Damage Evaluation of Non-Structural RC Walls using Experimental Results

Tokyo Institute of Technology, Kono Laboratory Emine KOSE, Nobuaki HIRATA

Background

In the world, most of buildings are designed for the life safety of structural components. Non-structural components are designd without much care about seismic performance. After Tohoku and Kumamoto earthquakes it was observed that, even if there is minor or no damage in structural components, damage to non-structural walls can cause serious dysfunction and sometimes leading to the demolition. This damage hinder functionality of building and requires repair.

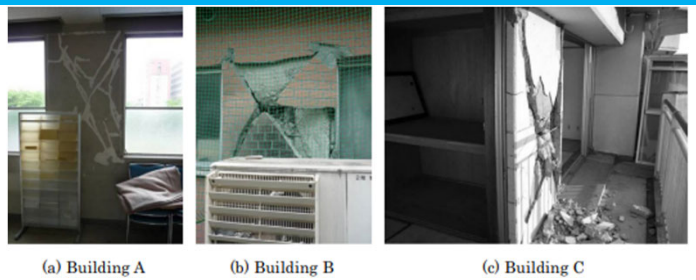

Fig. 1: Damage of RC non-structural walls after the 2011 Tohoku Earthquake.

Objective of study

In this study next generation PEER PBEE framework was used to target **Resilience and functionality** and Step of Damage Analysis on farmework was studied. The objective of study is carry out the damage evaluation of non-structural RC walls based on limit states defined in the 2004 AIJ Guidelines by using drift ratio as demand parameter.

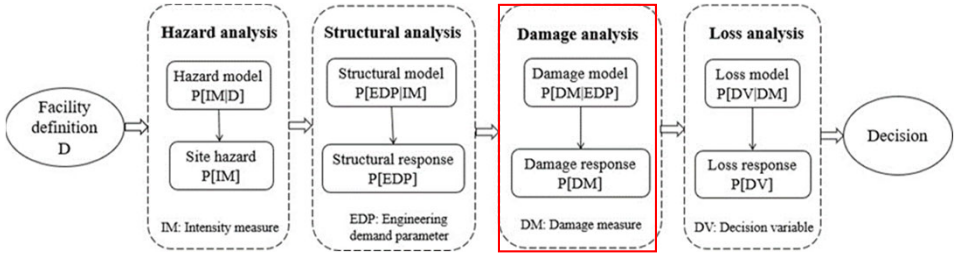

Fig. 2: General framework of PEER PBEE methodology (after Porter, 2003)

*Table 1: Quantification of AIJ Limit states values proposed by Obara et al [*1] by using using AIJ guidelines for prestressed concrete members.*

Limit state	Damage state				
	Longitudinal reinforcement		Concrete Residual	Residual Crack width	Residual drift
	AIJ 2004 Guidelines	Obara et al.	AIJ 2004 Guidelines	AIJ 2004 Guidelines	Obara et al.
Serviceability	Elastic	$\varepsilon \le \varepsilon_y$ [*1]	Stress < $2/3 f'_c$	<0.2mm	<0.10%
Repairability I	Slightly yielded	$\varepsilon < 1\%$ [*1]	minor cracks	0.2–1.0 mm	<0.25%
Repairability II	buckling		cover spalling	1.0–2.0 mm	<0.50%

The criterias which was taken from AIJ Guidelines for prestressed precast concrete members by Obara et al.

Table 3: Drift (%) reaching four criteria for three limit states in the 2004 AIJ Guidelines (After Egawa et al., 2018)

	Criteria	NSW1	NSW2	NSW3	NSW4	NSW5	NSW6
Serviceability Limit state (S LS)	$\varepsilon_{long} \le \varepsilon_y$	0.16	0.19	0.17	0.27	0.11	0.23
	$\varepsilon_{cv} \le$ strain at $2/3\ f'_c$	0.06	0.09	0.10	0.09	0.03	0.03
	$W_{re} \le 0.2$ mm	0.25	0.25	0.50	0.75	0.75	0.50
	$R_{re} \le 0.1\%$	0.25	0.50	0.75	1.50	0.50	0.73
Drift triggering S LS		0.06	0.09	0.10	0.09	0.03	0.03
Repairability I Limit state	$\varepsilon_{long} \le 1\%$	0.17	0.25	0.35	0.42	0.46	0.44
	Vertical cracking	0.75	1.00	0.50	1.50	0.50	0.50
	$0.2 < W_{re} \le 1$mm	0.50	0.50	1.50	-	1.50	1.50
	$0.1\% < R_{re} \le 0.25\%$	0.50	1.00	1.51	2.00	1.00	1.50
Drift triggering RI LS		0.17	0.25	0.35	0.42	0.46	0.44
Repairability II Limit state (RII LS)	Buckling is not allowed	-	1.00	-	2.00	2.00	3.00
	Concrete cover may spall but core is healthy	1.50	1.00	1.00	2.00	1.00	1.50
	$1 < W_{re} \le 2$mm	0.75	0.75	-	-	-	-
	$0.25 < R_{re} \le 0.5\%$	0.75	-	-	2.00	1.50	2.00
Drift triggering RII LS		0.75	0.75	1.00	2.00	1.00	1.50

ε_{long}: strain in longitudinal reinforcement, ε_y: yield strain of reinforcement, ε_{cv}: strain in cover concrete, f'_c: compressive strength of concrete, W_{re}: residual crack width, R_{re}: residual drift

Table 3 which modified by Egawa et al was used **to evaluate drift ratio for 6 walls**. In the table, minimum drift ratio that triggers any of the four criteria was chosen as the drift triggering. The same method applied to all other walls for other Limit states.

Conclusions

Damage analysis of six non-structural reinforced concrete wall specimens before collapse was performed by using drift ratio. Conctere is always controlling for the Serviceability LS and criteria for the concrete are extremelly small then others. That might be one of the factors we need to think about if we really want to take this criteria.

Contributions to Society

The damage evaluation method of non-structural shear walls facilitates post-earthquake damage assessment for engineers. Thanks to this method, the functionality and repair requirements of buildings can be properly decided by engineers.