외부사건 리스크 국내외 연구현황

2015. 10. 28.

외부사건 안전성 평가 현황 및 향후 연구방향 워크샵

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개요

External PSA

- Earthquake
- Tsunami
- Flood
- Typhoon
- Aircraft Impact

External PSA

- Aircraft impact (비행기 충돌)
- Avalanche (눈사태)
- Coastal erosion (염분으로 인한 부식)
- Drought (가뭄)
- External flooding (외부 홍수)
- Extreme winds and tornadoes (강풍 및 토네이도)
- Fire (화재)
- Fog (안개)
- Forest fire (산림 화재)
- Frost (서리)
- Hail (우박)
- High tide, high lake level, or high river stage (바다, 호수 또는 강 등의 높은 수위)
- High summer temperature (하절기 고온)
- Hurricane (허리케인)
- Ice cover (얼음)
- Industrial or military facility accident (산업체 또는 군대 시설 사고)
- Internal flooding (내부 홍수)
- Landslide (산사태)
- Lightning (번개)
- Low lake or river water level (호수 또는 강 저수위)
- Low winter temperature (동절기 저온)
- Meteorite (운석)
- Pipeline accident (gas, etc.) (배관 사고, 가스 등)
- Intense precipitation (강우)
- Release of chemicals in onsite storage (현장 저장 화학물질 누출)
- River diversion (수로의 전환)
- Sandstorm (모래 폭풍)
- Seismic activity (지진 활동)
- Snow (눈)
- Soil shrink-swell consolidation (토질 수축 및 팽창)
- Storm surge (폭풍 해일)
- Transportation accidents (운송 사고)
- Tsunami (해일)
- Toxic gas (독성 가스)
- Turbine-generated missile (터빈 미사일)
- Volcano activity (화산 활동)
- Waves (파도)
- Fuel handling machine drop (핵연료취급 장치 낙하)

IAEA 연구현황

IAEA/ISSC EBP 2nd phase

- WA1: EXTERNAL HAZARDS ASSESSMENTS
  - WA1-1: Seismic Hazard Assessment
  - WA1-3: Fault Displacement Hazard Assessment
  - WA1-7: Geotechnical hazards assessment
- WA2: DESIGNS AGAINST EXTERNAL HAZARDS
  - WA2-1: Soil-Structure Interaction Methodologies
  - WA2-3: Hybrid Simulation to Assess Performance of Seismic Isolation in NPP
- WA3: SAFETY ASSESSMENTS AGAINST EXTERNAL HAZARDS
  - **WA3-2: Integrated PSA and countermeasure procedure against fault displacement hazard**
  - **WA3-5: Safety Assessment for Multi-hazard and Multi-unit Site**
- WA4: SEISMIC EXPERIENCE DATABASE
- WA5: CAPACITY BUILDING

WA1: EXTERNAL HAZARDS ASSESSMENTS

- WA1-1: Seismic Hazard Assessment
- Objective : Provide more practical implementation guidelines for MSs as required.
- Outline of Task
  - PSHA
    - Testing and updating of the PSHA result
    - Enhance understanding and modelling of near field effects
    - Adjustment of ground motion of different site characteristics to target site
    - Modeling of seismogenic structures
    - Evaluation of Mmax
    - Deaggregation analyses/scenario basis earthquake
  - Ground motion simulation
    - GMPE and Simulated motion by fault rupture modelling
    - 3-D seismic input motion considering surface and body waves
    - Disminiation of scheme in SR developed in Phase 1
    - State-of-the-art simulation technics

WA1: EXTERNAL HAZARDS ASSESSMENTS

- WA1-3: Fault Displacement Hazard Assessment
- Objective :
  - Accumulate data of actual displacement from earthquakes.
  - We may need to evaluate fault dislocation theoretically.
- Outline of Task
  - Identification of capability of active faults
  - Experimental database of primary and secondary fault
  - Simulation using the fault rupture modelling

WA1: EXTERNAL HAZARDS ASSESSMENTS

- WA1-7: Geotechnical hazards assessment
- Objective : Provide more practical guidelines on slope instability and soil liquefaction
- Framework (Subtask 1)
  - Overall procedure
  - Risk informed decision making?
- Ground and Slope stabilities (Subtask 2)
  - Ground and Slope stabilities
  - Countermeasure of Ground and slope failures
  - Influence of ground and slope failures to nuclear installations
  - NRAJ will provide a detailed work plan for the slope stability.
- Non-linear soil effects including Liquefaction (Subtask 3)
  - Assessment of capability of liquefaction, etc

