

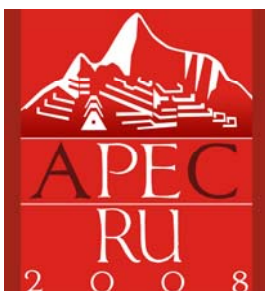


**Asia-Pacific
Economic Cooperation**

2008/TFEP/WKSP3/022

Development of Seismic Damage Assessment Analysis

Submitted by: Korea



**Workshop on Large-Scale Disaster Recovery in
APEC
Taipei, Chinese Taipei
22-23 September 2008**



Development of Seismic Damage Assessment Analysis

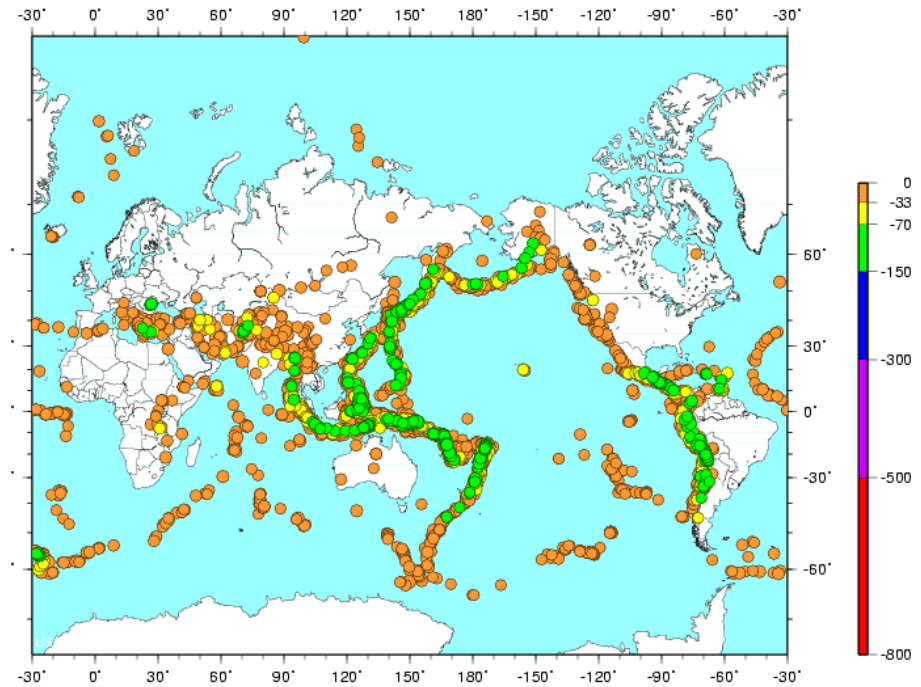
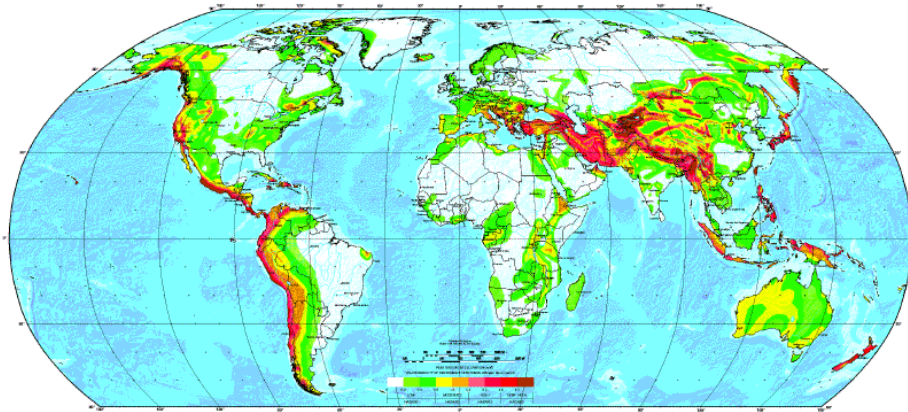
23 Sept. 2008

Byung-Cheol PARK

National Institute for Disaster Prevention, Republic of KOREA

Seismicity of the World

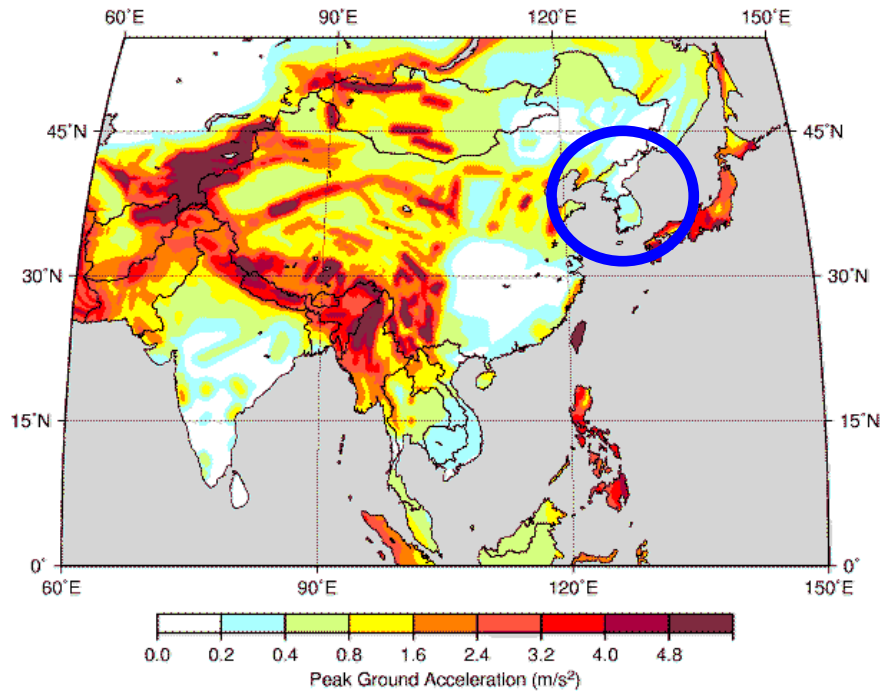
GLOBAL SEISMIC HAZARD MAP



$M \geq 6.0$ (1978 ~2008.7)

Seismicity of the Korea Peninsula

Seismic Hazard Map for Eastern Asia (Global Seismic Hazard Assessment Program)



**Moderate Seismicity
Region**

([Http://www.seismo.ethz.ch/gshap/eastasia](http://www.seismo.ethz.ch/gshap/eastasia))

Seismicity of the Korea Peninsula

Historical Records about Earthquake Activities

三國史記
 百濟本紀 第一 始祖溫祚王
 四十六年春二月壬癸
 多妻三溫祚王之元子器宇寬厚有威望溫祚
 王在位第二十八年壬子為太子至四十六年壬
 亮繼位
 三年春正月謁始祖東明廟二月于祀天地於
 南壇
 三年冬十月東部訖于東錄鞮戰於馬首山西
 甲十五年春夏冬旱草木焦枯冬十月地震傾
 倒人屋

27.11

<三國史記> Sept. 27
 Ground shaken and houses are
 collapsed.

