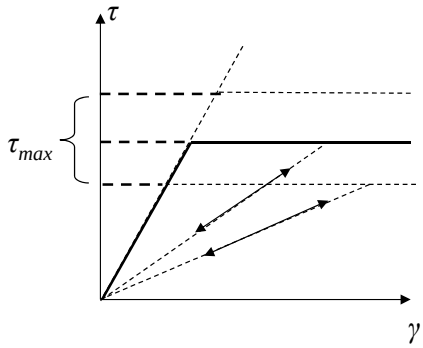
For regions within 1D (D: bar diameter) from the reinforcement surface, the concrete constitutive model is modified to account for interfacial zone between the reinforcement and the concrete (Salem et al. (2005)). In this zone, the elastic modulus of the spring is assumed to be a half of the original value.

(3) Steel-Concrete surface

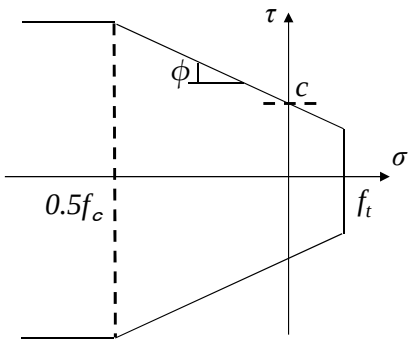
At steel-concrete interface, the normal spring is considered to be the same to that of the concrete element (Figure 2(a)), but with a tensile strength of only a half. The shear spring is assumed to behave elastic-plastic, with the yield strength calculated from same concept of criteria to concrete element. Moreover, the shear strength of the interface spring is assumed to decrease according to crack width to represent interface fracture (Figure 2(d)).



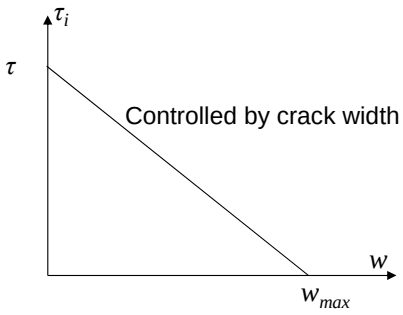
(a) Model of normal spring of concrete



(b) Model of shear spring of concrete



(c) Failure criterion of concrete



(d) Model of shear reduction of concrete

Figure 2: Constitutive models of springs

3. ANCHORAGE PERFORMANCE IN UNIAXALY REINFORCED CYLINDRICAL SPECIMENS SUBJECTED TO TENSION

3.1 Analysis case

The cylindrical specimens tested by Daigo (2010) are referenced to examine the proposed 3D RBSM models. Details of the specimen and loading condition are shown in Figure 3. The specimen was embedded to one D25 deformed bar placed at the center of 60mm cover thickness cylindrical specimen. A center-hole jack was used to pull the rebar from one-end. The development length of the reinforcement was 450mm, calculated using standard specification defined by JSCE (2007). To eliminate the effect of confinement near the loading end, a 300mm un-bonded area was considered. Material properties of the concrete and the reinforcement are shown in Table 1. In the analysis, displacement controlled loading was applied, with an increment of 0.2mm in 100steps.

Table 1: Material properties

Concrete				Steel		Maximum load		Number of elements
f'_c(N/mm^2)	f_t(N/mm^2)	E_c(kN/mm^2)	Poisson's ratio	E_s(kN/mm^2)	Poisson's ratio	ANA(kN)	EXP(kN)	
52	3.7	33	0.18	190	0.3	221	198	40,409

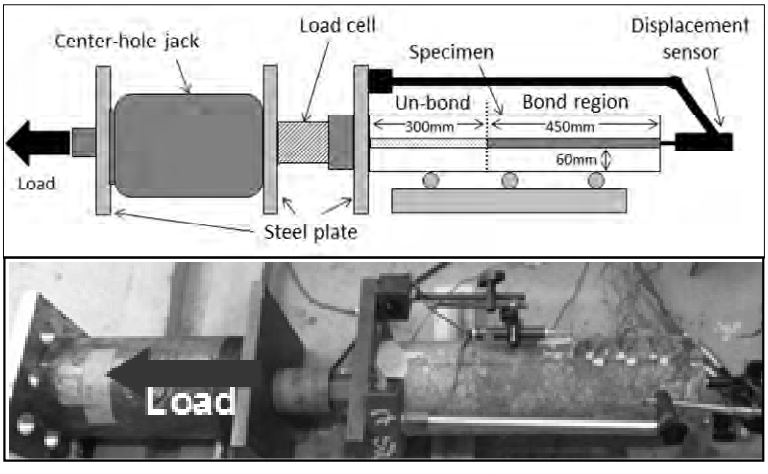


Figure 3: Experimental setup

3.2 Result of analysis

3.2.1 Failure pattern and Internal crack

The failure mode and the internal crack pattern obtain from the analysis are shown in Figure 4 together with the photo of test specimens after failure. The left end of each figure is the loading end.

In experiment, cylindrical specimen was splitting failure due to the stress transferred from rebar ribs. The analysis failure mode shows the crack propagated along with the reinforcement. And from internal crack image, it is confirmed that this crack is spread as plane around the rebar, and could be simulated the splitting crack observed in experiment.

3.2.2 Load-Slip relationship and Strain distribution

The load-slip relationship is shown in Figure 5, and the strain distribution of pull-out reinforcement is shown in Figure 6 by comparison to experiment. Here, the slip means integral of the strain of reinforcement along with the development length. And the maximum load of analysis and experiment are listed in Table 1.

The load-slip relationship shows that in experiment, the increasing of load stopped nearby the maximum load and only slip was increasing. This behavior means splitting crack was developed from reinforcement and being failure. While, analysis was not perfectly coincided with experiment, but the trend could be captured. Further, to focus on the initial slope of load-slip relationship, analysis was good agreement with experiment. Thus, it is confirmed that analysis can predict the slip with high accuracy in early stage of small crack propagation, and also can treat the behavior even with splitting crack.

The strain distribution of reinforcement shows the strain developed from loading-end to free-end. And comparing the strain value, analysis could simulate as well as the experiment.

4. FOUR REBARS PULL OUT SIMULATIONS WITH TRANSVERSE REBARS

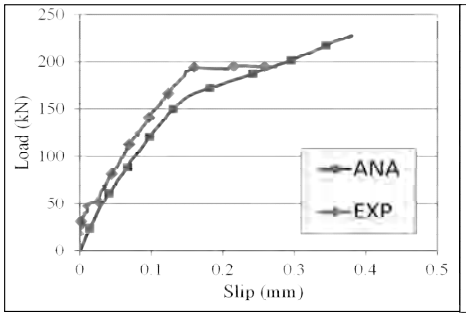


Figure 5: Strain distribution

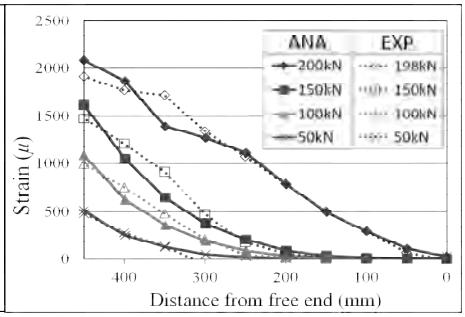


Figure 6: Strain distribution

4.1 Analysis case

Transverse reinforcements may greatly improve the bond performance, especially for reducing the risk of splitting cracks and for restraining concrete cover. To investigate these beneficial effects, simulations of specimens having different number of transverse bars along the longitudinal direction are carried out.

Table 2 lists all the analysis cases considered. The longitudinal reinforcements are pulled out together. Different spacing of transverse reinforcement are studied: 200mm (TR3), 100mm (TR5), 50mm (TR9), and no transverse reinforcement (TR0).

Table 2: Analysis cases

Case	Number of transversebar	Clear spacing of transversebar (mm)	Strength of concrete (N/mm^2)		Elastic modulus of steel (kN/mm^2)	Maximum Load (kN)		Number of elements
			f'_c	f_t	E_s	ANA	EXP	
TR3	D13×3	200	25	2.5	190	451.2	411.2	147,255
TR5	D13×5	100	25	2.5	190	534.8	504.9	167,179
TR9	D13×9	50	25	2.5	190	675.6	696.1	183,931
TR0	0	-	25	2.5	190	303.3	-	141,532

The computer models used in analysis are shown in Figure 7; for a comparison see the details of the test specimens shown in Figure 8. Upon computational time constraints, only 150mm from the top surface of each test specimen is modeled.

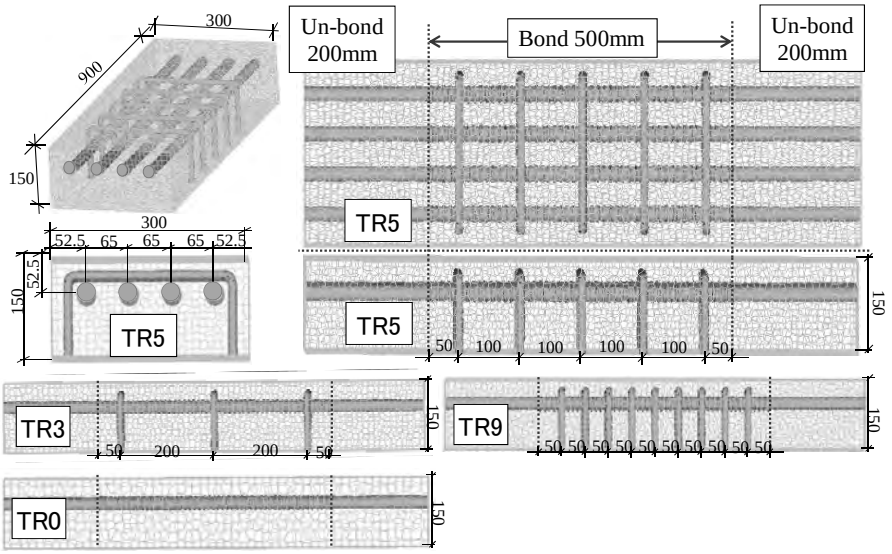


Figure 7: Analysis model

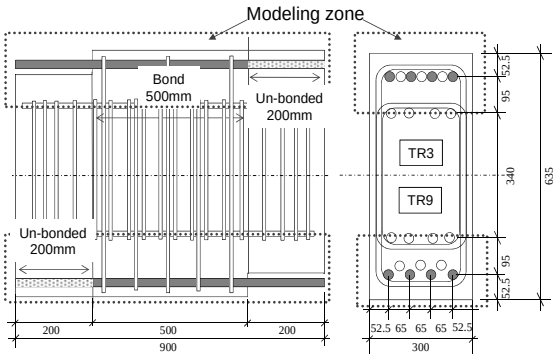


Figure 8: Boundary Condition

Reinforcing steels in the specimen model include 25mm deformed longitudinal bars and 13mm plain round bars. The plain bars are assumed in the analysis for simplifying the modeling process. All pull-out reinforcements have a development length of 500mm and un-bonded length of 200mm. The rebar ribs at the un-bonded zone are not modeled.

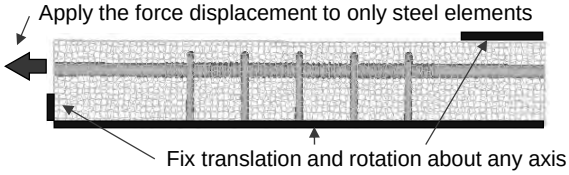


Figure 9: Boundary Condition

The boundary condition considered in the analysis is shown in Figure 9. Monotonically increasing displacement-controlled loading is applied to the steel elements on the loaded end surface.

4.2 Analysis result

4.2.1 Load-Displacement relationship

The load-slip relationship from analysis is shown in Figure 10(a), while that from experiment is in Figure 10(b). The load shown in both figures represents the total reaction load of four bars, while the displacement is the average relative displacement between reinforcement and concrete at the free-end. Table 2 shows the comparison between the predicted and observed maximum loads.

From the experimental data, it is observed that the loads corresponding to the start of the reinforcements being pulling out do not different significantly for the different number of transverse bars investigated. After the reinforcement starting to pull out, their behaviors change according to the numbers of the transverse reinforcements provided along the longitudinal direction. The more the transverse reinforcement numbers, the higher the load that can be attained.

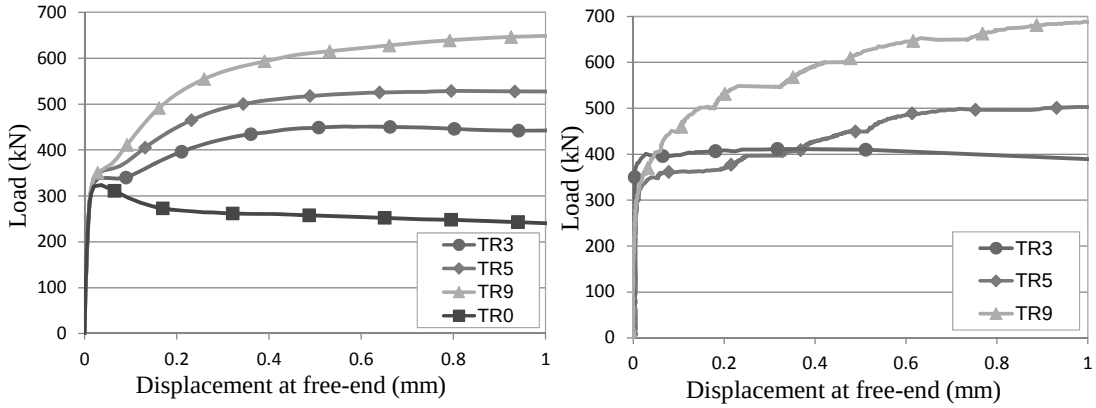
The same abovementioned behaviors can also be seen from analysis result. In TR0 (no transverse rebar), the specimen is predicted to attain the same load level before the reinforcement being pulled out. In other cases,

the load is predicted to increase, reaching a maximum value depending on the amounts of transverse reinforcement. The ability of the proposed models to simulation the different maximum load due to the effects of transverse bar confirms its superiority not only to simulation the formation of cracks in three-dimensional space, but also to consider their interactions under complex stress states.

4.2.2 Failure pattern

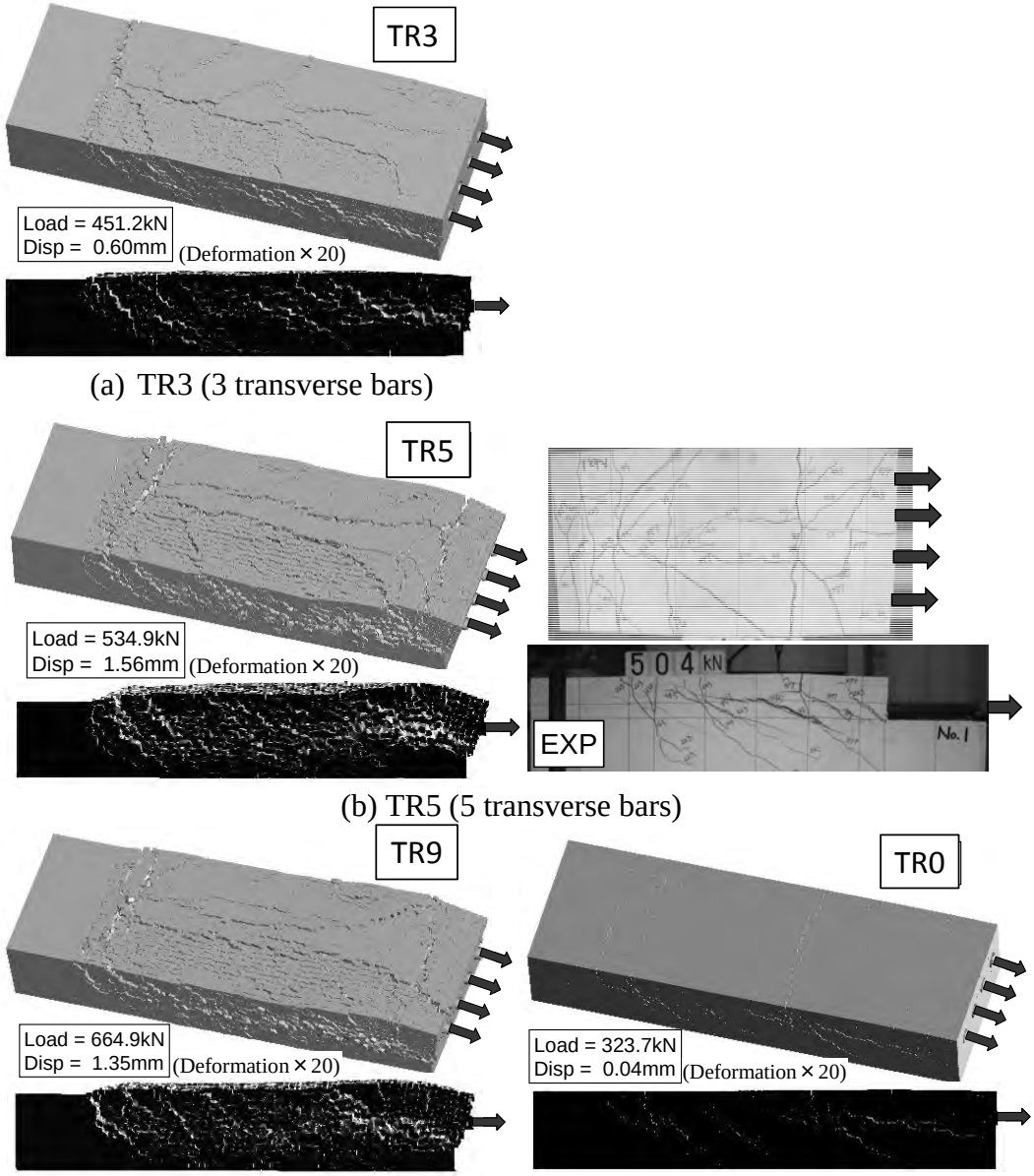
The crack patterns at the peak load are shown in Figure 11, only TR5, with the photo of relevant test specimen at the peak load, for a comparison. From TR5, the numerically obtained crack patterns replicate the observed patterns well, including the transverse and longitudinal splitting cracks and the intermittent diagonal cracks forming at both side of surface. The transverse splitting cracks that are caused by the merging of internal cracks are predicted to form at somewhat middle of the specimen, separating the specimen into two distinct parts: upper and lower parts (Fujii et al., (1982)). It is predicted that these splitting cracks are responsible for the failure.

The analysis also captures the splitting cracks along the longitudinal reinforcements toward the loading end at the center of specimen top surface. This crack forms subsequently after the aforementioned transverse splitting cracks. The formation of many diagonal cracks can also be well simulated. Analysis could show the tendency that increasing the amount of transverse reinforcement increases the crack number and damage extent by comparing TR3, TR5, and TR9. This reason is that the bond performance improved due to increasing the confining effects of the transverse bar, and the stress carried by top cover concrete became large. Thus TR0 (no transverse bar), the crack pattern shows that no longitudinal and diagonal crack developed at the top surface of specimen.



(a) Analysis (b) Experiment

Figure 10: Load-Displacement relationship



(a) TR3 (3 transverse bars)

(b) TR5 (5 transverse bars)

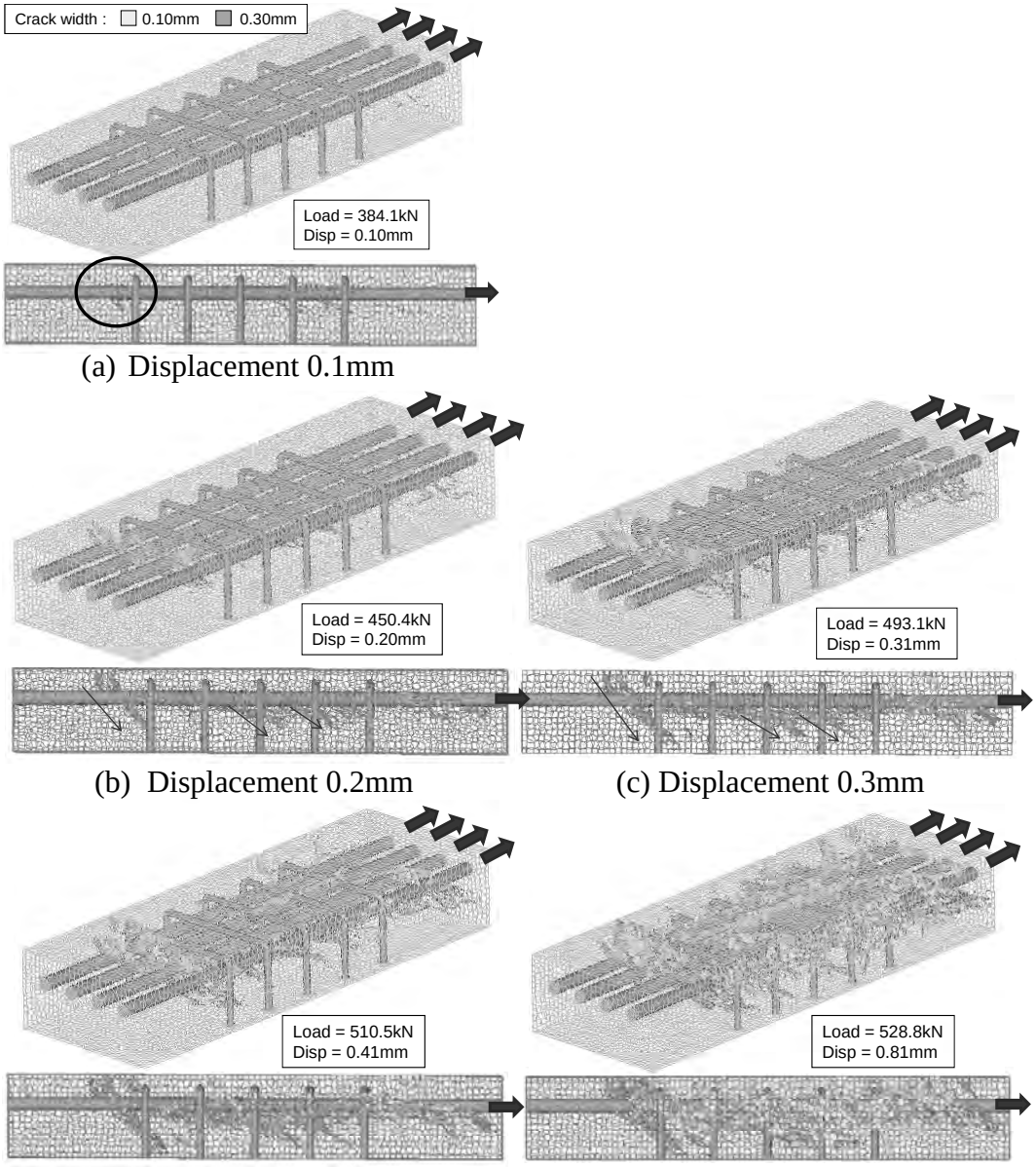
(c) TR9 (9 transverse bars) (d) TR0 (no transverse bar)

Figure 11: Failure pattern at the peak load (Analysis)

4.2.3 Crack development

Analysis also captured the crack development from the internal crack distributions. The distributions of internal crack of TR5 are shown in Figure 12. It is confirmed that the crack was formed at the end of development length (in the circle), when displacement is 0.1mm (Figure 12(a)), after starting of pull-out. This means that the pull-out behavior was started according to the development of tensile stress by the end of rebar. And comparing the internal crack of displacement 0.1mm and 0.2 (Figure 12(a), (b)), diagonal cracks developed toward the bottom of specimen in displacement 0.2mm (arrows in Figure). Further 0.3mm, these diagonal cracks developed more toward bottom, but in side of top surface, there were no significant difference (Figure 12(c)).

And Figure 12(d) and (e) show the internal crack at displacement 0.4 and 0.8mm, respectively, after load increasing became slowly. It is confirmed that the crack development toward bottom stopped and crack formed in the top cover surface of specimens at displacement 0.4mm. And 0.8mm, crack in top cover developed more, and also, crack was propagated to side cover concrete. Thus from analysis, crack developed toward bottom in the stage of load increasing after starting pull-out, and further, crack was propagated to top thin cover concrete and load increasing became slowly.



(a) Displacement 0.1mm

(b) Displacement 0.2mm (c) Displacement 0.3mm

(d) Displacement 0.4mm (e) Displacement 0.8mm

Figure 12: Distribution of internal crack

5. CONCLUSION

From the results of simulations investigating the anchorage performance on several rebar arrangements, the following conclusions are made.

(1)From the simulation of cylindrical specimen, analysis could be predicted the steel strain value and pull-out behavior of reinforcement, and also, failure pattern due to splitting crack.

(2)The advantage of discrete analysis RBSM is demonstrated in this study for simulating the development of cracks around reinforcements embedded in concrete, including transverse, splitting, and diagonal cracks.

(3)The analysis proposed successfully captures the advantage of transverse reinforcement to improve the bond performance, including the load-slip relationships and the load-slip relationships and the corresponding failure crack pattern.

(4)Analysis could simulate the crack development according to the pull-out behavior: crack developed toward bottom in the stage of load increasing just after starting of pull-out, thereafter, crack was propagated to top cover concrete and load increasing became slowly.

ACKNOWLEGE

The original data of pullout experiment investigating the effect of transverse reinforcement was provided from Shimizu Corporation.

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MODELING INTERMODAL TRAFFIC ASSIGNMENT AND APPLICATION

Yongtaek LIM[1], Cheol PARK[2]
[1] Professor, Chonnam NationalUniversity, Korea
[2] Graduate student, Chonnam NationalUniversity, Korea

ABSTRACT

This study aims to establish the intermodal network model and develop the intermodal traffic assignment model based on the dissimilar path searching algorithm. For the method used in this study, n-path algorithm considering the overlap ratio between links in searching the shortest path is used, and the searched path is to consider the transfer between transits. The intermodal traffic assignment model is established by applying the Direct Logit Loading model to the established path. One characteristic of this model is that the dissimilar path allows to overcome IIA, the limitation of the logit model to a certain degree. In addition, the developed model was evaluated with simple examples of network to establish the equilibrium condition through the traffic assignment.

Keywords*: Intermodal network model, dissimilar path, overlap, transfer, direct logit loading model, equilibrium condition*

1. INTRODUCTION

In order to establish the effective system for the eco-green traffic, it is required to not only expand traffic facilities but also introduce the transit modes and transfer centers including needs to manage the travel demand. In addition, as travelers come to have various transit modes, they become available to choose the lowest cost-path among paths to the destination by changing the mode into the transfer during the travel. Therefore, the intermodal network model is required to manage for the transit in order to describe actual travels in reality. For the study on this, the integrated model was suggested by Hyunmyung KIM and Yongtaek Lim (1999), which uses the equilibrium traffic assignment in the integrated network for the transit.

In addition, k-path algorithm is generally used to obtain practical effects on the traffic spread, but it has a certain problem in the overlap among drawn paths. On this wise, Yongtaek Lim (2004) suggested n-path algorithm to explore the shortest path to prevent the path overlap of higher than a certain level.

However, its study to explore the shortest path has not been conducted yet upon the consideration of the inter-path overlap drawn from the intermodal model for the transit. Therefore, this study intends to establish the intermodal network model based on the dissimilar path algorithm to

explore and develop the intermodal traffic assignment model by applying the logit route choice model.

2. LITERATURE SURVEY

2.1 Combined Model and Intermodal Model

Most demand models used in the traditional traffic plans have been divided into the model choice and the traffic assignment. However, as the transit mode diversifies, actual travelers come to change the transit mode through the transfer during the travel, and therefore, it is needed to analyze the mode choice and the traffic assignment processes by integrating them.
For the traffic assignment under the multiple-mode network, its methods are divided into the combined mode and the intermodal mode, respectively. The combined model forms the objective function to the minimize the travel cost of the entire network with keeping individual features of the traffic assignment model and the mode choice model, but the intermodal model forms the objective function with the mode choice and the traffic assignment processes to estimate modes and travel demand of individual links.

Hyunmyung KIM and Yongtaek Lim (1999) suggested the limitations of the combined mode through the comparison between the combined and the intermodal models. Accordingly, this study attempted to apply with the intermodal mode.

2.2 Link-based Shortest Path Searching Algorithm

The study to explore the shortest path with the link cost only, was conceptually suggested by Potts & Pliver (1972) for the first time, and demonstrated that this can resolve the problem in the turn penalty easily in case of exploring the path for links' sequences only based on the node. Hyunmyung KIM et al. (1999) applied this to the intermodal network for the transit between modes. This study targets to establish the intermodal mode based this method, and the optimum condition of the link-based shortest path algorithm is as follows:

$$LEC(o,i) + MCC[link(o,i), link(i,j)] + LC(i,j) \le LEC(i,j)$$

$$\forall o,i,j \in Nodest$$

St. $LEC(o,i)$ **:** link (o,i)'s link-end cost
$MCC[link(o,i), link(i,j)]$**:** transfer cost
$LC(i,j)$: link (i, j)'s travel cost

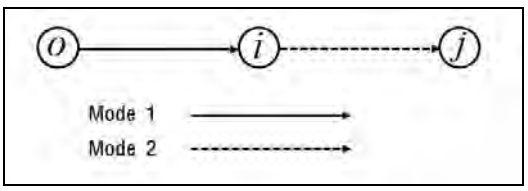

Figure 1. Link-based path

As the optimum path is explored based on the link, PI (predecessor link) is memorized in the existing algorithm.

2.3 k-path algorithm & n-path algorithm

k-shortest path algorithm is frequently used for exploring the shortest path in general, and saves other k-1 paths to generate. As for its fundamental concept, it explores the lowest cost path except the shortest path upon once the shortest path is explored, and then determines the second and third lowest cost paths. Such k-shortest path algorithm is generally difficult in applying in a direct way because most drawn paths share the same links (Yongtaek Lim, 2004)

Different from k-path algorithm, therefore, Yongtaek Lim (2004) explored the travel cost between existing end stops and the level of path overlap (op) as the path choice standard to suggest the algorithm which calculates the n-paths according to the level of path overlap (op), without setting the number of paths in advance, and defined the difference of algorithms between k-path and n-path as follows:

Table 1:Difference of algorithms between k-path and n-path

div.	k-path algorithm	n-path algorithm
Path choice standard	Travel cost	Travel cost + Level of path overlap (op)
Input data	No. of paths (k)	Level of path overlap (op)
No. of calculated paths	K (n) (set in advance)	- No setting of the number of paths in advance - n-paths drawn as the result

3. ESTABLISHING INTERMODAL NETWORK & SEARCHING DISSIMILAR PATH

3.1 Establishing the intermodal network

This study suggested simple examples to establish the intermodal network. As shown in Figure 2, the traffic network was composed of 12 nodes and 20 links. 9-12 modes were set for the available stations to transfer to the car or the public transit, and 16, 18, 20 links are for the public transit. And, link travel cost is Figure 3.

All travelers were assumed to travel from the node 1 as the origin and to the node 20 as the end stop, and q for all travel demands were assumed as 20.

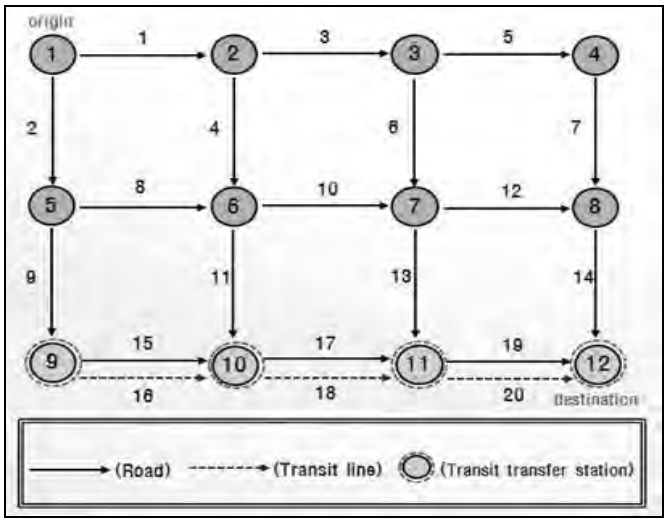

Figure 2: Example of intermodal Network

$t_1 = 1 + x_1$	$t_{11} = 1 + x_{11}$
$t_2 = 2 + x_2$	$t_{12} = 1 + x_{12}$
$t_3 = 2 + x_3$	$t_{13} = 2 + x_{13}$
$t_4 = 1 + x_4$	$t_{14} = 2 + x_{14}$
$t_5 = 1 + x_5$	$t_{15} = 2 + x_{15}$
$t_6 = 3 + x_6$	$t_{16} = 1(transit)$
$t_7 = 3 + x_7$	$t_{17} = 2 + x_{17}$
$t_8 = 2 + x_8$	$t_{18} = 1(transit)$
$t_9 = 1 + x_9$	$t_{19} = 2 + x_{19}$
$t_{10} = 2 + x_{10}$	$t_{20} = 1(transit)$
$t_{transfer} = 1.5(transfer)$	

Figure 3: Link travel cost

3.1 Searching the dissimilar path

For exploring the shortest path to connect the existing end stop in the general network, k-short path algorithm is generally used, but this have the problem in the overlap between drawn paths. According to examples in this study, the shortest path was explored as (1-4-11-18-20) if the initial travel demand is 0. Next, the lower-travel cost path is also explored and the path overlap is found like Figure 5. So, if there is the path overlap, effects of the traffic spread could not be expected in the actual network, but the traffic congestion instead.

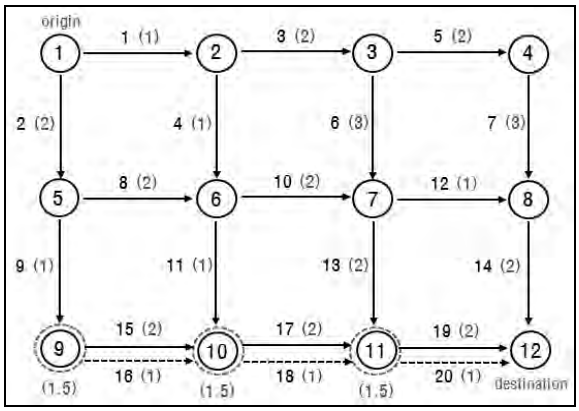

Figure 4: Link travel cost(initial)

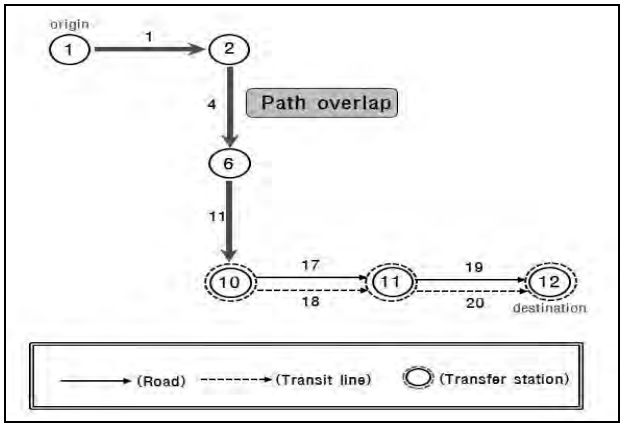

Figure 5: Path overlap

Therefore, this study intends to explore the dissimilar path by use of suggested the dissimilar path exploring algorithm (n-path) by Yongtaek Lim (2004). n-path algorithm figures out the path travel costs and the level of path overlap (op) around firstly explored shortest path to explore subsequent paths.