WA2: DESIGNS AGAINST EXTERNAL HAZARDS

- WA2-1: Soil-Structure Interaction Methodologies
- Objective : Review and critical assessment of state-of-the-practice SSI methods
- Summarize the available Soil-Structure Interaction (SSI) methodologies and it will address current technical issues related to soil response:
  - 1D versus 3D wave propagation modelling,
  - frequency domain versus time domain,
  - consideration of non-linear effects,
  - SSI + base isolation,
  - distributed foundation parameter and flexible volume methods, etc.

WA2: DESIGNS AGAINST EXTERNAL HAZARDS

- WA2-3: Hybrid Simulation to Assess Performance of Seismic Isolation in NPP
- Objective : Development and use of real-time hybrid simulation to validate the applicability of seismic isolation to nuclear structures
- Outline of Task
  - The ability of present numerical models for representing the behaviour of the isolators will be assessed against the results of the physical simulation.
  - The outcome of this task will be a technical report comparing pure numerical simulation with hybrid simulation results and conclusions will be drawn for design applications.

WA3: SAFETY ASSESSMENTS AGAINST EXTERNAL HAZARDS

- WA3-2: Integrated PSA and countermeasure procedure against fault displacement hazard
- Objective : Development of supporting document for
  - NS-G-1.6: Seismic Design and Qualification for Nuclear Power Plants
  - SSG-3: Development and Application of Level 1 Probabilistic Safety Assessment for Nuclear Power Plants
- Outline of Task
  - Enhancement of probabilistic fault displacement hazard from the viewpoint of PSA (Subtask 1)
    - Development of PDHA for practical implementation based on the latest research output
  - Development of fragility analysis of structures against fault displacement hazard (Subtask 2)
    - Development of fragility analysis for structures (e.g., reactor building, intake facility, and components)

WA3: SAFETY ASSESSMENTS AGAINST EXTERNAL HAZARDS

- WA3-5 : Safety Assessment for Multi-hazard and Multi-unit Site
- Objective : Development of supporting document for:
  - Safety Report on Framework and Process for Multi-unit Site Probabilistic Safety Assessment
  - Safety Report on External Hazard Considerations for Single and Multi-unit Probabilistic Safety Assessment
  - Safety Report on Technical Approach for Multi-unit Site Probabilistic Safety Assessment
- Outline of Task
  - Multi-hazard PSA
    - Information exchange
    - Hazards identification and screening/bounding analysis
    - Treatment of combined events (correlated/no-correlated events)
  - Multi-unit Site PSA
    - Information exchange
    - Trial application
  - Multi-hazard and Multi-unit Site PSA
    - Information exchange

WA4: SEISMIC EXPERIENCE DATABASE

- WA4: SEISMIC EXPERIENCE DATABASE
- Objective : Development of seismic experience database for seismic safety assessment
- Outline of Task
  - Application of database to safety assessment (Subtask 1)
    - Fragility curve
    - Damage indicators
    - Risk-informed decision making
    - etc.
  - Development of database (Subtask 2)
    - Agreement of treatment of collected data
    - Needed data, and its format
    - IT and its maintenance
  - Data collection (Subtask 3)
    - Agreement of participants' cooperation
    - Strategy of data collection (preparation of data collection mission)

OECD/NEA 연구현황

NEA Secretariat

William D. Magwood, IV
NEA Director-General

Kazuo Shimomura
Acting Deputy Director-General and Chief Nuclear Officer

Vacant post

Deputy Director-General for Legal Affairs and Strategic Resources

Ximena Vásquez-Maignan
Head of the Office of Legal Counsel

Ricardo Lopez
Head of the Office of Administration

Cynthia Gannon-Picot
Chief of Cabinet, Head of the Central Secretariat, External Relations and Public Affairs

Javier Reig
Head of the Division of Nuclear Safety Technology and Regulation

Javier Reig
Acting Head of the Division of Human Aspects of Nuclear Safety

Michael Siemann
Head of the Division of Radiological Protection and Radioactive Waste Management

