Seismic Capacity Evaluation of URM Infill Built in RC Frame
Part 3: Shear Strength Evaluation of URM Infill

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URM Infill, RC Frame, Seismic Capacity Evaluation, Cyclic test, Shear Strength, Compression strut

1. Introduction

In this paper, a shear strength evaluation method based on an equivalent diagonal strut is discussed, and the method is verified focusing on the test results of 1B-1S-H and 2B-1S-H specimens due to the limitation of the paper length.

2. Equivalent Diagonal Strut and Shear Strength of URM Infill

The lateral strength of an URM infill wall, based on an equivalent diagonal strut, was calculated by Equation (1). The equivalent strut is shown in Figure 1.

$$V_{CS} = W_{eq} \cdot cos\theta \cdot \sigma_m \cdot t \quad (1)$$

where, W_{eq}: the equivalent strut width, θ: the main strut angle, σ_m: the stress corresponding to the equivalent strut's principal compressive strain ε_m, based on three layered prism tests, t: the thickness of the wall (48 mm), respectively.

Calculations for the strut parameters were made as per the following procedure. For detailed discussions about the method, kindly see Reference [1].

A) Main strut angle (θ):

Main strut angle θ was calculated by Equation (2), where, l: number of blocks with $0<\theta_j<90$, ε_j: principal compressive strain of the j-th block, θ_j: principal direction of the j-th block.

$$\theta = \left(\sum_{j=1}^{l} \varepsilon_j \times \theta_j\right) / \left(\sum_{j=1}^{l} \varepsilon_j\right) \quad 0 < \theta_j < 90 \quad (2)$$

B) Formulation of wall sections:

To calculate the remaining parameters of the equivalent strut described in the following C) to E), the wall was divided by inclined sections, as shown in Figure 1. The inclined sections were perpendicular to a reference line at the angle θ from the horizontal axis obtained as above, and were equally spaced with a maximum spacing containing at least one CB unit of each horizontal layer. The wall was consequently divided into 19 sections, as shown in Figure 1. The strain gauge arrangements for 2B-1S-H specimen, shown in Figure 6(d) in Part 1, was planned so that the same logic was applied to the specimen as well.

C) Mean strain ε_m in the strut:

The mean value of principal compressive strain ε_i of CB units included on the i-th section (i=1 to 19) was calculated first. Next, the mean strain ε_m in the strut was calculated by Equation (3).

$$\varepsilon_m = \sum_{i=1}^{n} \varepsilon_i / n \quad (n = 19 \text{ herein}) \quad (3)$$

D) Central axis distance C_y of the equivalent strut:

The central axis distance C_y was calculated using the centroid

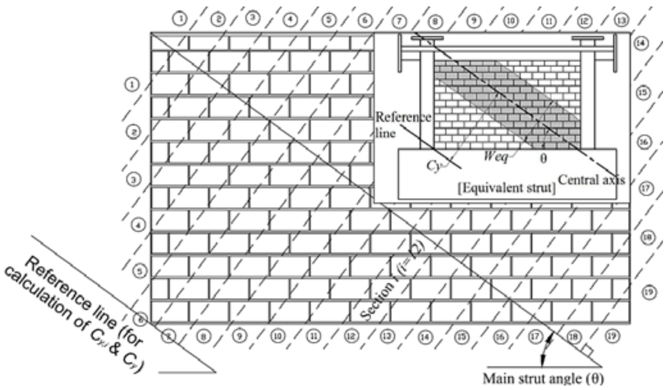
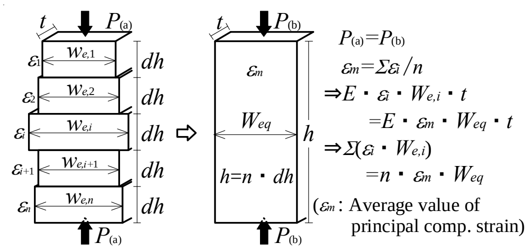


Figure 1. Description of parameters of equivalent strut



(a)Original strut (b)Equivalent strut

Figure 2. Equivalent diagonal strut width [1]

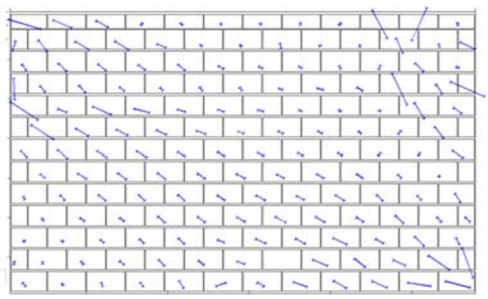


Figure 3. Principal strain distribution at 0.67%

distance $C_{y,i}$ at each section. $C_{y,i}$ and C_y were calculated using Equations (4) and (5), respectively, where y_i: distance of each block with $0<\theta_j<90$ in the i-th section from the reference line (shown in Figure 1), and m: number of blocks with $0<\theta_j<90$ in each section.

$$C_{y,i} = \left(\sum_{i=1}^{m} \varepsilon_j \times y_j\right) / \left(\sum_{i=1}^{m} \varepsilon_j\right) \quad (4)$$

$$C_y = \left(\sum_{i=1}^{n} \varepsilon_i \times C_{y,i}\right) / \left(\sum_{i=1}^{n} \varepsilon_i\right) \quad (n = 19) \quad (5)$$

E) Equivalent strut width (W_{eq}):

The effective width $W_{e,i}$ of strut at every section i was calculated first. $W_{e,i}$ was defined as the outermost distance between the CB units with principal strain angles between 0 and 90 degrees. Next, the equivalent strut width W_{eq} was calculated by Equation (6),

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according to a concept shown in Figure 2.

$$W_{eq} = \left(\sum_{i=1}^{n} \varepsilon_i \times W_{e,i}\right) / \left(\sum_{i=1}^{n} \varepsilon_i\right) \quad (n = 19) \qquad (6)$$

Figure 3 shows an example of the principal strain distribution at a drift angle of 0.67% for 1B-1S-H specimen, and Figure 4 shows the equivalent strut of 1B-1S-H and 2B-1S-H specimens calculated by the proposed method. As shown in Figure 4, two independent diagonal struts were seen in the 2-bay specimen.