In the example of this study, the initial travel cost was calculated upon the assumption of the initial travel demand as q^{rs} =0 in order to explore the dissimilar path, and the shortest path was explored as (1-4-11-18-20). Based on the shortest path, the allowable path overlap was also set as OP=0.4. According to this, the dissimilar path was explored and 3 paths were drawn as Figure 6.

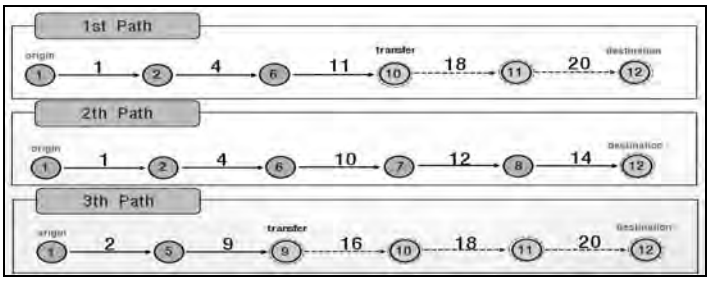

Figure 6: Searched dissimilar path

4. INTERMODAL TRAFFIC ASSIGNMENT MODEL

4.1 Intermodal traffic assignment model

4.1.1 Direct logit loading method

This study attempts to apply the intermodal traffic assignment through the direct logit assignment on the intermodal network. Direct logit assignment directly calculates equilibrium condition's path traffic volume (f_k^{rs}) from the logit mode of probabilistic user equilibrium condition. That is, the equation (I) is directly applied to the traffic assignment.

$$f_k^{rs} = q^{rs} \frac{\exp(-\theta c_k^{rs})}{\sum_{w \in W} \exp(-\theta c_w^{rs})} \qquad \text{(I)}$$

St. f_k^{rs} = k path's traffic volume between r to s

q^{rs} =Travel demand between r to s

c_k^{rs} = k path's travel cost between r to s

θ =Parameter

So, the intermodal traffic assignment process in this study is as Figure 7, and the calculation algorithm is as follows:

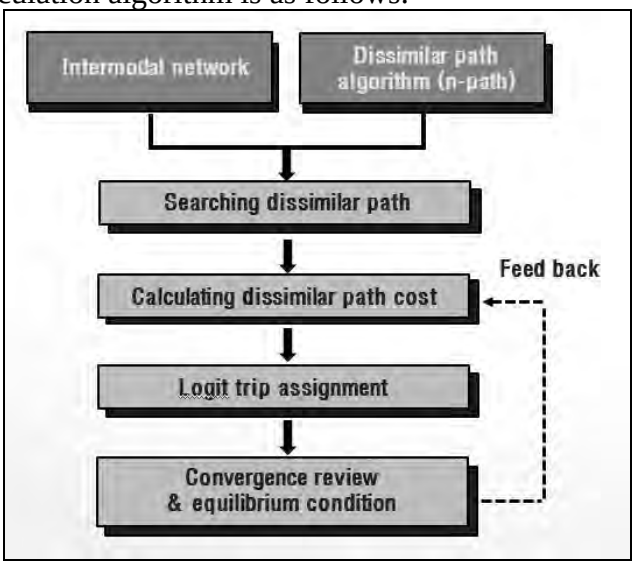

Figure 7: Intermodal traffic assignment process

4.1.2 Direct logit loading method algorithm

[Step 0]Initializing

- Setting the initial value: Initial path traffic cost { $c_k^{rs,0}(0)$ }

Travel demand q^{rs}, Spread parameter θ_r, Recurrence n=1

[Step 1]Based on { $c_k^{rs,n}$ }, calculating the path traffic volume { $f_k^{s,n}$ }

$$f_k^{s,n} = q^{rs} \frac{\exp(-\theta c_k^{rs,n})}{\sum_{w} \exp(-\theta c_w^{rs,n})}$$

[Step 2] Renewing the path traffic cost Based on
- { f_k^{rs} }, calculating the path travel cost (c_k^{rs})

[Step 3]Reviewing convergence

$$\text{If } \frac{\max\left|c_k^{rs,n} - c_p^{rs,n}\right|}{\max w \in W c_w^{rs,n}} < \varepsilon$$

$\forall k \neq p \in W$ (path set), then stop.
Otherwise, proceed to [Step 1] after n=n+1.

4.2 Calculating the dissimilar path cost

In order to calculate the initial travel cost of explored dissimilar path cost, the travel demand was setting as q^{rs} =0. Initial travel costs of 3 dissimilar paths mentioned earlier are as below Table 2.

Table 2: Initial travel cost by dissimilar path

Div.	Path	Cost
path1	1-4-11-18-20	6.5
path2	1-4-10-12-14	7
path3	2-9-16-18-20	7.5

In addition, the path travel cost changes according to the demand change after traffic assignment, and the renewal of the path traffic cost is as [Step 2] of algorithm shown earlier.

4.3. Direct logit loading method

In this study, the Direct Logit Loading Method was used for calculating the utility value and then directly multiplied by the travel demand (q^{rs})to get the path traffic volume (f_k^{rs}). As for its calculation, it is same as [Step 1] of algorithm suggested earlier. Also, the example of this study assumed as $\theta = 0.02$, and its calculation is as below:

$$f1 = \frac{\exp(-0.02 * 6.5)}{\exp(-0.02 * 6.5) + (\exp(-0.02 * 7.0) + (\exp(-0.02 * 7.5)} * 20$$

$$f2 = \frac{\exp(-0.02 * 7.0)}{\exp(-0.02 * 6.5) + (\exp(-0.02 * 7.0) + (\exp(-0.02 * 7.5)} * 20$$

$$f3 = \frac{\exp(-0.02 * 7.5)}{\exp(-0.02 * 6.5) + (\exp(-0.02 * 7.0) + (\exp(-0.02 * 7.5)} * 20$$

4.4. Convergence review & Equilibrium value

The logit model is aimed to calculate the equilibrium condition's path traffic volume (f_k^{rs}), in condition when the path travel cost (c_k^{rs})of individual alternative paths is fixed in the logit model. However, individual paths' travel costs are uncertain according to the change of each traffic

demand volume, and so it is hard to figure out the exact path travel cost. Therefore, the cyclic process between path cost (c_k^{rs}) and the path traffic volume (f_k^{rs}) is required (Yongtaek Lim, 2003).

Accordingly, this study attempted to calculate the equilibrium values through the example, and it is shown as below <Figure 8>.

Table 3: Path cost & Demand

	cost			demand		
Frequency	**path1**	**path2**	**path3**	**D1**	**D2**	**D3**
1	6.50	7.00	7.50	6.73	6.67	6.60
2	26.70	40.33	20.70	6.92	5.27	7.81
3	27.27	33.36	23.11	6.73	5.96	7.31
4	26.69	36.79	22.13	6.87	5.61	7.52
5	27.10	35.05	22.55	6.78	5.79	7.43
6	26.85	35.93	22.36	6.83	5.70	7.47
7	26.99	35.48	22.45	6.80	5.74	7.45
8	26.91	35.71	22.41	6.82	5.72	7.46
9	26.96	35.59	22.42	6.81	5.73	7.46
10	26.93	35.65	22.42	6.82	5.72	7.46
11	26.95	35.62	22.42	6.81	5.73	7.46
12	26.94	35.64	22.42	6.81	5.73	7.46
13	26.94	35.64	22.42	6.81	5.73	7.46
⋮	⋮	⋮	⋮	⋮	⋮	⋮

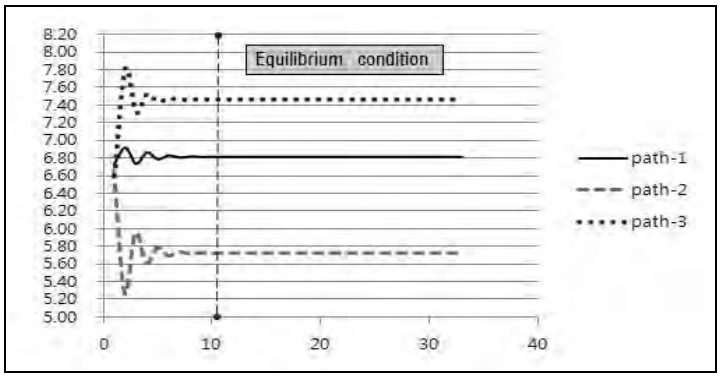

Figure 8: Equilibrium condition

5. APPLYING INTERMODAL TRAFFIC ASSIGNMENT MODEL

This study used the simple example to establish the intermodal network model and develop the presumed model of the travel demand. Also, by expanding the intermodal traffic assignment model, various applicability's are intended to review.

According to the review on the applicability of the model through Figure 8, firstly, if the transfer center is improved, it is considered its effectiveness could be assessed. For example, if the transfer cost is

decreased at the existing transfer center, it is considered that the study regarding the decrease of the total cost shall be conducted.

Secondly, if the travel cost of the public transit is decreased, it is considered the analysis of its effectiveness could also be performed.

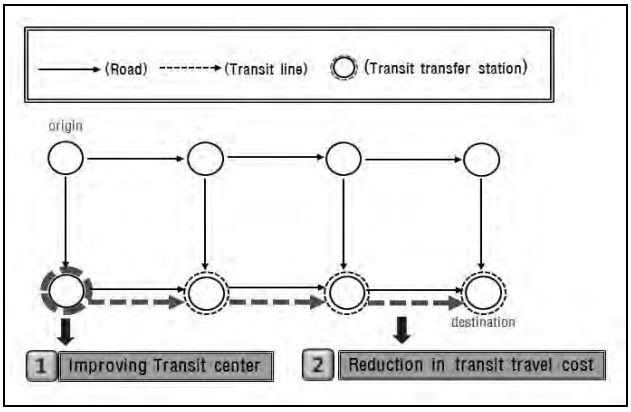

Figure 9: Application of intermodal traffic model

6. CONCLUSION

This study explores the shortest path based on the link, not the node, different from existing studies. Also, the intermodal network model was established with the dissimilar path exploring algorithm, and developed the intermodal traffic assignment model.

As for the methodology to study, the model was explained with more simple examples. In exploring the shortest paths, some alternative paths are explored upon the consideration of the overlap between links, and explored paths shall be explored again upon the consideration of the shortest path and the overlap. In this study, the overlap was set as OP 0.4 to explore 3 dissimilar paths. For explored dissimilar paths, the direct logit assignment was used. After calculating the effectiveness through the logit model, the path traffic volume(f_k^{rs}) was calculated by multiplying the direct travel demand(q^{rs}). Also, the path traffic volume (f_k^{rs}) changes according to the change of the travel cost (c_k^{rs}), and so it is required to have a certain repetitive cyclic process to have the single equilibrium value. Consequently, it was found that the example in this study calculates the equilibrium condition through cyclic processes of values.

In addition, various explicabilities were reviewed by expanding the establishing intermodal traffic assignment model. Reviewing the applicability of the intermodal model, it is considered available to study the decrease of the total cost when the transfer cost is decreased due to the improvement of the transfer center in the actual network of public transits and transfers. Also, if the travel cost of the public transit is decreased, it is considered available apply to the effectiveness analysis as well.

Considering there would be other various studies on the model application, future studies shall be performed through the larger-scale Sioux Falls network, and further in-depth shall be attempted for the applicability of the model.

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Analysis also captured the crack development from the internal crack distributions. The distributions of internal crack of TR5 are shown in Figure 12. It is confirmed that the crack was formed at the end of development length (in the circle), when displacement is 0.1mm (Figure 12(a)), after starting of pull-out. This means that the pull-out behavior was started according to the development of tensile stress by the end of rebar. And comparing the internal crack of displacement 0.1mm and 0.2 (Figure 12(a), (b)), diagonal cracks developed toward the bottom of specimen in displacement 0.2mm (arrows in Figure). Further 0.3mm, these diagonal cracks developed more toward bottom, but in side of top surface, there were no significant difference (Figure 12(c)).

SHEAR FATIGUE PERFORMANCE OF PVA-ECC BEAM MIXED WITH AGGREGATE UNDER PRE-CRACKED CONDITION

Rieko KOJIMA[1], Yoshiyuki TAKANO[2], Benny SURYANTO[3] and Kohei NAGAI [4]
[1]Undergraduate Student School of Eng., The University of Tokyo, Japan
r-kojima@iis.u-tokyo.ac.jp
[2] Graduate Student School of Eng., The University of Tokyo, Japan
[3] Researcher, The University of Tokyo, Japan
[4] Associate Professor, IIS, The University of Tokyo, Japan

ABSTRACT

Polyvinyl Alcohol Engineered Cementitious Composite (PVA-ECC) is a high performance fiber reinforced cementitious composite that has superior tensile ductility under single-directional tensile stress. Due to the absence of coarse aggregate, however, it has recently been found that cracks in PVA-ECC are susceptible to shear. The possible use of coarse aggregate was demonstrated to increase the resistance of the cracks to shear in previous research. This paper outlines the results of two types of experiments. One of them is simple beam test under fatigue load conditions in both pure PVA-ECC specimens and coarse aggregate mixed specimens, and the other is initially damaged anti-symmetric four-point-shear test under static and fatigue load in both materials. The purpose of anti-symmetric tests is to investigate shear behavior effectively and also to simply represent the complex multi-directional stress field by introducing initial damage and then changing load point. In simple beam tests, a contribution of aggregates to fatigue life was observed. Also from anti-symmetric experiments, obvious effect of aggregate for fatigue life (initially damaged) was observed. Furthermore, opening and slipping behavior of crack was investigated in fatigue load in anti-symmetric experiment, and the contribution of aggregates to reduction of shear slipping behavior was observed in the result of fatigue tests (initially damaged)

Keywords*: PVA-ECC, Aggregate, Shear, Pre-crack, Stress rotating*

1. INTRODUCTION

PVA-ECC is a Strain-Hardening Cementitious Composites (SHCC) which realize high ductility and quasi-strain hardening behavior by generating multiple cracks under uniaxial tensile stress due to contribution of PVA fiber, which mixed 2% by volume, to resist tensile stress by bridging between crack surface. Shear performance of PVA-ECC after the occurrence of crack, however, is not clarified perfectly, and application for

structural member, like bridge deck, is restricted. In previous research, PVA-ECC was found to be fragile in shear performance under cracked condition due to the absence of aggregate. Therefore, a certain volume of aggregate was introduced into PVA-ECC and improvement of shear behavior under stress rotating field was observed. In this research, experiments in beam specimens by using normal PVA-ECC and PVA-ECC which mixed with aggregate were performed to investigate into alterations of shear behavior by adding aggregate in structural members. Simple beam tests in fatigue loading were held to confirm the contribution of aggregate to shear. Also anti-symmetric four-point-shear tests under both initially cracked condition and not initially cracked condition were held to investigate into shear behavior under stress rotating field. Rotation of principal stress was represented by introduction of initial crack and change of loading point. The contribution of aggregate was judged by static capacity or fatigue life, crack pattern and shear behavior which obtained from the strain on the surface.

Table 1: Series of experiments

<table>
<tr><th colspan="3">Series of experiments</th><th>Name of specimen</th><th>Material</th><th>Size of specimen(mm)</th><th>Longitudinal reinforcement (%)</th><th>a/d</th><th>Reinforcement</th></tr>
<tr><td colspan="3" rowspan="2">Bending</td><td rowspan="2"></td><td>Normal ECC</td><td rowspan="2">100×100×400</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>ECC + Aggregates</td></tr>
<tr><td colspan="3" rowspan="2">Compression</td><td rowspan="2"></td><td>Normal ECC</td><td rowspan="2">φ100×200</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>ECC + Aggregates</td></tr>
<tr><td colspan="2" rowspan="2">Simple beam</td><td rowspan="2">Fatigue</td><td>ECC-F-S</td><td>Normal ECC</td><td rowspan="2">150×300×1800</td><td rowspan="2">3.80</td><td rowspan="2">3.10</td><td rowspan="2">3D25
USD685</td></tr>
<tr><td>CA-F-S</td><td>ECC + Aggregates</td></tr>
<tr><td rowspan="8">Anti-symmetric four point shear test</td><td rowspan="4">Static</td><td rowspan="2">Precracked</td><td>ECC-S-P</td><td>Normal ECC</td><td rowspan="8">100×200×1200</td><td rowspan="8">4.59</td><td rowspan="8">2.29</td><td rowspan="8">4D16
USD685</td></tr>
<tr><td>CA-S-P</td><td>ECC + Aggregates</td></tr>
<tr><td rowspan="2">Non-precracked</td><td>ECC-S-N</td><td>Normal ECC</td></tr>
<tr><td>CA-S-N</td><td>ECC + Aggregates</td></tr>
<tr><td rowspan="4">Fatigue</td><td rowspan="2">Precracked</td><td>ECC-F-P</td><td>Normal ECC</td></tr>
<tr><td>CA-F-P</td><td>ECC + Aggregates</td></tr>
</table>

2. OUTLINES OF EXPERIMENTS

2.1 Material

Tests were held for both Normal PVA-ECC (hereafter abbreviated “ECC”) and PVA-ECC with course aggregates (hereafter abbreviated “+CA”) in all test series. Aggregates were introduced about 10% by volume (15% by solid content) which value could be obtained from previous research (Suryanto et al, 2009). Also the size of aggregates was set as max 9.5mm, and the property of materials were the same in all experiment series. All experiments are shown in Fig.1.

2.2 Bending and compression test

Bending tests were held to investigate into tensile behavior of materials (4 specimens for ECC and 5 specimens for +CA). Detail setting and specimen size is shown in Figure1. Also, to investigate in the material property, compression test by cylinder were held.

2.3 Simple shear beam test under fatigue load

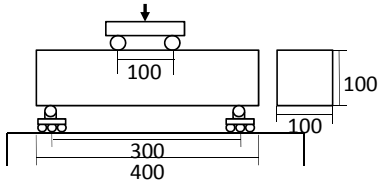

Figure 1: Bending test

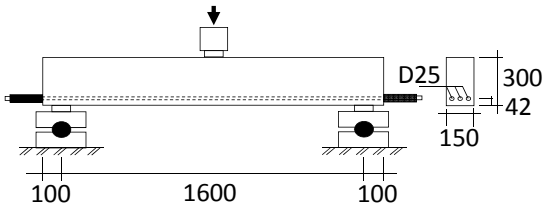

Figure 2: Simple beam test

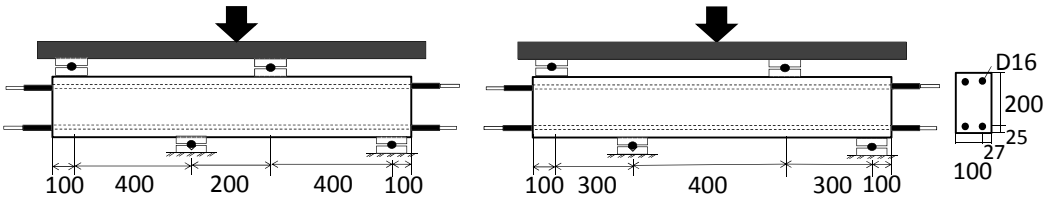

Figure 3: Anti-symmetric four-point-shear test

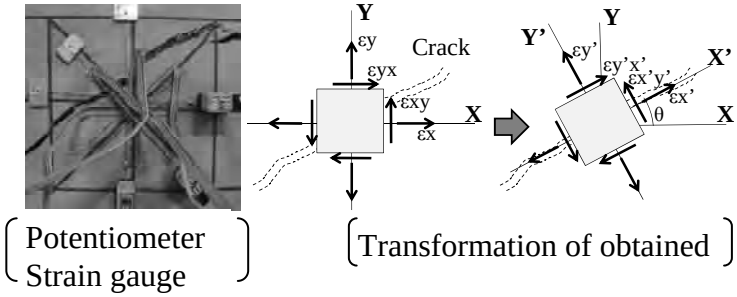

Figure 4: Measurement of strain in mid span

Fatigue loading test in simple shear beam was carried out. Details are shown in Figure 2. To avoid bending failure, high strength rebar (USD685, D25) was set as longitudinal reinforcement. Load level of fatigue test was decided as 60% for the maximum and 10% for the minimum of the static shear capacity of the same specimen (ECC: 284kN, +CA: 276kN) which had been obtained in other test.

2.4 Anti-symmetric four-point-shear beam test under static load

Static loading test in anti-symmetric four-point-shear beam was performed to investigate in the shear performance under stress rotating field. Details are shown in Figure 3. In this series, initial shear crack was introduced in short span under static loading at first (left part of Figure 3), and then loading point was changed and reloaded until the failure (right part of Figure 3). Anti-symmetric four-point-shear test was applied to conduct shear failure effectively in the middle area of span.

High strength rebar (USD685, D16) was set as longitudinal reinforcement, and no stirrup was prepared.

Tests in this series can be divided into two types. First is normal loading test, which is not introduced initial cracks, to obtain shear capacity of ECC and +CA. The other type is initially cracked as described former part. Influence of initial cracks for static shear capacity after principal stress

rotation was investigated by this test. Hereafter, the first test is abbreviated "non-precracked" and the other one is abbreviated "precracked", respectively. Added to this, initial crack was introduced in 55% of static capacity in non-precracked beam, which was considered as proper value for initial crack.

2.5 Anti-symmetric four-point-shear beam test under fatigue load

In this series, precracked type test was performed. The load value to introduce initial crack and the specimen settings are the same as static load test. Also, load level of fatigue loading is 60% for maximum and 10% for minimum of static load which was obtained from non-precracked static load test (ECC: 267kN , +CA: 210kN), respectively.

In addition, potentiometers and strain gauges were stuck on the center of middle span to investigate into strain development on the crack during fatigue loading (Figure 4). The obtained data were transformed along the crack, and "opening-closing" behavior and "shear slip" behavior was investigated. Furthermore, crack surface was observed by using microscope after the failure to know the state of PVA fibers.

3. RESULTS OF BENDING AND COMPRESSION TEST

Figure 5 shows the result of bending test for each material. As can be seen, course aggregate lower both tensile strength and ductility, and the same phenomena were observed in previous research. The reason for these phenomena is considered that the number of PVA fibers which bridge across the cracks is reduced because of the existence of aggregate, and PVA-ECC cannot perform its original tensile behavior. Added to this, the number and the distribution of multiple cracks are observed to be reduced because of aggregate.

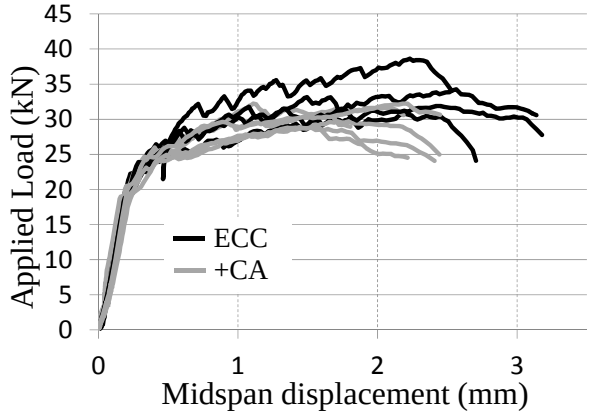

Figure 5: Result of bending test

Also, compressive strength of ECC and +CA was 37.84 MPa and 31.59 MPa by the average of 3 specimens, respectively. The reason for the reduction of compressive strength by adding aggregate is considered that aggregates produce heterogeneous stress field inside the material. Another reason may be that aggregate reduce the restriction, which performed by PVA fibers, to the perpendicular direction to loading axis during compression test.

4. RESULTS OF SIMPLE SHEAR BEAM TEST UNDER FATIGUE LOAD

Figure 6 shows the result of fatigue load test in simple shear beam. Fatigue life can be seen lengthened by adding aggregate, while there was an accident at around 7,500 cycles in the test of ECC to be loaded up to about 85% of static capacity. Considering that aggregate lower tensile and compressive property in material tests, it can be stated that shear resistance in fatigue life in beam member was improved by aggregate.

5. RESULTS OF ANTI-SYMMETRIC FOUR-POINT-SHEAR BEAM TEST UNDER STATIC LOAD

Figure 7 shows the result of static load test in anti-symmetric four-point-shear beam. In ECC materials, shear capacity of ECC-S-P dropped compared with ECC-S-N, and ECC-S-P showed little ductility around peak of load, which means brittle failure was occurred in ECC-S-P. This result is consistent with knowledge, which obtained in past research, that shear resistance of PVA-ECC on crack surface is low.

In addition, the capacity of CA-S-N exceeded ECC-S-N, which means aggregate contributed to improve static shear capacity in beam members. In another test to decide fatigue load in anti-symmetric shear beam, however, the static shear capacity of +CA was less than ECC. Generally speaking, there is considerable unevenness in static shear capacity, therefore the shear capacity of ECC and +CA can be considered as almost the same. Therefore,

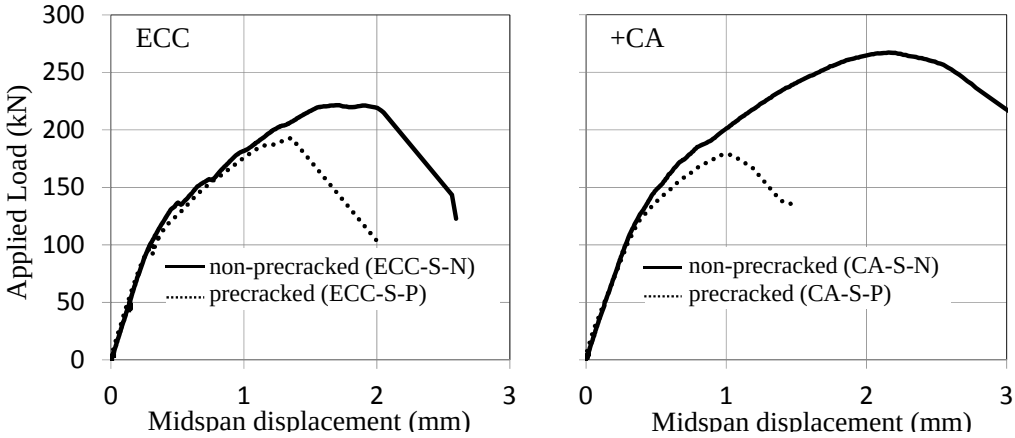

Figure 7: Result of static load test in anti-symmetric shear beam

the contribution of fiber for shear resistance is taken account in public code,

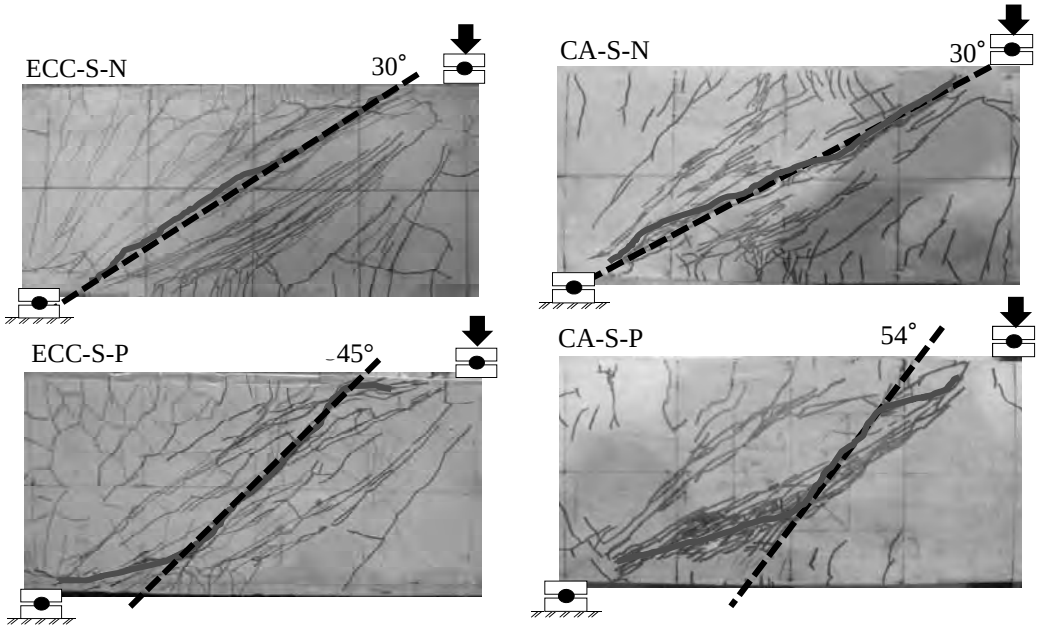

Figure 8: Crack observation after the failure

however this result implies that the fact is not completely follow the code. There is room for further investigation into the static shear capacity of +CA material.

On the other hand, there is no big difference between the shear capacity of CA-S-P and ECC-S-P, and decreasing rate of the capacity from non-precracked to precracked in +CA exceeded that of ECC. It is possible to consider that the result of this phenomenon is unfavorable distribution of aggregate in the specimen, however further investigation is required.

Furthermore, Figure 8 shows crack pattern of each specimen after the failure. In non-precracked specimens, the failure crack occurred on the line connected between the loading point and the fulcrum. On the other hand, failure crack in precracked specimens is on the initial crack, therefore it is obvious that initial crack had significant influence for shear failure. In CA-S-P, however, some cracks on the line connected between the loading point and the fulcrum are observed. This finding suggests that aggregate contributed shear resistance behavior on the initial crack, while the capacity of CA-S-P was relatively low.

6. RESULTS OF ANTI-SYMMETRIC FOUR-POINT-SHEAR BEAM TEST UNDER FATIGUE LOAD

Figure 9 shows the result of fatigue load test in anti-symmetric four-point-shear beam. As can be seen, fatigue life of +CA is longer than ECC, therefore it is clear that aggregate contributed for shear performance. Expressly, this fatigue test is in precracked condition, and considering relatively low static capacity of CA-S-P, the result shows that the contribution of aggregate is more remarkable in fatigue loading than static

loading. This tendency implies particular behavior of aggregate, therefore

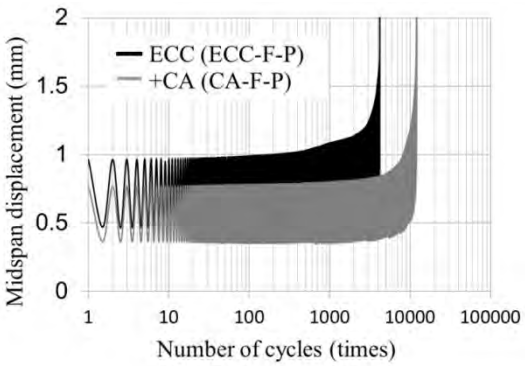

Figure 9: Result of fatigue load test in anti-symmetric shear beam

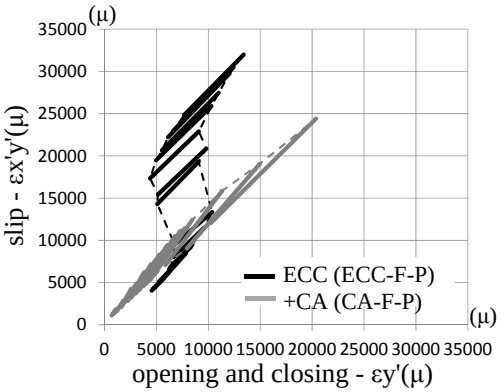

Figure 10: "opening-closing" and "shear slip" behavior on crack

the investigation from the point of view of crack "opening-closing" and "shear slip" behavior which obtained from strain measurement.
Figure 10 shows the relation of crack "opening-closing" and "shear slip" behavior until the failure. In this figure, the result from potentiometer is only shown because of accuracy of measurement.

In the beginning stage, behavior of both "opening-closing" and "shear slip" developed in ECC and +CA, from a particular point, however, "shear slip" behavior began to proceed in ECC. While the propagation rate of "opening-closing" and "shear slip" in +CA was almost constant. This result suggests the contribution of aggregate to shear resistance under fatigue loading again. From measurement by potentiometer, however, average strain in 10cm square can be obtained, therefore local strain on the failure crack, which is required to investigate into crack behavior directly, is not able to be procured by this equipment. Measurement by image data analysis is planned to be performed to obtain the local strain behavior.

Furthermore, surface of failure crack was observed by microscope after the failure. As can be seen in photos in Figure 11, PVA fiber can be hardly observed on the surface in both materials. Similar phenomenon was

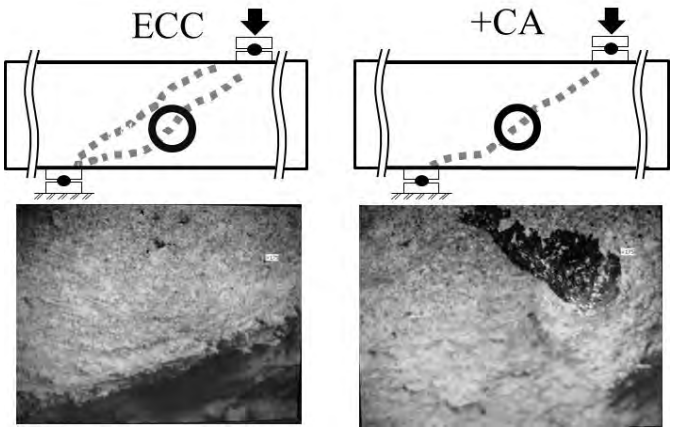

Figure 11: Observation of crack surface by microscope

also observed in previous research, and this result evinces that PVA fiber was demolished under opening, closing and slipping behavior of crack under cyclic loading. Contribution of aggregate is performed by interlocking therefore aggregate cannot prevent PVA fiber from these serious damage.

7. CONCLUSION

From previous expertise that aggregate contributes improvement of shear performance under stress rotating field, structural experiments in beam was performed in this research.

1) In bending test to investigate into tensile behavior, reduction of tensile capacity and ductility by adding aggregate was observed. Also, in compression test, the existence of aggregate lowered the compressive capacity.

2) In fatigue loading test in simple beam, certain contribution of aggregate was observed.

3) In anti-symmetric four-point-shear test under static loading with representing stress rotation field by introduction of initial crack and change of loading point, the effect of initial crack lowered static shear capacity. Especially the reduction was remarkable in the specimen of PVA-ECC with aggregate.

4) In pre-cracked anti-symmetric four-point-shear test under fatigue loading, contribution of aggregate for fatigue life was confirmed. Also, verification into “opening-closing” and “shear slip” behavior of crack clarified that the resistance of aggregate for shear is considerable.

5) From the observation of failure crack by microscope, PVA fiber was hardly observed in both materials (PVA-ECC with and without aggregate), and it was confirmed that aggregate cannot prevent PVA fiber from fracture in crack motion.