Jim Guilford
Head of the Division of Nuclear Science

Kiyoshi Matsumoto
Head of the Data Bank

Jaejoo Ha
Head of the Division of Nuclear Development

Committee Structure of the OECD Nuclear Energy Agency (NEA)

Steering Committee for Nuclear Energy

Committee on the Safety of Nuclear Installations — CSNI

- CSNI Programme Review Group (CSNI PRG)
- Working Group on Risk Assessment (WGRISK)
- Working Group on Analysis and Management of Accidents (WGAMA)
- Working Group on Integrity and Ageing of Components and Structures (WGIAGE)
  - Subgroup on the Integrity of Metal Components and Structures
  - Subgroup on the Ageing of Concrete Structures
  - Subgroup on the Seismic Behaviour of Components and Structures
- Working Group on Human and Organisational Factors (WGHOF)
- Working Group on Fuel Safety (WGFS)
- Working Group on Fuel Cycle Safety (WGFCS)
- Senior Expert Group on Safety Research Opportunities Post-Fukushima
- Task Group on Natural External Events (TGNEV)
- Task Group on Robustness of Electrical Systems of NPPs in Light of the Fukushima Daiichi Accident (ROBELSYS)

Committee on Nuclear Regulatory Activities — CNRA

- Task Group on Accident Management (TGAM)
- Working Group on Inspection Practices (WGIP)
- Working Group on Operating Experience (WGOE)
- Working Group on Public Communication of Nuclear Regulatory Organisations (WGPC)
- Working Group on the Regulation of New Reactors (WGRNR)

Radioactive Waste Management Committee — RWMC

- RWMC Regulators' Forum (RWMC-RF)
- Expert Group on Pre-disposal Management of Radioactive Waste (PMRW)
- Expert Group on Waste Inventorying and Reporting Methodology (EGIRM)
- Expert Group on Fukushima Waste Management and Decommissioning R&D (EGFWMD)
- Expert Group on Preservation of Records, Knowledge and Memory across Generations (RK&M)
- Integration Group for the Safety Case (IGSC)
  - Working Group on the Characterisation, the Understanding and the Performance of Argillaceous Rocks as Repository Host Formations (CLAY CLUB)
  - Expert Group on Repositories in Rock Salt Formations (SALT CLUB)
  - Expert Group on Operational Safety (EGOS)
- Forum on Stakeholder Confidence (FSC)
- Working Party on Decommissioning and Dismantling (WPDD)
  - Decommissioning Cost Estimation Group (DCEG)
  - Task Group on Radiological Characterisation and Decommissioning (TG-RCD)
  - Task Group on Nuclear Site Restoration (TGNSR)

Committee on Radiation Protection and Public Health — CRPPH

- Expert Group on Radiological Protection Aspects of the Fukushima Accident (EGRPF)
- Expert Group on the Implications of Recommendations (EGIR)
- Expert Group on Radiological Protection Science (EGRPS)
- Working Party on Nuclear Emergency Matters (WPNEM)
- Expert Group on Lessons Learnt from Non-nuclear Events (EGNE)

Nuclear Science Committee — NSC

- Expert Group on Improvement of Integral Experiments Data for Minor Actinide Management (EGIEMAM-II)
- Expert Group on Multi-physics Experimental Data, Benchmarks and Validation (EGMPEBV)
- Expert Group on Accident-tolerant Fuels for LWRs (EGATFL)
- Working Party on International Nuclear Data Evaluation Co-operation (WPEC)
  - High Priority Request List for Nuclear Data
- Working Party on Scientific Issues of the Fuel Cycle (WPFC)
  - Heavy Liquid Metal Technologies
  - Fuel Recycling Chemistry
  - Advanced Fuel Cycle Scenarios
  - Innovative Structural Materials
  - Innovative Fuels
  - Benchmarking of Thermal-hydraulic Loop Models for Lead-alloy-cooled Advanced Nuclear Energy Systems
- Working Party on Multi-scale Modelling of Fuels and Structural Materials for Nuclear Systems (WPMM)
  - Validation and Benchmarks of Methods
  - Multi-scale Modelling Methods
  - Structural Materials Modelling
  - Multi-scale Modelling of Fuels
  - Primary Radiation Damage
- Working Party on Nuclear Criticality Safety (WPNCS)
  - Advanced Monte Carlo Techniques
  - International Criticality Safety Benchmarks Evaluation Project
  - Burn-up Credit
  - Criticality Excursions Analyses
  - Assay Data of Spent Nuclear Fuel
  - Uncertainty Analyses for Criticality Safety Assessment
- Working Party on Scientific Issues of Reactor Systems (WPRS)
  - Reactor Physics and Advanced Nuclear Systems
  - Uncertainty Analysis in Modelling
  - Reactor Fuel Performance
  - Radiation Transport and Shielding