3. Estimations of the Shear Strengths of the Overall Frames

The overall strength of each frame was calculated as the sum of the strengths of the wall and RC frame. The strengths of the RC frames were calculated based on the theory of structural mechanics.

Figures 5 (a) and (b) compare the strengths of 1B-1S-H specimen calculated by the above method with the experimental results in the positive and negative loading directions, respectively. As shown in the figure, the overall strengths by the above method showed good agreements with the test results throughout the loading cycle. However, the strength by the proposed method was overestimated after a drift angle of 1.5% in the positive direction, since a sliding mode developed predominantly from this drift angle. The wall capacity was estimated by FEMA procedure[2] as well, as shown in Figure 5(a) and (b); it underestimated the capacity of the wall.

The same evaluations were also applied to 2B-1S-H specimen, which is plotted in Figure 6 and showed good agreements with the test results.

4. Conclusion

Cyclic static tests were carried out to evaluate the in-plane behavior of URM infill. In this paper, a strength evaluation method based on strain measurements was validated using the test results. The major findings can be summarized below.

(1) The proposed method evaluating an equivalent diagonal strut based on the strain measurements can accurately estimate the wall strengths for the 1 bay and 2 bay specimens throughout the loading cycle.

(2) Two independent diagonal struts were formed in the 2 bay specimen.

(3) The FEMA procedure significantly underestimated the lateral strengths of both specimens.

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[Reference]

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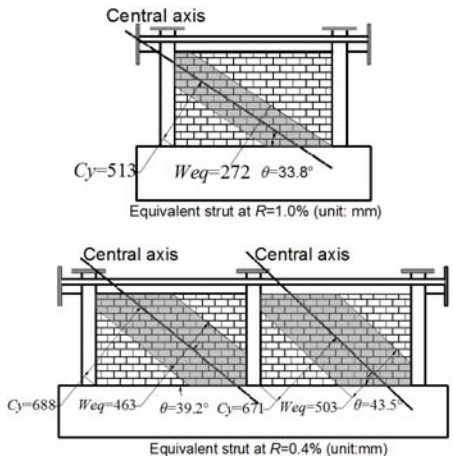
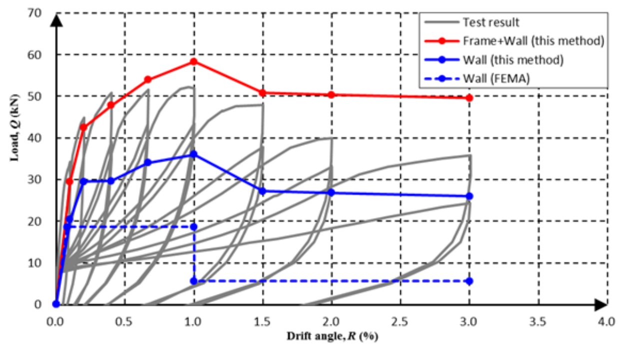
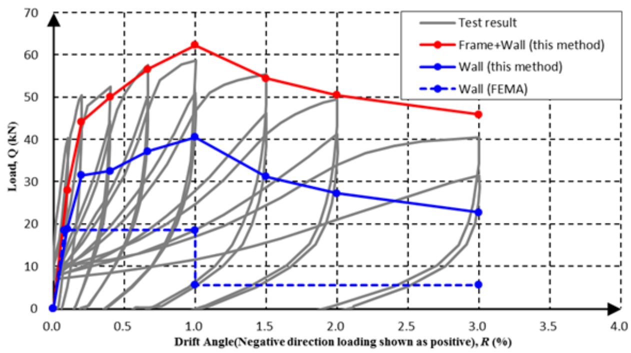


Figure 4. Equivalent strut of 1B-1S-H and 2B-1S-H specimens



(a) Positive loading



(b) Negative loading

Figure 5. Load-drift angle relationship for 1B-1S-H specimen

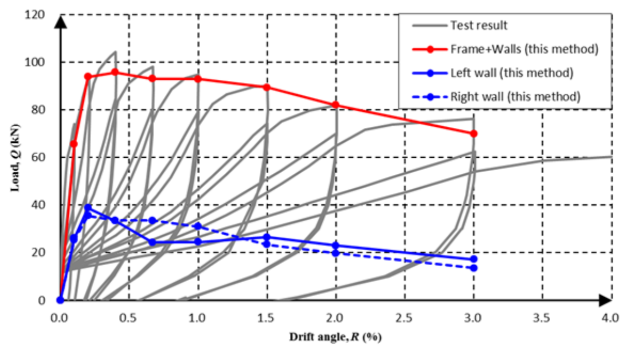


Figure 6. Load-drift angle relationship for 2B-1S-H specimen

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