高麗史
 世家 卷第六 靖宗
 災為禍今自春以來旱氣熾甚而聖上避殿
 減膳宵旰憂勞貴躬自省將爾應期膏潤同
 野重穡可期伏請御正殿復常禮親事如舊
 制曰案人不德致此旱災今雖得雨猶可
 慮然大臣之請不可違乃從之 戊辰京城
 及東京尚廣二州安邊府等管内州縣地震
 毀屋廬果亦三日而止 壬申有司奏門
 下侍中致仕庚方等十七人請限立秋每十
 日一賜水從之 秋七月戊寅中樞院奏制
 旨今遣人參三百斤近所遺一千斤足以供
 御用國府之貢皆民膏血不可妄歛乞勿令
 復進王不悅門下省駁奏古之帝王節嗜欲
 去奢後泰已侈身虛心納諫所以養民瘼而
 致大平也今災變屢作宜將心責躬豈可枉
 費無益損民膏血乞從密院所奏從之 辛
 巳宋商陳諒等六十七人獻土物 壬午制
 近者天地見怪微誠不德日慎一日不敢違
 寧群公庶僚除休暇朝外視事無怠以塞

1036.7.23

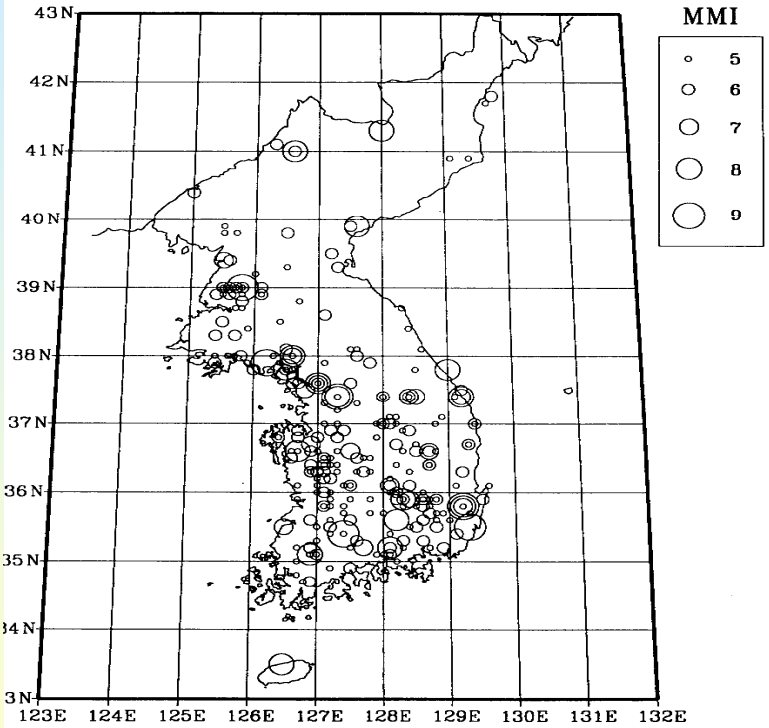
<高麗史> 23 July 1036
 Ground shaken and wooden houses
 are collapsed in Gaesung and Gyungju.
 Shaking is continued for 3days.

Seismicity of the Korea Peninsula

From A.D.2 to 1904

(by Historical Literatures)

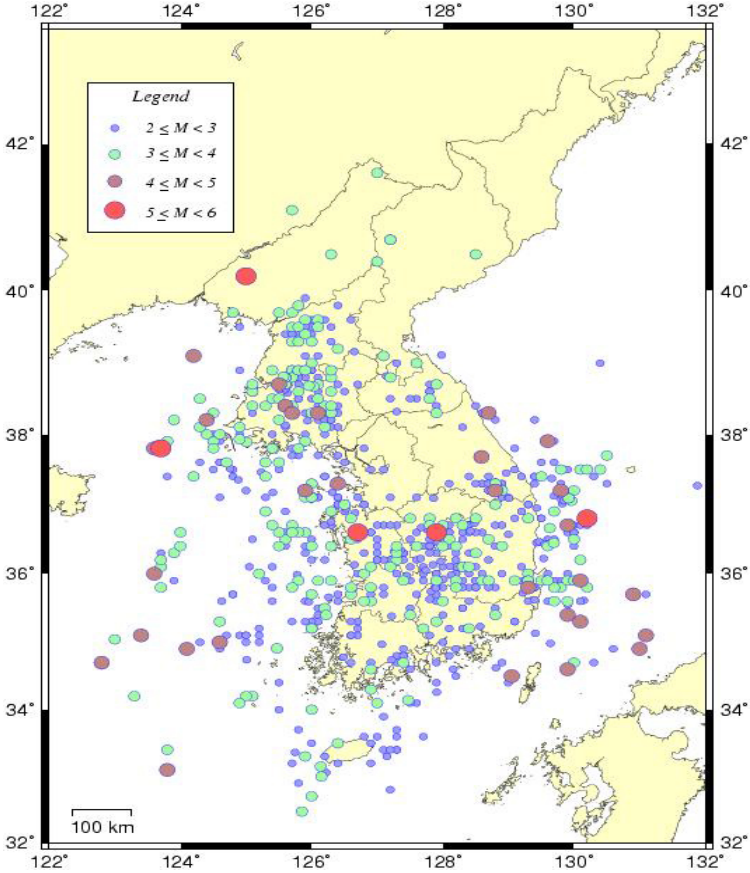
Epicenters of Historic Earthquakes in Korean Peninsula (AD 2 ~ 1904)



Classification	Frequency
≥ MMI V	389
≥ MMI VI	168
recorded damage	45

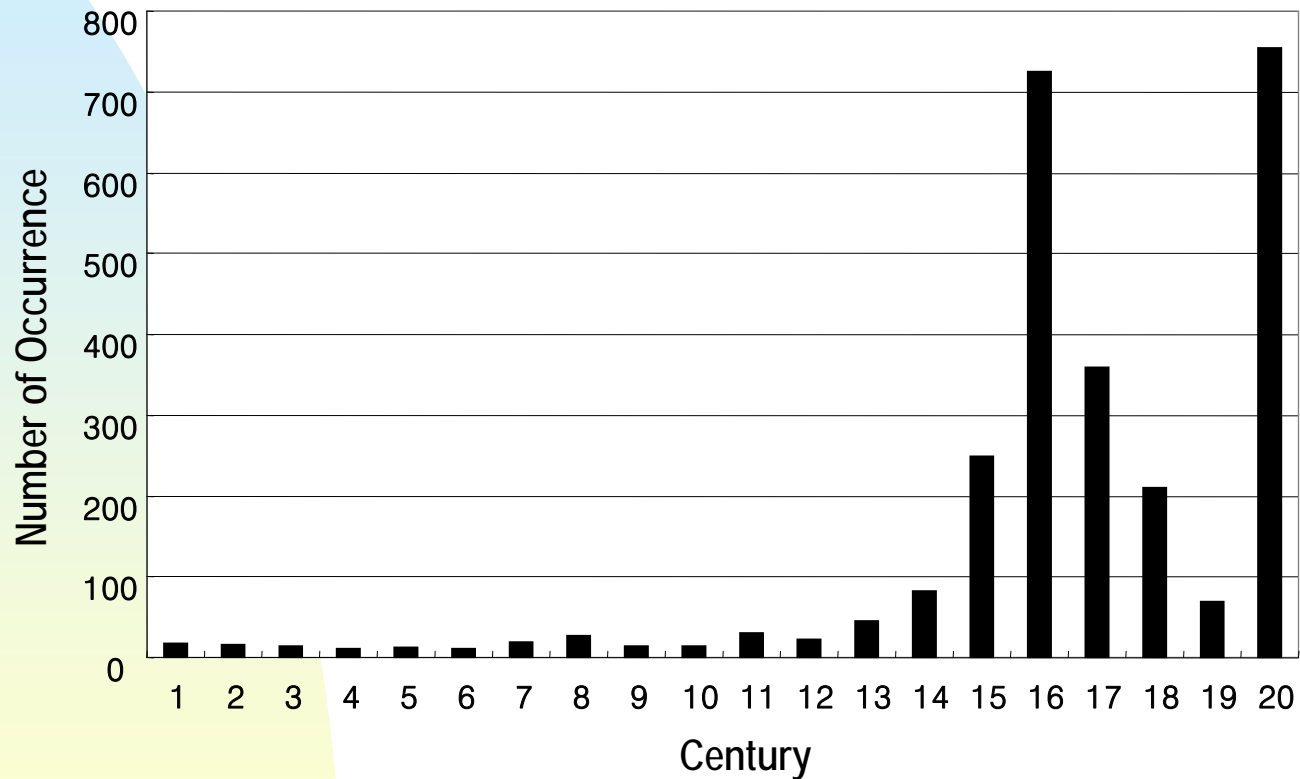
From 1905 to 2008

(by Seismometer)



