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# Structural Considerations for High Wind Walkdown of NPPs

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## 1. Introduction

After Fukushima accident, the USA continuously focused on the external event (e.g. seismic, flooding, high wind etc.) of NPPs. The probabilistic wind-born missile assessment was developed by Electric Power Research Institute (EPRI) [1]. In 2015, EPRI was published the high wind risk guideline which includes high wind and wind-born missile hazard assessment, fragility assessment and risk model of NPPs by high wind [2] and the guideline for high wind was published in 2015 [3].

Generally, the nuclear power plants (NPPs) were designed to resist the seismic and wind load. But old NPPs can be damaged by external hazards. Also Korea was annually attacked by 2~3 typhoons. Recent typhoon intensity (e.g. difference of central pressure and wind speed) has been increased by a climate change. From this reason, it is needed to perform the typhoon induced high wind risk assessment. For high wind risk assessment, high wind hazard and fragility analysis should be conducted. In this study, the structural consideration of high wind walkdown of NPPs was mentioned for high wind fragility assessment.

## 2. High wind hazard

The difference of temperature at surface of earth is occurred by the thermal energy from the sun. Low pressure was generated at high temperature region. While High pressure was generated at low temperature region. The wind is caused by air flowing from high pressure to low pressure.

### *2.1 Typhoon induced hazards*

Typhoon in Korea lead to the high wind, storm surge, heavy rain and flooding.

Generally, the sea surface is increased by low pressure and the the storm surge can be occurred by the high wind occurred in the track of typhoon. Also the high wind can generate wind-borne missiles which damage the exterior of structures and structure element. The typhoon including a humid air can be lead to the heavy rain.

Typhoon induced high wind have caused enormous losses of economic and life.

### *2.2 High wind induced damage*

The wind pressure and wind-borne missile can be generated by high wind load. Wind pressure are directly applied in SSCs. Structure and component of NPPs can be damaged/collapsed by the wind pressure. The overturning and shear failure mode can be occurred when structural damage occurred by wind load. The damage of exterior element can be lead to wind-borne missile.

## 3. Selection of high wind equipment list (HWEL)

To be complete and effective, the HWEL should be generated by a team consisting of the specialist (civil engineer and system engineer) who experienced in high wind hazards, fragilities, plant systems and PRA model. Structural specialists provide expertise to identify screening of SSCs and use the walkdown to obtain site information to assist in subsequent fragility calculation. System engineer participate in the walkdown to provide insights on the importance of equipment to PRA model.

### *3.1 procedure for developing a HWEL*

Figure 1 shows the procedure for developing a HWEL. The basic steps for HWEL are start with the internal events PRA and determine the accident sequences that are affected by a high wind. The SSCs that are not included in the selected accident sequences and non-equipment basic events are screened out. The SSCs that are located inside Class I structures and that are located away from vulnerable openings or features are screened out. The component dependent on offsite power should be determined. The structure engineer should identify additional vulnerable SSCs through drawings and SSC location. Finally, HWEL can be updated from the walkdowns.

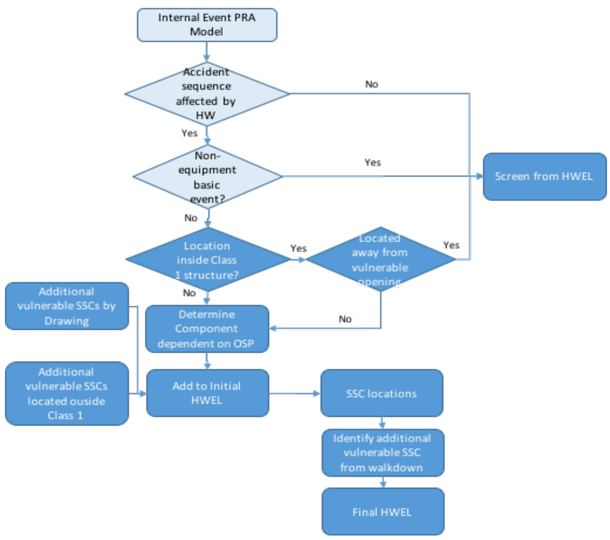


Fig. 1. Procedure for developing the HWEL [3]

### *3.2 Vulnerable SSCs walkdown*

A walkdown of SSCs included in the HWEL should be performed to determined all potential wind pressure and wind-borne missile failure mode. If it is determined that as SSC could be damaged during a high wind, additional information and environmental data of the SSC is gathered as described below.

- Prepare a general site drawing with overlaid missile zoning
- Identify discrepancies among drawings and uncertainties about the status of certain features
- Identify as-built as-operated conditions
- Identify thickness of protection wall
- Whether component expose to any opening in the structure or not
- Look for spatial interaction vulnerabilities from surrounding structures and equipment
- Check location of SSCs
- Identify the extent of barriers between target equipment and wind-borne missiles
- Identify wind directions
- Identify tanks and ventilation systems

### *3.3 Inclusions in walkdown note*

During the walkdown, it is noted that where SSCs damage/degrade or not because the probability failure can be increased by the state of SSCs. The dimension and robustness of support is important to calculate the wind fragility of SSCs. The information of protection wall can be used for evaluating a wind-borne missiles fragility. And Distance from non-Class 1 structures should be noted.

### *3.4 HWEL of Korea NPP*

The structure engineer should be defined the failure mode of SSCs before the field investigation.

For the wind fragility analysis, it is important to define a failure mode and criteria for the selected SSCs. A seismic load than wind load governed a reactor containment building and an auxiliary building. Therefore, two buildings were excluded for a wind fragility analysis. The wall of turbine building can be spalled by high wind because the wall was made by a thin steel plate. However, the spalling cannot lead to a critical structural damage of building the functional failure of components inside structure can occur. Transmission towers and transformers of switch yard can suffered a wind damage (collapse, line break, wind borne missile etc.). When the wind borne missile hits the tanks (oil storage tank, water storage tank), the loss of aux feed water in NPPs can occur.

Typhoon induced high wind can apply the lateral load to the structure. Therefore, the SSCs should be designed to resist a bending moment, shear force and spalling of claddings.

| | SSCs | Failure mode | Note |
|---|---|---|---|
| Structures | Reactor bldg. | - | Except |
| | AUX bldg. | - | Except |
| | Turbine bldg. | Functional | Pull out |
| Components | Transmission tower | Structural<br>Functional | Collapse<br>Line break |
| | Transformers | Functional | Wind born missile |
| | CST | Structural | Wind born missile |
| | Crane | Structural | Overturn<br>Collapse |
| | ESW pump room | Structural | Wind born missile |
| | CCW HX | Structural | Wind born missile |
| | EDG oil tank | Structural | Wind born missile |

Table 1. Selection of HWEL of Korea NPP

## 4. Conclusions

Because recent typhoon intensity has been increased, it is need to ensure the safety of Korea NPPs by the super typhoon. In this study, typhoon induced hazard was identified and the procedure of HWEL was developed. Suggestion of the structural considerations of HWEL can help structure engineer perform a high wind walkdown.

## Acknowledgement

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