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INVESTIGATING THE INFLUENCE OF HIGHWAY MEDIAN DESIGN ON DRIVER STRESS

Ratthaphong MEESIT[1], Kunnawee KANITPONG[2]
and Piyapong JIWATTANAKULPAISARN[3]
[1] Transportation Engineering Graduate,
Asian Institute of Technology, Thailand
ratthaphongmeesit@hotmail.com
[2]Associate Professor, Transportation Engineering Program,
Asian Institute of Technology, Thailand
[3] Transportation engineer, Bureau of Planning,
Department of Highways, Thailand

ABSTRACT

The objective of this study is to investigate the effect of highway median design on driver stress. Two types of highway median were considered, including raised-curb median and painted median. 80 drivers equally distributed between males and females across two age groups (i.e., 18-30 and 31-45 years old) were invited to participate in the experiment. Physiological changes in heart rate were measured and monitored before and during the driving tests. The subjects were also asked to rate their perceived stress level at the completion of each driving test. For divided highways with raised-curb median, the results from biometric measures as well as self-perception evaluations suggest that increasing the width of inner shoulder could help to reduce driver stress load. However, we found no effect from the width of painted median, though this is probably due to low volumes of oncoming traffic during the experiment.

Keywords*: median, raised-curb, painted median, driver stress*

1. INTRODUCTION

The road geometry can affect driver performance by influencing driver's perception-reaction and driver maneuverability. The driver performance is found as a function of driver stress which can indirectly increase risk of road accidents (Rowland et al., 2008). Excess stress while driving can cause the fatigue and also influences driving performance. In previous studies, the driver stress concept has been used as an indicator to assess the efficiency of different highway geometry in terms of safety (Ackert et al., 2000; Schießl, 2006; Hill and Boyle, 2007). It was reported that drivers with high stress are more likely to involve in the road crashes than those with less stress or no stress (Hill and Boyle, 2007). Ackert et al. (2000) stated that five main factors affecting driver stress are road characteristics, traffic condition,

weather, friction condition on the road, and initial stress of a driver before driving due to psychological problems.

It is well known that the geometric design of road plays important role in the road safety. Safe road design leads to sustainable reduction in the number of road crash and crash severity. The countermeasures for improving road safety include the improvement of road alignment, sight distance, road equipment, roadside features, and cross-section. When drivers maneuver their vehicles in the dangerous situations such as braking, overtaking, encountering another vehicle, and turning onto or off a road, the amount of available road space can influence vehicle control and chances to avoid accidents. The road cross-section is therefore one of the design elements that can improve road safety, such as the design of lane width and shoulder width, and the selection of median types.

In Thailand, raised-curb median has been sometimes chosen in the design of rural highways which commonly serve high-speed traffic, in addition to its typical use for urban road design. One area that has been a safety concern is the arbitrary design of inner shoulders in the rural cross-section. Some have narrow inner shoulders of 0.5 meters wide, while many others only have an offset of 300 mm. as required by curbing. However, these may be undesirable for driving under high-speed traffic conditions because the recovery area for errant vehicles is rather limited. Since driving at high speed increases the risk of vehicles leaving the roadway, narrow lateral clearance to the physical curb implies that one must be more careful while driving, which could in turn increase driver stress load.

Another issue is concerned with the lack of the design criteria for painted median on rural highways. In recent years, painted median has increasingly been used for road widening projects in Thailand. It is still questionable, however, that what should be the appropriate width for painted median, and how they will affect the driver stress and consequently driver performance.

The objective of this study is to investigate the effect of highway median design on driver stress. Two types of highway median were considered, including raised-curb median and painted median. The next section provides an overview of driver stress and its influence on road safety. Section 3 describes the experiment design and methodology used to monitor physiological changes in heart rate as a measure of driver stress and to perform self-perception evaluation of driving stress among 80 drivers who voluntarily participated in this study. The results from the experiment are presented in Section 4. Finally, we summarize and conclude the paper in Section 5.

2. DRIVER STRESS AND ITS INFLUENCE ON ROAD SAFETY

Stress is a feeling that normally occurred when people encounter the particular situation, and the stress will stimulate the physical response of

people such as spasticity, heightened alertness, etc. Stress can be generally distinguished in two terms, which are eustress and distress. Eustress is a positive stress that occurs in a short-term period, can motivate and focus energy, is perceived as within coping abilities, make people feel exciting, and can improve performance. However, if the eustress occurs for too long, it can be developed to distress or negative stress that can cause anxiety and unpleasant feeling, is perceived as outside of coping abilities, and finally decreases performance.

Diver stress is a stress which is created on the driver while driving. It can be both positive and negative impact to driver (Matthews et al., 1996). However, distress of driver is deliberately considered in this study. To study and conduct an experiment, basic knowledge about sources of driver stress should be carefully considered. Mackenzie (2011) has revealed four main factors that can affect the level of driver stress. These factors include driving environment (high-traffic density, narrow road space, poor road surface, adverse weather, etc. (Ackert et al., 2000; Design manual for roads and bridges, 1993), driver nutrition (taking too much sugar, caffeine or alcohol influencing unbalanced body (Mackenzie, 2011), driver emotion (anger, soreness, etc.), and driver physical abilities (sickness, health problems, etc.). In this study, the driving environment factor is focused to investigate the influence to driver stress.

Stress plays an important role as an impact on driving performance and hence safety. As pointed out by Matthews et al. (1997), little stress can be advantageous for increasing driver attention. However, if the driver is under the stress for a long period of time, it can increase higher risk of road crash (Beirness, 1993). This is due to the fact that driving under the stress can cause fatigue, thus affect driver performance. Moreover, stress causes driving discomfort, irritability, and annoyance. High level of driver stress is found to decrease driving performance (Design manual for roads and bridges, 1993). Therefore, improving vehicle technology as well as a proper design of road geometry could enhance the level of safety by reducing driver stress.

3. EXPERIMENTAL DESIGN

The driver stress was measured on 40 drivers while driving on the four-lane highways divided by raised-curb median with narrow and wide inner shoulder, and another 40 drivers while driving on the four-lane highways divided by narrow and wide painted medians.

3.1 Site Selection

Four highway sections were selected in the experiment based on the similarity in number of lanes, operating speed, and traffic volume. These four highway sections are as follows:

Section 1: Highway No. 3051, four-lane highway with raised curb median, narrow inner shoulder (0.5 m.)

Section 2: Highway No. 305, four-lane highway with raised curb median, wide inner shoulder (1.5 m.)

Section 3: Highway No. 4010, four-lane highway with narrow (1 m.) painted median width

Section 4: Highway No. 4142, four-lane highway with wide (2.5 m.) painted median width

Sections 1 and 2 were selected to evaluate the effect of inner shoulder width for raised-curb median on driver stress, and Sections 3 and 4 were selected to evaluate the effect of the width of painted median on driver stress. Table 1 summarizes the road characteristics and traffic data for all four highway sections. Figure 1 illustrates the general characteristics of the four high way sections.

Figure 1: Four highways sections in the experiment.

Table 1: Road characteristics and traffic data for all four highway sections

Characteristics of the road	Section 1 and 2		Section 3 and 4	
	No.3051	No.305	No.4010	No.4142
1. Number of lanes	4	4	4	4
2. Inner lane width (m.)	3.5	3.5	3.5	3.5
3.Average traffic volume (vehicles/hour)	340	360	200	200
4. AADT (vehicles/day)	10366	19303	2894	6737
5. Operating speed (Km/h)	100-110	100-120	90-100	90-100
6. Inner shoulder (m.)	0.5	1.5	1	2.5

7. Driving distance (Km.)	8	8	8	8
8. Type of central median	Raised-curb median		Painted median	

3.2 Driver Selection

The drivers were selected based on the groups of controlled variables, age and gender. The driver age was divided into two groups, 18-30 (young driver) and 31-45 (middle-age driver) years old. Ten drivers were randomly selected for each group of age and gender. Therefore, a total of 40 drivers were selected to participate in the experiment by driving a car on the highway with narrow and wide inner shoulder on raised-curb medians, and then the driving stress was measured. Similarly, another 40 drivers were selected to participate in another experiment for the highway with narrow and wide painted median width. The same car was used in the experiment. Table 2 summarizes the drivers participated in the study.

Table 2: Drivers participated in the experiment for each type of highway median

Age	**18-30 years**		**31-45 years**	
Gender	Male	Female	Male	Female
Sample Size	10	10	10	10

3.3 Driver Stress Measurement

This study has applied two methods of driver stress measurement: the Physiological Indicator and the Self-Report Response. For the Physiological Indicator method, we drew upon the literature by using heart rate as a measure of driver stress (Hamaoka et al, 2005; Johnson et al 2011; Kueting, 1977; Mehler et al, 2008; Probst, 1976; Reimer et al, 2010; Ritz et al, 2003; Rutley and Mace, 1972; Xiao-dong et al, 2005), in addition to its simplicity and practicability for measuring the stress while driving. The Self-Report Response is also another method that can be used for driver stress assessment. In this method, the questionnaire survey was applied to investigate the level of driver stress.

Heart Rate Measurement

The driver stress can be represented by the heart rate. As the heart rate increases, the stress increases (Ritz et al, 2003). The heart rate measurement is applied to assess driver stress that is affected by several sources such as road characteristics and traffic conditions in many studies (Hamaoka et al, 2005; Johnson et al 2011; Kueting, 1977; Mehler et al, 2008; Probst, 1976; Reimer et al, 2010; Ritz et al, 2003; Rutley and Mace, 1972; Xiao-dong et al, 2005).

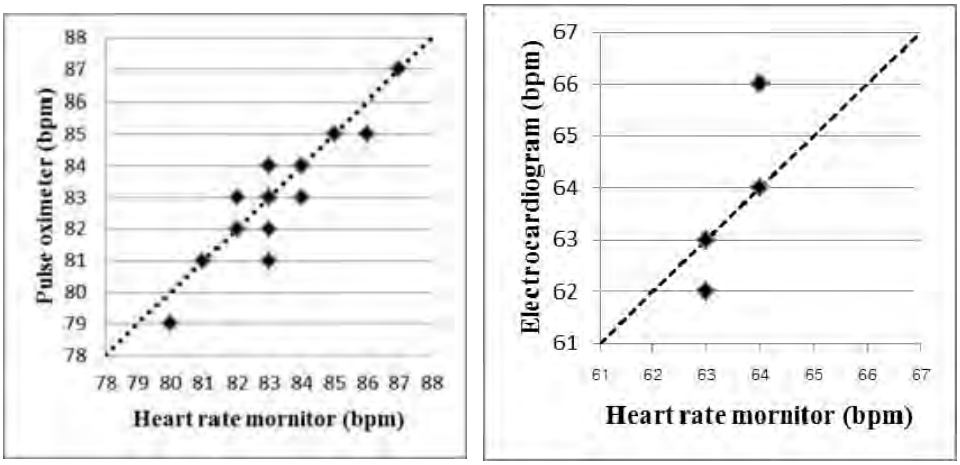
Heart rate measurement device is used for measuring the heart rate in the number of heart beats per minute (bpm). Heart rate measurement is widely used to assess driver stress because it can show number of heart beats continuously over time. In this study, a sport heart rate monitor (Polar FT4 Model) is applied as a device to measure driver stress. Polar FT4 can be

simply attached to the body of driver, and there is no interruption from the car vibration on the device. Other advantages of Polar FT4 are small feature, high accuracy, and lower cost than other equipment. Before using the heart rate monitor in this study, the calibration with other medical equipment is needed to ensure the accuracy of the heart rate measured from this device.

The heart rate monitor (Polar FT 4) was calibrated with the electrocardiogram (EKG) and the fingertip pulse oximeter. The EKG and pulse oximeter are the equipment that can correctly measure the heart rate of patients in the hospitals (Figure 2). The calibration was done under control by a professional medical technologist who has experience in measuring the heart rate. The test was conducted by wearing two types of equipment on the same person and measure heart rate by using two devices at the same time. Figure 3 shows the comparison between the average heart rate measured by heart rate monitor (Polar FT 4), EKG, and pulse oximeter. Two plots in Figure 3 present the comparable results between heart rate monitor (Polar FT 4), EKG, and pulse oximeter as the plots fall very closed to the equality line. Therefore, it can be concluded that the heart rate monitor (Polar FT4) is acceptable for the driver stress measurement, and can thus be used in this study.

(a) (b)

Figure 2: Electrocardiogram (EKG) (a), fingertip pulse oximeter and heart rate- monior (Polar FT 4) (b).



(a) (b)

Figure 3: Comparison between heart rate measured by heart rate monitor (Polar FT- 4), and fingertip pulse oximeter (a), EKG (b).

Questionnaire survey

Many studies have applied the questionnaire survey method to assess the driver stress (Hill and Boyle, 2007; Reimer et al, 2010; Gulian et al, 1989; Harrison, 2009; Matthews et al, 1997; Reason et al, 1990; Westerman and Haigney, 2000). In addition to monitoring the drivers' heart rate as a physiological measure of driver stress, this study also interviewed the drivers about their feelings on the stress level when driving on the road with different types of road medians. A questionnaire was designed by using the rating scale which is normally used for the estimation of quantitative driver's feeling (See Table 3). The questionnaire consists of three parts, including (1) personal characteristics, (2) driving characteristics, and (3) driver's opinion. The level of stress reported by the driver was determined in the last part of the questionnaire.

After driving a car on different types of road medians, an individual driver was interviewed to rate his/her perceived stress level while the driving tests. The pictures of the exact locations where the driving experiment was conducted were also presented during the interview. The answer is in a rating scale, ranging from 1 (not at all) to 5 (very much).

Table 3: Questions in questionnaire survey

No.	**Personal Characteristics**	**Answers**
1	Gender	☐ Male ☐ Female
2	Age	……..Years
3	Educational background	☐ Undergraduate ☐ Graduated
4	Career	☐ Student ☐ Worked
5	Are you always quick-tempered while driving?	☐ Never ☐ Rarely ☐ Sometimes ☐ Often ☐ Always
6	Are you always in rush while driving?	☐ Never ☐ Rarely ☐ Sometimes ☐ Often ☐ Always
No	Driving Characteristics	Answers
7	Driving Experience	……Years
8	Types of car	☐ Pick-up ☐ Sedan

9	How often do you drive on this highway per week?	☐ Never ☐ Rarely ☐ Sometimes ☐ Often ☐ Always
10	Do you have stress or pressure when you are driving a car on the inner lane as shown in pictures below?	
	 Raised median (narrow inner shoulder) ☐ Not at all ☐ Very little ☐ Somewhat ☐ Much ☐ Very much	 Raised median (wide inner shoulder) ☐ Not at all ☐ Very little ☐ Somewhat ☐ Much ☐ Very much
	 Painted median 1.0 meter ☐ Not at all ☐ Very little ☐ Somewhat ☐ Much ☐ Very much	 Painted median 2.5 meters ☐ Not at all ☐ Very little ☐ Somewhat ☐ Much ☐ Very much

3.4 Pilot Study on Measuring Driver Stress

A pilot study was conducted to examine how to properly measure the driver stress level while driving. In doing so, two drivers with different ages and driving experiences were asked to participate in a driving test. The first driver is a 35 years old male with 13 years of driving experience, and the second driver is a 59 years old male with 35 years of driving experience. They both were instructed to drive along a straight section of a four-lane highway for 8 kilometers and maintain the speed at 100-110 kph. The heart rate monitor (Polar FT 4) was used to measure their heart rate at every 5 seconds, starting two minutes before driving until the driving test was completed. In addition, a video camera was installed in the test car to monitor driving conditions and possible incidents that could affect driver stress such as vehicle or pedestrian crossing, unexpected or immediately changing lane of a vehicle in front. Each of the drivers was asked to perform this driving test twice.

After the driving test, the heart rate messured at every 5 seconds was ploted against the driving period in seconds and the driving distance in kilometers as shown in Figures 4 and 5. We found similar results for both drivers in that their heart rates during the first driving test tended to be higher than those measured during the second driving test. This could be due to the fact that both drivers were nervous during the first driving test and were later getting used to the experiment during the second driving test. In addition, it was found that the drivers' heart rate increased suddenly at the beginning of the driving tests, and then declined gradually until it became stable at certain levels which were still higher than the initial heart rates measured before starting the driving tests. This result is consistent with the study by Hunt et al (1968). In that people have a higher average heart rate while driving, probably due to a driver stress that normally occurs while driving a car in the road environment.

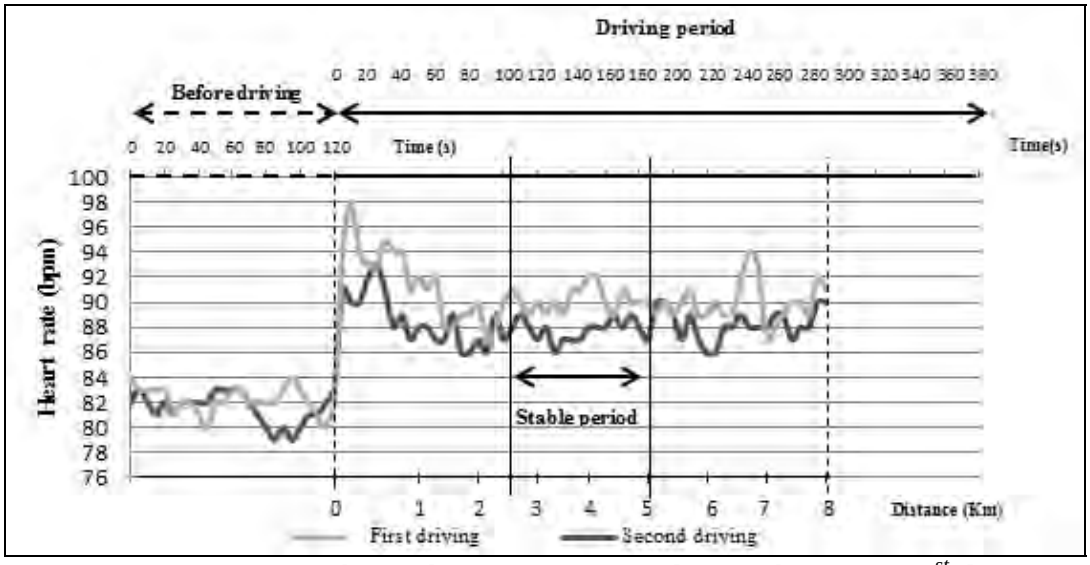


Figure 4: A pilot study on measuring a driver's heart rate (1st driver)

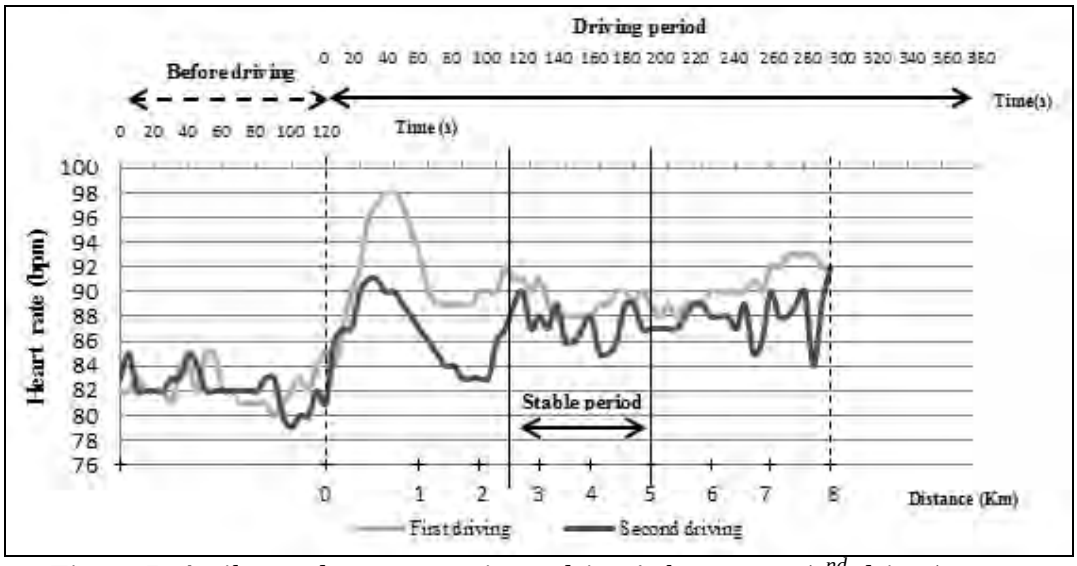


Figure 5: A pilot study on measuring a driver's heart rate (2nd driver)

Given the above findings, it was necessary to determine a period for which drivers' heart rates appeared to be stable in calculating the average heart rate while driving. As can be seen in Figure 4 and 5, for example, both test drivers seemed to have similar stable periods, starting approximately at 100 seconds from the beginning of the driving test until they drove about 5 kilometers. These suggest that it was only the first 5 kilometers of the driving test when the drivers' heart rates remained be stable, though the test drivers performed the driving test for 8 kilometers.

Based on the pilot study described above, the heart rate measurement procedures for the driving experiment can be concluded and summarized as follows:

1) A driver was given a full instruction for participating in the experiment. For example, the driver must have a full rest, no alcohol, or caffeine, or energy drink before driving test. This was to avoid any stress resulting from other external factors.
2) Prior to the test, the heart rate monitor was attached to the body of driver. Gel or glue was applied to the driver body for good attachment of the heart rate monitor in order to increase the measurement efficiency.
3) The temperature inside the car was controlled at 25 C for driver comfort.
4) Drivers were allowed to drive the test car for a certain period of time to adjust themselves before the experiment starts. During the experiment, they were instructed to drive at 100-110 km/h along 8 km. in the high-speed right lane on the straight section of the road. Each of the participants was asked to perform the driving test twice, and only the heart rate measurement from the second driving was used for the calculation of average heart rate.
5) Drivers' heart rates were simultaneously measured starting 2 minutes before driving until the test drive along 8 km. of the road was completed. During the driving period, a research assistant was seated quietly in the back of the care to record the data so as to avoid any interference to the driver. Given a limitation for the driver stress

measurement from the real driving test that some incident or unexpected circumstance might take place and could not be controlled as perfectly as a test undertaken using a driving simulator, the video image of the road condition during the driving test was taken.

6) The average heart rates before and during driving were calculated, and their variation could represent driver stress due to driving along the road section. In the case that the video image taken during the driving test indicated any incident or unexpected circumstance that could affect driver heart rate, the heart rate data recorded during incident or unexpected circumstance was excluded in the analysis.

4. ANALYSIS AND RESULTS

4.1 Effect of Inner Shoulder Width of Raised-Curb Median on Driver Stress

Results from Heart Rate Measurement

Based on the heart rate data measured from the driving test as previously described, an individual increase in heart rate is calculated using Eq.1.

$$IncHR_i = \text{Driving Heart Rate}_i - \text{Initial Heart Rate}_i \quad (1)$$

where

$IncHR_i$ = Increase in heart rate of i^{th} driver
Initial Heart Rate $_i$ = Average of heart rate of i^{th} driver measured for 2 minutes before driving
Driving Heart Rate $_i$ = Average of heart rate of i^{th} driver measured while driving

From the experiment, increases in heart rate while driving along 4-lane divided highways with raised curb median are summarized in Table 4. Overall, the results show that the driver stress occurred as the average of the heart rate measured while driving was about 3.0-4.5 bpm higher than that measured before driving. Increases in heart rate are found to be varied, depending upon differences in age and gender of drivers as well as inner shoulder width of raised-curb median. For the latter, we found that increases in heart rate while driving along the road with a narrow inner shoulder (0.5 m.) tended to be higher, compared to those measured for the road with a wide inner shoulder (1.5 m). The null hypothesis that there is no difference in the average increases in heart rates between these two driving situations can be rejected at the 5% significant level. This could imply that the width of inner shoulder for raised-curb median significantly affects the driver stress. With respect to age and gender, we found statistical evidence that young female drivers (aged from 18 to 30) tended to have higher stress when driving on the road with the narrower inner shoulder width.

Table 4: Increases in heart rate while driving along 4-lane divided highways with raised-curb median

Age (Years)	Gender	Narrow inner shoulder of 0.5m width		Wide inner shoulder of 1.5m width		Hypothesis test: Difference in Mean (p-value)
		Mean (bpm)	Standard deviation	Mean (bpm)	Standard deviation	
18-30	Male	4.006	4.076	3.055	3.751	0.1891
	Female	4.654	4.918	3.557	4.311	0.0165 **
31-45	Male	4.470	2.378	4.232	2.531	0.3751
	Female	3.859	2.897	3.832	3.389	0.9639
All drivers		4.248	3.574	3.669	3.443	0.0277 **

*Note: ** indicates significance at the 1% level, ** indicates significance at the 5% level, * indicates significance at the 10% level.*

Results from Questionnaire Survey

When analyzing the data from the questionnaire survey, the results are practically similar to those based on assessing driver stress through direct measurement of heart rate. As shown in Table 5, examining the self-reported stress rating scale reveals that drivers felt more stress while driving along the road with a narrower inner shoulder width. Similar findings have also been obtained when analyzing the data with respect to age and gender.

Table 5: Self-reported stress level towards driving along 4-lane divided highways with raised-curb median

Age (Years)	Gender	Narrow inner shoulder of 0.5m width		Wide inner shoulder of 1.5m width		Hypothesis test: Difference in Mean (p-value)
		Stress rating scale	Standard deviation	Stress rating scale	Standard deviation	
18-30	Male	2.000	0.942	1.600	0.699	0.0368 **
	Female	2.700	0.948	2.000	0.816	0.0445 **
31-45	Male	2.800	1.398	2.100	0.875	0.0095 ***
	Female	2.100	1.286	1.500	0.707	0.0237 **
All drivers		2.400	1.172	1.800	0.791	0.0000 ***

*Note: *** indicates significance at the 1% level, ** indicates significance at the 5% level, * indicates significance at the 10% level.*

4.2 Effect of Painted Median Width on Driver Stress

Results from Heart Rate Measurement

The results from applying Eq.1 to the heart rate data measured from the driving tests along the highways with painted median are presented in Table 6. Overall, we found that the average increases in heart rate were practically higher in the case of narrow painted median. An exception is the heart rate data obtained from young female participants, in which an opposing result was found. However, such differences were not statistically significant. Although this finding would imply that enhancing the design of painted median could not reduce driver stress, it was also likely that we were unable to capture the effect of painted median width due to the fact that the driving experiment was carried out under low-traffic conditions (i.e., average 144 vehicles per hour of oncoming traffic counted during the

driving tests for narrow painted median, and average 228 vehicles per hour for wide painted median).

Table 6: Increases in heart rate while driving along 4-lane divided highways with painted median

Age (Years)	Gender	Narrow painted median of 1.0 m. width		Width painted median of 2.5m width		Hypothesis test: Difference in Mean (p-value)
		Mean (bpm)	Standard deviation	Mean (bpm)	Standard deviation	
18-30	Male	4.571	3.931	4.140	5.526	0.6558
	Female	4.099	5.289	4.492	5.610	0.6125
31-45	Male	2.665	1.422	2.420	2.570	0.6774
	Female	4.153	4.625	2.923	3.102	0.2333
All drivers		3.872	3.995	3.494	4.336	0.3555

*Note: *** indicates significance at the 1% level, ** indicates significance at the 5% level, * indicates significance at the 10% level.*

Results from Questionnaire Survey

When asking all the 40 participants to express to what extent they felt stress which was then converted into the 1-to-5 rating scale, the results as summarized in Table 7 suggest that the width of painted median did not seem to affect driver stress. We found that the average stress rating scales from the experiment with narrow painted median were generally higher, though only marginally. Our statistical tests also confirmed that in the present study, participants felt no difference in their stress levels with respect to different widths of painted median.

Table 7: Self-reported stress level towards driving along 4-lane divided highways with painted median

Age (Years)	Gender	Narrow painted median of 1.0 m. width		Width painted median of 2.5m width		Hypothesis test: Difference in Mean (p-value)
		Stress rating scale	Standard deviation	Stress rating scale	Standard deviation	
18-30	Male	2.200	0.788	2.100	0.737	0.3434
	Female	2.600	1.075	2.700	1.059	0.3434
31-45	Male	2.500	0.707	2.400	0.699	0.3434
	Female	2.500	0.971	2.400	0.965	0.3434
All drivers		2.450	0.876	2.400	0.871	0.3234

*Note: *** indicates significance at the 1% level, ** indicates significance at the 5% level, * indicates significance at the 10% level.*

4.3 Contributing Factors Affecting Driver Stress

To examine the factors that could affect driver stress, the ordered logistic regression technique has been applied to the data from the questionnaire survey. The self-reported stress level towards type of highway median has been regressed against socio-economic and other factors using ordered logit models. The dependent variable is the 1-to-5 stress rating scale, with five orders defined as -1 for ‘not at all’, 2 for ‘very little’, 3 for ‘somewhat’, 4 for ‘much’, and 5 for ‘very much’. The independent variables considered in the analysis, as summarized in Table 8, include socio-

economic characteristics of the drivers, such as gender, age, education, occupation, personal habits, driving characteristics, such as driving experience, vehicle type, and driving frequency, and type of highway median. Testing multicollinearity indicates that there was no correlation among these variables.

Table 8: Definitions of the independent variables

Variables	Definition
GENDER	Gender : 1 = female, 0 = otherwise
AGE	Age
EDUCATION	Education: 1 = lower than Bachelor degree 0 = otherwise
OCCUPATION	Occupation: 1 = student, 0 = otherwise
EXPERIENCE	Years of driving Experience
VEHICLE	Type of vehicle commonly used 1 = car 0 = otherwise
DRIVING FREQ	Frequency of driving along the highway section 1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = always
TEMPER	Frequency of being quick-tempered while driving 1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = always
RUSH	Frequency of being in a rush while driving 1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = always
MEDIAN	Type of highway median • Raised-curb median 1 = wide inner shoulder of 1.5m width 0 = otherwise • Painted median 1 = wide painted median of 2.5m width 0 = otherwise

Table 9: Results from examining factors affecting self-reported stress level

Variables	Model 1: Stress Level towards Raised-Curb Median Highway		Model 2: Stress Level towards Painted-Median Highway	
	Coefficient	Significant Level	Coefficient	Significant Level
GENDER	0.536		-0.668	
AGE	0.083			
EDUCATION	-0.883		0.693	
OCCUPATION	-0.374			
EXPERIENCE	-0.138	*	-0.089	**
VEHICLE	-0.152		0.045	
DRIVING FREQ	-0.007		-0.920	**
TEMPER	0.086		-0.178	
RUSH	0.576		1.347	***
MEDIAN	-1.113	**	-0.155	
Log Likelihood	-97.879		-78.395	
Number of observations	80		80	

Note: *** indicates significance at the 1% level, ** indicates significance at the 5% level,
* indicates significance at the 10% level.

Table 9 presents estimation results from the ordered logit models. The estimated coefficients indicate whether and the extent to which factors could affect driving stress level. For highways with raised curb median, results from Model 1 suggest that drivers with longer years of driving experience are more likely to have less driving stress. This could be due to their driving skills that have been developed through the experiences, thereby making the drivers feel more confident and less tension while driving. With respect to the type of median, it is found that its estimated coefficient is statistically significant at the 5% level and has a negative sign. This suggests that driving on highways with wider inner shoulder is more likely to have less driving stress. This finding is consistent with other previous studies, showing the cross-section of highways has a great impact on driver stress. Wide shoulder provides more lateral space for drivers, which could in turn cause less stressful driving condition, especially along high-speed highways.

For highways with painted median, results from Model 2 indicate that driving experience, driving frequency, frequency of being in rush while driving are significantly related to the extent to which drivers feel stressful. The negative coefficients of "EXPERIENCE" and "DRIVING FREQ" variables imply that drivers with longer driving experience and those who travel more frequently along this highway section are more likely to have less driving stress. In addition, we find that drivers who travel in rush more frequently tend to have more driving stress as indicated by the positive coefficient of the "RUSH" variable. With respect to the width of painted median, however, the results in the study suggest that it does not significantly affect the drivers' perceived stress level.

5. SUMMARY AND DISCUSSION

Evidence revealed in this paper lends support to the notion that a proper design of road geometry could help to reduce driving stress on the road. The experiment was designed to evaluate the effect of highway median design on driver stress. Two types of highway median were considered, including raised-curb median and painted median. Data were collected from 80 drivers equally distributed between males and females across two age groups: 18-30 and 31-45 years old. The first 40 drivers were asked to drive along two highways with raised curb median that have different widths of inner shoulder. Physiological changes in heart rate were measured and monitored before and during the driving tests. Following the completion of the driving tests, the drivers were asked to assess their perceived stress level during the driving tests by completing a short questionnaire, which also included questions related to personal information. The same procedure was applied to investigate the effect of painted median widths on driving stress among the remaining 40 drivers.

For raised-curb median, the results showed that both increases in heart rate while driving and self-reported stress levels were significantly higher for the driving test along the road section with narrow inner shoulder. As driver stress load is related to safety and performance behind the wheel, this

finding suggests that the driver's well-being could be enhanced by increasing the width of inner shoulder for divided highways with raised-curb median. With respect to divided highways with painted median, the experiment in this study indicated that neither heart rate as physiological measure of driver stress nor perceived stress level was related to the design of the median width. However, this could be due to the fact that the driving experiment was carried out under low-traffic conditions. Future work is needed to explore the likely effects of painted median width on driver stress at high volumes of oncoming traffic.

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STUDY ON TRANSPORT PHENOMENON IN MORTAR USING THE CESIUM CARBONATE AS A TRACER BY X-RAY CT

Shohei IKEDA[1], Takafumi SUGIYAMA[2], Takasumi KIKKAWA[3] and Kazunori SHIMURA[4]
[1]Graduate Student School of Eng., The University of Hokkaido, Japan
heisho412@yahoo.co.jp
[2]Professor, Ph.D, The University of Hokkaido, Japan
[3]Graduate Student School of Eng., The University of Hokkaido, Japan
[4]Assistant Professor, D.Eng, The University of Hokkaido, Japan

ABSTRACT

Examine the mobility of cesium carbonate solution using a prism specimen having a notch by micro-focus X-ray CT. When cesium carbonate solution has 20wt%, 40wt% and 60wt%, it is found that the amount of penetration and the CT value is different depending on the concentration.

Keywords*: cesium carbonate, X-ray CT, X-ray contrast agent, CT value*

1. INTRODUCTION

In concrete structure, cracks may cause due to various reasons such as a load, drying shrinkage. Various problems such as salt damage and carbonation have arisen in the structure having a crack, and they cause the degradation of water-tightness and durability of the structure. The crack is the pathway of entry of deterioration factors such as water, chloride ion and carbon dioxide. Therefore numerous studies about the crack have been carried out in the past. However, the transport phenomenon is often studied by the crack width and length of the outside of the structure, and the elucidation of the mechanism of transport inside the structure is required. The usage of X-ray CT is effective to understand the internal structure, so various studies have been in Japan. It is confirmed that confirm cesium carbonate is excellent as X-ray contrast agent for the detection of cracks in some studies by Otsuka, so we decide to use cesium carbonate as a tracer to simulate the process of liquid ingress in concrete with crack in this study.