Executive Group of the NSC (Data Bank Management Committee)

- The Joint Evaluated Fission and Fusion File (JEFF) Project
- Task Force on the Future Programme of the NEA Data Bank

Committee for Technical and Economic Studies on Nuclear Energy Development and the Fuel Cycle — NDC

- High-level Group on the Security of Supply of Medical Radioisotopes (HLG-MR)
- Joint NEA/IAEA Group on Uranium (UG)
- Working Party on Nuclear Energy Economics (WPNE)
- Ad Hoc Expert Group on Climate Change: Assessment of the Vulnerability of Nuclear Power Plants and Cost of Adaptation
- Ad Hoc Expert Group on Costs of Decommissioning
- Ad Hoc Expert Group on Cost of Nuclear Accidents, Liability Issues and Their Impact on Electricity Costs

Nuclear Law Committee — NLC

Committee on the Safety of Nuclear Installations (CSNI)

- Working groups
  - CSNI Programme Review Group (PRG)
  - Working Group on Integrity and Ageing of Components and Structures (WGIAGE)
  - Working Group on Analysis and Management of Accidents (WGAMA)
  - Working Group on Risk Assessment (WGRISK)
  - Working Group on Human and Organisational Factors (WGHOF)
  - Working Group on Fuel Safety (WGFS)
  - Working Group on Fuel Cycle Safety (WGFCS)
  - Working Group on External Event (WGEV)

WGIAGE

- Mission :
  - to advance the current understanding of those aspects relevant to ensuring the integrity of structures, systems and components under design and beyond design loads,
  - to provide guidance in choosing optimal ways of dealing with challenges to the integrity of operating new nuclear power plants, and to make use of an integrated approach to design, safety and plant life management.
- The working group shall report to CSNI and assist the committee with its work.
- OECD member country representatives are joined at the group's meetings by representatives from the IAEA, the European Commission and JRC Petten.

WGIAGE

- The WGIAGE consists of
  - main group
  - a) integrity and ageing of metal structures and components;
  - b) integrity and ageing of concrete structures and;
  - c) seismic and other external events behaviour of components and structures.
  - All subgroups deal with the structural integrity issues in a broad sense,
- The principal mechanisms
  - a) the conduct of meetings to share information and plan/coordinate/manage activities;
  - b) the collaborative writing of consensus documents (e.g. state-of-the-art reports, technical reports and technical opinion papers) and;
  - c) highlights related to the integrity and ageing of components and structures via technical notes

WGEV

- Main mission :
  - to improve the understanding and treatment of external hazards
- Focus
  - external hazards
  - combinations of seismic with other hazards (e.g. flooding)
  - concentrate on natural hazards.
    - Man-made hazards will be addressed only if there is a particular link to a natural hazard
    - Later on, the scope of work might be extended to include man-made hazards

WGEV

- **Goals**
  - **Goal 1** - Regulation of External Hazards
  - **Goal 2** - Technical Basis for External Hazards, Data Collection, Quantification and Addressing Uncertainty
  - **Goal 3** - Combinations of Inter-related Hazards
  - **Goal 4** - Probabilistic Methods to Characterize External Hazards
  - **Goal 5** - Challenges and Impacts
  - **Goal 6** - Effective Protection and Mitigation Concepts

WGEV

- **WORKSCOPE**
  - Coastal Storms
    - Tropical and extra tropical, high winds, intense wide spread precipitation (wet of frozen), lightning, coupled with airborne debris and storm surge with waterborne debris
  - Severe Local Storms
    - Tornados, high winds, local intense precipitation coupled with intense lightning
  - Riverine Flooding
    - Causal factors – frequent storms (rain or snow) affecting the watershed, dam failure(s) – associated hazards include waterborne debris, erosion, wind driven wave, high river water velocities etc.
  - Extreme Temperatures
    - extreme prolonged heat or extreme prolonged cold
  - Tsunami
    - extreme storm surge propagation resulting from seismic event
  - Dam Failures
    - dam failure mechanisms for various dam types; dam failure breach modelling; safety assessment and maintenance, etc