Seismicity of the Korean Peninsula

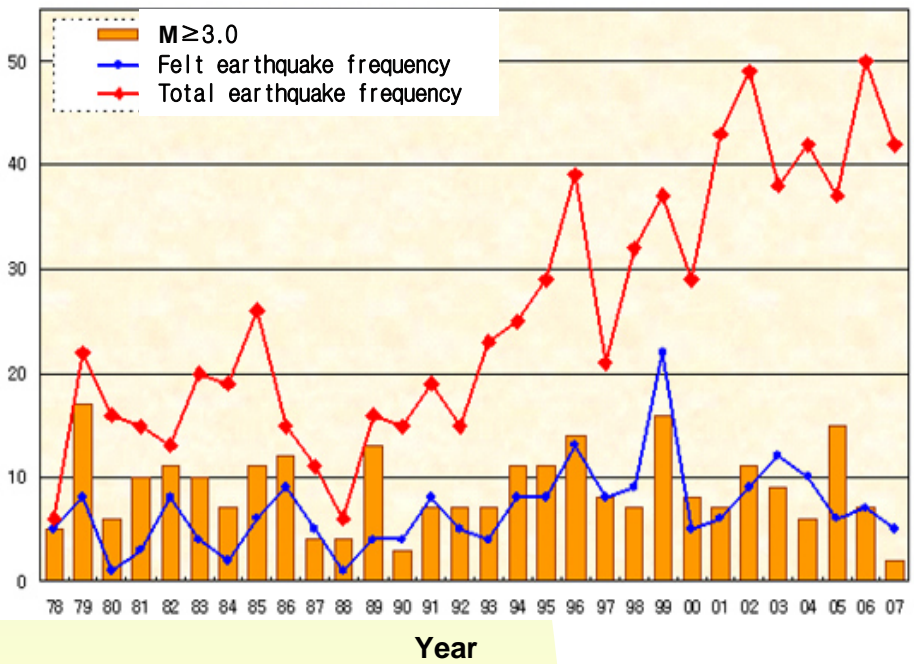
Time distribution of earthquake occurrence



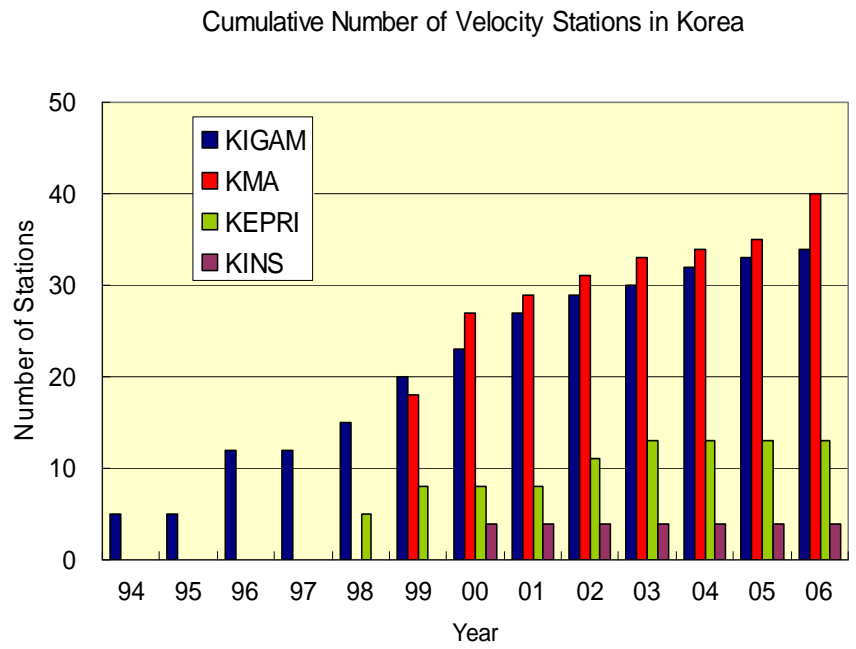
Recent Earthquake Activities of Korea

It is doubtful that earthquake frequency is truly increase.

- A felt earthquake is not increase.
- Total earthquake frequency is increase with station.



Earthquake Activities (1978~2007)



Causes for Public Awareness

(1) Experience of Neighboring Countries and Korea

Tangshan Earthquake in 1976 (China)

Kobe Earthquake in 1995 (Japan)

Chi-Chi Earthquake in 1999 (Taiwan)

Odaesan Earthquake in 2007 (Korea)

Wenchuan Earthquake in 2008 (China)

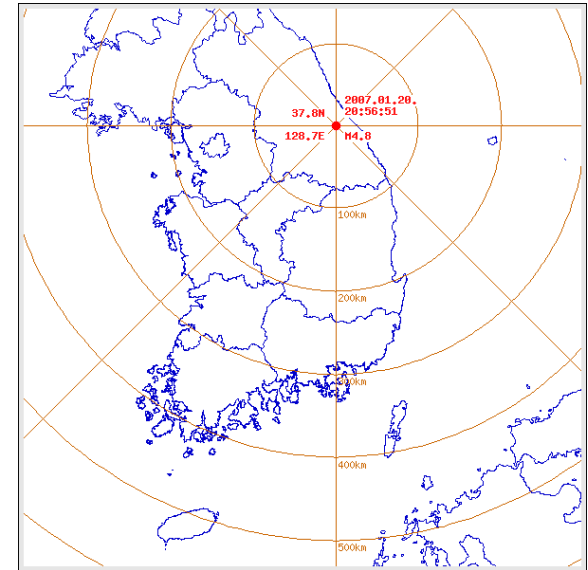
(2) Research Results

Damage Records in Historical Literatures

Increasing seismicity in the 20th century

Characteristics of Intraplate seismicity

irregular strain in both space and time



(3) Public Opinion

On structural safety (lack of confidence)

On the fear of devastating earthquake (effect of media)

Earthquake Mitigation Countermeasures

- ❖ **National Disaster Countermeasures Act (1995)**
 - Earthquake is added to the disaster list**
 - 20 types of structures should be designed with seismic design concept**

- ❖ **National Earthquake Disaster Countermeasures Act (2007)**
 - Comprehensive Countermeasures**
 - from Observation, Preparedness, Response, and R&D**



Earthquake Disaster Response System in NDMS

Developed by NEMA (from 2006)
 seismic damage estimation system is included

✓ Main Page

The screenshot shows the main page of the National Disaster Management System (NDMS) in Microsoft Internet Explorer. The browser address bar shows the URL: http://10.1.5.61/index.jsp. The page features a navigation menu with tabs for: 진도분포도 및 피해추정 (Damage Estimation), 기초데이터 관리 (Data Management), 피해추정현황 (Estimation Status), 대응절차 및 매뉴얼 (Standard Operating Procedure), 자동경보 관리 (Alarm Management), and 시스템 관리 (System Management). The main content area includes a banner for the National Disaster Management System, a section for '최근 지진 정보' (Recent Earthquake Information) showing details for an earthquake on 2008-02-05, and a table for '최근 피해 현황' (Recent Damage Status) listing damage across various regions.