2. OUTLINE OF EXPERIMENT

2.1 X-ray contrast agent

Cesium carbonate is used to visualize the movement of water in the cracks. This is the X-ray contrast agent and emphasizes certain parts of the image with a contrast. Because cesium carbonate is material having X-ray absorption rate differs significantly from the surrounding material. In X-ray CT, material which does not absorb the X-ray is black and material which absorbs this is white. For example, air is black and material having high density is white. The density of cesium carbonate used this experiment is bigger than the density of the material of mortar, so cesium carbonate is white in the image.

2.2 CT value

Light and shade of the image got in the X-ray CT is based on the CT value. It is the number that defined in equation (1) by using the X-ray absorption coefficient of object. It is generally believed that the CT value is proportional to the density of object.

$$C = (\mu_t - \mu_w) / \mu_w \times K \quad (1)$$

C: CT value, μ_t: X-ray absorption of object, μ_w: X-ray absorption of water, K: proportionality constant

2.3 Prepared mortar

Table 1 shows the mix proportion and Table 2 shows the materials used. Grain size of fine aggregate was less than 1.7mm. Driving to the type of frame 40×40×160mm fresh mortar, frame removal was 24 hours later. Thereafter, curing was carried out 320 days in water.

Table 1: The mix proportion

	W/B (%)	**Unit quantity(kg/m^3)**				**Air content (%)**	**Compressive strength (N/mm^2)**
		W	**C**	**S**	**AE agents**		
P	50	274	548	1370	0.016	5.2	45.7

Table 2: The materials used

Material	Type	Density (g/cm^3)
Cement	Ordinary Portlandcement	3.16
Fine aggregate	Crushed sand	2.67
AE agent	Alkyl ether	
X-ray contrast agent	Cesium carbonate powder	4.07

2.4 Experiment with prismatic specimens

Examine that cesium carbonate solutions having the different concentrations are going to penetrate to the interior of mortar with time by using prismatic specimen with a notch.

2.4.1 Preparation of prismatic specimens

Figure 1 shows the specimen dimensions and axes. Size of the specimen is 20×20×40mm and shape is prism. Provide with a notch having about 2mm in width, 20mm in height on the bottom. There are three test pieces. Affix the adhesive tape to the side only to prevent the penetration of cesium carbonate solution from the side in immersion time. Because penetration is only from the bottom.

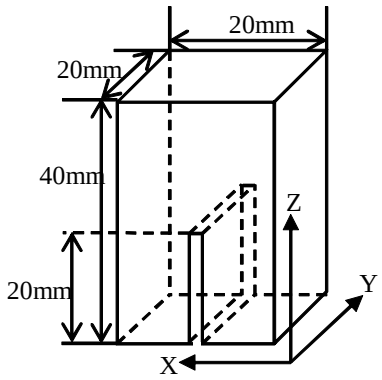

Figure 1: The specimen dimensions and axes

2.4.2 Experimental condition

Their test pieces were immersed in cesium carbonate solution having 20wt%, 40wt% and 60wt%. Height of immersion is 2mm from the bottom. Immersion time is 3h and 12h and 24h. Mass change is measured and the transport of cesium carbonate is investigated by X-ray CT. The density of each solution used this experiment is 1.20g/cm^3(20wt%), 1.47g/cm^3(40wt%), 1.91g/cm^3(60wt%). The density is determined from average of a total of three times measurement of mass and volume of solutions.

3. RESULT AND DISCUSSION

3.1 Experiment with prismatic specimens

Create X-Z cross-sectional images and the line profile of CT values from the images. Consider about the migration behavior of cesium carbonate solution from the dates created and the relationship between amount of penetration and immersion time.

3.1.1 Experiment by using cesium carbonate solution having 20wt%

In the image for 3h, cesium carbonate solution has risen to the top notch and penetrated a little from the notch surface already. Thereafter, the range of penetrating specimen is spread and white has been shown deep over every time.

Figure 5 shows X-Z cross-sectional image (y=10mm) of immersion for 24h and Figure 6 shows the line profile of the CT values (z=10mm). It is

found that white in the image of immersion for 24h has been shown to be deeper than the image of immersion for 3h and 12h because the CT values of surface notch and the range of penetration. However, the difference of the CT values of the penetration part and non-penetration part is small and it is difficult to determine visually the front penetration in the image. From Figure 6, the CT values were below the 0 in notch part and outside of specimen because there is air and it does not absorb the X-ray. In the mortar part of specimen, CT values were 350 to 400 because it absorbs the X-ray. In part of penetration of cesium carbonate solution, CT values were 400 to 500 and bigger than the mortar part because cesium carbonate absorbs X-ray. At the surface notch, the CT value was approximately 740 and the biggest in the line profile. This is estimated that cesium carbonate adheres to the surface notch and absorbs a lot of X-ray.

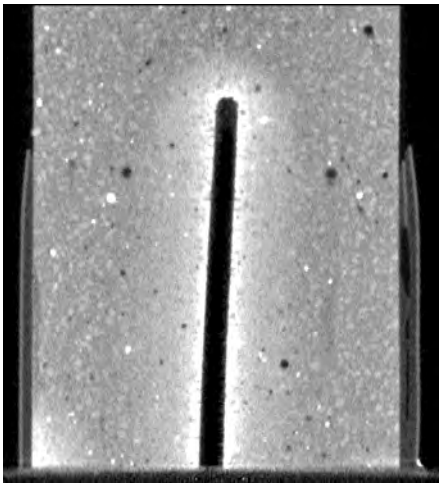

Figure 5: X-Z cross-sectional image (y=10mm) of immersion for 24h

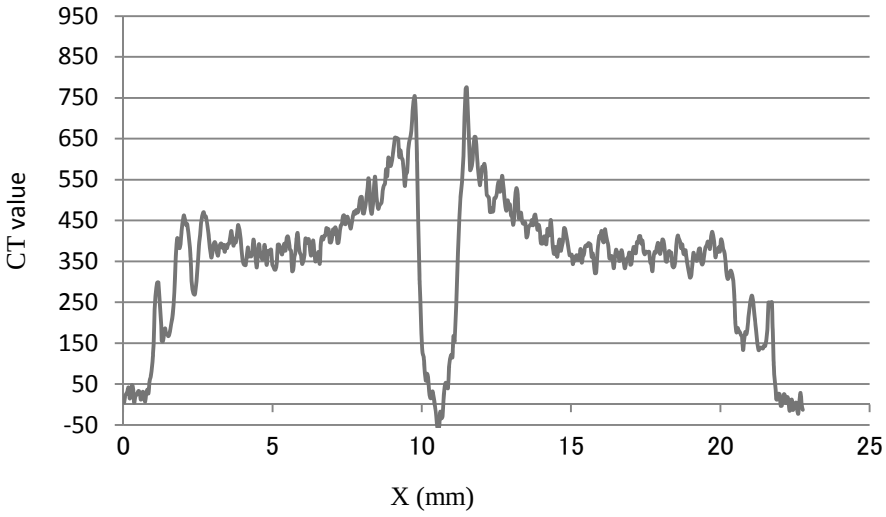

Figure 6:The line profile of the CT values (z=10mm)

3.1.2 Experiment by using cesium carbonate solution having 40wt%

In the image and the line profile of the CT values of each time, cesium carbonate solution has risen to the top notch and penetrated to mortar from the notch surface already. This state is similar to state of 20wt%. The CT values of the notch surface and penetration part in 40wt% is bigger than the CT values in 20wt%, but the penetrative depth in 40wt% nearly equals the penetrative depth in 20wt%. It is decided that the penetrative range in 40wt% nearly equals the penetrative range in 20wt%. In addition, the difference of the CT values of the penetration part and non-penetration part is slightly big it is easy to determine visually the front penetration in the image of immersion for each time because this is estimated that the density of cesium carbonate solution having 40wt% is big and there are a lot of the penetrating cesium carbonate.

Figure 7 shows X-Z cross-sectional image (y=10mm) of immersion for 24h and Figure 8 shows the line profile of the CT values (z=10mm). From Figure 8, the CT values were 350 to 400 in mortar part and this result is similar to the result of 20wt%. The CT values of penetration part are bigger than the CT values of mortar and 400 to 650 because cesium carbonate absorbs X-ray. The CT value of the surface of notch is the biggest in the line profile of 40wt% and approximately 780 and bigger than 20wt%.

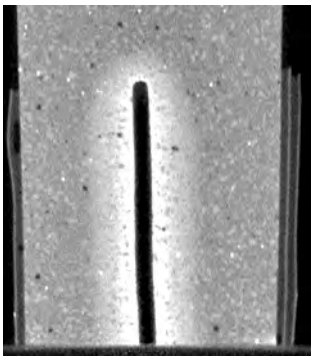

Figure 7: X-Z cross-sectional image (y=10mm) of immersion for 24h

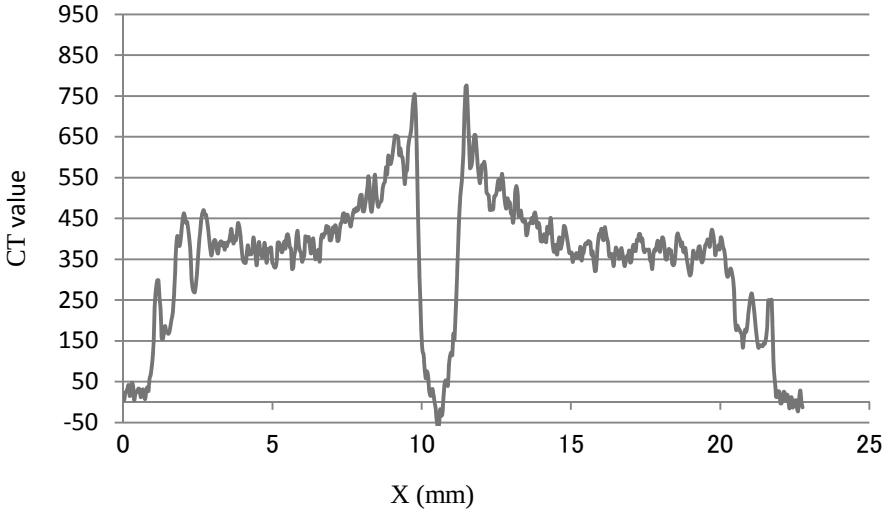

Figure 8: the line profile of the CT values (z=10mm)

3.1.3 Experiment by using cesium carbonate solution having 60wt%

In the image and the line profile of the CT values of each time, cesium carbonate solution has risen to the top notch and penetrates to mortar from the notch surface already. This state is similar to state of 20wt% and 40wt%. The CT values of the notch surface and penetration part in 60wt% is bigger than this in 20wt% and 40wt%, but the penetration depth is small. This is estimated that the resistance to penetration into the mortar is increased because the density of cesium carbonate solution having 60wt% is big. In addition, it is easy to determine visually the front penetration in the image of immersion for each time because the difference of the CT values of the penetration part and non-penetration part is slightly big.

Figure 9 shows X-Z cross-sectional image (y=10mm) of immersion for 24h and Figure 10 shows the line profile of the CT values (z=10mm). From Figure 10, the CT values were 350 to 400 in mortar part and this result is similar to the result of 20wt% and 40wt%. The CT values of penetration part are bigger than the CT values of mortar and 400 to 780. The CT value of the surface of notch is the biggest in the line profile of 60wt% and approximately 900 and bigger than 20wt% and 40wt%.

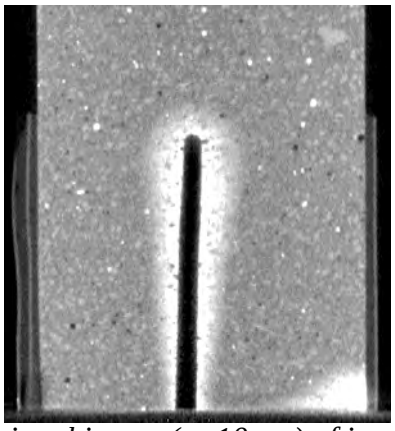

Figure 9: X-Z cross-sectional image (y=10mm) of immersion for 24h

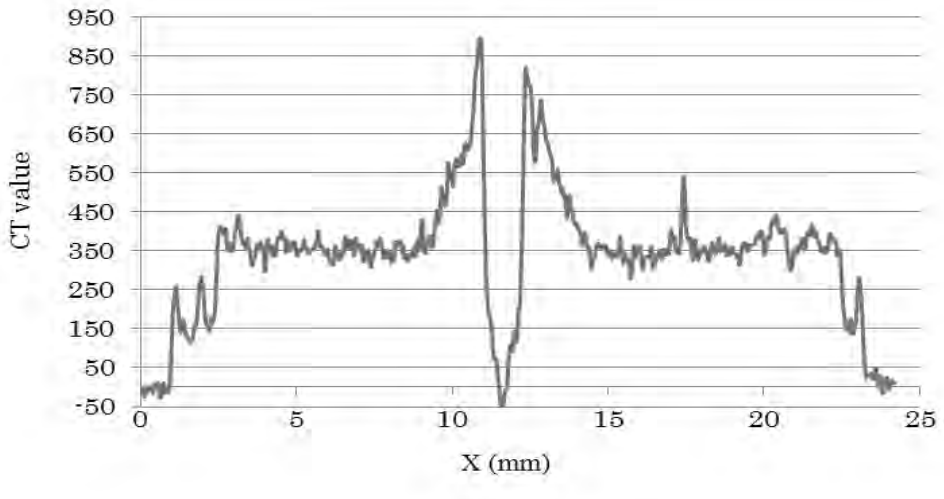

Figure 10: the line profile of the CT values (z=10mm)

3.1.4 The relation between immersion time and amount of penetration

Calculate the amount of penetration from the density of each cesium carbonate solution and results of the mass measurement. Figure 11 shows the relation between immersion time and amount of penetration. From Figure 11, over half cesium carbonate solution penetrated into specimen for 24h penetrates for 3h. But penetration velocity is decreased for 3h to 12h and 12h to 24h. The amount of penetration in 40wt% is about half of the amount of penetration in 20wt%. The amount of penetration in 60wt% is the lowest in 3 types of solutions. It is estimated that cesium carbonate solution having the density is close to the water penetrates many to mortar through the notch.

It is determined that the penetrative range in 40wt% nearly equals the penetrative range in 20wt%, but the amount of penetration in 20wt% is larger than 40wt%. It is estimated that cesium carbonate solution in 20wt% penetrates to the range of penetration determined by the image and the line profile of CT values.

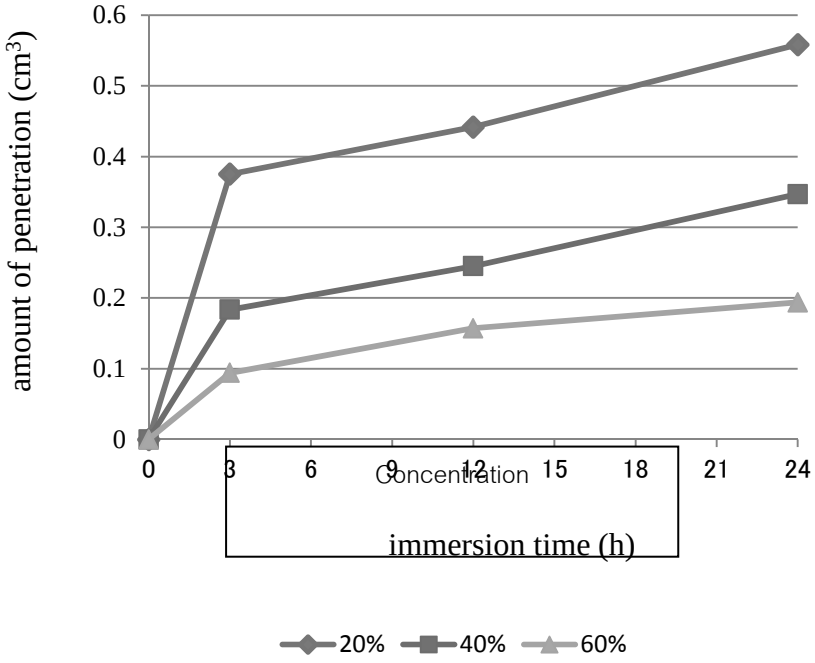

Figure 11: the relation between immersion time and amount of penetration

4. CONCLUSION

It is possible to visualize the movement of cesium carbonate in mortar by using cesium carbonate. It shows that the amount of penetration to mortar and the CT values is difficult by each concentration. However, it is necessary to examine in detail the nature of cesium carbonate solution about the relevance of moisture movement in the future.

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SERVICE INNOVATION FOR DISASTER RESPONSIVENESS WITH MULTI-SPATIAL INFORMATION SHARING

Kulapramote PRATHUMCHAI[1], Masahiko NAGAI[2]
[1] Graduate Student School of Engineering and Technology, RS/GIS,
Asian Institute of Technology, Thailand
st113954@ait.ac.th
[2] Associate Director, Geoinformatic Center,
Asian Institute of Technology, Thailand
nagaim@ait.ac.th

ABSTRACT

The disaster responsiveness activities are a kind of service, which interface between government to civilians and business to customer or NGO to people. When a disaster occurs, the critical performance of disaster relief operations is timely responsiveness, which can reduce human suffering and lives lost. Since disaster management is required spatial information for decision making, therefore, multi sources of the spatial information would need to integrate for responding to the help requests which are highly dynamic according to disaster situations. The propose of method, how to implement the multi-spatial information and mapping technology can be a service innovation to improve on the disaster responsive service.

Keywords*: disaster responsiveness, service, spatial information, flood, social medias*

1. INTRODUCTION

1.1 Background

Thailand's worst flood in five decades has occurred during September until December 2011. Flood has destroyed a number of industrial parks and put thousands of factories out of commission. The cost of flooding damage is widely estimated to reach $ 2500 Billion.

It became apparent that activities in the disaster response such as evacuation and critical assistance need an improvement for better management. In order to achieve a higher level of efficiency and accountability in handling those activities, real time or up-to-date data is crucially needed for supporting a decision making as a service.

1.2 State of Problem

Multi-spatial information can be gathering from many sources and in verities format. Spatial information is involving to the data, which contain the geographic information. One source of information that most live in real time is data from internet, through social network application.

1.3 Objective of the Study

Objective of this study is attempting to integrate and handle multi-spatial information applying for flood disaster responsive improving along with concept of service innovation. Specific Objectives is bellow.

- Propose service innovation for flood responsiveness improvement
- Review and pre-analysis on multi-spatial information to support in disaster responsiveness service

2. LITERATURE REVIEW

Service innovation is a combination of technology innovation, business model innovation, social- organizational innovation and demand innovation with the objective to improve existing service systems, create new value propositions or create new service systems. Often radical service innovation will create a large population of new customers. Service innovation can also result from novel combinations of existing service elements. (IfM and IBM, 2008)

2.1 Service Case Study of flood responsiveness

Disaster management can be described as the processes of guiding, coordinating and allocating all resources from all related organizations. The management can be divided into three phases as follows:

- Preparation and Prevention activities prior to disasters
- Response activities during disasters
- Recovery and Reduction activities after disasters

2.2 Case Study of Flood Volunteer Working Group

As providing of the information from government and television could not supply the trust of people therefore the social media become one powerful channel that people can access and get the update the real situation of flood event. There are many groups formed the team and delivered information via the social media, Facebook. “Rootannam” is one of the volunteer working groups. This flood volunteers working group has been selected to study on the service term and considering the probability to improve their service. The service is illustrated as the working concept diagram in figure 1 as follow.

Figure 1: Working plan concept diagram of Rootannam's working group

2.3 Using Service Blueprint to visualize and analyze service

One method of measuring the effectiveness of specific services processes is called services blueprinting, a method by which services can be analyzed, and even visualized, from the customer perspective.(W.P. Carey School of Business ,2008) Service blueprint can clarify interaction between customer interactions, employee roles, operational processes and information technology. This process is attempting to apply service blueprint for the flood working group activities service. The tasks on service of the working group of Rootannam can be analyzed for the detail of service has been shown in figure 2.

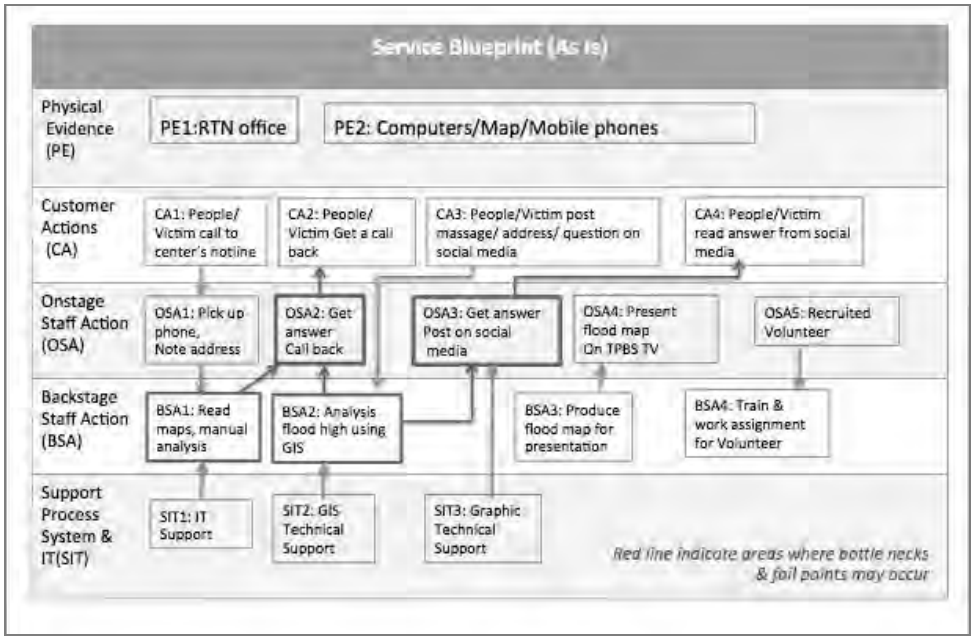

Figure 2: Detail service blue print of Rootunnum

The activities in red box and interaction through red line is indicated areas where bottle necks and fail points may occur. We could considered

that weak points of the services would be at the process of onstage staff action (OSA), to answer of flood high level by calling back to people (OSA2) or answer by posting at social media page of the group (OSA3). Staffs mostly use Google map or manually find elevation value and calculate flood high in worse case scenario on paper map sheets. Therefore, this process makes difficulty to provide immediate interaction.

3. PROPOSE SERVICE INNOVATION

3.1 Challenges

It has become increasingly difficult to execute information with fully completed government data, especially when disaster occurs. The challenge of providing help services during disaster is timely response. The key success factor in handling responsive activities is real time data which can be provided by the local people living in affected areas via social media. Therefore, mixed social media and multi spatial information is essential for disaster management.

3.2 The Improving Disaster Responsiveness with a Social Media and e-Government mix

Figure 3 shows the conceptual framework which illustrates how data from different sources can be extracted, integrated, harmonized and verified in order to support disaster assistance management, particularly the mixed social media data and the government data. There are three major sources of data including social media, government agencies and private organizations. The mixed data can support the processes of disaster assistance management in terms of Supply management; Request management and Assistance provision.

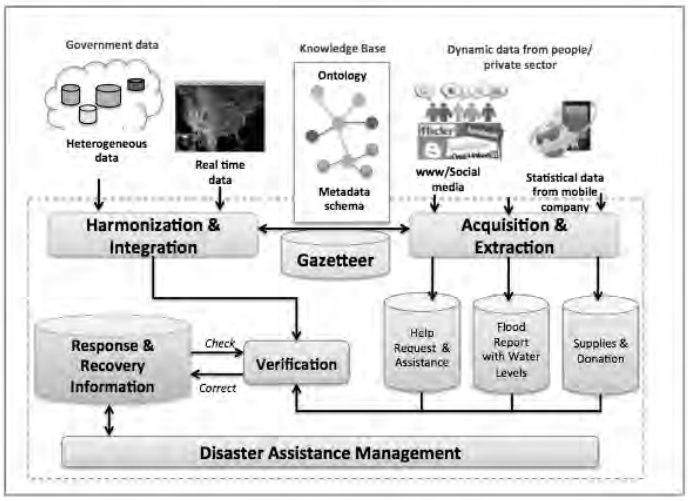

Figure 3: Conceptual of Social Media Data Acquisition and Extraction

3.3 Proposed Solutions

During disaster responding phase, information flows are very important in providing disaster assistance and managing supply chain (Day et.al, 2009). However, there are many issues relating to acquiring, harmonizing, integrating and verifying various data supporting the operations.

3.3.1 Social Media Information Acquisition and Extraction

We can extract interested information from social media with several steps; retrieving data from social media by using a message gathering tool, filtering and classification those data, and then using information extraction technology to extract useful information and organized into structural data.

3.3.2 Data Verification

Before using help demand data received from various sources e.g., social media, telephone calls, we need to assess the level of data quality (McGilvray, 2008): completeness, accuracy, redundancy, data source reliability and timeliness.

3.3.3 Data Harmonization and Integration

The syntactic issue raised due to multiple data formats can be resolved by transforming into a single standard form. As XML has become the de-facto standard language for exchange of web data; this problem can be overcome by converting the data from various sources into common XML data model.

- **Data Harmonization**

For semantic difference, data standards can be used to harmonize data for interoperability. As recommended of the previous study (Kawtrakul et.al, 2011a; Kawtrakul et al.,2011b), Thailand has not established data standards at the national level yet, hence to prepare for and respond to disasters that might occur in the future, the processes needed to be prepared would be (1)establishing universal core data standards and (2)Forming a collaborative group, a Community of Interest, this group should create disaster responsive common or domain specific data standards.

- **Ontology Based Data Integration**

An ontology is an explicit specification of a conceptualization (Gruber, 1993). It can identify data relationships, both schematic and semantic relations. Therefore, ontology can be used to support semantic data sharing and data integration among these organizations (Blomqvist and Öhgren, 2007; Dahap et al., 2008; Janssen et al., 2009). Hence, the concept of ontology is recommended here to support data sharing and integration.

- **Gazetteer Based Spatial Data Integration**

Water level estimation cannot be monitored by the satellite remote sensing even it can monitor water extend. The flood water depth is collected by social network and integrated with spatial data such as DEM (Digital Elevation Model), flood extend map, etc. Flood depth is point information that is provided in meters with latitude and longitude. Those point data from social network usually identify the location by geographical names, such as city name, village name, landmark, etc. Gazetteer is utilized to convert geographical names to latitude and longitude (Nagai and Ono, 2008). Geographical point data are analyzed and interpolated to grid data which will then be overlaid and integrated with spatial data so as to support flood level estimation. In this study, combination or integration of satellite data and ground field data from social media is very important (see Figure 4).

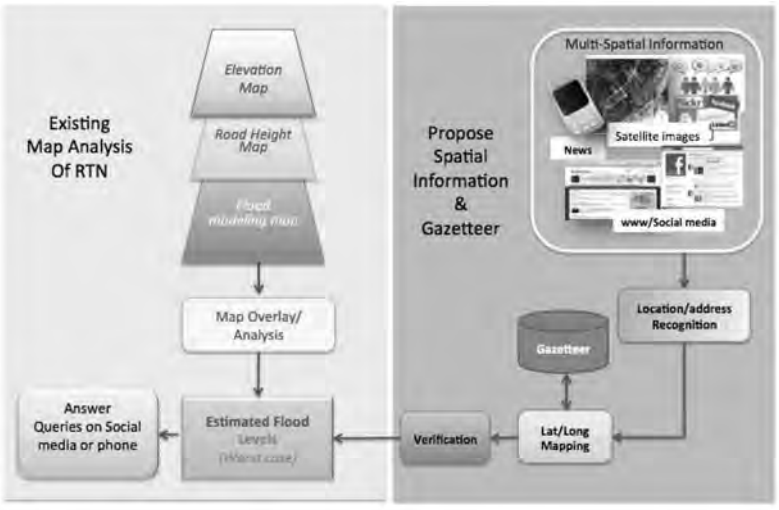

Figure 4: The framework of integrating data from social media or ground field to the initial spatial data or satellite data

Proposing the usage of gazetteer and multi-spatial information which extracting from multi-sources such as social media also can be implemented to the searching location process. If the place of disaster can be located by using address that people posted on the social media, it will be very useful and will improve the service on disaster responsiveness as well.

4. IMPLEMENTATION EXPERIMENT

4.1 Testing of location matching

According to proposing of gazetteer usage concepts with multi-spatial data, it drives to the data testing process within the conceptual of using gazetteer and multi-spatial information.(see figure 5)

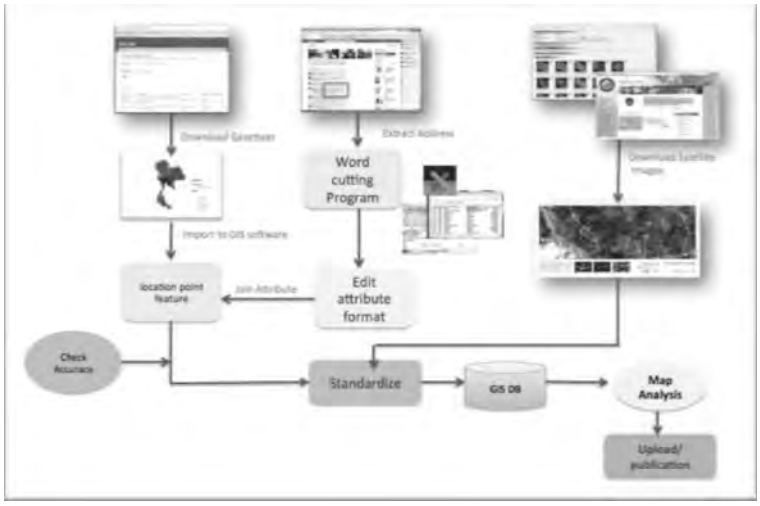

Figure 5: Conceptual method of using gazetteer and multi-spatial information

4.2 Data Used

Data in this study are mainly for testing of using the address or geographic name and gazetteer integration. Explain about A and B

Table 1. Data used in the testing of using gazetteer data

Set	Data	Feature Type	Language	Source
A	• Address • Gazetteer	• Text (100 words location name) • Geographic location (20,435 features)	• Thai • English	• Facebook/Rootannam • www.diva-gis.com
B	• Address • Gazetteer	• Text (100 words location name) • Geographic location (19,577 features)	• Thai • Thai	• Facebook/Rootannam • http://earth-info.nga.mil/gns/html/

4.3 Data testing

In this experiment, the data testing is imitated the process of finding the location of victim or flood occurrence on the map by using the address information that people have post in social media as they want to know that, what is highest level of flood in case. The text of address is capturing and is attempting to match with the gazetteer which it was downloaded from the open source website.

4.3.1 Working with dataset A (Address text from social media and gazetteer from DIVA-GIS Server)

Firstly, the dataset A, the address text was gathered from social media, in this case, from Facebook of 'Rootannam'. Number of locational name is approximately 100 words. The set of word has been copied for English translation by using Google Language translator. The translation method is needed to do because the location name of gazetteer dataset A is performed in English. Then the outcome of address in English is taken to check and compare with the original Thai address text. It was found that the correctly of spelling and meaning name, is remain only about 50 words. After that,

the translated words is input in Excel program for wording separation. Then, applying the gazetteer data which downloaded from DIVA-GIS website (http://www.diva-gis.org). The file is open into ArcGIS program and using the geographic attribute to plot the point locations onto the map. Finally, the address words from previous process are imported join the attribute location name. Result of testing with dataset A has shown in figure 6. In the attribute table, it is found that 27 features can be matched. As there are duplicated locations thus the point of locations is displayed only 4 locations on the map.

4.3.2 Working with dataset B (Address text from social media and gazetteer from NGA Server)

The dataset B comprises of address text that is the same with dataset A, the difference is the gazetteer data which acquired from the website of National Geospatial-Intelligence Agency (http://earth-info.nga.mil/gns/html). The original geographic location name is in English, the data has been translated to be Thai words. Thus the address text has directly open into ArcGIS program together with gazetteer new set. Then, attribute of two data has been joined with geographic name in Thai fonts. Result of testing with dataset B has presented in figure 6. In the attribute table, it is found the joined 95 features. The matched points are rather cluster distribution at the central part of Thailand. This locations plot is high accurate as the most of address came from the recent flood victims in mainly Bangkok and surrounding provinces.

4.4 Results of data testing and Discussion

The geographic name that can be joined with gazetteer of dataset A. In the original gazetteer data which contain of 20,435 features, those features are location points is taken only central part of Thailand. At the translation process, from address name in Thai to English, the translation program can provide the accurate geographic location name about 50%. Then when matching to the gazetteer, location can be matched together at slightly more than 50% (27 of 50 features). However, there some notify that the most frequent geographic name matching is ‘Bangkok’ which is found at 25 features.

Summary result of testing dataset B. The geographic name that can be joined with gazetteer of dataset B is 95 features from about 100 words of input data. The result matching of address location in Thai font with the gazetteer dataset B, can deliver the correct joining more than 90%.
In the original gazetteer data which gather feature only central part of Thailand has number of location around 19,577 words or features. The most occurrence matched name is ‘**คลองหนึ่ง**.’(Cannel number One), counting at 20 features.

Figure 6: The results map of location matching using dataset A and B

4.5 Success case of Sentinel Asia Project

This session is to expression the success case of implementing the gazetteer and geographic location name which is acquired from the local news. The case is preparing flood map product to support Sentinel Asia service activity.

In the web map service of the Sentinel Asia, the country Kyrgyzstan, Villagers Kazarman in Jalal-Abad reported that flooding continued from channel breakout. Breakthrough of the channel occurred during the day March 27 2012.

The satellite data, pre and post disaster were used the city name of flood occurrence is extract from the providing information. Geographic name is found that is ‘Kazarman’ and ‘Jalal-Abad’. Next process is finding the gazetteer data and matching the location by with the city names.Geographic names of Kyrgyzstan can be joined with the gazetteer and found the location on the map. (See figure7)

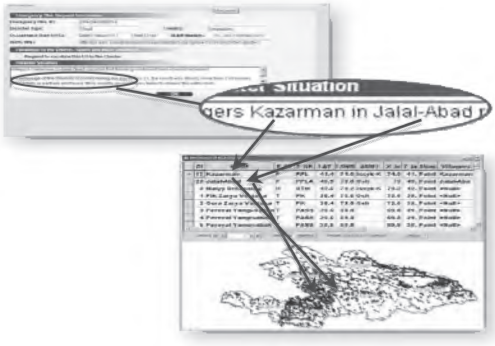

Figure 7: Using information join into gazetteer data

Figure 8: Flood mapping of Kyrgystan

When the disaster image is acquired, flood mapping has been produced . Figure 8 displayed the outcome flood map in the Central of Kyrgyzstan. However, there is some other limitation to show the flooded area, as it also depending on the available of satellite images. Therefore, either flood phenomenal is not large enough or the spectral/temporal of the receiving images may be not proper to show the inundated area.