미국 및 일본의 연구현황

USA (Seismic)

John Richards, Seismic Reevaluations in the United States, IAEA/ISSC Meeting on Selected Topics in Seismic Safety, June 2, 2014

- Updated Seismic Hazard
  - NRC Regulatory Guide 1.208, March 2007
  - A new central and eastern U.S. (CEUS) seismic source characterization analysis started in April 2008
  - The **Great Tohoku** and **Mineral Virginia** earthquakes raised the profile of the CEUS SSC project
  - NRC Near Term Task Force (NTTF) report and 50.54(f) Request for Information asked all U.S. plants to estimate new EQ ground motions using the PSHA process

USA (Seismic)

John Richards, Seismic Reevaluations in the United States, IAEA/ISSC Meeting on Selected Topics in Seismic Safety, June 2, 2014

- Seismic reevaluation guidance published in 2013
  - **EPRI 1025287**, Screening, Prioritization and Implementation Details (SPID), March 2013
    - Guidance for developing site-specific ground motion response spectra (GMRS), including site amplification calculations
    - Comparing GMRS with the site seismic design basis
    - Determining which plants might need to perform seismic reevaluations
    - Supplemental SFP and high-frequency seismic evaluations
  - **EPRI 3002000704**, Augmented Approach, May 2013
    - Guidance for performing an expedited seismic evaluation process (ESEP)
    - Simplified, quick seismic margin evaluations of selected plant equipment

USA (Seismic)

John Richards, Seismic Reevaluations in the United States, IAEA/ISSC Meeting on Selected Topics in Seismic Safety, June 2, 2014

- Full Seismic Risk Evaluation
  - Plants submitted site specific seismic hazards and GMRS by March 31, 2014
  - NRC issued prioritization letter on May 9, 2014
    - NRC reviewed submitted information and performed their own seismic hazard and GMRS calculations
    - Prioritized plants into 3 groups
  - For plants needing risk evaluations, use guidance in EPRI 1025287, SPID to perform risk evaluations at selected plants
    - Many plants expected to perform Seismic PRAs in accordance with the ASME/ANS PRA Standard
  - Many plants identified to perform **Spent Fuel Pool** Evaluations
  - Many plants have **high frequency exceedances**, requiring further analysis

USA (Seismic)

John Richards, Seismic Reevaluations in the United States, IAEA/ISSC Meeting on Selected Topics in Seismic Safety, June 2, 2014

- **Ongoing Research**
  - Full reevaluation of **ground motion attenuation model** (with NRC and DOE)
  - Evaluating **scenario earthquake methods** for determining **fragilities**
  - Performing **seismic testing** to determine the **high frequency (20-40 Hz) sensitivity of components** such as relays and breakers
  - Reviewing high level earthquake data to improve earthquake experience-based seismic capacities
    - Significant capacity increases were achieved in the first two trial equipment classes (MCCs and fans)
    - Ongoing work reviewing additional equipment classes

USA (External Flooding)

- Extreme Precipitation Events
- Flood-Induced Dam and Levee Failures
- Tsunamis Flooding
- Riverine Flooding
- Extreme Storm Surge for Coastal Areas
- Combined Events Flooding
  - flooding caused by **seismically-induced dam or levee failure**
  - flooding caused by combinations of snowmelt, rainfall and ice;
  - flooding caused by **combinations of coastal and riverine events**;
  - basin or system-wide performance and impacts;
  - human and organizational factors;
  - and other scenarios.