시 도	건축물				인명		
	전파(붕괴)	전파(비붕괴)	반파	부분손실	사망자	부상자	피난자
전국	0	0	0	0	0	0	0
서울특별시	0	0	0	0	0	0	0
부산광역시	0	0	0	0	0	0	0
대구광역시	0	0	0	0	0	0	0
인천광역시	0	0	0	0	0	0	0
광주광역시	0	0	0	0	0	0	0
대전광역시	0	0	0	0	0	0	0

Earthquake Disaster Response System in NDMS

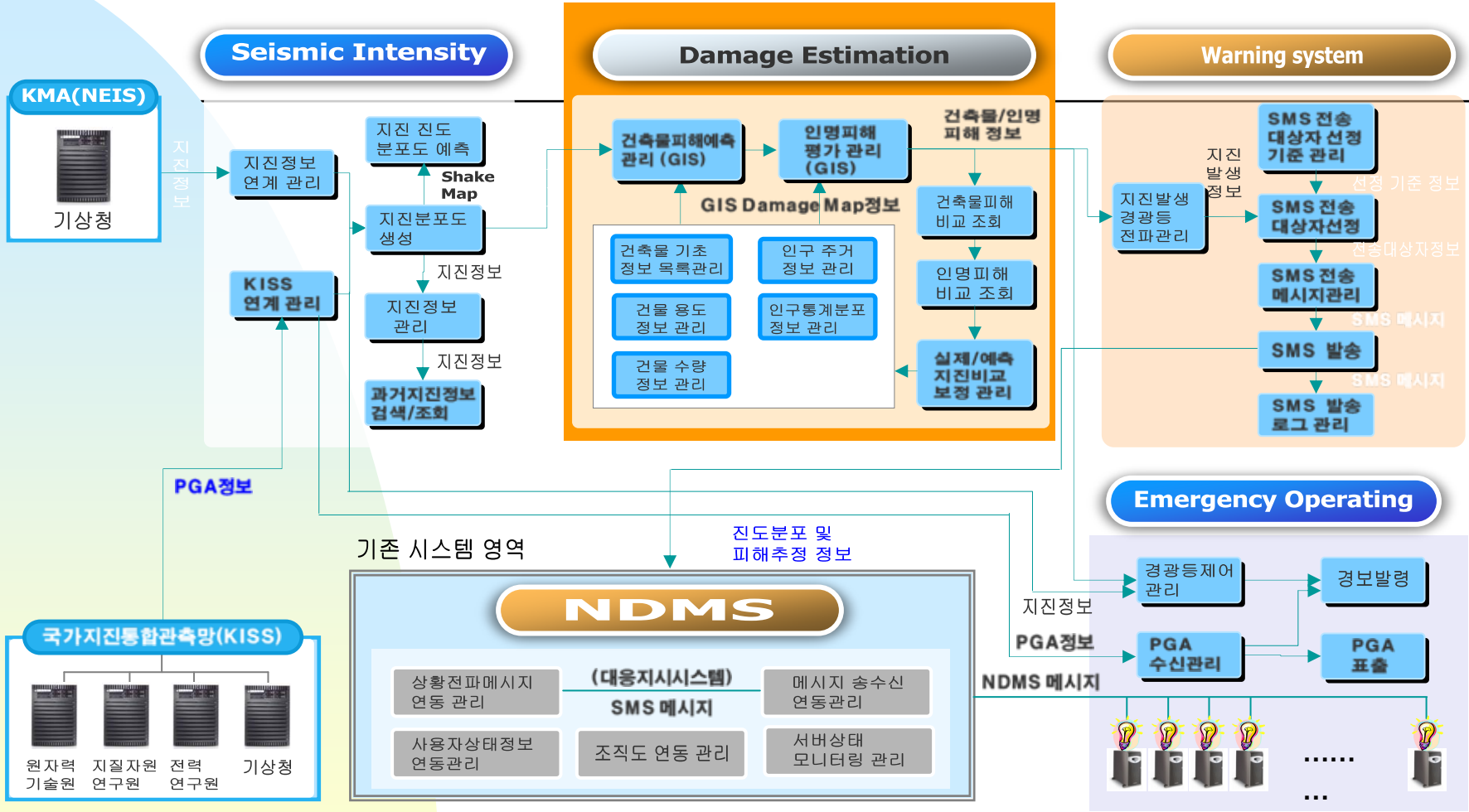
✓ Estimation Status

The screenshot shows the 'NDMS 지진재해 대응시스템' (NDMS Earthquake Disaster Response System) interface. The main content area is titled '피해추정현황' (Estimation Status) and displays a table of earthquake events. Below this, there is a detailed view for a specific event (2008-02-05 10:06:12) showing its location (Hwanghae-do Sariwon) and a table of impact status across various regions.

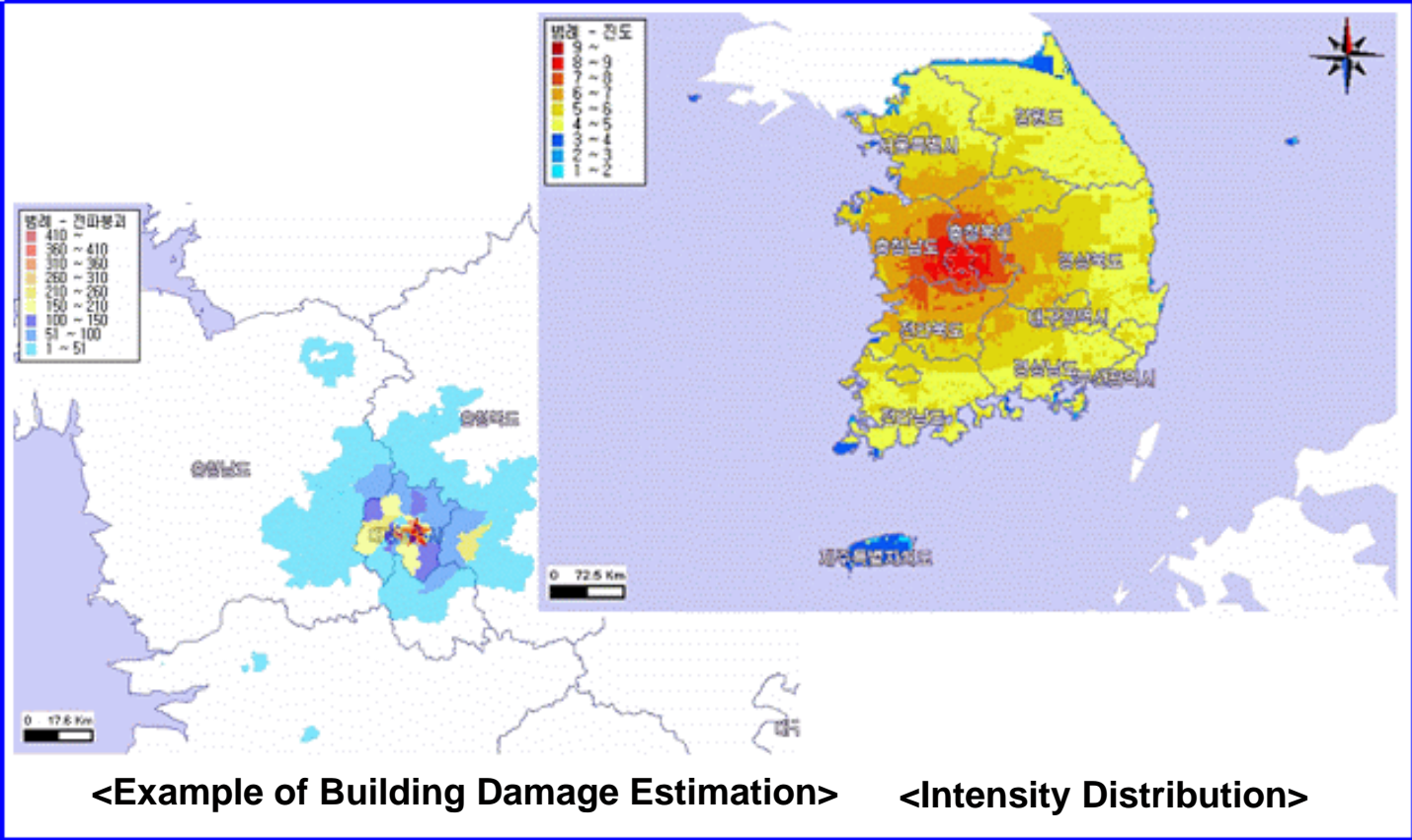
번호	진원시	위도	경도	규모	깊이	지역
2008033	2008-02-05 10:06:12	38.41	125.9	2.3	10	황해도 사리원 남동쪽 16.41km
2008019	2008-01-16 19:58:00	35.65	125.37	3.9	10	전라북도 부안군 위도면 서쪽 82.93km
2008016	2008-01-14 18:03:14	36.19	127.54	2.2	10	충청남도 공산군 군북면 북서쪽 1.3km
2008013	2008-01-10 22:51:55	35.09	125.06	2.2	10	전라남도 신안군 흑산면 북서쪽 57.48km
2008002	2008-01-01 06:33:33	40.2	127.18	3	10	함경북도 함흥 북서쪽 42.69km