5. CONCLUSION

In conclusion, the study has achieved the learning on service innovation approaching to improve the disaster responsiveness activities. Conclusion for data testing can summarized as following;

- Service innovation on disaster management can develop by implementing of multi-spatial information and mapping technology.
- It is high potential to use the gazetteer to identify the victim location in the disaster crisis situation with social media information.
- Geographic name of Thailand is more efficient to match with the gazetteer in Thai font format.
- In future study on multi-spatial information integration, it would involve more issues such as gazetteer creation, data extraction, ontology and data standard.

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STUDY OF MECHANISMS OF LANDSLIDE DUE TO SOIL PIPES USING HOLLOW CYLINDER SHEAR APPARATUS

BIRUK ADANE
Graduate Student
Department of Civil Engineering, The University of Tokyo, Japan
biruk@iis.u-tokyo.ac.jp

REIKO KUWANO
International Centre for Urban Safety Engineering,
Institute of Industrial Science, The University of Tokyo, Japan
kuwano@iis.u-tokyo.ac.jp

ABSTRACT

Heavy rainfall incidents are among major causes of landslide and derby flow all over the world. Even though a lot of studies are conducted on studying the effect of rainfall on reduction of matric suction and increment of excess pore water pressure which ultimately result in slope failure, the other major cause of landslide, due to blockage of naturally existing soil pipes, are not known in detail.

This study use Hollow cylinder shear apparatus with modifications to study effect of soil pipes on triggering landslide and derby flow. Specimen with various initial moisture content and relative densities were loaded into various stress ratios and subjected into water injection. The resulting shear strain and axial strains were recorded and analyzed.

From this study it was found that, samples with higher initial saturation and with artificially induced soil pipes are found to undergo excessive deformation during water injection. Implying both building up of high pore-water pressure and collapse of soil pipes has similar impacts mobilization of high shear and axial strains in the specimen.

Moreover, using colored water it was found that dissemination of water within the specimen to be non-uniform (both lateral and vertically).

Keywords*: landslide, pipe flow, rainfall, collapse*

1. INTRODUCTION

Landslide can be triggered by various factors either natural or manmade. Earthquake, rainfall, snow melting, groundwater variation, are among the major natural causes of landslides. Of all these, rainfall has the major role in triggering landslide. For example, in Italy 69.4% of the landslide is caused by precipitation and infiltration (Kalsnes et al, 2008). Landslides due to

rainfall can be caused due to creation of excess pore water pressure and reduction of apparent cohesion due to matric suction. Various researches (laboratory and model tests) are conducted to study slope failure due to rainfall. However, most studies focus on failure due to increment of pore water pressure which resulted in reduction of effective stress. It is also possible to have slope failure due to blockage of soil pipes, due to erosion of fine particles, leading into collapse of soil pipes.

Soil-pipes are chain of connected macropores, developed nearly parallel to the soil surface (Uchida etal., 2002) and are often detected in collapsed slopes scar.

According to the investigation on the granite hill slopes, Out of 64 debris slides scars, only four had no pipes. The remaining 60 had at least one pipe and there was on average 3.6pipes in a slide scar (Tsukamoto et al. 1982).

A closed pipe will raise the groundwater table downslope from the pipe outlet natural soil pipes provide important pathways for subsurface movement of water and solutes, as well as contributing to landslide (Sidle et al. 1995).

Soil pipes can facilitate slope failure due to either internal erosion of sediments which has effect on soil structure or creation of excessive pore water pressure in the sample due to sudden blockage of soil pipes due to heavy rainfall or combination of both.

Sharma et al. (2011) performed model tests on hill slope models prepared in a flume are with three different soil-pipe configurations: a) no pipe, b) closed pipe and c) open pipe latter closed. Pore-water pressures were measured at six different locations along a slope. Their results revealed that the scenario with open first then closed latter of soil pipe has higher increment of pore-water pressure close to its lower end. It was observed pore water pressure rises rapidly, leading to immediate soil mass movement.

On the other hand, soil pipe might act as drainage means and will facilitate downhill water drainage and reduces the pore-water. In the current study, it was investigated the effect of soil pipes on affecting the soil slope stability (landslide or derby flow) with the help of water injection into specimen to simulate rain fall. The results obtained analyzed by considering various cases using the resulted shear and axial strains as indicators.

A case study of landslide and derby flow in Hiroshima prefecture was used as basis condition for this study. However for the current study Edosaki sand was used. Foe the next phase material obtained from landslide area in Hiroshima prefecture (Aida sand) will be used. In this study slopes having angle between 20~30 degree were created by applying various stress ratios, axial and shear stresses.

For the continuation of this study material obtained from landslide area in Hiroshima prefecture is planned to be used in addition to Edosaki sand.

There testing conditions are envisaged,

Case 1: study the soil property with respect to variation of saturation degree and change in matric suction. (Using Edosaki and Aida sand) without escape of soil particles.

Case 2: study the effect of soil pipes will be incorporated using repeated saturation and drainage of water to facilitate soil erosion using open mesh type pedestal (using both Edosaki and Aida sand).

Comparison of the two conditions will give clear idea of effect of escape of soil particles in soil pipes.

However for the current tests only Edosaki sand is used. The main selection criteria of Edosaki sand are its high content of fines and availability of previous research results. The specimen was prepared with variable initial moisture content and relative density.

2. TEST APPARATUS AND PROCEDURE

A Hollow cylinder shear apparatus is used for this study; the apparatus has been modified to make it suitable for this test. The dimension of the specimen used was reduced from the original dimension to 100 mm in height and 100mm and 60mm for outer and inner diameter respectively. The main reason was to have uniform water distribution throughout the specimen within reasonably short time.

Water is supplied from bottom to top. Water will start drain out from the sample from top after few minutes and uniform conditions can be assumed to be achieved through out the specimen. There will be collapse of soil structure at the beginning of water injection. By keeping the same infiltration rate in all tests similar conditions are thought to be maintained in the current study.

Sample was prepared by tamping technique and 5 layers having thickness of 20 mm was used. The target relative density (Dr) was 70%. The specimen then will be left to consolidate for few hours before shear and axial stress, with predetermined stress ratio was applied. Then the specimen will be put on creep for few hours and water was injected. The resulting shear, axial and amount of water entering into and draining out of the sample were recorded at interval of 0.2 seconds.

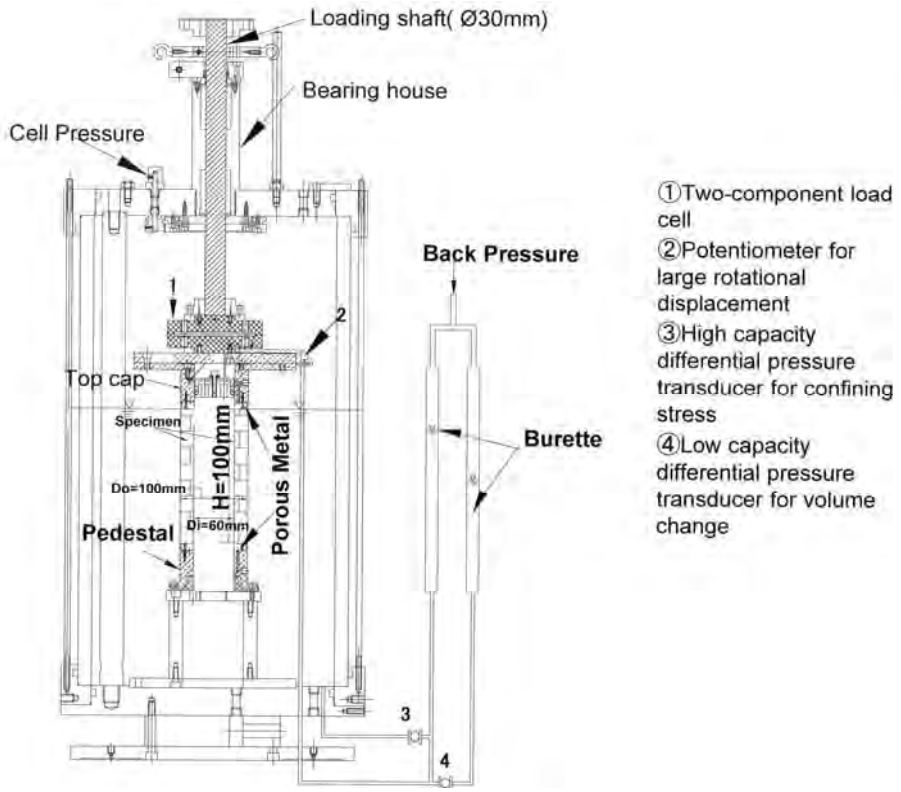

Figure 1: Hollow cylinder shear apparatus

The details of experimental conditions are shown in Table 1 and test findings are discussed in section 4 below.

The particle size distribution of the material used is indicated in figure 2.dosaki sand has Gs=2.705, ρmin=1.135 and ρmax=1.448 gm/cm^3.

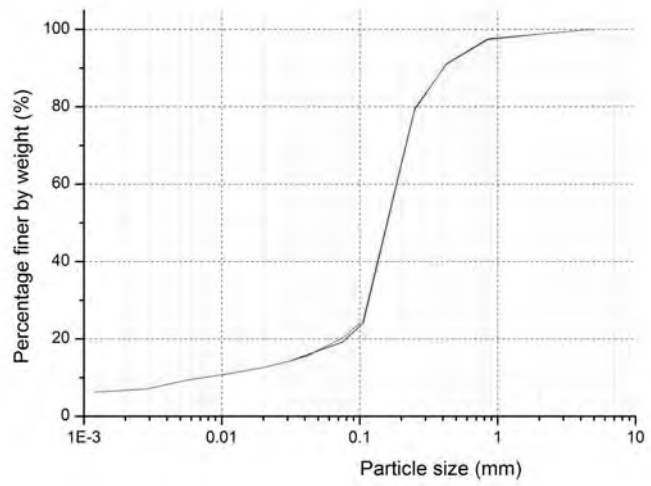

Figure 2: Particle size distribution of Edosaki sand.

Table 1: Testing conditions

Test	$_z$ (kpa)	r (kpa)	(kpa)	(kpa)	(%)	Angle	Dr (%)	Remark
1	60	60	60	24	7	21.80^0	0.20	
2	60	40	40	24	7	21.80^0	0.56	
3	60	40	40	24	8	21.80^0	0.55	Colored water injected from top
4	50	25	25	24	8	25.64^0	0.63	
5	50	25	25	24	8	25.64^0	0.76	With artificial soil pipe
6	40	25	25	20	8	26.57^0	0.70	With artificial soil pipe
7	40	25	25	20	15.6	26.57^0	0.66	

Note: Axial Stress (z), Radial stess(r), Circumferential stress( ), shear stress( ) moisture content ( ), Relative Density (Dr)

3. DEFINITION OF INDICES

The following are some of the indices in this research.

Table 2: Definition of Indices in this research

Index	Definition and description
Injection of water	Application of water from height of 1.2 meter, with back pressure of 10 kpa.
Soil pipes	Artificially made water passage in the specimen using hose having diameter of 3 millimeter.
Water drained out	Drained water collected from the specimen

4. TEST RESULTS AND EVALUATION

Tests were conducted to analyze the effect of water injection on the soil structure, using the resulted shear and axial strains. Moreover, the effect of various factors on the shear deformation has been studied. Testing conditions used are as indicated in Table 1. In one of the tests, the effect of water injection on soil collapse and how water disperses into the specimen

was studied using colored water, by injecting it from top to bottom for maximum collapse effect.

The results obtained are discussed hereunder.

4.1 Effect of Anisotropy

In order to simulate the exact stress path in actual slope failure and land slide due to rainfall, a predefined stress path should be adopted. Moreover, to compare the results obtained using hollow torsional cylinder shear apparatus with previous results using other apparatus, such as simple shear, certain anisotropy was applied. As shown in figure 3 below.

From results obtained it can be seen that in the case of anisotropic condition significant axial strain is observed due to increment of axial stress. On the other hand the resulted shear strain due to water injection was not significantly increased. In both cases failure of the slope does not occur.

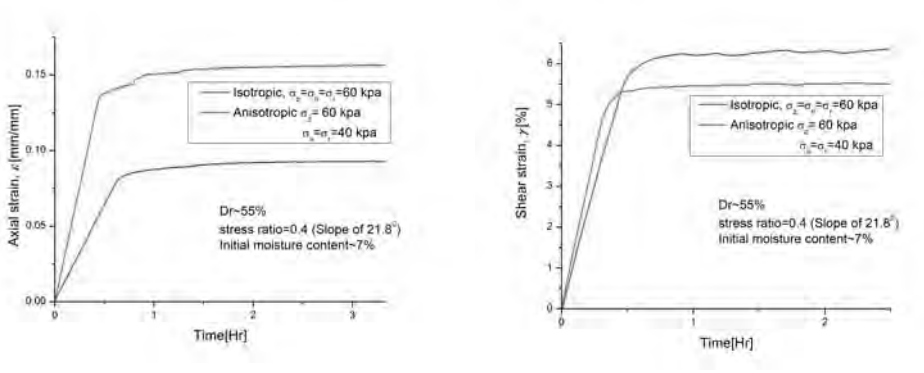

Figure 3: effect of Anisotropy on Shear and axial strain due to water injection.

4.2 Effect of Initial water content.

Most of the tests as shown in Table 1 were conducted with more or less similar initial water content. However, the observed shear and axial strains remain very small indicating the specimen with the give material and stress ratio conditions are safe from failure. For the sake of studying the effect of initial state of a saturation degree, to simulate creation of high pore-water pressure creation, prepared with higher initial moisture content (ω), 15.6%.

From the results obtained, as shown in Fig4 below, for similar stress ratio and relative density the slope with higher water content (saturation) has significantly higher shear and axial strains as a result of injection of water into the specimen.

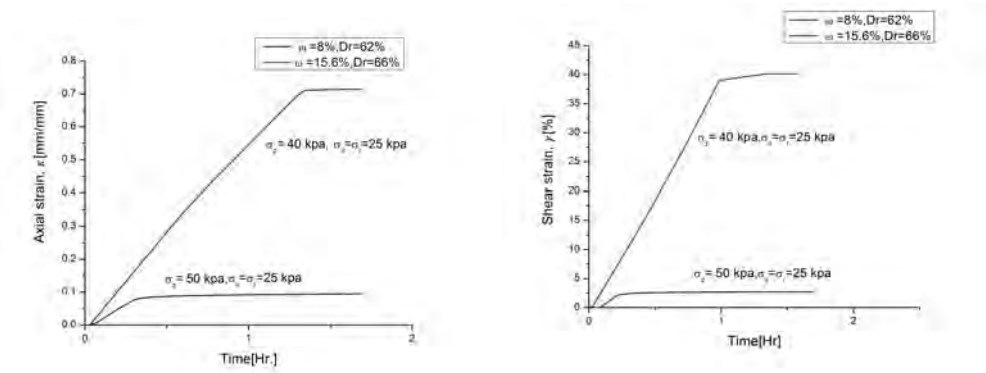

Figure 4: Increment of Shear and axial strains due to initial degree of saturation while water injection.

4.3 Effect initial collapse of soil structure on the shear strain observed.

Due to application of water there will be non-uniform moisture condition in the specimen initially. As a result of this non uniformity effect there will be soil collapse. To study its impact on the observed deformation one test was conducted.

For this test, water was injected from top of the specimen so that there will be significant collapse. Moreover, to study how the water is dispersing in the specimen colored water was used.

Due to collapse of the soil structure there was relatively rapid deformation initially as the top part becomes denser than the bottom. However, rate of deformation decrease quickly and the specimen finally becomes stable.

Regarding water dissemination in the specimen it was found that water movement is not uniformly distributed throughout the specimen it tends to follow certain paths.

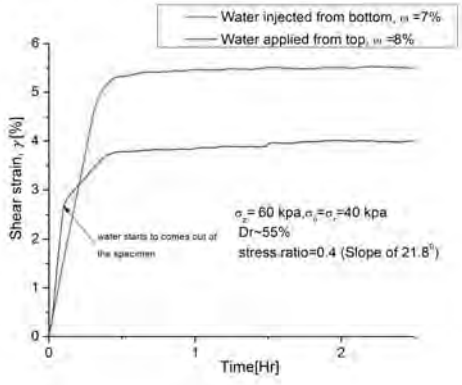

Figure 5: Difference in Shear strain created due to collapse of soil structure .

4.4 Effect of artificially introduced soil pipes on the stability of the structure.

Two tests were conducted to investigate the impact of soil pipes on the soil structure and drainage performance improvement. The result has revealed that there will be sudden rise shear strain in the soil.

The possible reasons for this scenario can be due to quick drainage of water from specimen as result of pipes, there will be erosion of fine particles. This erosion will result in high deformation on the soil structure. As shown in Figure 6 below.

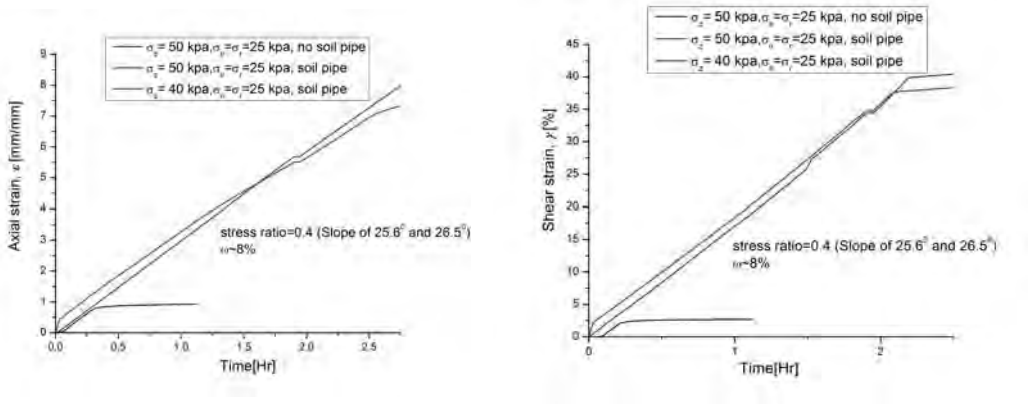

Figure 6: effect of soil pipe

4.5 Summary

From the results obtained it can be said that a specimen with higher initial degree of saturation(which can simulate excess pore water pressure generated) and having soil pipes when subjected to high rainfall events will undergo sharp displacement and deformation.

The main reason can be erosion of soil as water will be traveling in higher speed in the soil pipes. Eroded soil particles along with the pipe as soil was not able to drain out from the pedestal and it will accumulate at the out let and will result in excess pore water pressure.

5. ADDITIONAL EXPERIMENTS FOR EVALUATING FINES EROSION AND EFFECT OF MATRIC SUCTION.

The results obtained here do not incorporate basic parameters for unsaturated soil mechanics like pore water and air pressure which define matric suction.

Currently the pedestals used for this study does not have means for escape of fine particles from the specimen. Therefore, further modification of the apparatus is mandatory. This modification will help detailed study of the real situation.

6. PROCESS AND MECHANISM OF LANDSLIDE DUE TO SOIL PIPE

General process of expansion of landslide in slopes with soil pipes suggested like as follows.

A) Initial higher deformation on soil structure due to immediate collapse of soil structure.
B) Deformation will progress until failure occurs or slope stabilizes.

7. SUMMARY AND FUTURE PLAN

Factors which affect shear and axial strain mobilization due to application of water were 1) initial saturation degree 2) presence of soil pipes and 3) fines wash away.

Combination of these factors will increase the effect of shear and axial strains. With help of using other parameters such as matric suction, fine particles erosion.., detailed investigation will be conducted and impact of soil pipes can be investigated in detail.

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TRAFFIC ACCIDENT ANALYSIS BASED ON TAAS DATABASE SYSTEM

Yong-hwan HWANG[1],Sung-hi AN[2],Choong-shik LEE[3]
and Hyunmyung KIM[4]
[1]Researcher/Transportation Planning Lab,
Department of Transportation Eng,
College of Engineering The MyongJi University, South Korea
Hyh8905@nate.com
[2]Graduate Student School of Eng., The MyongJi University, South Korea
[3]Graduate Student School of Eng., The MyongJi University, South Korea
[4] Doctor, Director, MyongJi University, South Korea

ABSTRACT

The purpose of this work is to develop a new method to evaluate traffic safety and apply it in Gimpo-city. By using four types of databases systems, the new method can evaluate the safety level of roads and intersections in a quantitative way. In order to find the weighted valued used in the developed method, transportation experts participate to the Analytic Hierarchy Process (AHP) survey. With these data, the new index, Traffic Safety Weakness Index (TSWI), is developed. So, with TSWI, we give weighted value for each traffic accidents and apply this new index to Gimpo-City and select 28 intersections as high frequency accidents zone. Also, our work analyzes these intersections and suggests improvements for each intersection.

Keywords*: Database system, AHP survey, TSWI*

1. INTRODUCTION

In Korea, there is a database system for storing traffic accidents related information; Traffic Accident Analysis System (TAAS). TAAS is operated by Korea Road Traffic Authority and it serves the GIS(Geographical information system) data about traffic accidents in a whole Korean area. This database system has a great potential for investigating and analyzing the reason of traffic accident. However, no traffic safety evaluation index sufficiently uses the full information of the database system yet in Korea and only very simple methods have been employed to evaluate the safety of road.

The number of cumulated traffic accident last three-year and traffic accident rate of change are basic index to evaluate traffic safety. However, it has been criticized since it is not able to reflect the details of traffic accidents. Thus, it has to be needed to set a new methodology for traffic safety. Based on AHP (Analytic Hierarchy Process) method, a new traffic

safety evaluation index is developed named TSWI(Traffic Safety Weakness Index).

Based on the index, accident-prone intersections and road sections are selected, and the analysis of traffic accident is performed.

The purpose of this work is finding a new methodology and analyzing a traffic accident deeper. So, additional data, road traffic counts, safety facilities from Korea Transport DB and other sources are also used. With TSWI, we can do the detail evaluation of traffic accidents and have more elaborated tool for diagnosing safety level of road. The new index in applied to a Korean city, Gimpo-city.

2. TRAFFIC SAFETY DATA-BASE SYSTEM IN KOREA

2.1 TAAS

TAAS is composed of an Input Management System, a Statistical Analysis System, a Spatial Analysis System, and a Web-service System. The Input Management System aggregates and refines the traffic accident data that is collected from the different agencies. The Statistical Analysis System conducts multi-dimensional accident analyses using the R-OLAP tool (Relational Online Analytical Processing). The Spatial Analysis System analyzes the characteristics of accident locations using GIS (Geographic Information Systems). The Web-service System provides the aforementioned traffic accident information through the Internet in real time. KoROAD will manage road accident in-depth analysis systems and will provide road safety action plans for national, regional and local governments. KoROAD will continuously strive to ensure its function as the National Road Safety Information Hub.

The TAAS contribute greatly to effective planning of traffic safety through offering a variety of information such as traffic accident statistics and spatial information services to traffic administrative organizations.

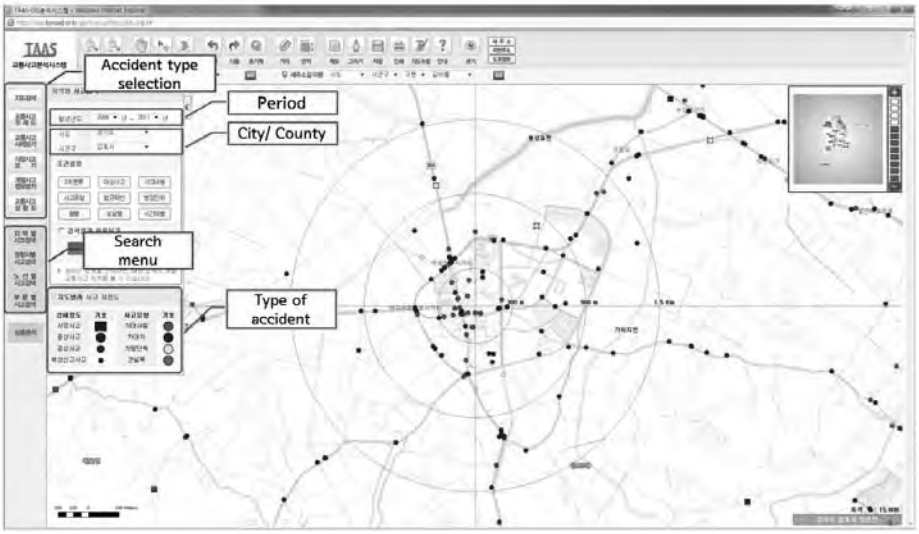

Figure 1:TAAS system

2.2 GyungGi-Do Traffic DataBase Center

The purpose of the Traffic DB is to compile the traffic characteristic, traffic facilities, land use and social-economic indicator for identifying the current traffic condition and makingpolicies. So, GyungGi-Do Traffic DataBase Center builds Integrated Management System to collect and analyze traffic Data. It also sets a policy evaluation system to support sustainable traffic policies for counteracting a sudden change in traffic environments.

2.3 Traffic Monitoring System

Traffic Monitoring System(TMS) is a traffic information provider system. It is a main purpose that gives information about road plans, road building, maintenance and managements, and various kinds of data for investigating the current traffic volume of national expressway, general national road, and local road.

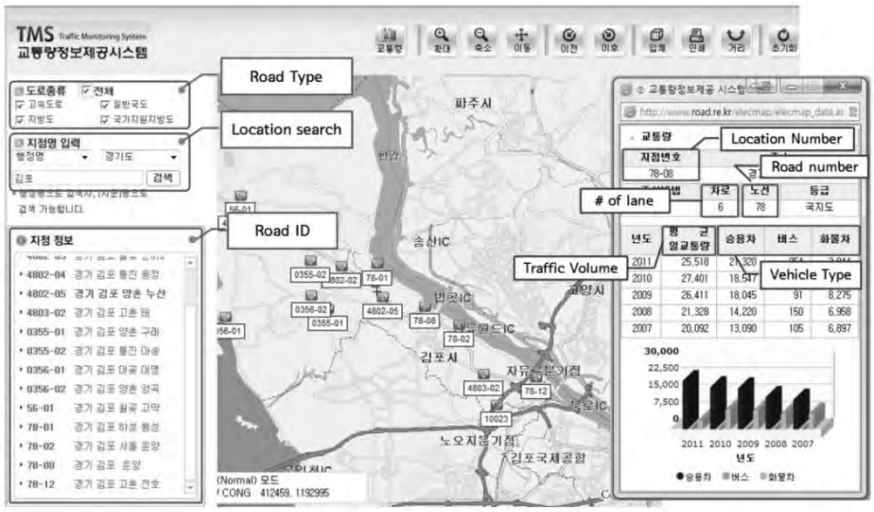

Figure 2: TMS system

2.4 Traffic Accident Database System by the National Police Agency

Traffic Accident Database System(TADB) is an accident data record written by police officer at an accident site. A police officer uses it as an official record to judge and analyze traffic accident legally. As shown in Figure 3, TADB describes accident maps graphically.

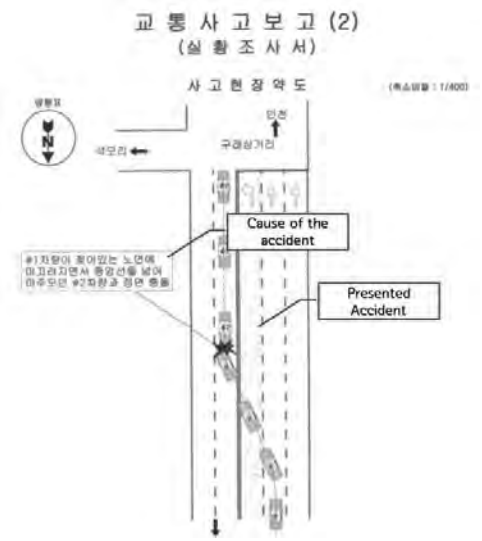

Figure 3: Accident map

3. METHODOLOGY

This work uses socioeconomic index and traffic accident data for analyzing traffic accident pattern and developing a new traffic safety index. First, we investigate last 3-year socioeconomic and traffic data for all cities and counties in GyungGi-Do.

Second, we use TAAS to analyze traffic accidents. TAAS is statistic traffic accidents system and GIS analysis system. The data of statistic traffic accidents system are collected from four databases which are the National Police Agency Database, the Property Insurance Company Database and the Mutual Benefit Association Database. Using these data, we collect and analyze 31 cities' traffic accident in Gyunggi-do.

For traffic accident analysis, we divide accident factors into 4 parts as month, day, time of day, and pedestrian accident to figure out accident location's quality and accident pattern. Considering traffic volume and length of roads, this work analyzes traffic pattern with socioeconomic indexes and traffic situations.

Last, we develop a new index named TSWI(Traffic Safety Weakness Index) and apply it to analyze traffic accidents at Gimpo city. Beside the cumulated number of accident during last three years and the accident rate change comparing to last year, road safety levelis defined in terms of an accident rate with consideration of traffic volume and length of road.

Figure 4: Traffic safety diagnosis process

3.1 AHP

3.1.1 AHP Analysis

Analytic Hierarchy Process (AHP) is a multiple criteria decision method. In AHP, all factors are formed with a multiple hierarchy and the weighted values are defined to the factors subjected to the same level. With the weights, all influencing factors are used for a decision making or evaluation.

AHP is an important tool to set a weighted-value for each type of accidents. There are three basic types of traffic accidents that are vehicle versus vehicle accident, vehicle versus pedestrian and vehicle only accident. 20 transportation experts are asked to join the AHP survey. The hierarchy of TAAS data which is used in this work is as shown in Figure 5.

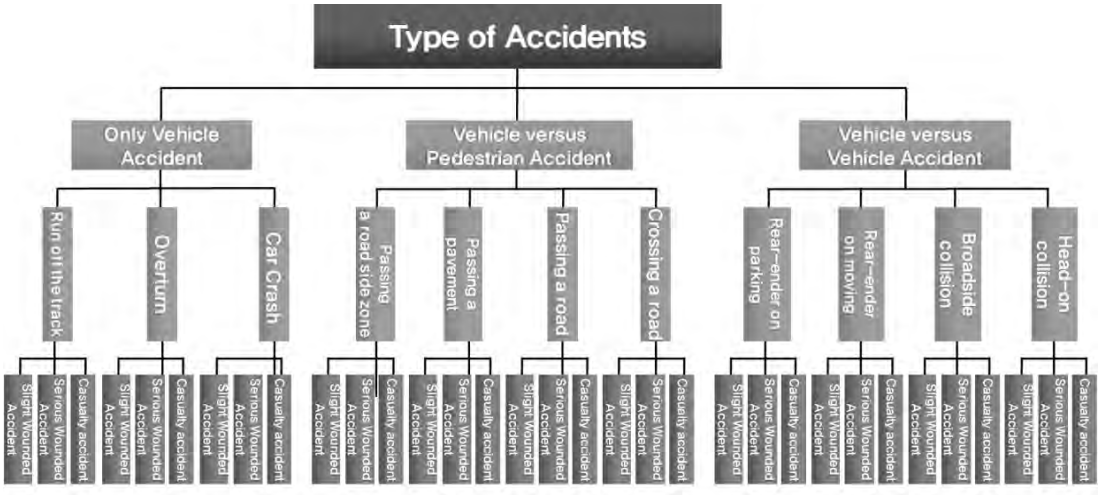

Figure 5:Hierarchy of TAAS Data

3.1.2 Result

Figure 6 shows weight value in accident type. The weighted-value fora casualty accident is 0.706. For a serious wounded accident, the weighted-value is 0.223 and slight wounded accidents' weight is 0.071. Ten slight wounded accidents have almost the same value as a one casualty accident. A one casualty accident, also, has more value than three serious wounded accidents.

In pedestrian accidents, this work decides that an accidents severity in age will have a difference. So we divide pedestrian victims into three groups and evaluate accidents severity for each group. Group 1 is children 15 and younger and Group 2 is people aged 65 and over. Last, Group 3 is the other people.

Figure 6: Weighted-value in Injury type

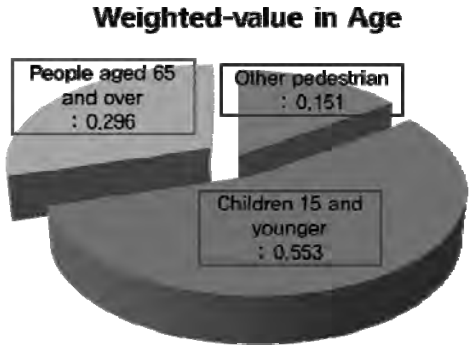

Figure 7: Weighted-value in Age

This work considers another weighted-value for other factors. Table 1 shows other weighted-value.

Table 1: Weighted-value table

	Type	Weight	Rank
Accident Type	Vehicle vs Vehicle	0.198	2
	Vehicle vs Pedestrian	0.700	1
	Vehicle only	0.102	3
Vehicle vs Vehicle Accident	Head on Collision	0.607	1
	Broad Side Collision	0.221	2
	Rear-Ender on Moving	0.109	3
	Rear-Ender on Parking	0.063	4
Vehicle vs Pedestrian Accident	Crossing a Road	0.517	1
	Passing a Road	0.109	4
	Passing a Pavement	0.249	2
	Passinga Road Side Zone	0.125	3
Vehicle Only Accidnet	Car Crash	0.240	3
	Overturn	0.419	1
	Run off the track	0.341	2

3.1.3 Result of AHP Intersections Analysis

With Figure 6 and Table1, this work computes AHP weighted-value for each intersections in Gimpo-City.

