

Failure Patterns of Reinforced Lightweight Aggregate Concrete (RLAC) Walls after High Temperature

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Abstract. This study utilizes and sinters the reservoir sediment to produce high-quality lightweight aggregates. Not only does the recycling of reservoir sediment into useful building material save resources, but it also increases the reservoir capacity, prolongs reservoir life, and is more conducive to environmental protection. This research focuses on this kind of reinforced lightweight aggregate concrete (RLAC) walls. After performing a standard temperature rising fire-resistance test, the failure patterns behavior of the wall sample are studied under a lateral horizontal load. The research results showed that the reinforced lightweight aggregate concrete wall retained its mechanics after the fire-resistance test. The test results also showed that RLAC and reinforced normalweight aggregate concrete (RNAC) walls exerted the same influence on failure patterns.

Introduction

For a long time, damages to structures caused by earthquake have been the focus of public attentions. Most research in the past also focused on the fields of seismic analysis, seismic design and seismic isolation. However, few studies were done on the materials used for the structure. As the weight of structure constructed with LWAC is lighter, the seismic force it generates is also smaller while withstanding the effects of earthquake acceleration [1-2]. In addition, better damping property of LWAC may reduce the dynamic response of the structure. Undoubtedly, under the same condition, the seismic capacity of LWAC is much better than that of NWAC. In contrast to most past research, which concentrate on the seismic capacity of NWAC, fewer research were conducted on RLAC walls, especially in the field of mechanics behavior of walls under repeated horizontal loads. Therefore, this paper explores the mechanics behavior of RLAC walls under the lateral effect of repeated horizontal loads after the fire-resistance test under standard temperature condition, as well as the results of the failure patterns of the wall specimens to evaluate the seismic resistance of RLAC after being treated with high temperature [3].

Experimental Plan

Specimens planning

To compare the differences on fire-resistance performances between RLAC and RNAC walls, this concrete specimens for this research include lightweight and normalweight aggregates with and without high temperatures with the consideration of vertical steel spacing at 10cm, 20cm, and 30cm and with the dimension (width \times height \times thickness) at 150cm \times 150cm \times 7.5cm and 85cm \times 150cm \times 7.5cm, respectively. With regard to the specimens' number, size, and material properties, and the information on the 28-day compressive strength test for concrete walls, please refer to Table 1.

Table 1. Numbers and parameter of internal composition of the specimens.

Series*	Wall size (cm) (W \times H \times tw)	Coarse aggregate type	Vertical steel		W / C	fc' (kg/cm ²)
			Number – Steel spacing	ρ		
LW85S10B	85 \times 150 \times 7.5	Lightweight aggregate	# 3-10cm	0.00894	0.46	216.5
LW85S20B	85 \times 150 \times 7.5	Lightweight aggregate	# 3-20cm	0.00447	0.46	201.3
LW85S30B	85 \times 150 \times 7.5	Lightweight aggregate	# 3-30cm	0.00335	0.46	234.6
LW85S30	85 \times 150 \times 7.5	Lightweight aggregate	# 3-30cm	0.00335	0.46	196.3
LW150S30B	150 \times 150 \times 7.5	Lightweight aggregate	# 3-30cm	0.00317	0.46	216.8
NW85S30B	85 \times 150 \times 7.5	Normalweight aggregate	# 3-30cm	0.00335	0.66	196.9
NW85S30	85 \times 150 \times 7.5	Normalweight aggregate	#3-30cm	0.00335	0.66	202.3
NW150S30B	150 \times 150 \times 7.5	Normalweight aggregate	# 3-30cm	0.00317	0.66	211.6

* L: lightweight aggregate, W: wall width is 150cm, S: Steel spacing is 20cm, B: burned sample, N: normalweight aggregate.

Fire-resistance test

The aforementioned wall specimens were placed in a high-temperature furnace for this study. The specimens were heated according to the standard temperature rising curve of ASTM E119. According to ASTM E119, the temperature in the furnace needs to reach 700°C within 10 minutes, and the heating shall continue for another 50 minutes until the final temperature reaches 950°C[3]. In addition, two thermocouples of CH1 and CH3 were buried inside specimens and a temperature test rod was mounted on the surface of the wall specimens at the location (see Figure 1) in order to obtain the interior and exterior temperature changes of the specimens. Finally, the wall specimens were removed after completing the aforementioned fire-resistance test for observation. After observing the surface damages caused by high temperature, the repeated horizontal thrust test was conducted.

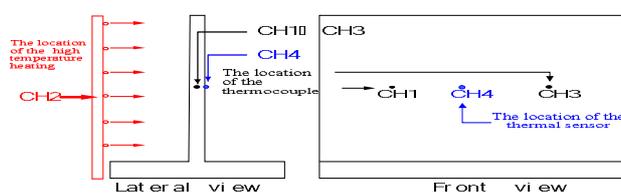


Figure 1. The location of measuring point for specimens in the fire-resistance test.