시도	건축물수	전파(붕괴)	전파(비붕괴)	반파	부분손실	인구수	사망자	부상자	피난자
전국	6,818,670	0	0	0	0	47,032,917	0	0	0
서울특별시	692,608	0	0	0	0	9,762,546	0	0	0
부산광역시	398,090	0	0	0	0	3,504,030	0	0	0
대구광역시	274,018	0	0	0	0	2,456,016	0	0	0
인천광역시	212,684	0	0	0	0	2,517,680	0	0	0
광주광역시	196,376	0	0	0	0	1,413,644	0	0	0
대전광역시	145,234	0	0	0	0	1,438,551	0	0	0
울산광역시	137,094	0	0	0	0	1,044,934	0	0	0
경기도	946,500	0	0	0	0	10,341,006	0	0	0
강원도	364,266	0	0	0	0	1,460,770	0	0	0
충청북도	361,331	0	0	0	0	1,453,872	0	0	0
충청남도	494,848	0	0	0	0	1,879,417	0	0	0

Earthquake Disaster Response System in NDMS



Earthquake Disaster Response System in NDMS



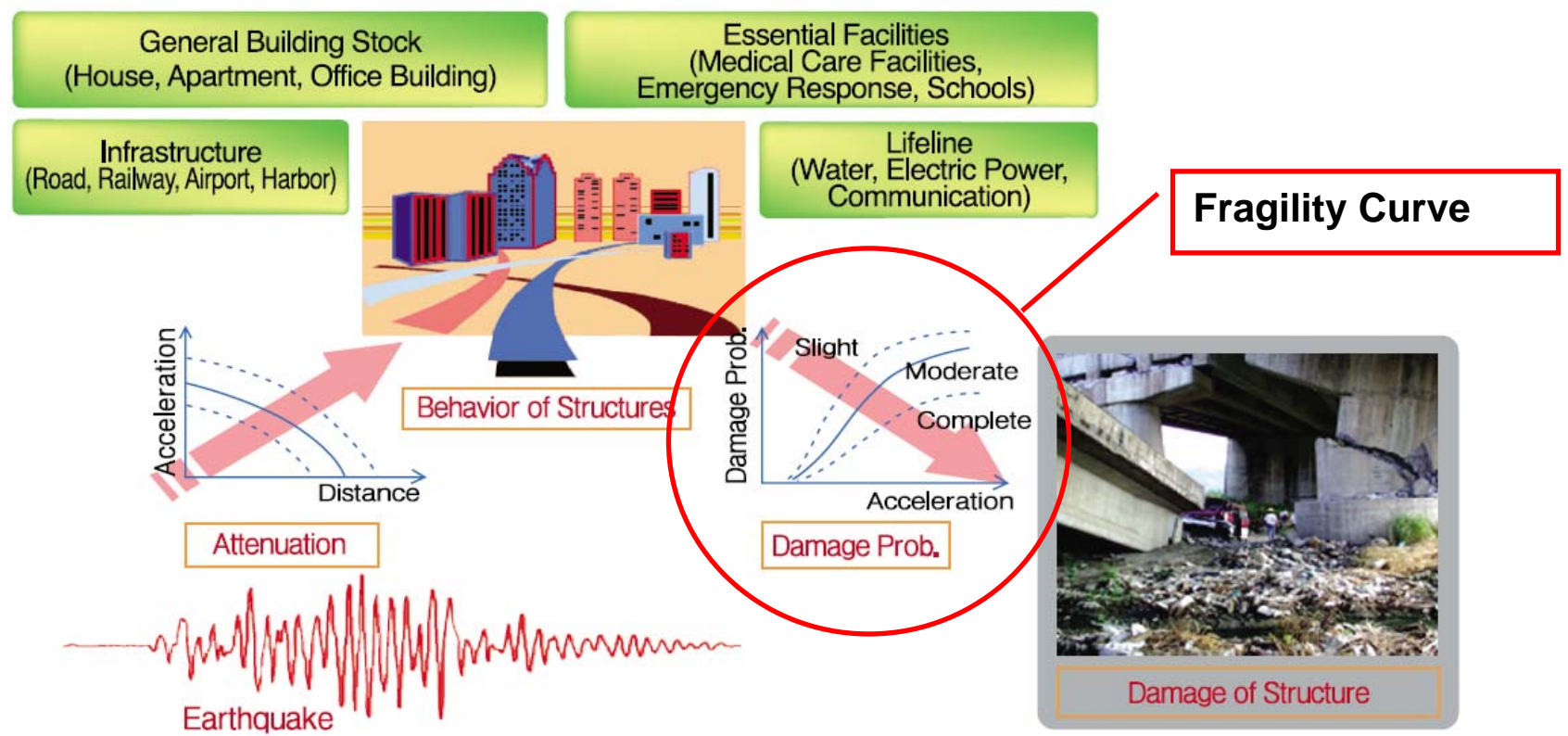
The Accountability (Reliability) of the Result ?

How can get the reliability ?

Development of Seismic Damage Assessment Analysis

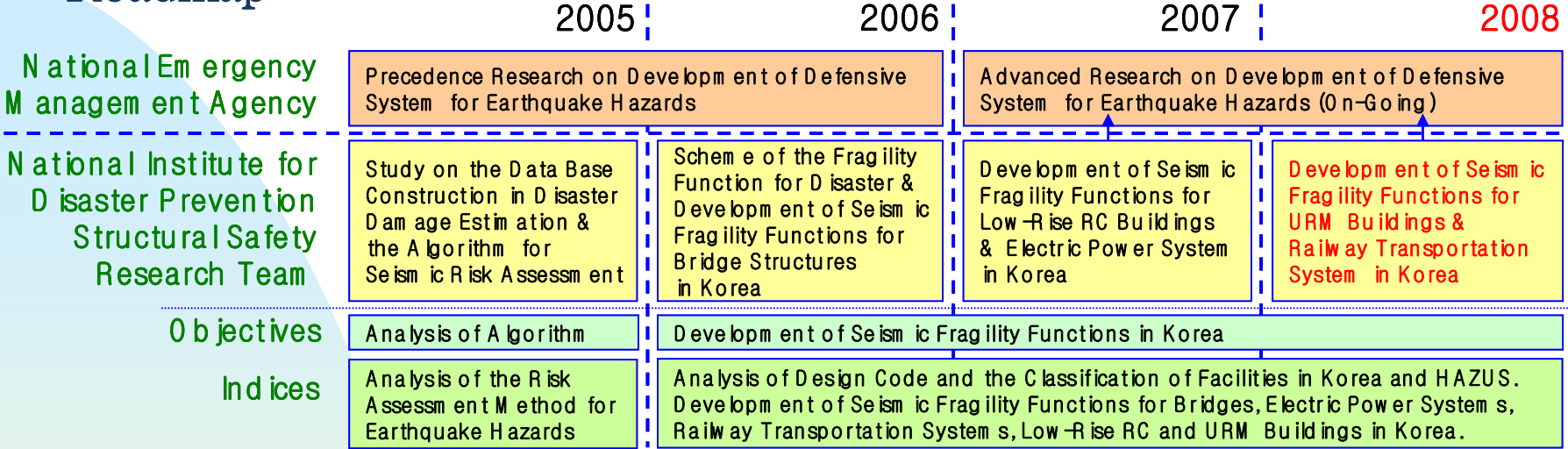
Objectives

- To estimate the structural damages of the society for effective responses and proper mitigation countermeasures in the emergency management of earthquake
- To develop the seismic fragility functions applicable to the structures in Korea



