Assessment of HCLPF Considering of Aging Deterioration at Nuclear Power Facility

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1. Introduction

In general, SPRA (Seismic Probabilistic Risk Assessment) has been applied to assess the seismic performance of the operating nuclear power plant. Also, Aging deterioration is occurring gradually at the nuclear power facilities as operation period of nuclear power plant is increased. However, when the seismic performance is assessed for nuclear power facilities, SPRA has not been considered the aging deterioration enough.

Therefore, seismic walkdown is performed to investigate the aging deteriorations intended for the operating nuclear power facilities and seismic fragility analysis of nuclear power facilities is carried out considering the aging deterioration in this study.

2. SPRA

SPRA consists of seismic hazard analysis, seismic fragility analysis and system & accident-sequence analysis. CDF (Core Damage Frequency) of nuclear power plant induced by seismic event can be presented by these analyses. For use in SPRA, seismic performance of component is determined by seismic fragility analysis as a HCLPF (High Confidence Low Probability of Failure) capacity defined as ground acceleration capacity with 95% confidence value on 5% probability failure. In seismic fragility analysis, 50% median and 5% & 95% confidence curves of all components are presented respectively. For developing these curves median ground acceleration, randomness and uncertainty values are needed for dominant failure mode of a component and these values are able to be developed by detailed analyses using enough design information.

3. Seismic Walkdown

3.1 Investigated Equipment

The investigated equipment is the mechanical and electrical equipment needed to achieve and maintain safe shutdown conditions in a nuclear power plant during and after safe shutdown earthquake. The No. of the investigated equipment is 378 at K-nuclear power plant and 152 at W-nuclear power plant.

3.2 Aging Deterioration

When the seismic walkdown is performed at nuclear power plant, the concerned aging deteriorations are as follows,

- Crack
- Steel corrosion
- Concrete compressive strength
- Anchor tightness

In case of crack, it is found at 8 equipment at K-nuclear power plant and 30 equipment at W-nuclear power plant as shown in figure 1.

Figure 1. Crack at Control Panel

Several steel corrosions are found at equipment but they don't have a large influence to the seismic performance of equipment. Also, average concrete compressive strength is 292 kgf/cm^2 at K-nuclear power plant and 316 kgf/cm^2 at W-nuclear power plant. They show larger than design concrete compressive strength.

At last, average anchor tightness is more than 2.0 kgf-m and this result satisfies tightness criteria of SQUG GIP. The crack only has a influence on the HCLPF of equipment from the above analysis.

4. Seismic Fragility Analysis

Among the aging deteriorations, only crack is considered for HCLPF of equipment because the other deteriorations have no influence on HCLPF.

4.1 Equipment

Electrical panel is considered for comparison of HCLPF according to the crack existence as shown in figure 2. The properties and dynamic characteristics of electrical panel are as follows,

- Height : 96 in.
- Weight : 2,400 lb
- Concrete compressive strength : 3,700 ksi
- Peak ground acceleration : 0.2g
- Spectral acceleration : 0.74g
- Seismic demand for each bolt :
  + Tension : 1.96 kips

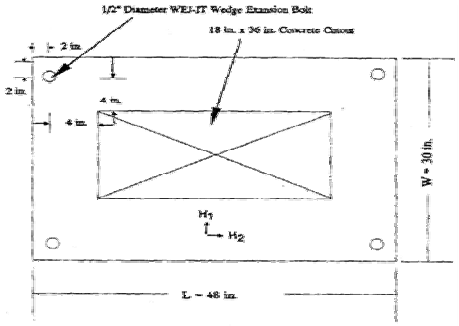

Figure 2. Electrical Panel

+ Shear : 0.63 kips

This study considers 3 cases to analyze the crack's influence to HCLPF of electrical panel. 3 cases mean the no crack, hairline crack and small crack, and both hairline and small crack consider the occurrence probability of 20% and 40%.

4.2 No crack

In case of no crack, HCLPF of electrical panel is 0.27g from the seismic fragility analysis. Figure 3 shows the seismic fragility curves with 5%, 50%, and 95% confidence.

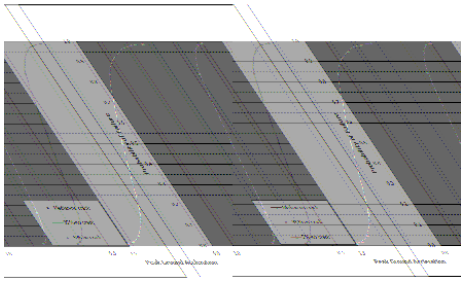

Figure 3. Seismic Fragility Curves for No Crack

4.3 Hairline crack

Hairline crack means crack which has a crack width with 0 – 0.25mm. In case of hairline crack, HCLPF of electrical panel is 0.21g for occurrence probability of 20% and 0.17g for 40%. Figure 4 shows the seismic fragility curves with no crack and hairline crack.

4.4 Small crack

Small crack means crack which has a crack width with 0.25 – 0.51mm. In case of small crack, HCLPF of electrical panel is 0.19g for occurrence probability of 20% and 0.15g for 40%. Figure 5 shows the seismic fragility curves with no crack and small crack.

Table 1 shows the HCLPF and HCLPF reduction rate according to the crack.

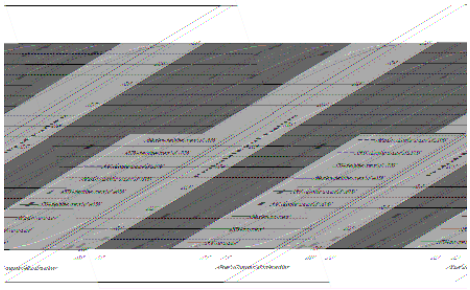

Figure 4. Seismic Fragility Curves for Hairline Crack

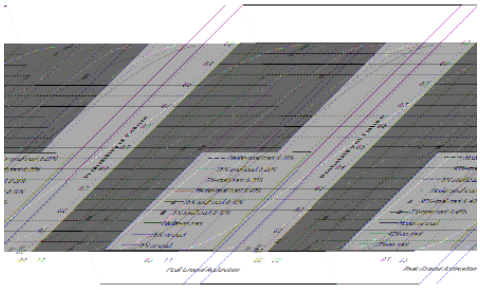

Figure 5. Seismic Fragility Curves for Small Crack

Table 1. Crack's Influence to HCLPF

	Anchor with crack				Anchor without crack
	Hairline crack		Small crack		
	20% Probability	40% Probability	20% Probability	40% Probability	
HCLPF	0.21g	0.17g	0.19g	0.15g	0.27g
HCLPF Reduction rate (%)	22	37	30	44	0

5. Conclusion

Seismic walkdown is performed to investigate the aging deteriorations intended for the operating nuclear power facilities and seismic fragility analysis is carried out considering the aging deterioration in this study.

Maximum HCLPF reduction rate is 37% for the hairline crack and 44% for the small crack from seismic fragility analysis. Therefore, crack has a influence on the HCLPF and CDF of nuclear power plant. So, maintenance and reinforcement of aging deteriorations are needed for the improvement of safety of nuclear power plant.

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