Table 2: Result of Intersections AHP Analysis

#	Name of intersection	number of accident			number of victim			traffic-safety evaluation index	pedestrian accident				AHP weighted value	AHP weighted value considering victim (per100p.p)
		death	serious wound	slight wound	death	serious wound	slight wound		under 15	15 to 65	over 65	ratio of trans-portation vulnerable		
1	Sin-god intersection	3	32	44	3	39	84	34.7	0	9	2	18%	0.277	0.398
2	Front Han-hwa APT intersection	0	31	24	0	44	72	29.96	1	2	0	33%	0.189	0.301
3	Terri intersection	2	14	19	2	33	39	20.9	0	0	1	100%	0.111	0.369
4	Ma-song intersection	3	20	9	3	23	15	16.42	4	8	3	47%	0.414	1.100
5	Pung-mu intersection	0	13	15	0	15	17	10.34	0	4	3	43%	0.092	0.498
6	Ha-song terminal intersection	1	14	11	1	19	35	14.58	0	4	0	0%	0.128	0.424
7	North-side terminal intersection	0	11	14	0	11	24	9.5	0	2	0	0%	0.072	0.386
8	Korea communication intersection	1	13	10	1	18	26	12.92	0	2	0	0%	0.098	0.400
9	Front playground intersection	0	12	12	0	13	19	9.54	2	4	0	33%	0.062	0.392
10	Front Hyun-dai APT intersection	1	15	7	1	16	8	10.32	1	6	3	40%	0.259	1.181
11	Gimpo-2dong intersection	1	13	8	1	16	15	10.84	0	3	2	40%	0.135	0.563
12	Sin-pung elementary sch. Intersection	0	9	12	0	9	19	7.74	3	4	0	43%	0.175	0.703

#	Name of intersection	number of accident			number of victim			traffic-safety evaluation index	pedestrian accident				AHP weighted value	AHP weighted value considering victim (per100p.p)
		death	serious wound	slight wound	death	serious wound	slight wound		under 15	15 to 65	over 65	ratio of trans-portation vulnerable		
13	Humansia APT. Intersection	1	14	5	1	16	16	10.92	1	3	0	25%	0.161	0.621
14	Dae-gug intersection	0	13	7	0	19	19	11.14	1	1	4	83%	0.084	0.488
15	Front Go-chon office intersection	0	12	8	0	14	12	8.68	0	1	1	50%	0.066	0.420
16	Su-song road three-way intersection	0	12	7	0	14	18	9.32	0	1	0	0%	0.033	0.243
17	Jung-bong intersection	0	10	9	0	10	11	7.04	2	2	0	50%	0.119	0.761
18	Front Se-jin park intersection	2	8	7	2	15	22	11.3	0	0	0	0%	0.025	0.202
19	Front ju-gong intersection	0	13	4	0	20	8	9.88	0	2	0	0%	0.114	0.623
20	Ha-song intersection	0	12	5	0	21	17	11.14	0	0	0	0%	0.045	0.332
21	Dok-ja-gol intersection	0	8	9	0	9	11	6.34	2	3	1	50%	0.101	0.653
22	Jan-gi intersection	0	8	8	0	10	18	7.4	0	1	1	50%	0.077	0.428
23	Black-bridge intersection	0	8	7	0	11	21	7.98	0	1	0	0%	0.038	0.252
24	Dae-myung elementary sch.Intersection	0	8	7	0	11	13	7.02	1	3	1	40%	0.072	0.556
25	Yang-gok post office intersection	0	10	3	0	12	8	6.8	2	2	3	71%	0.225	1.268
26	Ha-song township office intersection	0	10	3	0	10	4	5.72	7	1	0	88%	0.231	1.832
27	Front Han-sol part intersection	2	7	2	2	10	8	7.52	0	5	0	0%	0.097	0.623
28	Front Dong-gwang APT intersection	3	1	1	3	2	2	4.12	0	2	1	33%	0.132	1.641

4. RESULT

4.1 Socioeconomic index and traffic condition in Gimpo-city

The GyungGi-Do includes 31 cities and Gimpo-city is one of them. The population of the Gimpo-city is about twenty-five million. Of the 31 cities, its population comes in 17th. Also, every year its population has increased by 3.61%. And it causes traffic growth. Figure 8 is the 2010 population of Gimpo-city.

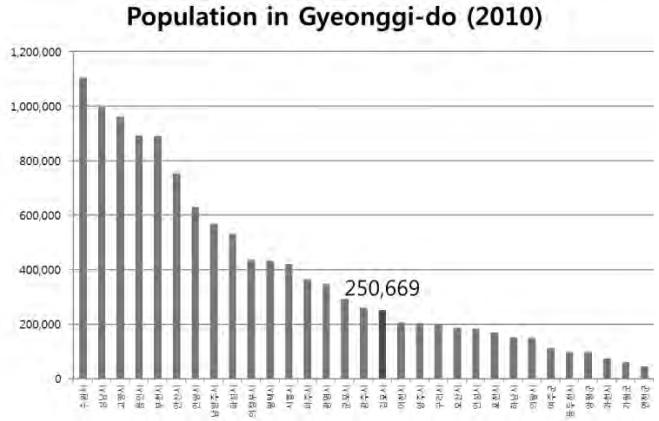

Figure 8: Population in GyungGi-Do (2010)

The transportation vulnerable is divided into two groups. Group1 is Children 15 and younger and Group 2 is people aged 65 and over. Figure 9 shows changing rate of group 1 during the last five years in Gimpo-city and its rate counts -0.36%. Considering other 31 cities', its rate comes in 10th. Figure 10 describes changing number of group 2. It increases consistently and its rate is 7.21%. This rate ranks 9th comparing with other cities'. It shows that Gimpo-city rapidly becomesan aging society. It means that number of transportation vulnerable is increasing, too. So analysis for transportation vulnerable has to be needed.

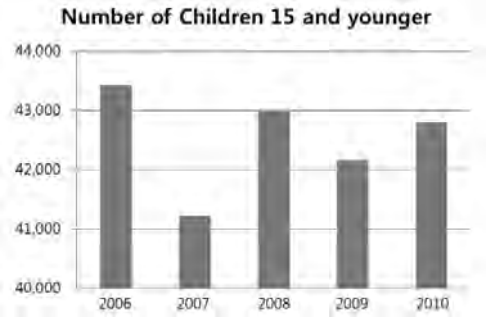

Figure 9: Changing population of Group1

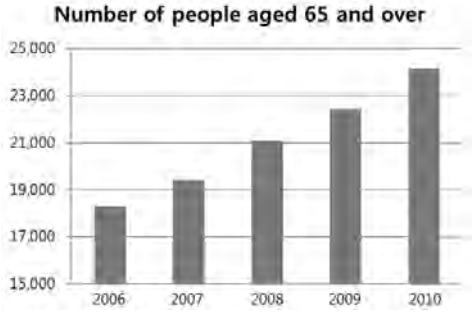

Figure 10: Changing population of Group 2

The number of registered vehicles in Gimpo-city takes ranking 15th and it is increasing 4.22% per year. Figure 11 shows 2010 vehicle registration number in GyungGi-Do.

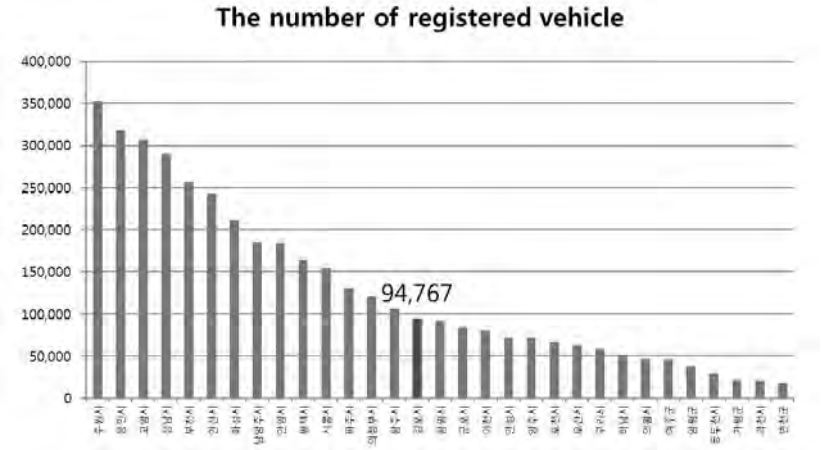

Figure 11:The number of registered vehicle in GyungGi-Do (2010)

4.2 Analysis of intersection and road section

4.2.1 Analysis of Intersection

For AHP analysis, 28 intersections are selected as a high accident frequency location and 11 intersections are selected for making an improvement.

With these 28 intersections, this work compares and analyzes in two-ways. First, based on total number of traffic accidents, the safety of inter sections is analyzed. Second, traffic-safety evaluation index for a logistics company

The level of traffic safety at an intersection has been measured in terms ofthenumber of traffic accidents in Korea. However, it does not consider the detail safety level of intersection. The notable example is 26thintersection (Ha-song township office intersection) in Table 3. 13 traffic accidents were happened in this area during the past three year, so it is regarded as a safe area. Considering pedestrian accidents, however, this intersection is ranked as 4th grade. It means this area is not safe.

Table 3: Rank of high accident-frequency spot for in Gimpo-City

#	Name of Intersection	Number of Accidents			Pedestrian Accidents			AHP weighted value
		total # of accidents	traffic-safety evaluation index	ratio of death	total # of accidents	accident severity	ratio of transportation vulnerable	
		Ranking			Ranking			
1	Sin-gok intersection	1	1	11	2	4	19	2
2	Front Han-hwa APT intersection	2	2	12	17	16	15	6
3	Terri intersection	3	3	5	24	21	1	14
4	Ma-song intersection	4	4	4	1	1	9	1
5	Pung-mu intersection	5	12	12	5	7	10	18
6	Ha-song terminal intersection	6	5	10	14	16	20	11
7	Nort-side terminal intersection	7	16	12	19	21	20	21
8	Korea communi-cation intersection	8	6	9	19	21	20	16
9	Frontplayground intersection	8	15	12	8	10	15	24
10	Front Hyun-dai APT intersection	10	13	8	3	3	12	3
11	Gimpo-dong intersection	11	11	7	11	11	12	9
12	Sin-pung elementary school Intersection	12	20	12	5	7	10	7
13	Humansia APT Intersection	13	10	6	14	14	18	8
14	Dae-guk intersection	13	8	12	8	6	3	19
15	Front Go-chon office intersection	13	18	12	19	19	5	23
16	Su-songroad three-way intersection	16	17	12	24	25	20	27
17	Jung-bong intersection	16	23	12	14	13	5	12
18	FrontSe-jin park intersection	18	7	3	27	27	20	28
19	Front ju-gong intersection	18	14	12	19	21	20	13
20	Ha-song intersection	18	8	12	27	27	20	25
21	Dok-ja-gol intersection	18	26	12	8	9	5	15
22	Jan-gi intersection	22	22	12	19	19	5	20
23	Black-bridge intersection	23	19	12	24	25	20	26
24	Dae-myung elementary school .Intersection	23	24	12	11	11	12	22
26	Yang-gok postoffice intersection	25	25	12	5	3	4	3
28	Ha-song township office intersection	25	27	12	4	2	2	4
27	Front Hansol park intersection	27	21	2	11	14	20	17
28	Front Dong-gwangAPT intersection	28	28	1	17	16	15	10

If we consider only total number of accidents, the 1st intersection (Sin-gok intersection) is the most serious intersection in Gimpo-city. However, if we consider pedestrian accident severity, the 4th inter section (Ma-song intersection) has more pedestrian accidents than the 1st intersection. The 4th intersection also has high death rate.With TAAS database, Figure 12 shows the number1 intersection (Sin-gok intersection). This spot is the highest accident frequency location in Gimpo-city. 35 traffic accidents were happened during the last three years. Accidents between vehicle versus vehicle were happened 26 times, and there were nine accidents to vehicle versus pedestrian. Three incidences of casualty were occurred on this intersection and all of these accidents are pedestrian accidents at night. .

Figure 12: Accident map at the No.1 intersection (Sin-gok)

Figure 13 and Figure 14, demonstrates time of day accident patterns and accident types patterns, respectively. Most incidences of casualty are happened when people are walking at night. Other accidents are happened during the morning/evening rush hour time. Most accidents are happened between vehicle versus vehicle

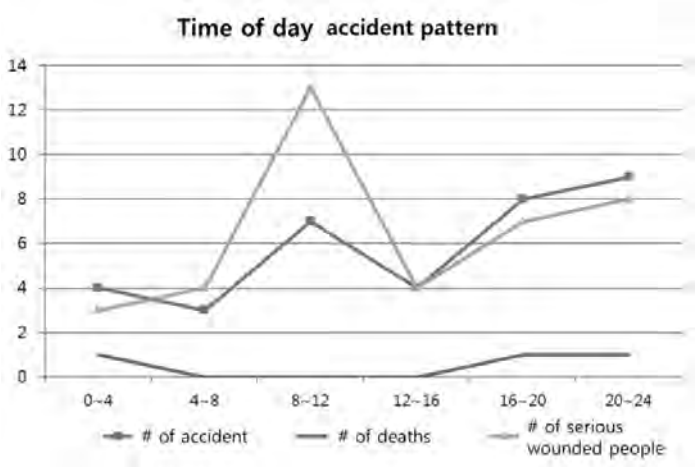

Figure 13: Analysis of time od day accident pattern

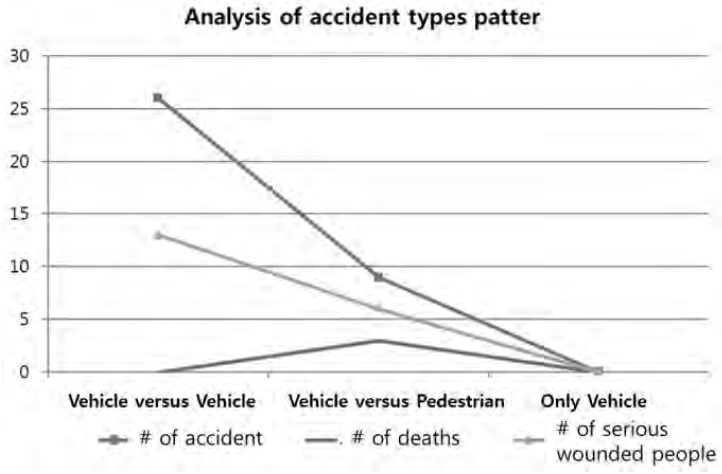

Figure 14: Analysis of accident types pattern

4.2.2 Analysis of Road Section

Figure 15 describes accident map at the Gimpo-market road. Many pedestrian accidents are happened on this road section. This area is a commercial district and only has a single lane on each direction. Every fifth day, the side of road is occupied by market stalls and merchants so the pedestrian road in this area is very crowded. Mainly vehicle versus pedestrian accidents are occurred on this street and two incidences of casualty are happened.

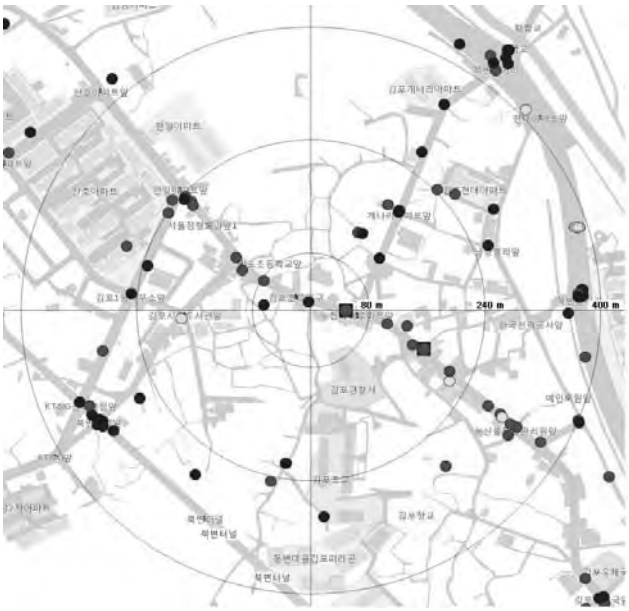

Figure 15: Accident map at the Gimpo-Market Road

Figure 16 shows time of day accident patterns. The greatest occurrence of traffic accident is in 12:00 to 16:00. Most road accident victims are women in their 40s who visit market.

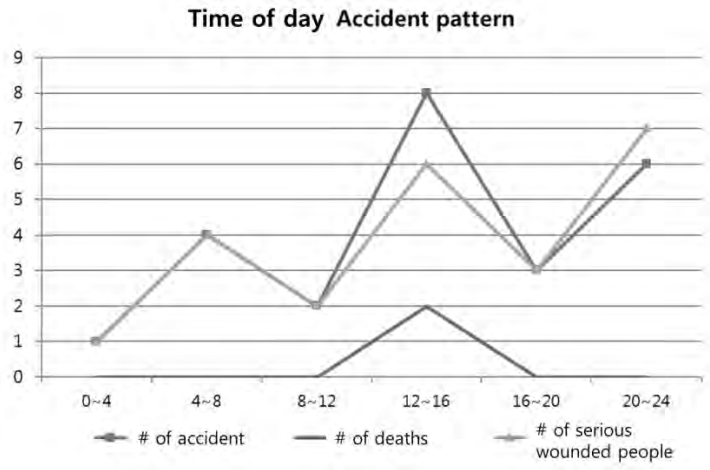

Figure 16: Analysis of time of day accident pattern

5. CONCLUSION

With TAAS which is web-based system, our work creates new safety evaluation index by using various kinds of data. 20 of transportation experts participate to the AHP survey to set TSWI. With TSWI, we analyze 28 intersections in Gimpo-city. The high accident frequency zones differ by method of analysis: Analysis by total number of accidents and TSWI. Gimpo-city is currently showing an increase in transportation vulnerable population, therefore the TSWI is more adequate.

In the future, more accurate levels of AHP value will be acquired through additional professional assistance. Also, through survey targeting the general people, comparison and analysis will be made between the professionals and the general people regarding their notions about the weights.

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MODELING OF TENSILE BEHAVIOR OF MORTAR IMMERSED IN NaCl SOLUTION

Taito MIURA[1], Yasuhiko SATO[2]
[1]Doctoral 2nd degree Student, Faculty of Eng., Hokkaido University, Japan
t.miura@eng.hokudai.ac.jp
[2]Associate Professor, Faculty of Eng., Hokkaido University, Japan

ABSTRACT

In this study, meso-scale mortar specimens were immerged in NaCl solution for 180 days and then three-point bending tests of the specimens and chemical analyses were conducted so as to determine tensile softening curves from load displacement curves using a back analysis and to clarify how the amount of hydrate affects tensile characteristics. Consequently, it was found that the elastic modulus and the tensile strength decreased as the amount of hydrates CH and C-S-H decreased. Besides, based on the experimental results, the model formula of elastic modulus, tensile strength, fracture energy and tensile softening curve that can consider the amount of hydrate change were proposed.

Keywords*: leaching, hydrate, tensile strength, elastic modulus, fracture energy, tensile softening curve*

1. INTRODUCTION

In concrete structures exposed to freshwater, Calcium leaching would cause reduction of the hardness of hydrated cement (Taylor, 1997). Leaching is a relatively slow phenomenon that may reduce the durability of marine structures and radioactive waste treatment plants (Faucon, 1997 and Xie, 2008). In snowy cold region, de-icing agent containing NaCl would accelerate the deterioration caused by leaching (Yokozeki, 2002). In addition, chloride ions accelerate freezing and thawing deterioration (JCI, 1999), and as a result mass transfer resistance and the mechanical characteristics of concrete are changed. Therefore, the mechanisms of leaching and of freezing and thawing deterioration in the presence of chloride ions should be clarified.

In this study, using meso-scale specimens with the height of 5mm (Sato, 2010), the relationships between chemical composite and tensile behavior, such as elastic modulus, tensile strength, fracture energy and tensile softening curve are clarified. Besides, the model formulas of tensile behavior which can consider that hydrates change with time are proposed.

2. EXPERIMENTAL OVERVIEW

In this study, the concentration of CH and C-S-H in the specimens was reduced continuously so as to evaluate the relationships between the amount of hydrate and the tensile characteristics with time. Soaking periods of 0, 30, 60, 90 and 180 days were applied, and ten specimens were tested in each soaking period in order to improve the reliability of the results.

2.1 Specimens conditions

The specimens were made from ordinary Portland cement. Fine aggregates whose maximum size was 1.7 mm were used. Water-to-cement ratio was set to 50%. The ratio of water, cement, and fine aggregates was 1: 2: 6.

Firstly, in this experiment, mortar prisms with a height of 40 mm, a width of 40 mm and a length of 160 mm had been casted and cured in water for 60 days. After curing, meso-scale specimens with 5 mm height, 30 mm width and 70 mm length were cut from the mortar prisms. Actual size of specimens was within the range of ±0.5 mm of the target one.

2.2 Experimental conditions

Immersion solution made from powdery NaCl and ion-exchanged water so as to be solution with a chloride ion concentration of 20g/l. Ten specimens were hanged with corrosive-resistant strings were placed in a 15l poly container filled with the solution, as shown in Photo 1. The containers with the specimens were maintained at 20 ^{o}C in a temperature-controlled room. The immersion solution in each container was replaced with fresh solution every 30 days.

2.3 Bending test

After the immersion test, the specimens were dried in desiccators for 24 hours, and then bending tests were conducted. The LVDT sensors were located at the center of the span and at the supporting points of the specimens, as shown in Photo 2. The loading speed was set to 1μm /sec.

Photo 1: Immersion condition

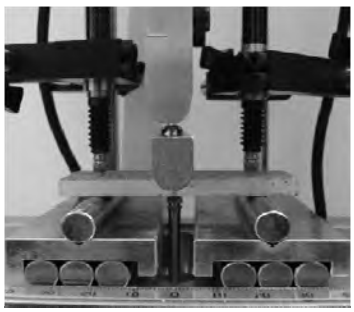


Photo 2: Bending test condition

2.4 Chemical analysis

The amount of CH was determined by the thermo gravimetric and differential thermal analysis (TG-DTA), and the amount of C-S-H was determined according to an analysis using heavy liquid and salicylic acid/methanol. The amount of CH and C-S-H in the specimens was measured during each soaking period. In addition, 4 specimens were randomly selected among ten specimen tested and pulverized in a ball mill to powder with the grain diameter of 0.04 mm.

2.5 Determination of tension softening curves

With JCI-S-001-2003 (JCI, 2003), a multi-linear approximation technique was used to transform the load displacement curves into tension softening curves. In the back analysis, the tensile strength was also determined, and the fracture energy was calculated from the area enclosed by the tension softening curve and the x-axis.

3. RESULTS AND DISCUSSIONS

3.1 Chemical composition change

The relationships between the change in CH and C-S-H in specimens immersed in NaCl solution and the duration of the soaking periods are shown in Figure 1 and 2. The weight percentage of CH decreases incrementally as the duration of the soaking period and the weight percentage of CH becomes almost zero after 90 days. The weight percentage of C-S-H does not change for the first 30 days. After that, it is gradually decreased and then, after 180 days, the C-S-H concentration becomes approximately 37% of the initial one.

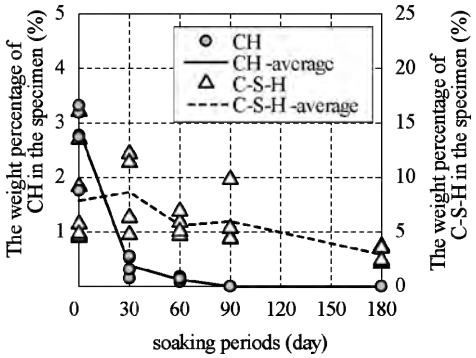


Figure 1: The change in CH and C-S-H in specimen with time

3.2 Stress displacement curve and elastic modulus

The average of flexural stress and displacement curves of the specimens immersed in NaCl solution with time is shown in Figure 3. The flexural stress was calculated as follows;

$$\sigma = \frac{3PL}{2bh^2} \quad (1)$$

where P is the applied load (N), L is the span length (50 mm), b is the width (30±0.5 mm) and h is the height (5±0.5 mm)

Figure 4 shows the relationships between elastic modulus and the duration of the soaking periods. As shown in Figures 3 and 4, flexural strength and elastic modulus decrease as soaking period becomes longer. After 180 days, the average value of elastic modulus becomes approximately 38% of the initial one. When taking particular note of softening zone of stress and displacement curves shown in Figure 3, the softening gradient just after the peak stress does not change with time.

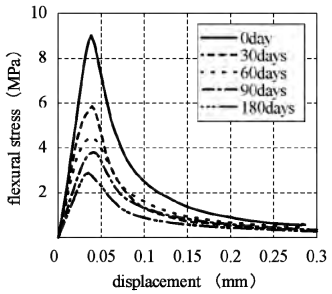


Figure 3: The change in stress and displacement curves with time

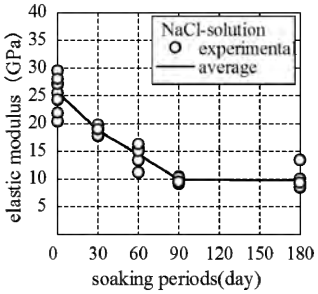


Figure 4: The change in elastic modulus with time

3.3 Tensile characteristics

Figure 5 shows the change in the average of tensile softening curves, while Figures 6 and 7 show the relationships between the change in tensile strength and soaking periods and fracture energy and soaking periods, respectively.

As shown in Figure 5, it can be found that tensile stress when crack width is greater than 0.03 mm is almost the same for different periods. As shown in Figure 6, tensile strength tended to decrease along with time. As

shown in Figure 7, it appears there is no relationship between fracture energy and soaking periods.

3.4 Tensile characteristics and amount of hydrate change

Figure 8 shows the relationships between tensile strength, elastic modulus, and fracture energy normalized by initial one and reduction rate of hydrate to initial amount of hydrate. Elastic modulus and tensile strength decreased along with the reduction of the amount of CH and C-S-H, as shown in Figures 8(a), 8(b), 9(a) and 9(b). As shown in Figure 8(c) and 9(c), fracture energy does not show strong connectivity with the reduction of CH and C-S-H.

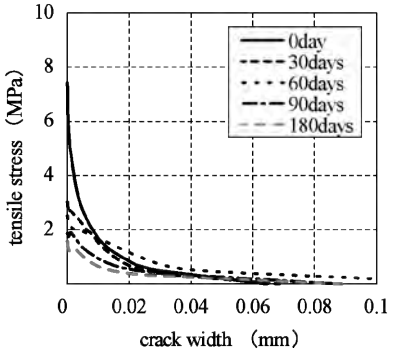


Figure 5: The change in tensile softening curve with time

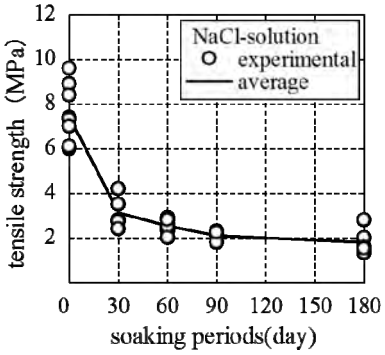


Figure 6: The change in tensile strength with time

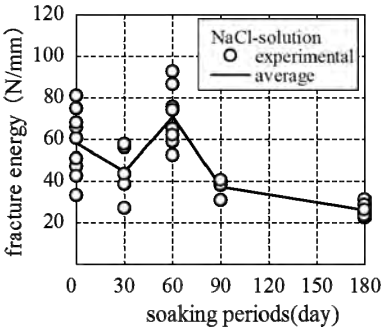
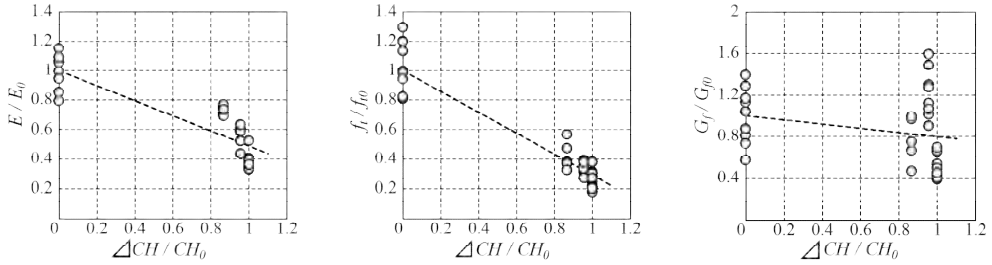
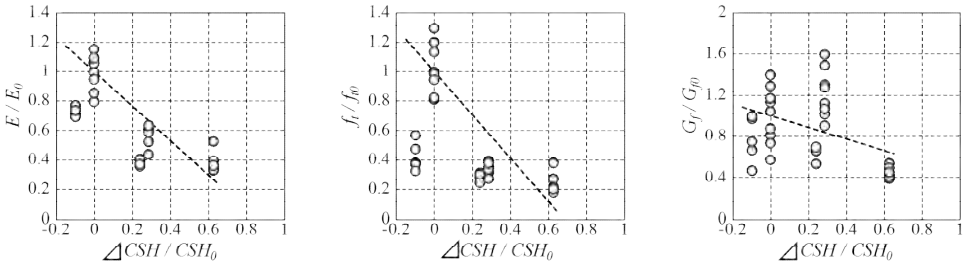


Figure 7: The change in fracture energy with time



(a) Elastic modulus (b) Tensile strength (c) Fracture energy

Figure 8: The relationships between the reduction of CH and tensile behavior



(a) Elastic modulus (b) Tensile strength (c) Fracture energy

Figure 9: The relationships between the reduction of C-S-H and tensile behavior

4. MODELING

In this experiment, the change in tensile behavior influenced by the chloride ion was determined. Then, the model formulas of elastic modulus, tensile strength and fracture energy which can take into consideration the amount of hydrates are proposed based on the experimental results.

It is well-known that strength decreases along with increasing of porosity size (Roy, 1975). Therefore elastic modulus and fracture energy can be also related to its strength. In this paper, elastic modulus, tensile strength and fracture energy are approximated by the following equations because the reduction rate of hydrate might be related strongly to the porosity change.

$$\frac{E}{E_0} = \exp\left[-\left\{\alpha_E \cdot \frac{\Delta CH}{CH_0} + \beta_E \cdot \frac{\Delta CSH}{CSH_0} + \gamma_{\alpha E} \cdot \frac{\Delta CH}{CH_0} + \gamma_{\beta E} \cdot \frac{\Delta CSH}{CSH_0}\right\}\right] \quad (2)$$

$$\frac{f_t}{f_{t0}} = \exp\left[-\left\{\alpha_{ft} \cdot \frac{\Delta CH}{CH_0} + \beta_{ft} \cdot \frac{\Delta CSH}{CSH_0} + \gamma_{\alpha ft} \cdot \frac{\Delta CH}{CH_0} + \gamma_{\beta ft} \cdot \frac{\Delta CSH}{CSH_0}\right\}\right] \quad (3)$$

$$\frac{G_f}{G_{f0}} = \exp\left[-\left\{\alpha_{Gf} \cdot \frac{\Delta CH}{CH_0} + \beta_{Gf} \cdot \frac{\Delta CSH}{CSH_0} + \gamma_{\alpha Gf} \cdot \frac{\Delta CH}{CH_0} + \gamma_{\beta Gf} \cdot \frac{\Delta CSH}{CSH_0}\right\}\right] \quad (4)$$

where E and E_0 are elastic modulus and initial one, f_t and f_{t0} are tensile strength and initial one, G_f and G_{f0} are fracture energy and initial one, ΔCH is the reduction of CH, CH_0 is the amount of CH before immersion, ΔCSH is the reduction of C-S-H, CSH_0 is the amount of C-S-H before immersion, α_E, α_{ft}, and α_{Gf} are the coefficient factors of which $\Delta CH/CH_0$ influences each tensile behavior, β_E, β_{ft}, and β_{Gf} are the coefficient factors of which $\Delta CSH/CSH_0$ influences each tensile behavior, respectively.

With this understanding, the coefficient values α and β were determined from regression analyses with experimental results and the coefficient values and determination coefficient $|r^2|$ are shown in table 1.

Table 1: Coefficient values

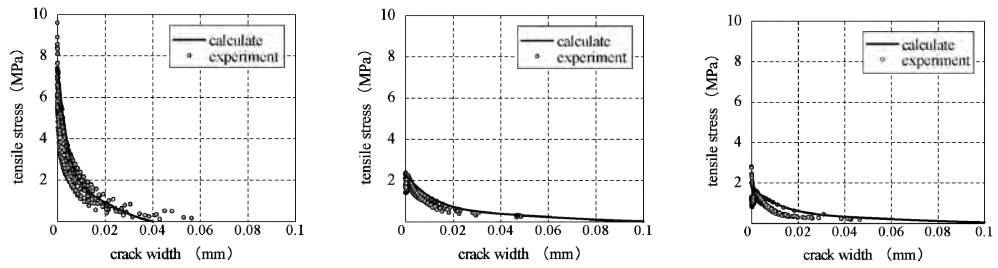
E			f_t			G_f		
α_E	β_E	$\|r^2\|$	α_{ft}	β_{ft}	$\|r^2\|$	α_{Gf}	β_{Gf}	$\|r^2\|$
0.4	1.0	0.875	1.0	0.7	0.910	0.1	0.4	0.532

In this study, the prediction equation for softening curves proposed by Hordijk (1991) is used.

$$\sigma = f_t \cdot \left[\left\{ 1 + \left(c_1 \cdot \frac{w}{w_c} \right)^3 \right\} \cdot \exp\left(-c_2 \cdot \frac{w}{w_c} \right) - \frac{w}{w_c} \cdot \left(1 + c_1^3 \right) \cdot \exp\left(-c_2 \right) \right] \quad (5)$$

$$w_c = {5.14 \cdot G_f} \Big/ {f_t} \quad (6)$$

where f_t is tensile strength, σ is tensile stress, w_c is maximum crack width, w is crack width, $c_1$and c_2 are constant values (c_1=3, c_2=6.93(Hordijk, 1991)). Figure 10 shows the comparisons of experimental tensile softening curves and the predicted one calculated by the equations 2 to 6. The proposed equations can predict the tensile behavior appropriately.



(a) before immersion (b) after 90 days (c) after 180days

Figure 10: The verification of tensile softening curves calculated by model equation

5. CONCLUSIONS

The changes in elastic modulus, tensile strength, fracture energy and tensile softening curves along with the change of the amount of CH and C-S-H in meso-scale specimens immersed in NaCl solution were clarified. Elastic modulus and tensile strength tended to decrease linearly along with the reduction of hydrate.

The model formulas of elastic modulus, tensile strength and fracture energy which can consider the change of the amount of hydrate were proposed.

With the model formula of tensile strength and fracture energy, tensile softening behaviour of the deteriorated mortar immersed in solutions including chloride ions was predicted with reasonable accuracy.

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INFLUENCE OF SURFACE STRESSES ON A THREE-DIMENSIONAL ELASTIC MEDIUM WITH MODE-I CRACK

Pong-in INTARIT[1], Teerapong SENJUNTICHAI[2], Jaroon RUNGAMORNRAT[3]
[1] Doctoral candidate, Faculty of engineering, Chulalongkorn University, Thailand
[2] Professor, Faculty of engineering, Chulalongkorn University, Thailand
Teerapong.S@eng.chula.ac.th
[3] Assistant Professor, Faculty of engineering, Chulalongkorn University, Thailand

ABSTRACT

Study on nanoscale systems has received wide attentions in recent years due to its importance in various advanced engineering applications. The surface-to-volume ratio of nanoscale elements is relatively high compared with that of macroscale elements and the effect of surface free energy becomes important. Surface energy effects are also important in the study of soft elastic solids. A theoretical framework based on continuum mechanics was developed to incorporate the influence of surface energy effects by Gurtin and Murdoch. In this paper, a penny-shaped crack in an infinite elastic medium subjected to mode-I loading is considered with the presence of surface stresses by employing the Gurtin-Murdoch continuum theory of surfaces elasticity. Hankel integral transforms are used to solve the boundary-value problems associated with surface stresses. A set of simultaneous dual integral equations is solved by employing appropriate solution scheme. Selected numerical results are presented to portray the influence of surface stresses on the bulk elastic field. It is found that the surface stresses have a significant influence on the bulk elastic field. Numerical results also reveal that material becomes tougher with the presence of surface stresses. In addition, the bulk elastic field shows the size-dependent behavior with the consideration of surface stresses. The solutions presented in this study provide fundamental understanding of the influence of surface stresses on the bulk elastic field in fracture mechanics of nanoscale structures and soft elastic solids.