JAPAN (NRRC in CRIEPI)

- Seismic/Tsunami PRA
  - Establish the methodology in 1-2years.
- Other External Hazards
  - Develop a preliminary probabilistic risk assessment methodology in a few years.
  - Fault displacement, Tornado/Typhoon, Volcanic activity
  - Combination of seismic motion and tsunami

JAPAN (NRRC in CRIEPI)

- Seismic PRA/Key Challenges
  - Hazard Assessment:
    - NRRC/Electric utilities will conduct the probabilistic seismic hazard assessment according to the SSHAC Process.
  - Fragility Assessment:
    - NRRC/Electric utilities have been conducting various experiments and numerical simulations in order to evaluate realistic response and capacity.
    - NRRC has been conducting the fragility evaluation based on the earthquake experience data.
- Tsunami PRA/Key Challenges
  - Hazard Assessment:
    - SSHAC implementation (similar to Seismic PRA)
  - Fragility Assessment:
    - Pre-Fukushima accident; tsunami evaluation focused mainly on water level change.
    - Hydrodynamic load, Debris impact, Debris deposition and so on should be considered.
    - NRRC has started to establish the methodology for tsunami fragility evaluation.

JAPAN (NRRC in CRIEPI)

- Other External Natural Hazards
  - Fault Displacement
    - Improving the current methodology of PFDHA by conducting progressive numerical analysis and InSAR analysis
    - Developing the fragility evaluation
  - Tornado/Typhoon
    - Developing the tornado model with respect to the local topography near the target site.
  - Volcanic Activity
    - Develop preliminary probabilistic volcanic ash fall model.
    - Negative effect of important facilities caused by volcanic ash along side with electric utilities.
  - Combination of hazards
    - NRRC prioritizes the combination between seismic motion and tsunami.

KAERI의 연구현황

Previous Research

- Input Motion Development for Fragility Analysis
  - Used site specific median spectrum (kori site) for SPSA
  - PSHA was performed for all NPP sites
  - Seismic hazard curves were used for the seismic risk quantification
  - UHS has not been used owing to a large uncertainty and lack of consensus

Previous Research

- Fragility Test for a Seismic Safety Assessment
  - Electrical cabinet (480 V MCC)
  - Concrete anchor with/without crack
  - Piping element test for ultimate capacity
  - Shaking table test for piping system with two shaking tables (to consider multiple input motions)

Previous Research

- Realistic Seismic Safety
  - Ageing-Related Degradation Effect
    - Crack and corrosion
    - Change the response, capacity, and failure mode
      - Example structure: CST
      - From sliding to overturning

Mean fragility curves for multiple degradation

HCLPF vs. Time for Multiple Degradations

Previous Research

- Damage Acceptance Criteria
  - Based on a risk informed approach
  - Acceptance criteria for core damage frequency (RG 1.174)

Previous Research

PRASSE
(Probabilistic Risk Assessment of Systems for Seismic Event)

- Purpose
  - System Fragility and HCLPF Evaluation
  - Initiating Event Frequency of Seismic Event
- Function
  - Development of Boolean Equation which based of FT, ET
  - Consideration of uncertainty of seismic fragility and hazard
  - LHS and MCS

FT, ET

Initiating Event Frequency Analysis

Previous Research

- Tsunami PSA
  - Development of tsunami hazard analysis method
  - Determination of tsunami fragility for equipment and structures
  - Development of system analysis procedure
  - Apply to the sample NPP

Ongoing Research

Aircraft Impact (AI) Risk Assessment

Ongoing Research

Aircraft Impact (AI) Risk Assessment

- 항공기충돌 리스크 평가 매개변수에 대한 재해도 평가 방법론
  - 항공기 종류, 질량, 속도를 고려한 매개변수의 확률분포 특성 정의
  - 충돌 구조물, 위치에 따른 충돌 확률밀도함수 도출

- 항공기충돌 리스크 평가를 위한 시범원전 ET/FT 모델 개발 방법론
  - 항공기충돌 시범원전 Event-Logic Tree 구체화
    - 전 분기 모사(ex: 직/간접 충돌, 내/외부 화재 & 폭발, 진동 손상)
    - ET/FT 모델 개발 필요 초기사건 항목 도출
  - 시범원전 대표 초기사건 항목 선정
    - 대표 초기사건에 대한 ET/FT 도출

Ongoing Research

Aircraft Impact (AI) Risk Assessment

- 항공기충돌에 의한 외부화재 영향범위 및 지속시간 평가(결정론적 방법)
  - 화재 범위 평가를 위한 항공기 유류의 입자화 모델링 및 유류 입자 확산 시뮬레이션
  - 평가 대상:
    - 보조건물 충돌 시 Yard 화재
    - 격납건물 충돌 시 보조건물 지붕 화재

y(m) \ x(m)	0	5	10	15	20	25	30	35	40
0	2116.8	177.6	110.4	76.8	38.4	43.2	52.8	43.2	
5	753.6	76.8	105.6	110.4	67.2	76.8	28.8	43.2	
10	393.6	115.2	96	86.4	72	52.8	52.8	43.2	
15	379.2	62.4	57.6	91.2	67.2	62.4	38.4	48	
20	139.2	124.8	110.4	43.2	72	52.8	52.8	38.4	
25	4.8	19.2	62.4	43.2	72	86.4	48	19.2	
30									