Horizontal thrust test and repeated horizontal thrust test

In this study, the wall specimens were locked tightly with bolts on solid floor 28 days after casting and a horizontal thrust was exerted directly on them. The pressure head of the horizontal thrust equipment, a MTS device of 50 tons in weight, was mounted on the reaction wall. The readings from the signals were transformed into actual physical quantity by load cell for a series of analyses on the test results. As stated above, this study will apply repeated load force directly onto the wall specimens according to the test method. By means of displacement control, signal readings from the data collection system were transformed into actual physical quantity and then saved on a desktop as the files for test result analysis.

Analysis and discussion on the test results

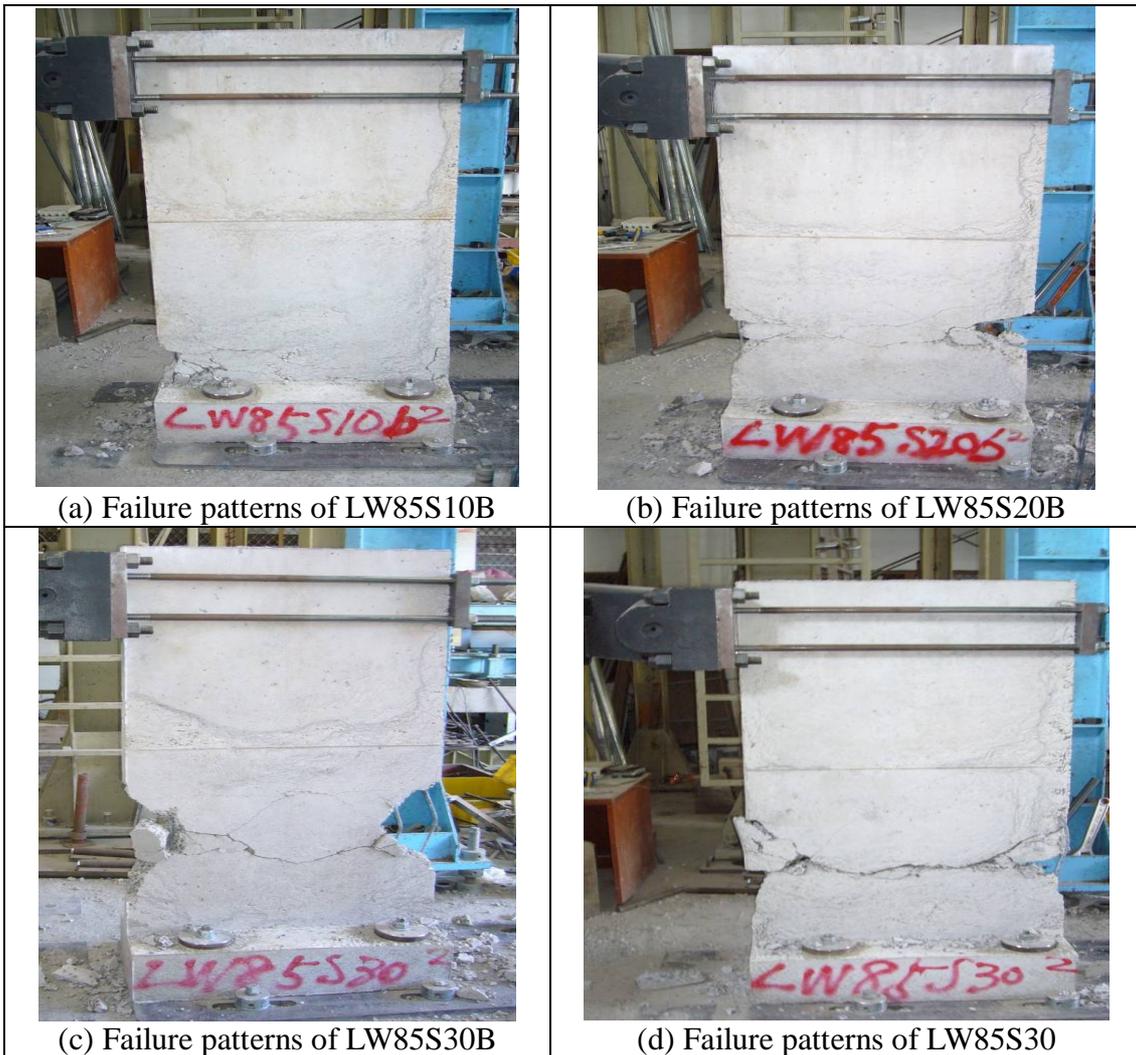


Figure 2. Failure patterns of RLAC wall specimens

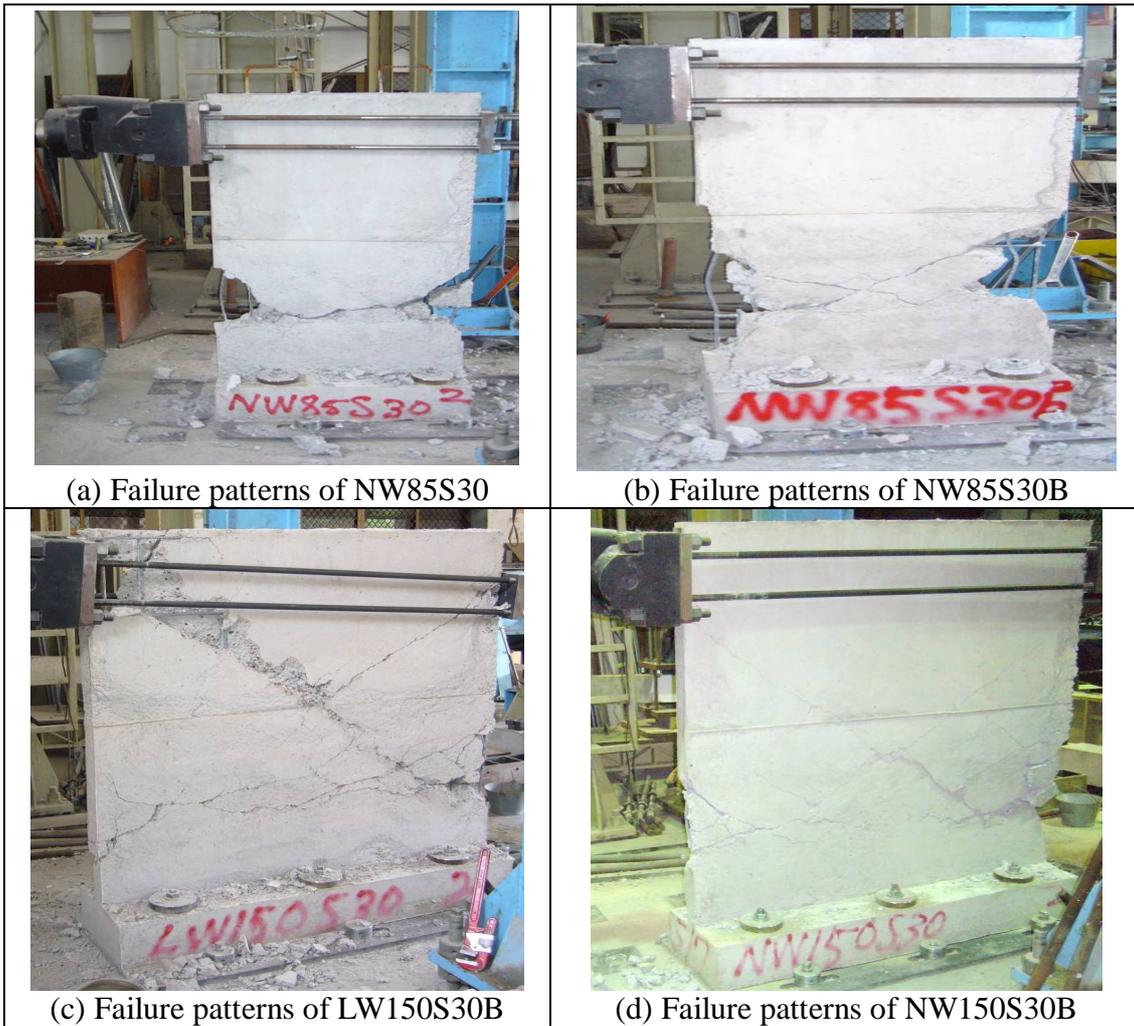


Figure 3. Failure patterns of RLAC and RNAC wall specimens

The failure pattern of specimens are demonstrated in Figure 2(c) and Figure 3(b). The reason behind this is that after fire-resistance test, the concrete will gradually exhibit the phenomenon of decomposition of cement hydrates and pellets decay, leading to the decrease in structural strength of wall specimens and affecting the failure patterns of specimens. Failure patterns of walls with different widths are shown in Figure 2(c) and Figure 3(c). LW85S30B specimens with the width of 85cm generated diagonal and horizontal cracks simultaneously in the beginning and these cracks were getting wider and deeper following the repeated lateral loads; while the cracks on LW150S30B specimens were initially diagonal, which then extended to the center and became horizontal cracks. Under the repeated lateral loads, those cracks were also widened and deepened. The above results showed that comparing to the 150cm wide walls, the 85cm wide walls had more flexure effects and a flexural failure pattern; while the 150cm wide walls had more shear effects and with the shear failure pattern.

NW85S30B specimens with the width of 85cm initially generated diagonal and horizontal cracks on both sides of the wall simultaneously. These cracks got wider and deeper following the repeated lateral loads. NW150S30B wall specimens with the width of 150cm generated diagonal cracks on both sides of the wall initially and these cracks were getting wider and deeper following the back and forth pressures of loads, as shown in Figure 3(b) and (d). The test results showed that RLAC and RNAC walls exerted the same influence on failure patterns.

Conclusions

The study found that there was no significant difference on the failure pattern, between RLAC and RNAC walls after the fire-resistance test under the effects of repeated loads. The failure pattern of RLAC walls with the width of 30cm after the test of fire-resistance and under the effects of repeated loads is bending moment of flexure, while under the same conditions, the failure pattern of RLAC walls with smaller steel spacing is a combination of flexure and shear forces.

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