Keywords*: Continuum mechanics; crack; fracture mechanics; surface elasticity; surface stresses*

1. INTRODUCTION

Study on the mechanics of nanomaterials and nanostructures becomes important in various advanced engineering applications due to their possession of superior properties. In nanoscale structures, the influence of surface/interfacial free energy becomes significant due to their high surface-to-volume ratio. Naturally, analysis of nano-scale materials can be carried out by employing an atomistic modeling technique. However, this approach is computationally demanding when applied at a device/system level. Considering nanosize effects based on continuum concepts is very efficient option to obtain first-approximation solutions in the analysis of nanoscale systems. The effect of surface energy, which is generally ignored in the conventional continuum mechanics, is one of the aspects that have been employed to describe the properties of structures and devices in the range of nanometer. A rigorous theory based on continuum mechanics concepts was developed to incorporate the surface and interfacial energy effects by Gurtin and Murdoch (1975, 1978). The surface is modeled as a zero thickness layer perfectly bonded to the underlying bulk material. Miller and Shenoy (2000) examined the size effect of the nano-scale plates and bars by employing Gurtin-Murdoch continuum model associated with surface stresses and found that the results were in excellent agreement with those based on atomistic simulations.

Fracture mechanics study is one of most interesting field in an engineering approach. It has important applications for improving the mechanical properties of engineering devices and structures. Several crack and dislocation problems were studied in the context of classical continuum theory by considering the influence of surface stresses (Wu, 1999; Wang et al., 2008; Fu et al., 2008; Intarit et al., 2010; Kim el al., 2010, 2011). A literature survey indicates that all existing studies related to crack problems with the presence of surface stresses are concerned with plane problems. In this paper, a fundamental problem of penny-shaped crack in an infinite elastic medium is examined by adopting Gurtin-Murdoch theory of surface elasticity. An axisymmetric vertical load is applied on the crack surface and a perfectly sharp crack tip is assumed. Hankel integral transform together with a solution technique for dual integral equations are employed to solve the boundary-value problem involving non-classical boundary conditions associated with the surface stresses. Selected numerical results are presented to describe the influence of surface stresses on the elastic field.

2. GOVERNING EQUATIONS AND GENERAL SOLUTIONS

Consider a penny-shaped crack with a radius a subjected to axisymmetric vertical loading in an infinite elastic medium as shown in Fig. 1. The response of the elastic medium is modeled by the Gurtin-Murdoch continuum theory (Gurtin and Murdoch 1975, 1978). According to this model, the surface energy effects are considered by modeling the surface as a mathematical layer of zero thickness with relevant elastic properties and residual surface tension that is perfectly bonded to the underlying bulk material.

In the absence of body forces, the equilibrium, the constitutive equations and the strain-displacement relationship of the bulk material are given respectively by where u_i, σ_{ij} and ε_{ij} denote respectively the components of displacement, stress and strain tensors. In addition, μ and λ are Lamé constants of the bulk material.

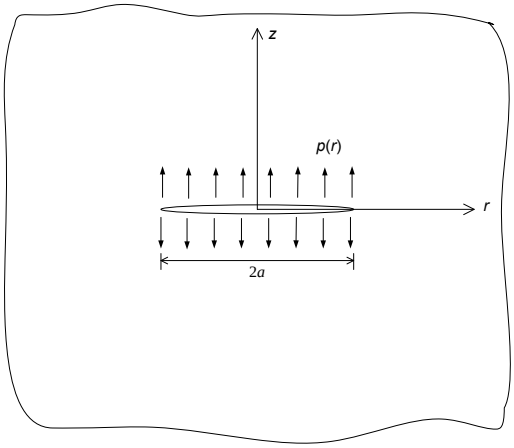

Figure 1: A penny-shaped crack in an infinite elastic medium

$$\sigma_{ij,j} = 0 \tag{1}$$

$$\sigma_{ij} = 2\mu\varepsilon_{ij} + \lambda\delta_{ij}\varepsilon_{kk} \tag{2}$$

$$\varepsilon_{ij} = \frac{1}{2}\left(u_{i,j} + u_{j,i}\right) \tag{3}$$

On the crack the surface, the equilibrium equation, constitutive laws and strain-displacement relations can be expressed as (Gurtin and Murdoch 1975, 1978).

$$\sigma^s_{i\alpha,\alpha} + \sigma_{ij} n_j = 0 \tag{4}$$

$$\sigma^s_{\beta\alpha} = \tau^s\delta_{\beta\alpha} + 2\left(\mu^s - \tau^s\right)\varepsilon_{\beta\alpha} + \left(\lambda^s + \tau^s\right)\varepsilon_{\gamma\gamma}\delta_{\beta\alpha} + \tau^s u^s_{\beta,\alpha},\ \sigma^s_{3\alpha} = \tau^s u_{3,\alpha} \tag{5}$$

$$\varepsilon^s_{\alpha\beta} = \frac{1}{2}\left(u^s_{\alpha,\beta} + u^s_{\beta,\alpha}\right) \tag{6}$$

where the superscript '*s*' is used to denote the quantities corresponding to the surface; μ^s and λ^s are surface Lamé constants; τ^s is the residual surface stress (or surface tension) under unstrained conditions; and n_i denotes the

components of the unit normal vector of the surface. In addition, Greek subscripts denote the field quantities associated with the surface and take the value of 1 or 2, while the Latin subscripts adopt values from 1 to 3.

Due to the symmetry about the *z*-axis of the penny-shaped crack shown in Fig.1, the stress fields under consideration are therefore independent of θ, i.e. $\sigma_{r\theta} = \sigma_{z\theta} = 0$. The general solutions for the bulk stresses and displacements can be expressed with respect to a cylindrical coordinate system by using Hankel integral transforms as (Sneddon 1951),

$$\sigma_{rr} = \int_0^\infty \xi \left[\lambda \frac{d^3\Phi}{dz^3} + (\lambda + 2\mu)\xi^2 \frac{d\Phi}{dz} \right] J_0(\xi r)\, d\xi - \frac{2(\lambda+\mu)}{r} \int_0^\infty \xi^2 \frac{d\Phi}{dz} J_1(\xi r)\, d\xi \tag{7}$$

$$\sigma_{\theta\theta} = \lambda \int_0^\infty \xi \left[\frac{d^3\Phi}{dz^3} - \xi^2 \frac{d\Phi}{dz} \right] J_0(\xi r)\, d\xi + \frac{2(\lambda+\mu)}{r} \int_0^\infty \xi^2 \frac{d\Phi}{dz} J_1(\xi r)\, d\xi \tag{8}$$

$$\sigma_{zz} = \int_0^\infty \xi \left[(\lambda + 2\mu) \frac{d^3\Phi}{dz^3} - (3\lambda + 4\mu)\xi^2 \frac{d\Phi}{dz} \right] J_0(\xi r)\, d\xi \tag{9}$$

$$\sigma_{rz} = \int_0^\infty \xi^2 \left[\lambda \frac{d^2\Phi}{dz^2} + (\lambda + 2\mu)\xi^2 \Phi \right] J_1(\xi r)\, d\xi \tag{10}$$

$$u_r = \frac{\lambda + \mu}{\mu} \int_0^\infty \xi^2 \frac{d\Phi}{dz} J_1(\xi r)\, d\xi \tag{11}$$

$$u_z = \int_0^\infty \xi \left[\frac{d^2\Phi}{dz^2} - \frac{\lambda + 2\mu}{\mu} \xi^2 \Phi \right] J_0(\xi r)\, d\xi \tag{12}$$

where

$$\Phi(\xi, z) = (A + Bz)e^{-|\xi| z} \tag{13}$$

Note that $J_n(\xi)$ denotes the Bessel functions of the first kind of order *n*. In addition, *A* and *B* are the arbitrary functions to be determined from the appropriate boundary conditions.

3. SOLUTIONS OF BOUNDARY-VALUE PROBLEMS

Consider a penny-shaped crack with a radius *a* subjected to axisymmetric vertical loading $p(r)$ in an infinite elastic medium as shown in Fig. 1. Due to the symmetry about *z*-axis of the problem together with the assumption that surface tension is constant, the boundary conditions on the crack surface ($z = 0$) can be expressed as

$$\sigma_{zz} + \tau^s \left(\frac{d^2 u_z}{dr^2} + \frac{1}{r} \frac{du_z}{dr} \right) = -p(r) \qquad \text{when } 0 < r < a \tag{14}$$

$$u_z = 0 \qquad \text{when } a < r < \infty \tag{15}$$

$$\sigma_{rz} + \kappa^s \left(\frac{d^2 u_r}{dr^2} + \frac{1}{r} \frac{du_r}{dr} - \frac{u_r}{r^2} \right) = 0 \qquad \text{when } 0 < r < a \tag{16}$$

$$\sigma_{rz} = 0 \qquad \text{when } a < r < \infty \tag{17}$$

where $\kappa^s = 2\mu^s + \lambda^s$ is a surface material constant. By substituting stresses and displacements from Eqs.(7) – (12) into Eqs.(14) - (17), a set of simultaneous dual integral equations is constituted. The arbitrary functions A and B can be obtained by solving dual integral equations using solution technique proposed by Erdogan and Bahar (1964)

4. NUMERICAL RESULTS AND DISCUSSION

Due to the complexity of fundamental solutions for the penny-shaped crack considering the effects of surface elasticity, the solutions for elastic fields have to be computed by using numerical quadrature scheme. In this section, selected numerical results are presented to demonstrate the influence of surface stress on the elastic field of the medium. The surface elastic constants can be obtained by employing atomistic simulations (Miller and Shenoy 2000, Dingreville). In the numerical study, It is convenient to introduce the following non-dimensional quantities, $r_0 = r/\Lambda$; $z_0 = z/\Lambda$ and $a_0 = a/\Lambda$, where $\Lambda = |\kappa^s/\mu|$ and it has the dimension of length. The numerical results in the present study correspond to the case of a penny-shaped crack in an infinite elastic medium subjected to a uniformly distributed vertical load, P_0 applied on the crack surface. In addition, the material properties of λ/μ = 1.94, Λ = .24983 nm and τ^s = 0.6056 N/m for Si [100] (Miller and Shenoy, 2000) are used in the present study.

To verify the accuracy of solution technique used in the study, the convergence of the present study solution is plotted for the classical case, where the surface stress is excluded (i.e. $\kappa^s = \tau^s = 0$), compare with the analytical solution in classical elasticity. In Fig. 2, the convergence of present solution is shown for non-dimensional vertical stress in the vicinity of crack tip. Note that the broken line denotes the classical elasticity solutions. It can be seen from the figure that the present solution shows excellent agreement with classical elasticity solution proposed by Fabricant (1989).

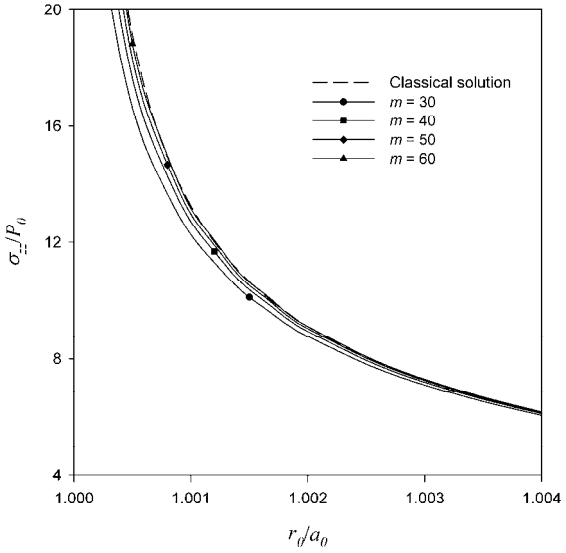

Figure 2: Convergence of non-dimensional vertical stresses in the vicinity of crack tip

Figures 3 and 4 demonstrate the influence of surface stress on the elastic field of an elastic medium near the crack region. A non-dimensional crack radius, a_0 = 1.0 is considered in the numerical study. In Fig. 3, the variation along the *r*-axis of non-dimensional vertical stresses in the region near the crack tip is presented, whereas Fig. 4 displays the non-dimensional crack opening displacements. The non-dimensional stresses and displacements shown in Figure 3 and 4 are presented for Si [100] and hypothetical material (λ/μ = 1.94, Λ = .24983 nm) with different values of residual surface stress (i.e. τ^s = 0.1 and 1.0 N/m). Note that the broken lines in Fig. 3 and 4 denote the classical elasticity solution (Fabricant, 1989), which can also be obtained from the present solution with the absence of surface stress (i.e. $\kappa^s = \tau^s = 0$).

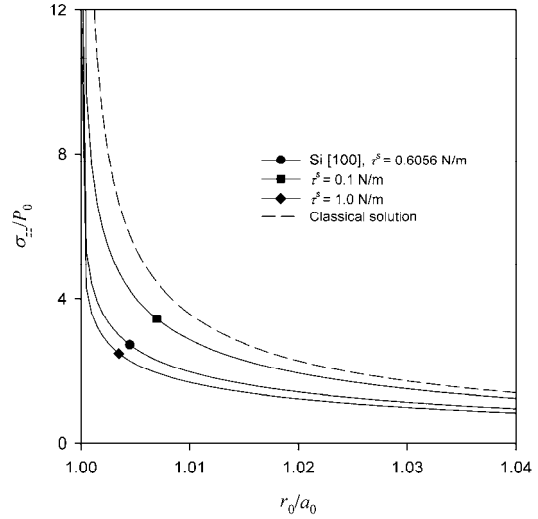

Figure 3: Non-dimensional vertical stress profiles in the vicinity of crack tip under uniformly distributed vertical load for different residual surface stresses.

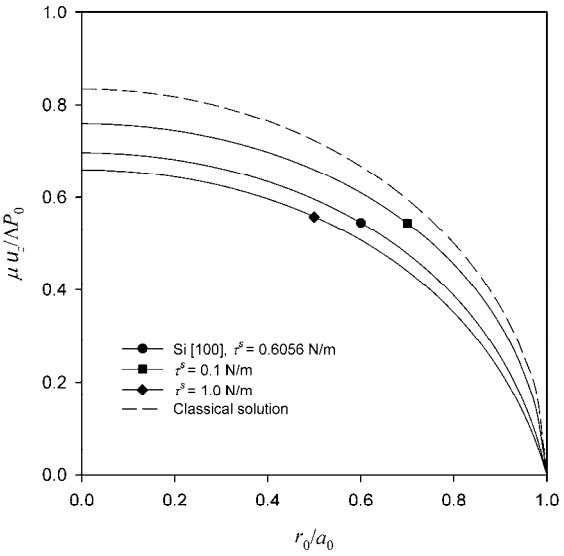

Figure 4: Non-dimensional crack opening displacement under uniformly distributed vertical load for different residual surface stresses

The variation of non-dimensional vertical stress on the crack plane in the region near the crack tip shown in Fig. 3 reveals that the surface stress has a significant influence on the vertical stresses, especially in the vicinity of the crack tip where the vertical stress approaches infinity for both classical and present solutions. It is observed from the figure that the presence of surface stress effects results in the reduction of vertical stresses. Similar aspect is also found in the case of plane strain cracks (Kim et al., 2011), except that in their cases the stress at the crack tip is finite due to the assumption of finite stress at crack tip. In Fig. 4 the influence of the surface stress on the crack opening displacement is presented. As in classical elasticity, the maximum displacement is located at the center of the crack before gradually reduces to zero at the crack tip. In addition, it can be seen from the figure that the presence of surface stress causes the reduction of the crack opening displacement.

5. CONCLUSIONS

The fundamental solution of a penny-shaped crack in an infinite elastic medium is derived with the consideration of surface stress influence by adopting the Gurtin-Murdoch continuum theory and the Hankel integral transform. A set of simultaneous dual integral equations is solved by employing appropriate solution scheme. The solutions of stresses and displacements are expressed in terms of semi-infinite integrals and can be computed accurately by employing a numerical quadrature scheme. It is found from the numerical results that the surface stress has a significant influence on the elastic field. Both vertical stress and crack opening displacement from the present study show similar trends with their classical solutions. It is also found that the consideration of surface elasticity effects

results in some decrease in the solutions when compared to their classical counterparts.

ACKNOWLEDGEMENT

The work presented in this paper was supported by research grants from the Thailand Research Fund (TRF).

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DESIGN OF RECONSTRUCTION TO SAVE PEOPLE IN IWANUMA, MIYAGI

Rina GOTO
Graduate Student School of Eng, The University of Tokyo, J apan
Mikio Koshihara Laboratory
Rina1119@iis.u-tokyo.ac.jp

ABSTRACT

The catastrophic earthquake and tsunami devastated the Pacific coast of north-eastern, Japan, on Friday, March 11,2011. The magnitude of the earthquake was 9.0, the most powerful earthquake ever measured in Japan. About 19,000 people are dead and missing. However, the damages are varied in areas. In the Sendai plain, where has plains along the shore but not hills, flooding area spread widely.

This year, from April to July, as a part of the reconstruct of MIYAGI area, the design studio was held. Building sites are the west of Tamaura town, Iwanuma city. The site is 27.8ha, spreading from Megumino residential area to paddy fields. In the eastern side, there are a main road and educational, public facilities. In recent years, the center of the city, Megumino has been developed and urbanized. A farming village has survived around area.

We design in terms of topography, vegetation, and view. In our proposal, Tamaura mound will save more and more people than before.

Keywords*: a devastating earthquake, Iwanuma area, sea shore, mound, Igune, a rice field (except a proper noun)*

1. INTRODUCTION

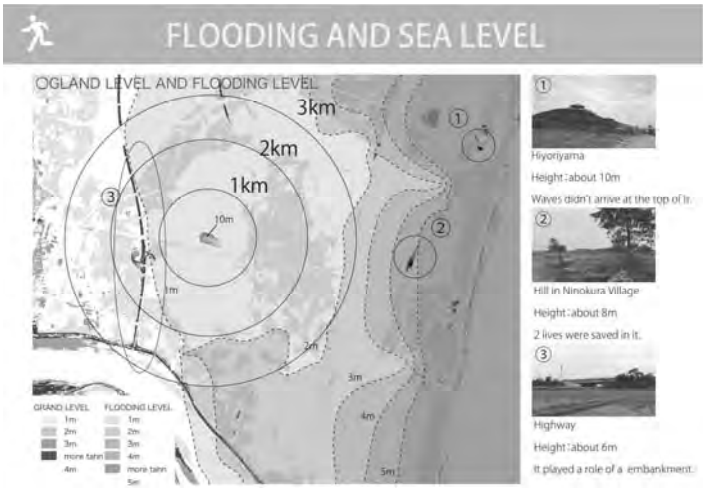
Hiyoriyama, a small man-made mound, saved some flood victims in tsunami.

For the mound is 10 meters in height, waves didn't come to the top of it. Since then, Hiyoriyama have been the help of their memories. Coming people said to have an emotional time, remembering the disaster and native places. Therefore, we proposed that Tamaura mound save more and more people in the disaster and everyday life. When waves are coming, the mountain has a large capacity, 1500 people in the site and 2400 people in Megumino. In daily, they have an emotional time, looking at the village and Megumino area. Igune, a kind of woods in this area, save their houses from the strong wind. In addition, some kinds of events are held for seasons there and taken over for next generation.

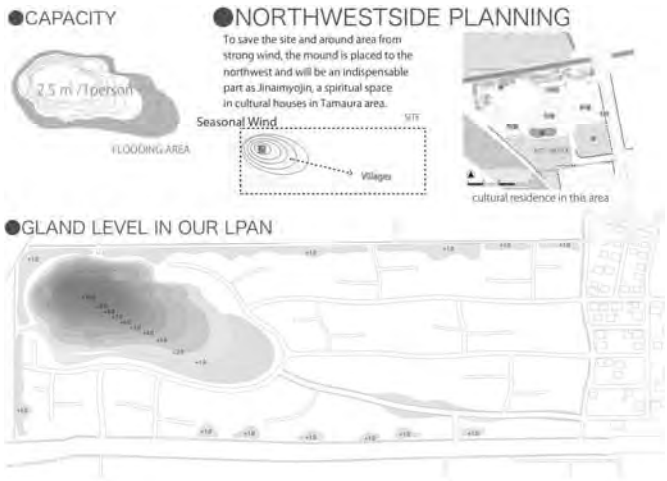
2. ANALYSIS AND PROPOSAL

2.1 Flooding and sea level

In Sendai plain, these figure and data show that a little mound is a place of refuge. For example, Hiyoriyama is 10 meters in height and waves didn't arrive at the top of it. Highway played a role of a tide embankment. Moreover, this map shows that people can take refuge from the tidal wave to Tamaura mound.

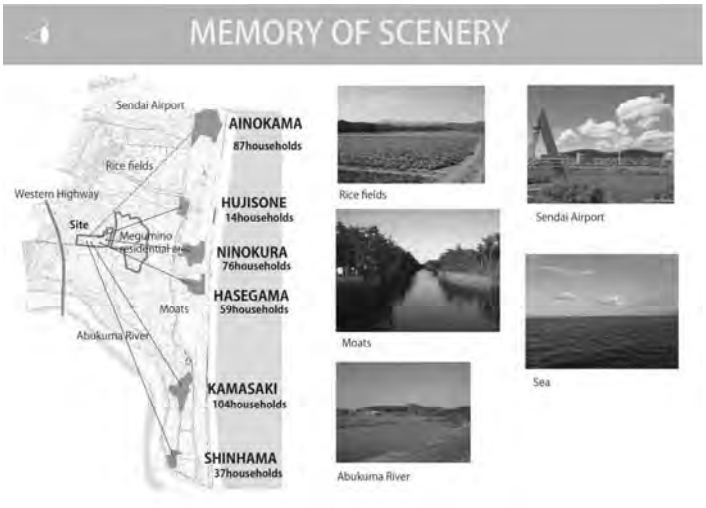


Tamaura mound developed in the site is 37500 ㎡ in area, as an open space or a park provided by the reconstruction plan. We establish the mound 10 meters to have an incline for living people, a capacity as a shelter, and a fine view. To save the site and around area from strong wind, the mound is placed to the northwest and will be an indispensable part as Jinaimyojin, a spiritual space in cultural houses in this area.

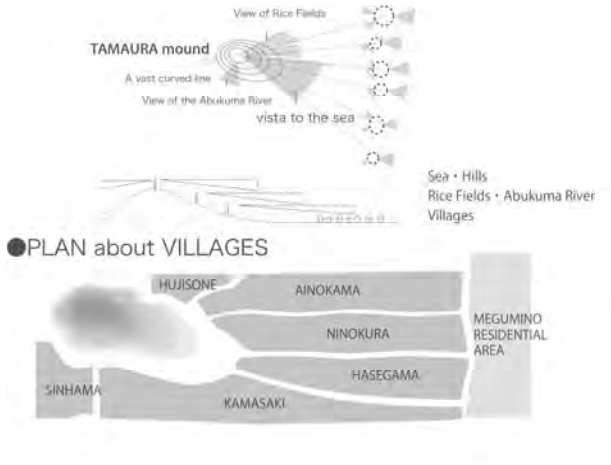


2.2 Memory of scenery

Six villages coming from sea shore area had seen moats, rice fields, rivers, and the sea, where people had rowed a boat, fished and swum. In our plan, Tamaura mound sees new sceneries. Six villages surround this mound and a reservoir spread at the foot of it.

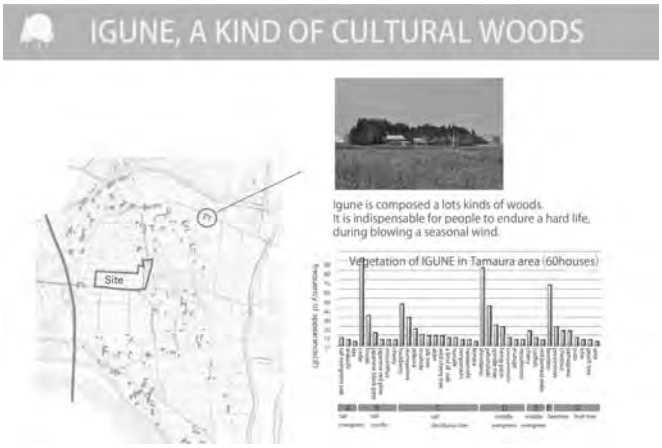


For several years, Tamaura mound will make people see an extensive rice fields, the sky high above them, the eternal flowing rivers, a vast curved line, a pine grove, the horizon, sea over there, and native paces. These sceneries save them to recall the past, not to forget their important memories.

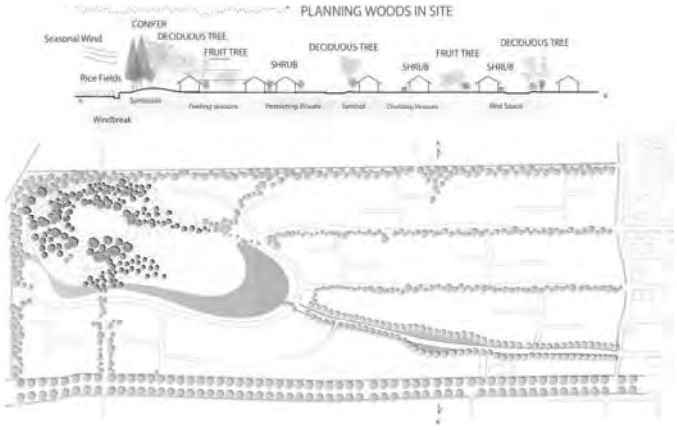


2.3 Igune, a kind of cultural woods

Igune, composed a lot of kinds of woods, appears to be a small forestry scenery and is indispensable for people to endure a hard life, during blowing a seasonal wind.

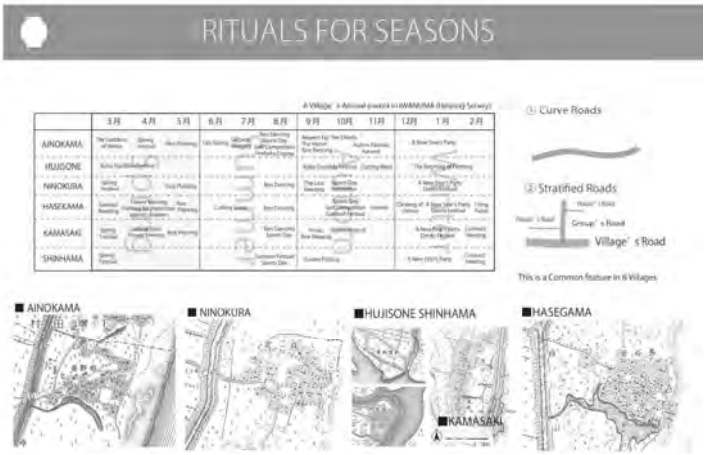


Igune plays an important part in dividing areas, such as playgrounds, seasonal symbol, secure of the privacy, a place of rest and relaxation. Children work hard and play hard. Cherry trees make the street more bustling. People can spend a calm time for the shade of trees in their own houses.

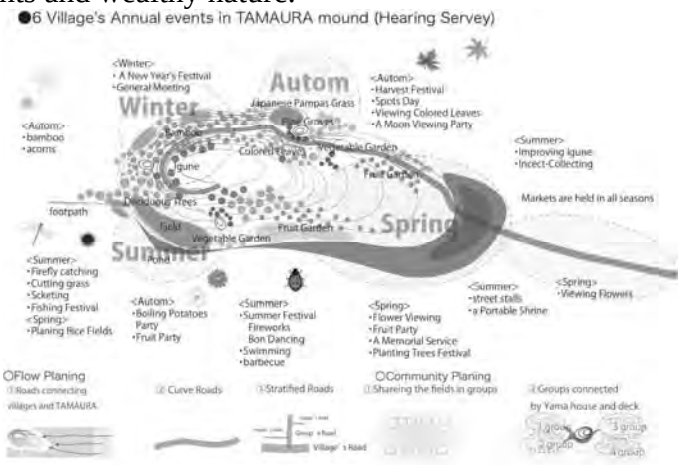


2.4 Rituals for seasons

This site as shown in figure was given the earliest as the place for a group move in stricken area, for a close bond of affection during villages. This bond has been made up by people admiring the beauty of seasons.

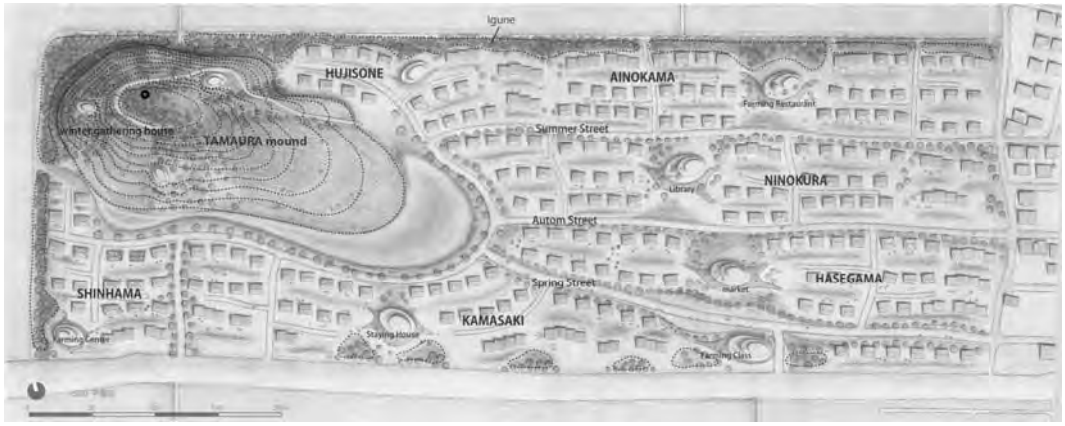


Annual events, cultural festivals will be taken over in this new site. Tamaura mound colored by seasons have people connected to nature and six villages integrated at seasonal changes. Living people continue to admire cultural events and wealthy nature.



3. PLANNING

Six villages, Hujisone, Ainokama, Ninokura, Hasegama, Kamasaki, and Shinhama, surround Tamaura mound and are divided softly by Igune. Groups composing villages possess fields. Anyone can use Yama house freely. It connects one group to another. Tamaura mound overlooks a vivid life for villages and stand in front of them. Living people know plentiful seasonal views anywhere.



4. NEW LANDSCAPE IN TAMAURA

A row of cherry trees leads to Tamaura mound. Spring festival is held in each village under the trees.

Summer night coming, feeling summer festival over there, and looking at lighting bugs in a stream, will have reminded climbing people of moats along the sea.

In autumn, harvest time, deck is filled with people and the crops. Igune turns yellow and shroud each village gently.

A general meeting having taken over for a long time will have been held continuously, during wintertime, in the gathering house. The trees are shedding their leaves. Their fields of a vision suddenly open up. The grandeur of nature stands in front of us.

Therefore each culture unifies communities and people live in symbiosis with nature throughout the year. For several years, spring coming, the great sceneries, glittering fields, Igune, villages, and sea over there, will have revived again.

5. CONCLUSIOON

We proposed that Tamaura mound saved more people. If these villages decline in several decades, streets and mound will be left and continue to work as an evacuation route. Prospects spreading around villages have been engraved on their mind. Igune leading to the mound makes up features of the scenery and give them the presence of mind. Seasonal events stimulate succession to nature and culture. Therefore our suggestion aims at sustainable reformation. We desire that our design save lives and memories of more and more people.

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ANALYSIS OF TRANSBOUNDARY IMPACTS OF HYDROPOWER DEVELOPMENT IN THE MEKONG: CASE OF 3S SUB-BASIN

Seemanta BHAGABATI[1], Akiyuki KAWASAKI[2],
Mukand BABEL[3]and Peter ROGERS[4]
[1]Graduate Student, School of Engineering and Technology,
Asian Institute of Technology, Thailand
seemanta0605@gmail.com
[2]Visiting Associate Professor, WEM, SET,
Asian Institute of Technology, Thailand
[3]Associate professor, WEM, SET,
Asian Institute of Technology, Thailand
[4]Gordon McKay Professor of Environmental Engineering,
Harvard University

ABSTRACT

Hydropower dam development has enormous economic, environmental, and social impacts at a local, national, and trans-national level. It has become a priority in water resources, environmental, and economic planning in transboundary water systems. The impact on downstream users is of particular concern, as hydropower development has historically both positively and negatively impacted downstream players in significant ways. It has been suggested that transboundary water conflicts, such as those that may arise from hydropower dam development, may be resolved through benefit sharing. Game theory has been used as a conceptual tool to analyse the possibilities for benefit sharing and their relative optimality and equitability. This study attempts to investigate the utility of a game theory approach for the impact of hydropower dam development on water resources adaptation in transboundary sub-basins. The study area is the 3S basin in the Mekong River Basin, covering areas in Cambodia, Laos, and Vietnam. Regional stakeholders' feedback has been incorporated to define models and methodologies, and an adaptation strategy for the area has been proposed. This study proposed a methodology for analysing complex transboundary river-basin issues, which will provide an important basis for local policy decisions and regional planning in the Mekong River and beyond.

Keywords*: 3S sub-basin, Cambodia, game theory, hydropower development, Laos, Mekong River Basin, optimization, transboundary water issues, Vietnam*

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 and human settlement has always been near-by Rivers. A healthy river is typically one with: protected watersheds, preserving soil fertility and reducing contaminant and sediment soil transport; conserved wetlands, floodplains and groundwater recharge areas, to maintain their natural capacity to buffer river flow and water quality variations; protected aquatic and riverine terrestrial biodiversity; and controlled water abstraction and wastewater discharge, to manage river flows and water quality (Sadoff, C.W. et al, 2002).

There are hundreds of rivers in the world, out of which there are more than 200 river basin shared by two or more countries. Hence these rivers are called International River and their basins are known as International river basins. Proper water resources allocation is a very important issue and there have been many critical debates and conflicts throughout the world in the history of mankind. Conflicts among the riparian countries prevent them from making the best use of their shared water resources. Negotiating for the adequate sharing of these resources is a very critical subject of discourse involving fields like public policy, environmental sciences, engineering and economics. The work has evolved in the recent years as previous literature has used numerous economic and mathematical frameworks to quantify and guide the decision-making process in water resource allocation.

The impact of hydropower development on transboundary basins is a key issue and it must consider local, national as well as transnational stakeholders . With the increasing demand of energy along with the population growth and increasing domestic, agricultural and industrial needs, hydropower development has become increasingly critical in policy decisions. It has always been perceived that water allocation is a zero-sum game, i.e. water resources are finite and that one use will always preclude another. Although physically speaking, water is finite, but there are many non-consumptive uses of water as well, viz. hydropower generation, fisheries, recreation and navigation. The use of water in these will not necessarily diminish the water availability in the ecosystem for other uses. Hence, if proper planning and cooperation exists, water allocation may be converted into a positive sum game.

1.1 Statement of problems

The demand of energy has been increasing rapidly. Energy is one of the vital requirements for developing countries like Vietnam, Thailand, Cambodia, etc. With the depleting coal mines and petroleum, which were the main sources for energy production, it is required that new sources of energy to be found out. Hydropower is a renewable source of energy and is also environmental free. Its maintenance cost is also fairly low compared to other sources of energy and doesn’t produce any waste products.