Development of Seismic Damage Assessment Analysis

Roadmap



Contents and Applications

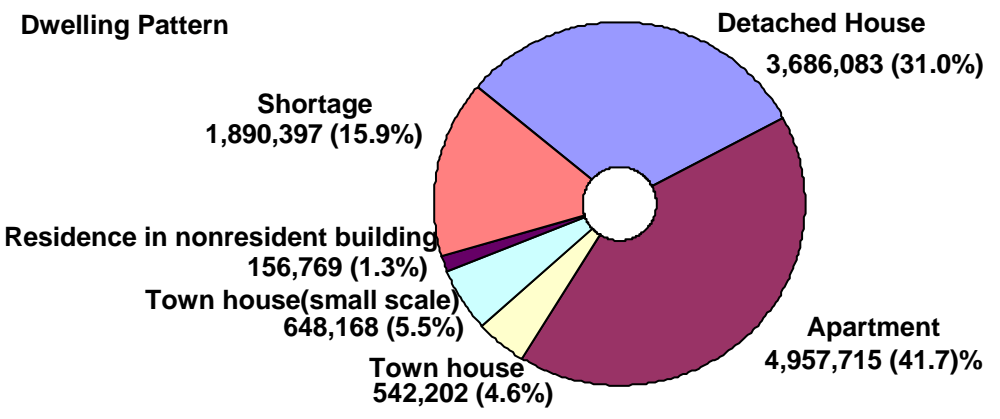
- Analyzing the algorithm of the method estimating seismic damages
- Strategic research for the localization of the fragility functions by analyzing the parameters
- Development of the fragility functions of the major kinds of structures in Korea
- Supporting the information on the structural vulnerability against earthquake
- Providing the guideline and countermeasures for maximizing the effects of the disaster mitigation efforts.

Development of Seismic Damage Assessment Analysis

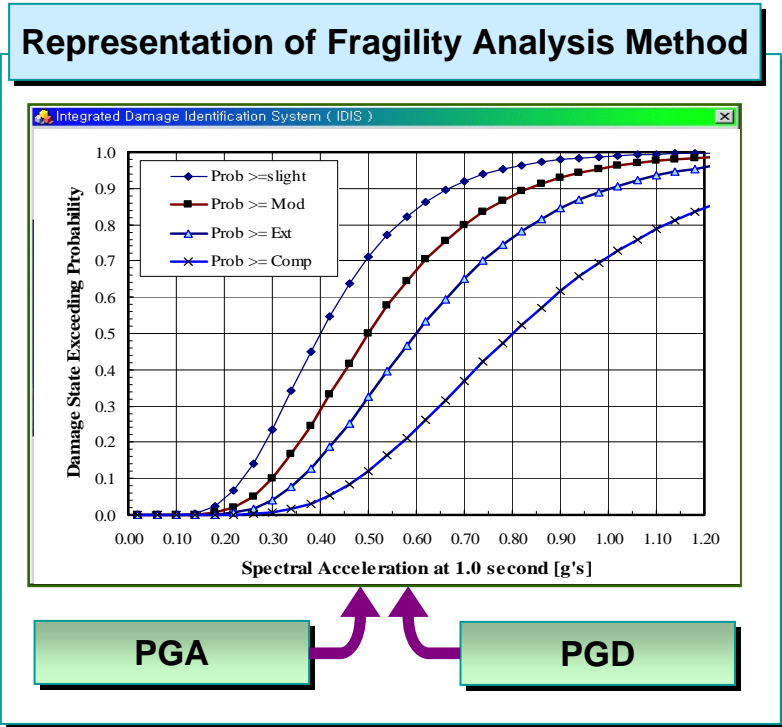
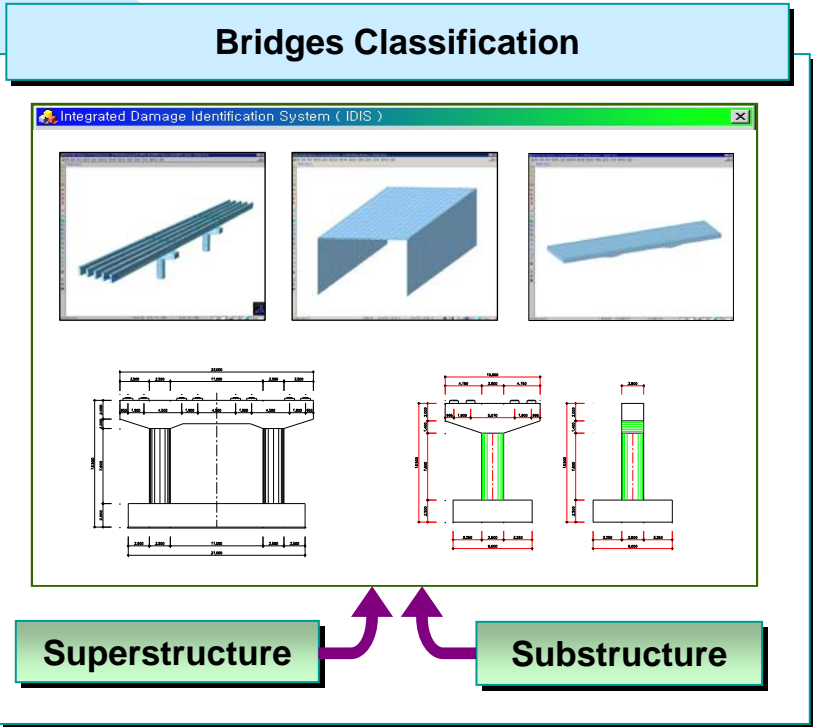
Development of Seismic Fragility Curves for Structures in Korea

< Structures >

- Road Bridges (2006) with KOSHAM
- Low-rise RC buildings (2007)
- Electric Power System (2007) with KAERI
- Unreinforced Masonry Buildings (2008)
- Railway Structure (2008) with KAERI