(Unit: kg)

Ongoing Research

태풍통과시 일최대순간풍속 순위 (1937-2014년)

순위	태풍번호	태 풍 명	지 명	일 최대순간풍속 (m/s)	나타난 일자
1위	0314	매미(MAEMI)	제주	60.0	20030912
2위	0012	쁘라삐룬(PRAPIROON)	흑산도	58.3	20000831
3위	0215	루사(RUSA)	고산	56.7	20020831
4위	0711	나리(NARI)	울릉도	52.4	20070917
5위	1215	볼라벤(BOLAVEN)	완도	51.8	20120828
6위	9219	테드(TED)	울릉도	51.0	19920925
7위	8613	베라(VERA)	울진	49.0	19860828
8위	0514	나비(NABI)	울릉도	47.3	20050907
		)	제주	46.9	19590917
			통영	46.6	19950723

태풍통과시 일최다강수량 순위 (1904-2014년)

순위	태풍번호	태 풍 명	지 명	일 최다강수량 (㎜)	나타난 일자
1위	0215	루사(RUSA)	강 릉	870.5	2002,
2위	8118	아그네스(AGNES)	장 흥	547.4	1981,
3위	9809	예니(YANNI)	포 항	516.4	1998,
4위	9112	글래디스(GLADYS)	부 산	439.0	1991,
5위	0711	나리(NARI)	제 주	420.0	2007,
6위	0314	매미(MAEMI)	남 해	410.0	2003,
7위	7214	베티(BETTY)	해 남	407.5	1972,
8위	7119	올리브(OLIVE)	삼 척	390.8	1971,
9위	9907	올가(OLGA)	동두천	377.5	1999,
10위	9507	재니스(JANIS)	보 령	361.5	199

구분	최대풍속 (m/s)	비고
약	17–25	간판이 떨어져 날라가고 (15 m/s), 지붕이나 기왓장이 뜯겨져 날아감 (25 m/s).
중	25–33	허술한 집이 붕괴됨(33 m/s).
강	33–44	기차가 넘어지고 (35 m/s), 사람이 날아감 (40 m/s).
매우강	≥ 44	철탑이 휘어짐 (60 m/s).

슈퍼태풍: 1분 평균풍속 67 m/s, 일 1,000 mm 이상 폭우 동반

Ongoing Research

슈퍼태풍재해

Ongoing Research

- Selection of site specific natural hazard for Korea
  - 53 kinds probable external events were considered
  - High wind, Heavy rain, Land slide, Sea water rise/descent were selected for risk assessment
- For Ulchin site
- High wind
  - Instantaneous wind velocity and maximum instantaneous wind velocity are 60m/s, 51.8m/s, respectively.
  - Maximum wind velocity of 100 year : 40m/s
  - High probability of super typhoon occurrence (maximum wind speed of 1 minute: 65m/s)
- Heavy rain
  - Maximum precipitation per hour and day are 100.5mm, 870.5mm, respectively
  - Design criteria of Ulchin site:
    - Maximum precipitation per hour: 60mm, Maximum precipitation per day:307.5mm
- Land slide
  - Land slide occurrence probability is little high
- Sea water rise/descent
  - Typhoon and heavy rain intensity were more an more increased

Ongoing Research

- Variation of natural hazard intensity

Ongoing Research

- Hazard analysis for OEE
  - Typhoon hazard analysis

Occurrence analysis
↓
Transition analysis
↓
Wind field evaluation
↓
Surface wind evaluation

Occurrence model

Transition model

Wind field model

Surface friction model

  - Flooding hazard analysis

Local intense precipitation and associated site drainage
↓
Computation of watershed discharge
↓
Routing the flood to the site

Site drainage

Subbasin for watershed discharge

Aggregate probable maximum precipitation rainfall depths

Estimated probable maximum flood

감사합니다.

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