Although, Hydropower is very promising, it has many negative impacts on the downstream region. In case of an International river, the upstream and downstream may not lie in the same country, resulting disputes and conflicts among the riparian countries. The environmental dimensions of geopolitics is needed to be rethought and the relation of humanity to 'nature' is to be reconsidered (Dalby, S. 2003). Hence, if the riparian countries cooperate then these disputes can be minimised and the outputs can be maximised.

1.2 Objectives of the Study

The study aims in studying the transboundary water issues in the 3S Basin of the Mekong River. The objectives can be summarized as:

1. Development of a comprehensive method to assess the benefits and costs of HEPs.
2. Optimization of the hydropower development with benefit sharing.

1.3 Game Theory for transboundary analysis

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 Jean-Pierre P Langlois, 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. The discussion on benefit sharing takes it for granted that there are indeed benefits of cooperation in the transboundary context that can be realized and shared. In this context, Sadoff & Grey (2002) distinguished benefits from river, to the river and beyond the river, as well as reduced costs because of the river. Dombrowsky (2009) has pointed out: "The idea is that cooperation can be driven by direct benefits from various water uses, by joint concerns for environmental protection, by a broader interest in regional integration or by the will to reduce the costs of conflict".

2. STUDY AREA

2.1 The 3S sub-basin: Sekong, Sesan and Sre Pok

The Sekong, Sesan and Sre Pok sub-basins, commonly known as the 3S Basin, is the largest tributary system of the Mekong River. It covers the border areas of the "Indochina Junction" in Cambodia, Laos and Vietnam. With a total area of 78,650 km^2, the 3S is the largest tributary system of the Mekong River. The 3S basin amounts to 10% of the Mekong River basin and contributes 17% of the total runoff (He, J. et al, 2010). The 3S basin is located in Cambodia (33.03%), Lao PDR (28.69%) and Vietnam (38.28%).

2.2 Hydropower in the 3S sub-basin

Hydropower potential of the 3S area has attracted attention for more than 50 years. A number of hydro-power plants (HEP) are already constructed and many are under construction or in the designing or master plan phase. The total number amounts to 41 (as of April 2009) (Asian Development Bank, 2009). These 41 plants are shown in the Figure 2.1 based on their stage.

Currently, power production in Cambodia is heavily relied on fossil fuels. A significant percentage of the energy is imported. Hence, Cambodia would like to reduce its dependence on imported energy. In Laos, one of the most sparsely populated countries in the world, while domestic energy demand is growing, hydropower development is focused on revenue generation through exporting energy to Vietnam and Thailand. Vietnam, on the other hand, already has many HEPs but still it has to import energy to meet its requirements.

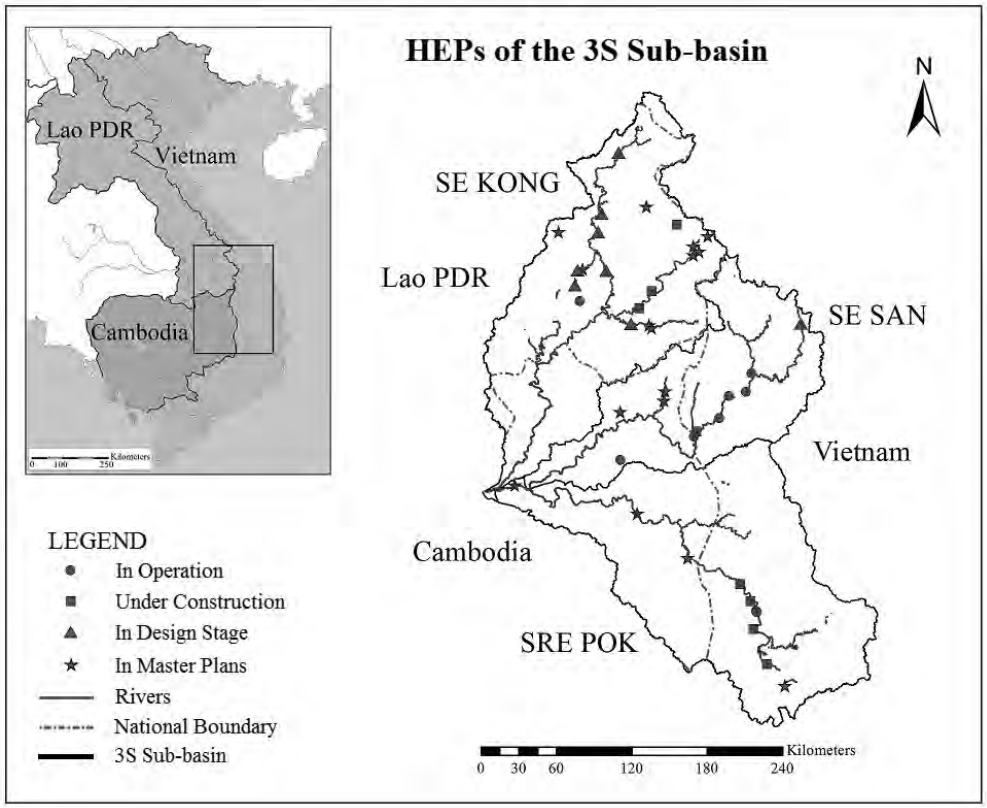


Figure 2.1: The hydropower plants based on stage of the 3S sub-basin

3. 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.

3.1 Economic valuation of benefits

Hydropower dams, apart from the production of electricity, provides many other forms of benefits as well, such as benefits from reservoir fisheries, irrigational benefits, flood control, saline intrusion, recreational benefits and so on. For the present study the following four factors have been considered for calculating the benefits viz. (a) Energy production, (b) Irrigational benefits, (c) Benefits from fisheries and (d) Flood control.

(a) Energy production

There exist many different methods for estimating the costs and benefits of hydropower projects. The valuation method based on the concept of "replacement cost" has been used. It calculates benefits from alternative energy production to produce the equivalent amount of energy provided by a HEP. It is different for each country based on the most popular method of alternative energy generation (coal in Vietnam, coal/diesel combination in Laos and Cambodia). This valuation also includes the benefits and costs of export/import of electricity. This method was chosen because of its suitability for the policy decisions with which this study is concerned. Using this method, based on the annual energy production, the benefits from energy production of all the HEPs were calculated.

(b) Irrigational benefits

Large scale irrigation, using irrigation canals, is often seen in agricultural fields. The irrigation canals drastically improve the agricultural productivities. The same can be seen in the case of Nam Theun 2 multi-purpose hydropower plant (NTPC, 2011). Based on the past governmental records of irrigated yield for the year 2007 and the projected yield for 2030 (with optimal water management), the annual net benefits from irrigated crops for the three countries has been estimated (MRC, 2010). The individual country benefits, based on the 3S area, were then distributed evenly among the HEPs constructed for the purpose of Irrigation.

(c) Benefits from fisheries

Directly or indirectly, most of the local communities along the river basin are dependent on fisheries and aquaculture. Reservoirs of the hydropower plants promote aquaculture to a great extent. For estimating the economic benefits, market prices of 2010 and culture fish were used. The annual benefit also considered the production/fishing costs along with the marketing expenses. Due to lack of reliable data, for the estimation of benefits from fisheries, household surveys were done my MRC, which surveyed peoples' consumption of fish and other aquatic animals. Based on the 3S area, the benefit of each country was calculated. A linear relation between the catchment area and this benefit has been established for all the three countries. Using this relation, the benefits for each HEPs has been calculated based on the catchment area of each HEP.

(d) Flood Control

The annual economic benefits of mitigating floods during the wet season due to the improved regulation of river flows has been estimated

(MRC, 2010). This benefit includes lower crop losses and well as reduced damage to houses, businesses and public infrastructures, i.e. roads, schools, health centres etc. The area of land benefiting from flood risk reduction was estimated from the expected hydrological changes resulting from the construction of the UMB and LMB dams. These locations were then mapped using the GIS database and the resulting benefited areas were estimated. This total reduction of annual net economic damage due to flooding has been evenly divided among the HEPs constructed for the purpose of flood control.

3.2 Economic valuation of Costs

The estimation of all the costs of a HEP in a transboundary river basin is a very challenging task. Apart from the cost of construction or the investment cost, there are many other costs such as loss of fish, social losses like resettlement loss, water quality loss, cultural loss, navigational loss, loss of natural habitats like wetlands, grasslands, etc. which are related with the construction of a hydroelectric power project. Estimating the cost of all of these factors is beyond the scope of this study. For the present study the costs that were considered are (a) Annual costs of project (b) Cost of transmission lines (c) Socio-economic costs (d) Loss of fish (e) Navigational loss (f) Environmental loss

(a) Annual cost of project

The annual cost of the project is the amortized annual value of the investment cost calculated using the Capital Recovery Factor (CRF). CRF is the ratio of a fixed annuity to the current value of receiving the annuity for a given period of time i.e., CRF converts a present value into a number of equal annual payments for a given period of time, for a specific discount rate (interest).

CRF is calculated as:

$$\text{Capital Recovery Factor} = \frac{[(1+r)^L] * r}{[(1+r)^L] - 1}$$

where, r = discount rate and L = time period.

In context of hydropower development, estimated project life, L is considered as 50 years with a discount rate r of 10%.

(b) Cost of Transmission lines

A total of 14 HEPs have the provision of exporting electricity. The cost of construction has been calculated based on the distance of the destination grid of the country from the dam site. The cost of the "Na Bong-Udon Thani Power Transmission Project" has been used as a reference. The project includes a 27 km 500 V transmission line and the 500/230kV Na Bong substation (ADB, 2007). The total cost of the project is 760,000 US$. Based on the total cost of the project and the length of the transmission line along with the sub-station to be constructed, the price of construction of transmission lines per km has been found out to be US$ 28,150 per km of length. It was assumed that the hydropower importing country bears this cost.

(c) Socio-Economic Costs

This cost includes resettlement of local communities and compensation measures used. It also includes livelihood programs adopted for the welfare of the local communities, water quality monitoring, wildlife programs, public training and watershed management. These costs for the Nam Theun 2 (NT2) dam had been estimated to be around US$ 88 million (ADB, 2004). Using this data, a linear relationship between the socio-economic loss and the active storage of NT2 HEP has been formed as

$$SEC(i) = \frac{88}{3680} A(i)$$

where *SEC(i)* is the total socio-economic cost of HEP *i* in millions USD and *A(i)* is the active storage of HEP *i* in million cubic meters.
Annual socio-economic costs, $SEC_a(i) = SEC(i) \times CRF$.

It has been observed that for the NT2 dam, the communities up to 50-60 kms downstream were severely affected by the construction of the dam. Hence, for the present study, same concept has been used. Simple GIS has been used to calculate the affected areas and hence the costs were divided accordingly whenever needed.

(d) Loss of Fish

The seasonal fish migration is an important factor of the economic welfare and sustenance of the communities throughout the basin. Construction of dams on the river course restricts the migration of which hampers the fish productivity a lot. This loss of fish due to hydropower development has been extensively estimated by MRC for the three countries. The loss of fish per unit catchment area has been calculated, taking into account the total catchment area of the HEPs of each country. From this relation, the individual annual net loss of fish has been calculated.

(e) Navigational Loss

Water transport is one of the most economical inland navigational systems (Mihic, S. et al, 2011). Many communities of the 3S depend on inland navigation (especially country boats) as the main mode of transport of goods as well as mass. Construction of dams affects this system by restricting their free movement. This loss has been calculated and assigned to each of the three countries based on the 3S sub-basin area they share. This loss is then assigned equally among all the HEPs of the three countries.

(f) Environmental Loss

As environmental losses only the loss to the wetland for the 3S sub-basin was available. MRC 2010 has estimated the wetland loss in the 3S sub-basin resulting from HEP development. For this estimation only readily available data was used, no fieldwork was done. The assessment was limited to areas directly affected by changed hydrological and water quality conditions in the mainstream, including areas affected by combined flooding (backwater flooding) near the confluences of tributary rivers and also to areas where there was a direct dependence on capture fisheries, delineated by the extent of fish migration. This annual loss was then assigned to each HEP on its active storage.

Optimization Model

The hydropower planning process is modelled as a mathematical program where each country is a player and has two options: to build or not to build additional dams. The objective is to maximize the net total annual benefits (difference between total annual benefits and total annual costs) for the 3S. The Grand Coalition case seeks to maximize total benefit across all the three countries.

Sets	I	HEPs identified by Project ID
	J	Countries – Cambodia, Laos, Vietnam
Parameters	$stage_i$	1 – operational, 2 – under construction, 3 – design phase,
		4 – master plan
	$country_i$	1 – Laos, 2 – Cambodia, 3 – Vietnam
	$budget_j$	country hydropower investment fund
	$b_{i,j}$	benefits of HEP i on country j
	$c_{i,j}$	costs of HEP i on country 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 seven possible coalitions.

The constraints of this optimization models are the Benefit-cost ratio of individual HEPs and the individual country investment funds.

Scenarios considered

Seven different scenarios were considered. They are briefly explained below.

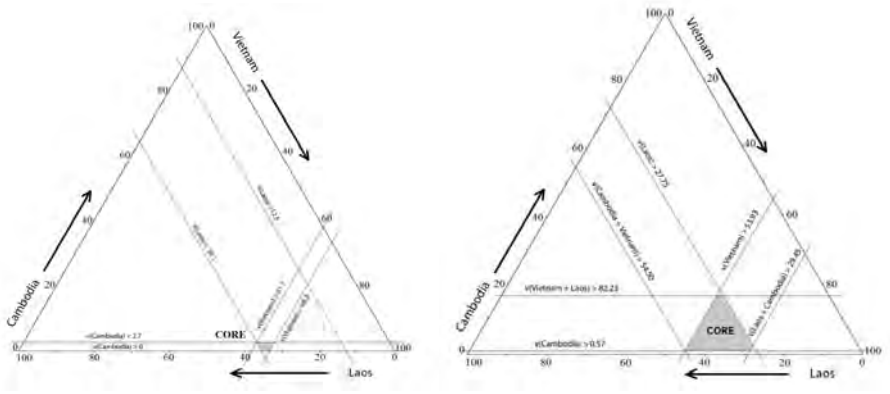
0. Status quo: Only the HEPs in operation, i.e. only Stage 4 HEPs, have been selected.
1. Complete current projects: All HEPs under construction (stage 3) have been considered along with scenario 0.
2. Maximize individual country benefits: Each country maximizes its benefits by constructing additional HEPs in stage 1 and 2 within individual budget constraints.. (a) Laos, (b) Cambodia and (c) Vietnam
3. Maximize two countries: Two countries maximize individual benefits (i.e., builds HEPs in stage 1 and 3) simultaneously within individual budget constraints; third country does not build any additional HEP. Results of scenario 1 have also been added. (a) Laos & Cambodia, (b) Cambodia & Vietnam and (c) Vietnam & Laos
4. Maximize two countries with joint budget: Two countries combine their individual budgets and then maximize within the joint budget constraint; third country does not build any additional HEP. Results of scenario 1 have also been added. (a) Laos & Cambodia, (b) Cambodia & Vietnam and (c) Vietnam & Laos

5. Grand coalition with separate budgets: All the three countries maximizes together but within their individual budget limits. Results of scenario 1 have also been added.
6. Grand coalition with joint budgets: All the three countries combine their budgets and then jointly maximizes. Results of scenario 1 have also been added.

4. RESULTS AND DISCUSSIONS

For individual country maximization, the highest benefit was achieved when 2(a) Lao PDR maximizes (the total benefit increased by 204.7 Million US$). For two player coalition, highest benefit was reaped when 3(c) Vietnam and Lao PDR maximizes together. The total benefits increased by 242.8 Million US$ (38.1 Million US$ more than 2(a) scenario). Again for two player coalition with joint budget, 4(c) Vietnam and Lao PDR maximizes together, gives the highest benefits.

The grand coalition will offer the maximum individual benefit to Cambodia of 251.1 Million US$, more than two times the maximum benefit achieved (123.5 Million US$) when it jointly maximizes with Vietnam (scenario 4(b)). In case of Vietnam, the small decrease in benefits of 44.2 Million US$ can be seen; whereas for Laos, the benefit decreases to 239.5 Million US$. But the total benefits increased from 856.0 Million US$ (scenario 4(c)) to 990.9 Million US$ (increase of 134.9 Million US$). Normally, it will not matter much for Vietnam to cooperate unless there exists any benefit sharing.



(a) (b)

Figure 4: Graphical representation of the benefit core for (a) present situation and (b) future scenario

Figure 4.1 is a ternary plot with Laos, Cambodia and Vietnam in the three axes. For Cambodia, the line is drawn parallel to Laos, for Laos it is parallel to Vietnam and for Vietnam it is parallel to Cambodia. For each of the three countries two values are shown, first is the maximum individual country benefit while the second one shows the maximum benefit that can be achieved through cooperation and benefit sharing. Figure 4.1 (a) shows the present situation whereas figure 4.2 (b) shows the future scenario.

5. CONCLUSION

Energy is a vital requirement for developing countries like Thailand and Vietnam. Hydropower is very promising in terms of energy production. It is a renewable source of energy, is highly efficient and is environment friendly. But in the context of an international river basin, hydropower development has resulted in disputes especially due to the downstream costs. While these costs minor compared to the benefits, deep understanding and estimation of these costs is very vital to develop strategies to effectively counter them.

The study tried to estimate to a total of 10 parameters related to the hydropower development such as energy production, benefit from irrigation, socio-economic costs, fish loss, environmental loss, etc. To some extent, all the costs and benefits for the HEPs in the study area have been estimated. Various scenarios were assumed and then optimized for maximizing benefits.

A game theoretical analysis allowed us to quantify and examine the roles of the three players in the game. Although Lao PDR has the lowest GDP of all three countries, this analysis has evidenced its political power in the hydropower game as a key exporter. Lao PDR's decisions about where and how much energy it will produce and to whom it will export this energy greatly influences the resulting benefit allocations.

As seen from all the coalition scenarios, there always exist partial coalition scenarios which yield higher individual net benefits compared to the grand coalition scenario. In order for cooperation schemes to be successful, there must be economic incentives for individual players to stay in the grand coalition.

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Student Report

REPORT FROM STUDENT PARTICIPANTS ON 5TH JOINT STUDENT SEMINAR ON CIVIL INFRASTRUCTURE

DATE: August 20-21, 2012

Participants at Sasa International House, Chulalongkorn University

PRESENTATION SESSION

Seminar room and participants

On the first day, the 5th Joint Student Seminar on Civil Infrastructure was held at the Sasa International House. This seminar was composed of four parts: keynote presentations, student presentations, review comments and closing remarks, followed by an award presenting banquet.

Keynote presentations

The first speaker was Dr. Michael Henry from Hokkaido University, who spoke about "Information collection and needs after disasters: lessons from the 2011 Tohoku Earthquake and 2011 Thai Flood." He mentioned the importance of information networks because many foreigners panicked due to the lack of accurate information from the Japanese government. The second keynote speaker was Dr. Punchet Thammarak from Chulalongkorn University, who spoke about "Numerical analysis of lateral pile motion under dynamic loadings."

Student presentations

Sixteen students from AIT (Thailand), Chulalongkorn University (Thailand), Chonnam National University (Korea), Myongji University (Korea), the University of Tokyo (Japan) and Hokkaido University (Japan) gave presentations. Four students presented about city planning, four talked about traffic planning and eight presented about civil engineering topics such as concrete technology, geo-techniques and hydrology.

Review comment, closing remarks and banquet

Prof. Hiroshi Yokota from Hokkaido University gave some comments in review of the seminar, and Dr. Kunnawee Kanitpong from Chulalongkorn University closed the seminar. After that, a wonderful banquet was held at the Sasa International House, and one Japanese student and one Korean student were awarded as Best Presenters.

Best Presenters: Ms. Suug-hi Ah and Mr. Yoshiyuki Takano (second and third from left)

Seminar attendees from Hokkaido University

Field Trip in Joint Student Seminar 2012

We went on a field trip on the second day. The first place we visited was Vimanmek Palace in the central part of Bangkok. It was the former residence of Thailand president, built in 1900s, and currently a national asset. Kings' collection of hunting weapons, tapestry and tableware were kept. Then we had lunch, enjoying the Thai cuisine together before taking a boat trip.

Group photo at Vimanmek Mansion

Lunch time at Thai restaurant

The boat trip was along the Chao Phraya River in Bangkok. The tour guide explained us about the historical places and area we passed by the boat. There are lots of residential areas on the waterfront side. We also fed fish.

Boat tour on Chao Phraya River

Boat tour on Chao Phraya River visiting Koh Kred Island

About one hour journey, our boat reached Wat Arun Temple, one of the important temples in Bangkok. The temple's skyline looked beautiful from the water, covered by Chinese porcelain. It was built in Ayuthaya period in 18th century. On the way back, we visited the Throne Hall, an Italian style building. Then we came back to the hotel.

At Wat Arun Temple

Group photo at Ananda Saamakhom Throne Hall

Impressions from the Student Participants

The 5th Joint Student Seminar on Civil Infrastructure was a good experience for me. I attended the seminar last year. Attended as a participant, I had to learn the various fields of research. After the field trip I and friends from Tokyo University went to Khaosan Road, where we had a good time.
This year seminar was very interesting for me and I've got information to be studied. I participated in the last year seminar only as a listener, but this year I was also a speaker and presented my study.
Unfortunately, due to some technical problems with my PPT-presentation I stressed a lot, but it was a useful experience for me. The seminar had very interesting research topics. And I was very impressed by the presentations' structure of other colleagues.
I had great time during this field trip, and I would like to attend the next seminar as well.
(by Cheol Park, Chonnam National University, Korea)

The 5th Joint Student Seminar on Civil Infrastructure in Bangkok was very meaningful experience for me. Actually I have never participated in any conferences, even speaking in English, related to my major, so I was very excited but nervous on the one hand. The seminar's atmosphere was warmer and friendlier than I thought, because most people, speakers and observers, in this seminar are students. So I could concentrate and understand comfortably what speakers want to say about, also it was easy to present my work such speaker. In presentation sessions, we shared our researches with many students from Thailand, Japan, South Korea and so on. Though there are various fields in civil engineering, I felt it is not so wide and I could widen up my scope on different areas of civil engineering from the seminar.
Without reference to seminar, transportation system in Thailand was very interested for me. Especially BTS, one of the most important public transportation in Bangkok, was so impressive. When I visited BTS Control Surveillance Center, the COO explained what BTS has problems and we shared some ideas for solving these problems. It gave me good experience and I felt confidence and pride about my major. Also it was good opportunity to experience characteristics of walking and driving environment in Thailand. I hope that there are more international conferences like this seminar to share and meet other countries' students.
(by Sung-hi Ah, The Myongji University, South Korea)

The Joint Student Seminar on Civil Infrastructure provided me with a fantastic experience to meet new friends, present my research work in front of foreign students who came from several countries, and this made me know about how to present a paper at an academic conference. It also gave me a good chance to learn different areas in civil engineering such as structure engineering, geotechnical engineering, and so on. Therefore, it was a great pleasure for me to attend the Joint Student Seminar for Civil Infrastructure. Finally, I am willing to say "thank you very much" for everybody who made this wonderful event happened, and I hope that it will have a good seminar like this for very year.
(by Ratthaphong Meesit, Asian Institute of Technology, Thailand)

This is the third time that I join in the Joint Student Seminar on Civil Infrastructure. However this is the first time for me as a presenter. The Joint Student Seminar on Civil Infrastructure gave me a very good opportunity to gain more knowledge with a lot interested researches related to my research area. I hope this Joint Student Seminar will be held continuously in order to forward the great opportunity to next generation.

(by Bhawat Chaichannawatik, Asian Institute of Technology, Thailand)

The 5th Joint Student Seminar of Civil Infrastructure was a great platform for amateur researcher students to present their work in an international environment. Although I attended it the last year as an audience, I participated this year as a speaker. It was a nice experience for me. I got the opportunity to meet students from a wide variety of fields and got to know about the parallel researches going on in other countries. I really enjoyed the seminar along with the field trip. I would like to express my sincere thanks to all the participants who shared their work 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, Asian Institute of Technology, Thailand)

This was my first time to present my study at The Joint Student Seminar on Civil Infrastructure held at the Asian Institute of Technology (AIT). It was great opportuniny for my experience on international presentation. It was also good chance to open my ideas and knowledge by listening our friend's works. These motivate me to improve my work and presentation skill. Moreover, I could gain more network among students from Asian countires. Finally, I wish this program is continuing for long as it is very worth for students who will be good researchers.
(By Kulapramote Prathumchai, Asian Institute of Technology, Thailand)

I wish to take an outstanding moment to express my deep appreciation to the organizing committee of the 5th International Joint Student Seminar on Civil Infrastructure, 2012 for providing me such valuable platform to present my idea and work during the Seminar. I also would personally like to express my sincere thanks to respected Dr. Akiyuki Kawasaki for offering me such wonderful opportunity. Last but not the least; my word would be incomplete without expressing my reverential gratitude to honorable Dr. Masahiko Nagai for his exquisite supervision, valuable suggestions and feedback as a supervisor. The seminar conveyed knowledge regarding various researches going on in the field of Civil Infrastructure to me. At the same time, it gave me a chance to interact with the students of other universities with multi-cultural background. It was indeed a very good experience I had from academic and social point of view. I really look forward to join the other continuing seminars of International Joint Student Seminar in the future as well.
(by Ashik Rajbhandari, Asian Institute of Technology, Thailand)

5th Joint Student Seminar was really good experience for me. This was my first time to give a presentation in English. I can't say I did well, but have no doubt that preparation for this seminar improved my English and presentation skills.
Also, other students from various universities inspired me to broaden my outlook. I think having interest in not only my own research topic, but also other related fields is very important for civil engineers.
Field trip was also interesting. The ornament of temples was great. It was a bit similar to Japanese temples. I felt I should learn more about Japanese history and culture to enjoy foreign culture.

Making use of this experience, I would like to spend meaningful study life.
(by Rieko Kojima, The University of Tokyo, Japan)

The Joint Student Seminar was a valuable experience for me by giving a presentation to the international meeting and sharing the research with the other participants. Because I come from a background of urban planning and architecture, sometimes it was difficult for me to understand specific terms in structural engineering, but it is very good that this seminar gave me new knowledge and widens my viewpoints in problem solving. During the coffee-break and lunchtime/dinner, we got opportunity to discuss more about our research and activities with the other students and researchers. Not only discussing about academic aspects, but also our culture and becoming friends with the participants. The field trip on the second day was also interesting. I really appreciate and thank the organizer of this seminar, for the opportunity to attend, also to the participants for the knowledge and experience.
(by Maria B K Dewi, The University of Tokyo, Japan)

The 5th Student Seminar was a great experience to me. Students were from the universities in Thailand and Korea, and their nationalities were various. It was a great chance for me to communicate with people from different countries. Also, in the lecture and presentation session, I could learn about many topics on civil engineering, such as traffic, geotechnology, urban planning, information in disaster, and concrete material and structure. Furthermore, in the field trip, I learned beautiful culture upon the Kingdom of Thailand, and the size of damage from the flood which attacked wide area in Thailand in 2011. The seminar gave me an opportunity to think about the importance and necessity of infrastructure, and I would like to continue learning about civil engineering.
(by Yoshiyuki Takano, The University of Tokyo, Japan)

The 5th Student Seminar was a great opportunity and privilege for me to take part in. I got an opportunity to present my research topic and receive valuable comments and suggestion from participants and professors attending the seminar. Moreover, I got a chance to learn about various research topics from other fellow students attending the seminar and it had helped me to widen my knowledge.

I also made friends from students from various countries especially from Korea and Thailand. Field trip has given me a chance to know about the Thai flood occurring in 2010 and culture and History of Thailand. Finally I would like to express my deepest gratitude and appreciation for ICUS and others who have arranged the successful 5th Joint Student Seminar.

(by Biruk Adane, The University of Tokyo, Japan)

I had a presentation about Tohoku Disaster. It was what I worked hardest in this semester. Still now, many people are worried about their lives but they have had hope for the future. In this seminar, I wanted to tell about the real condition and their hope. Everyone had a great research and presentation. It was stimulate. Coming back to Japan, I thought that I wanted to study more and try again. It was good for me to have a next aim. Moreover, we could see a lot of things in Thailand. There are unknown views, such as many remains. I don't forget scenery in Ayutthaya. I thought that it was real great to have rich nature and history. This is precious for us to know Thailand. Thank you, ICUS for us to have great experiences. I will continue to have an aim and send out my study.

(by Rina Goto, The University of Tokyo, Japan)

In this 5th Joint Student Seminar in Thailand, I learned research of civil engineering, architecture and city planning and Thailand culture. This seminar is my third time of English presentation. I tried to present attractively but I could not do that because of unskillfulness of my English proficiency. However, at the question and answer period, I built confidence because I could communicate in English. In addition, I felt that our final goal of study is almost same though methodology is different, especially, many Japanese presenters spoke about the great east Japan earthquake. On the other hand, I had visited to Southeast Asia at the first time. So, I touched very interesting culture of developing country in Asia. In Thailand, I felt the speed

and forcefulness of developing country because Thailand is so bigger and more modernistic city than I imagined. I would like to visit to Thailand once again for experiencing culture of Southeast Asia.
(by Taito Miura, Hokkaido University, Japan)

The 5th Joint Student Seminar on Civil Infrastructure and Field trip Program in Bangkok were a great experience for me. In Presentation session, I am glad to share our researches with many students from Japan, Thailand, and Korea. Although it was difficult for me to understand their presentation perfectly, I am interested in various researches. Also, after presentation I could not discuss about my topic because it was very hard for me to speak English. So I want to study English for speaking it very well. In Field trip, I studied industry and history, culture and got very good memories in Thailand. Particularly, red pepper I ate at lunchtime gave me a strong impact. So I want to be careful if I have a chance to eat the red pepper then. Finally, I would like to show gratitude all people involved in the 5th Joint Student Seminar.
(by Shohei Ikeda, Hokkaido University, Japan)

It is a great honor for me to participate in this 5th Student Seminar in Thailand. This was the first time for me to present in English. I felt little nervous until my turn come, fortunately my turn was the third on student presentation, it ended all too soon and I was able to listen to presentation of others carefully. All speeches were very interesting though the subjects of those were varied. This impression might be had caused by fundamental knowledge of civil engineering I have as a student majoring civil engineering. During coffee breaks, mealtimes, and the next day field trip, I could talk with students from University of Tokyo, Korea, and Thailand in English. There were free from tension of academic seminar, we could talk about casual things with a friendly manner in English. These times were very important and blessed for me. All experience in this Student Seminar were very useful to me, so I hope this seminar be held continue and more student participate in it.
(by Yuriko Yamamoto, Hokkaido University, Japan)

5th Joint Student Seminar on Civil Infrastructures

Venue: Sasa International House (Room: Dipak C. Jain), Chulalongkorn University
Date: 20 August 2012

Time	Topic	Speaker
8.30	Registration	-
9.00-9.30	Opening remarks	Dr. Akiyuki Kawasaki
9.30-10.00	Group Photo & Coffee Break	
Invited Lectures (chair: Dr. Kunnawee Kanitpong)		
10.00-10.45	Information collection and needs after disasters: Lessons from the 2011 Tohoku Earthquake and 2011 Thai Flood	Dr. Michael Henry, Hokkaido University
10.45-11.45	Numerical Analysis of Lateral Pile Motion under Dynamic Loadings	Dr. Punchet Thammarat, AIT
Lunch		
Student Presentation 1 (chairs: Dr. Hyunmyung Kim)		
13.00-13.15	Reconstruction of Kamaishi-city after the 2011 Tohoku Earthquake and Tsunami.	Maria B.K. Dewi, University of Tokyo
13.15-13.30	Activity-based land use and transportation combined model and its application	Yonghwan Hwang, MyongJi University
13.30-13.45	Analysis of transboundary impacts of hydropower development in the Mekong: case of 3s sub-basin	Seemanta Sharma Bhagabati, AIT
13.45-14.00	Structural performance assessment of deteriorated unreinforced concrete structures	Yuriko Yamamoto, Hokkaido University
14.00-14.15	Mesoscopic Simulations of RC Anchorage Performance in Multi-directional Reinforcements by 3D Discrete Analysis	Yoshiyuki Takano, University of Tokyo
14.15-14.30	The analysis of three dimensional crack in an infinite elastic medium with surface elasticity.	Pong-in Intarit, Chulalongkorn University
14.30-14.45	Modelling Intermodal traffic assignment and application	Cheol Park, Chonnam National University
14.45-15.00	A Shear Performance of PVA-ECC Beam with Coarse Aggregate in Damaged Condition under Static and Fatigue Load	Rieko Kojima, University of Tokyo
Coffee Break		
Student Presentation 2 (chairs: Dr. Henry Michael)		
15.30-15.45	Study on transport phenomenon in mortar using the cesium carbonate as a tracer by X-ray CT	Shohei Ikeda, Hokkaido University
15.45-16.00	Departure-time choice (DTC) behaviour for Inter-city travel during a long-holiday in Bangkok, Thailand	Mr. Bhawat Chaichannawatik, AIT
16.00-16.15	Mechanism of Rainfall induced landslide	Biruk Adene, University of Tokyo
16.15-16.30	Traffic accident analysis based on TAAS data base system	Sung-Hi An, MyongJi University
16.30-16.45	Modelling of tensile behaviour of mortar immersed in NaCl solution	Taito Miura, Hokkaido University
16.45-17.00	Influence of highway geometry on driver stress	Mr.Ratthaphong Meesit, AIT
17.00-17.15	Design of reconstruction to save people in Iwanuma, Miyagi	Rina Goto, University of Tokyo
17.15-17.30	Review comment Closing Remarks	Prof. Hiroshi Yokota Dr. Kunnawee Kanitpong
18.00	Dinner at Sasa International House	

5th Joint Student Seminar on Civil Infrastructures

Field trip Program

Date: 21 August 2012

Time	**Descriptions**
09.00	Meet everyone at Lobby
09.30	Grand Palace (Vimanmek Mansion) - Please be reminded that you are on the palace grounds and noises kept at low level - Proper dresses should be worn, no shorts, no dresses showing bare shoulders (Clothes rental available inside) - Please do not enter flowers garden or pick the flowers - It is prohibited to carry weapons
11.30-12.00	Departure from Grand Palace
Lunch	
13.00-15.30	Traveling along the Chao Phraya River -visit koh kred island To inspect riverside communities affected by last year's floods, along the Chao Phraya River hit by severe flooding late last year.
15.30	Depart from Chao Phraya River
16.00	Go back to Chula University

Expected No. (Bus)

	No. of Student	No. of Faculty
Japan	9	2
Thai	4	Organizing team 2
Korea	4	0
Total	17	4

International Center for Urban Safety Engineering
Institute of Industrial Science, The University of Tokyo
4-6-1 Komaba, Meguro-ku,
Tokyo 153-8505, Japan

Tel: +81-3-5452-6472
Fax: +81-3-5452-6476
http://icus.iis.u-tokyo.ac.jp
E-mail: icus@iis.u-tokyo.ac.jp

ISBN4-903661-59-8