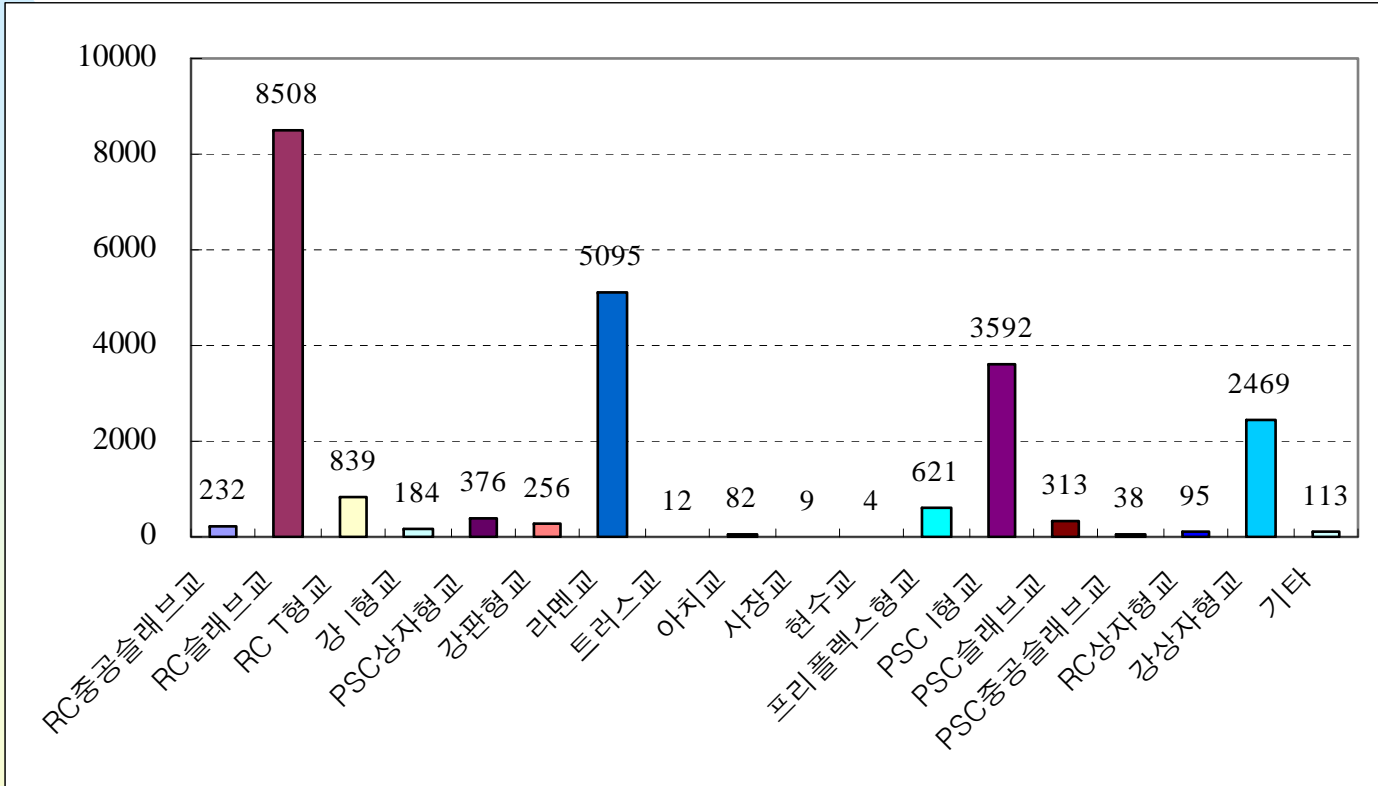
Seismic Fragility Curve of Bridge



The Development of Seismic Fragility on Bridges

Seismic Fragility Curve of Bridge

✓ Status of Bridges in Korea



Status by Superstructure, 2006

Seismic Fragility Curve of Bridge

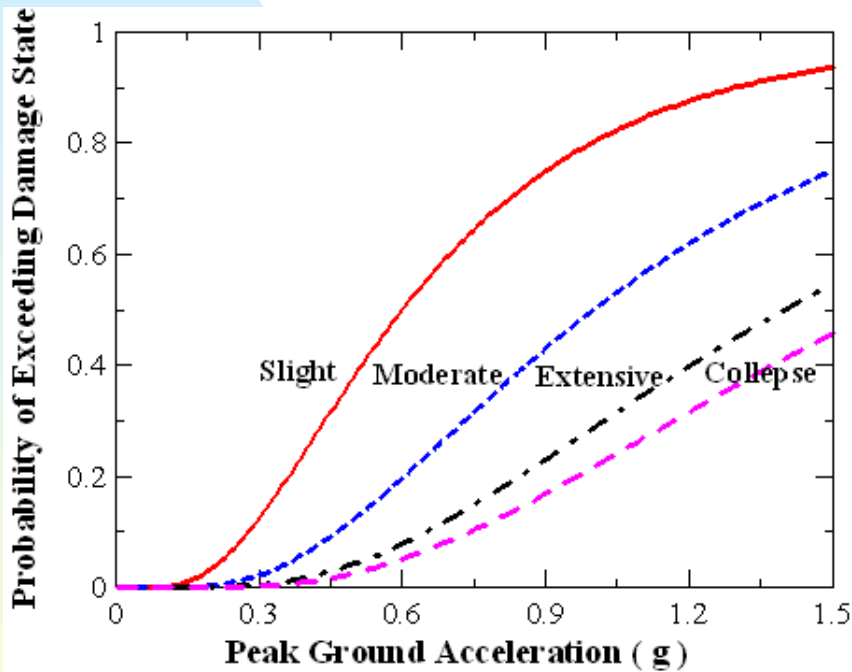
✓ Classification

Types	Super	Sub	Design	Indication
RC	RC Slab		Conventional	KHWB 01
			Seismic	KHWB 02
	RC Rahmen		Conventional	KHWB 03
			Seismic	KHWB 04
	Simple Sup.	Wall	Conventional	KHWB 05
			Seismic	KHWB 06
		Single Col.	Conventional	KHWB 07
			Seismic	KHWB 08
		Multi-Col.	Conventional	KHWB 09
			Seismic	KHWB 10
	Multi-Span	Wall	Conventional	KHWB 11
			Seismic	KHWB 12
		Single Col.	Conventional	KHWB 13
			Seismic	KHWB 14
		Multi-Col.	Conventional	KHWB 15
			Seismic	KHWB 16

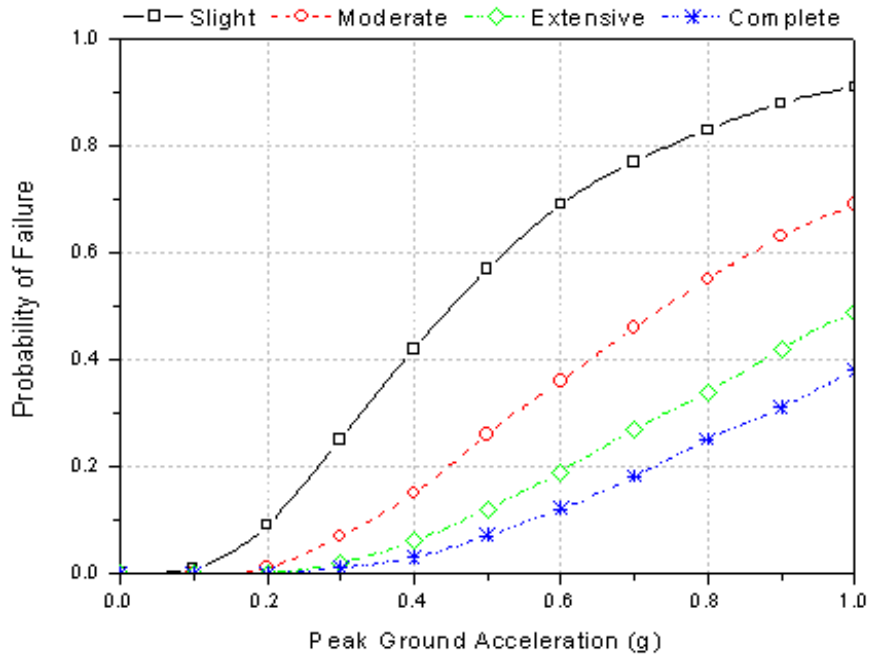
PSC	PSC I Beam		Conventional	KHWB 17
			Seismic	KHWB 18
	Simple Sup.	Single Col.	Conventional	KHWB 19
			Seismic	KHWB 20
	Multi-Span	Multi-Col.	Conventional	KHWB 21
			Seismic	KHWB 22
Steel	Multi-Span	Single Col.	Conventional	KHWB 23
			Seismic	KHWB 24
	Simple Sup.	Multi-Col.	Conventional	KHWB 25
			Seismic	KHWB 26
Steel	Steel Box		Conventional	KHWB 27
			Seismic	KHWB 28
	Simple Sup.	Single Col.	Conventional	KHWB 29
			Seismic	KHWB 30
	Multi-Span	Multi-Col.	Conventional	KHWB 31
			Seismic	KHWB 32
Steel	Multi-Span	Single Col.	Conventional	KHWB 33
			Seismic	KHWB 34
	Simple Sup.	Multi-Col.	Conventional	KHWB 35
			Seismic	KHWB 36
All other Bridges				KHWB 37

Seismic Fragility Curve of Bridge

✓ Fragility Curves



PSC Box Girder Bridge



PSC Beam Girder Bridge

Seismic Fragility Curve of Electric Power System

Classification of Electric Power System for Seismic Damage Evaluation

Electric System	Group	Remarks
Transmission Substation	Low Voltage Level (154kV)	154kV, 66kV, 22kV
	Medium Voltage Level (345kV)	
	High Voltage Level (756kV)	
Generation Power Plants	Hydraulic Power	Hydraulic Power, Pumped Storage
	Fossil Power	Steam Power, Internal-combustion Power
	Nuclear Power	
Distribution System	Surface System	Steal Tower, Concrete Tower
	Underground System	Underground Distribution Facility

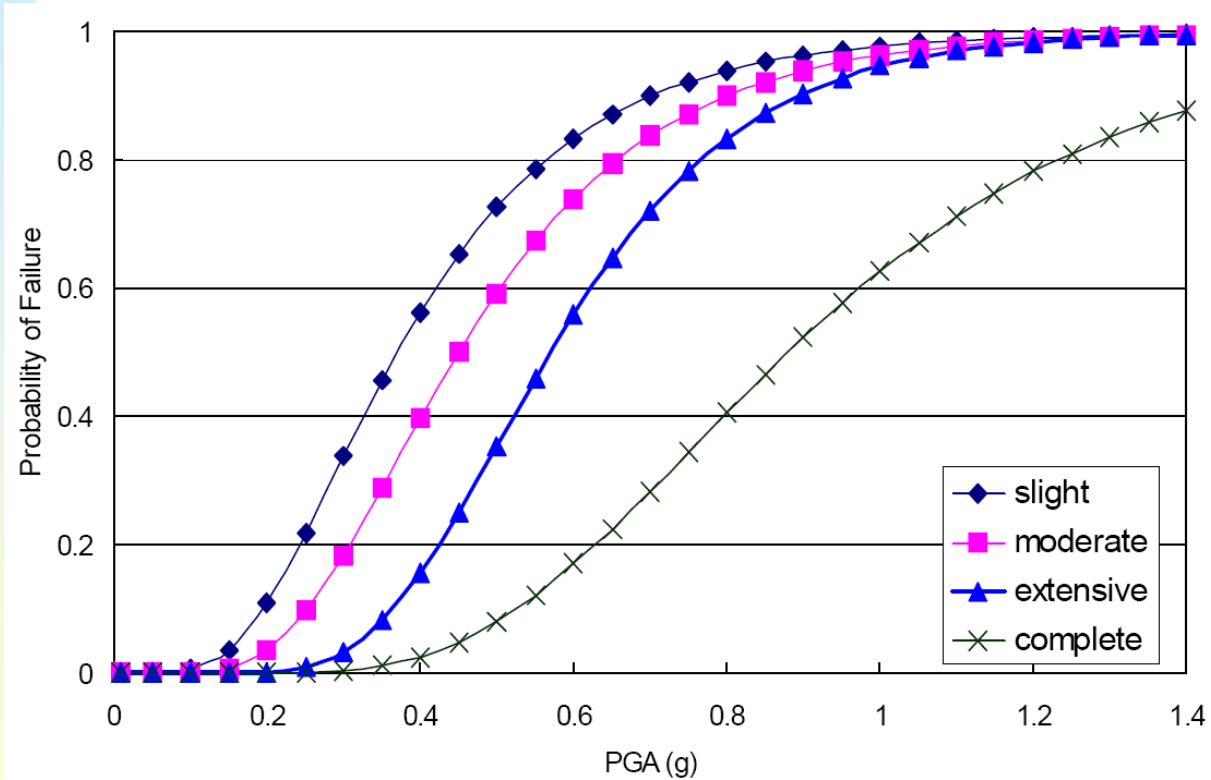
Seismic Fragility Curve of Electric Power System

Damage State Definition for a Substation

Damage Stated	Definition	4 Bank System
Slight/Minor Damage	25% of functional damage	Failure of transformer or bushing of 1Bank
Moderate Damage	50% of functional damage	Failure of transformer or bushing of 2Bank
Extensive Damage	100% of functional damage	Failure of transformer or bushing of 4Bank
Complete Damage	Failure of all transformer Failure of all bushing	Failure of all transformer or Failure of all bushing

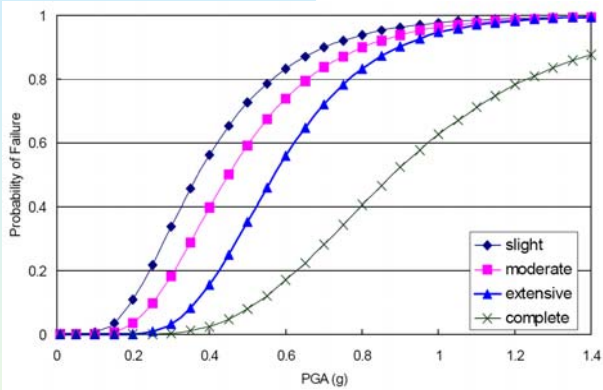
Seismic Fragility Curve of Electric Power System

Seismic Fragility Curves for Substation System

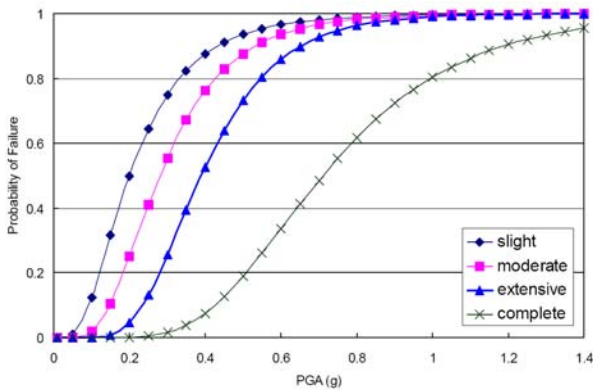


Seismic Fragility Curve of Electric Power System

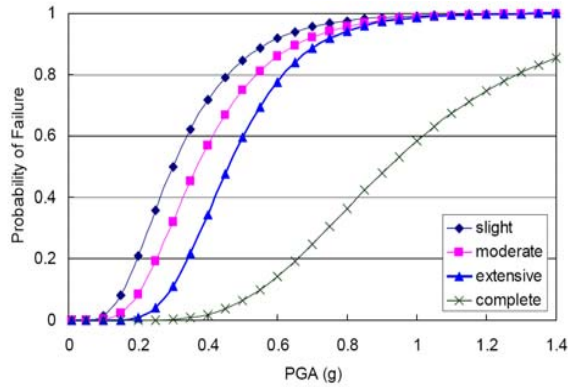
Seismic Fragility Curves for Substation System



765kV



345kV



154kV

The Accountability (Reliability) of the Result ?
How can get the reliability?

Major Subject of the Earthquake Damage Assessment

- ✓ **Classification**
- ✓ **Damage Function and State**
- ✓ **Fragility Analysis**
- ✓ **Economic Value**

Thank you