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SEISMIC PERFORMANCE OF MASONRY PARTIALLY INFILLED RC FRAME BASED ON NUMERICAL ANALYSIS APPLYING STRUT MODEL

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ABSTRACT: This paper presents the results of a numerical study on reinforced concrete (RC) frame structures with partial masonry infill, conducted using the pushover method in the SeismoStruct program to evaluate their seismic performance. Various diagonal strut models were employed to analyze the strut width and the contact length between the column and infill, which were used in the pushover analysis to represent the masonry infill element. The study investigated three RC frame models: one with full masonry infill and two with partial masonry infills. The numerical results were validated against experimental findings, which showed that the lateral strength, stiffness, and ductility of the structural models were reasonably consistent between the numerical and experimental data. Both sets of results indicated that the lateral strength of the RC frame with full masonry infill decreased by approximately 29% and 46% when compared to frames with three-quarter and half-height infills, respectively. Partial masonry infill was also found to alter the crack patterns and failure mechanisms of boundary columns. In RC frames with partial infills, the walled portions of the columns become stiffer, leading to increased cracking and short-column damage. These findings demonstrate that the diagonal strut approach is effective for evaluating the seismic performance of RC frames with partial masonry infill.

Keywords: Diagonal strut model, Numerical study, Partial masonry infill, Reinforced concrete frame, Seismic performance,

1. INTRODUCTION

Unreinforced brick masonry is commonly used as infill in reinforced concrete (RC) buildings in earthquake-prone areas like Sumatra Island, Indonesia. A study by Maidiawati and Sanada [1] after the 2007 Sumatra earthquake showed that these infill walls helped the buildings stay standing. However, they also caused a "soft-story" effect, which reduced the buildings' overall earthquake resistance. Similar problems have been seen after other earthquakes in West Sumatra, Pidie Jaya, Wenchuan and Lushan in China [2], and Palu-Sulawesi [3].

Many studies over the past few decades have looked at how brick masonry infill affects the earthquake performance of RC frame structures. These studies include both experimental tests and computer-based analyses. Maidiawati et al. [4] tested RC frames with full brick masonry infill, while Tanjung and Maidiawati [5,6] used local brick masonry from West Sumatra in their experiments. Other researchers, such as Al-Chaar [7], Cavaleri and Trapani [8], and Korkmaz and Taciroglu [9], also carried out large-scale experiments. The results showed that adding brick masonry infill to RC frames improves their lateral strength and stiffness and delays failure, but it also makes the structure less ductile.

To study how masonry infills affect the earthquake performance of frame structures, several methods have been developed. One common approach is to represent the infill wall with a diagonal strut, either as a single strut or multiple struts. Many researchers—such as Holmes [10]; Smith and Carter [11,12]; Mainstone [13]; Leuchars and Scrivener [14]; Paulay and Priestley [15]; Liau and Kwan [16]; El-Dakhakhni et al. [17]; and Maidiawati and Sanada [18]—have proposed different diagonal strut models. These models mainly focus on calculating the effective width of the strut to help predict the infill's behavior during earthquakes.

The majority of the experimental and analytical investigations described above have focused on full masonry infill in RC frame structures. Currently, there are very few studies available on partially infilled brick masonry walls. A partial wall refers to a masonry infill that does not extend to the full height of the frame, typically to allow for window openings, ventilation, or other functional requirements. Tanjung et al. [19], Maidiawati and Tanjung [20], and Pradhan et al. [21] conducted studies on partial masonry infills in RC frames.

Numerical studies using finite element analysis with the SeismoStruct program to assess the seismic performance of single-bay RC frames with masonry infills were carried out by Crisafulli [22]. Carvalho et al. [23] and Smyrou et al. [24] extended this work by examining RC frames with full infill and infill walls containing openings. Their results were compared with experimental data.

This paper presents the results of a numerical analysis of RC frames with partial masonry infill walls. The analysis was performed using SeismoStruct software, which models the partial infill walls using an equivalent diagonal strut approach. The paper also discusses the significance of the research, reviews different diagonal strut models, presents numerical studies based on various modeling techniques, and compares the results with experimental data.

2. RESEARCH SIGNIFICANCE

This research enhances the seismic evaluation of reinforced concrete frames with partial masonry infills, a structural system prevalent in both existing and newly constructed edifices. The study presents a refined analytical model utilizing SeismoStruct software and the equivalent diagonal strut approach, providing a more precise depiction of partial infill panels' behavior under seismic circumstances. This enhanced modeling technique can be used in numerical simulations to predict the structural performance more accurately during earthquakes. The results offer engineers and structural designers a practical modeling method that facilitates more informed decision-making in the design and assessment of structures, especially in seismically active areas.

3. DIAGONAL STRUT MODEL OF MASONRY INFILL

Many scholars [10–18] have suggested diagonal strut models for evaluating the seismic performance of masonry infill in framed structures. The strut models, as illustrated in Fig. 1, were developed with the objective of estimating the width of the brick infill strut (W) and/or discussing interactions between the infill and its surrounding frame.

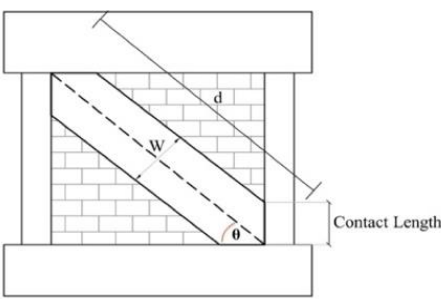


Fig. 1 Diagonal strut model and frame-infill contact of masonry infill

Holmes [10] offered a model that sreplaces the infill with an equivalent diagonal strut having a width equal to one-third of the infill's diagonal length (d). This model assumes full contact between the infill and the surrounding frame to calculate the strut width. Holmes verified the model through experimental studies on single-bay steel frames filled with brick infill, as reported in reference [10]. Mainstone [13] adopted the concept of replacing the infill with an equivalent diagonal strut and proposed several formulas to calculate the infill’s stiffness, cracking strength, and ultimate strength. Mainstone used experimental tests on single-bay, single-story RC frames with and without masonry infill to relate the effective strut width to the diagonal length of the infill, as given by Eq. (1). The analytical model assumes good bonding between the infill and frame [13].

$$w = 0.16\,\lambda_h^{-0.3}\,d \tag{1}$$

in which the λ_h is relative stiffness of the infill to the surrounding frame, as defined by Smith and Carter [11,12], and given by Eq. (2).

$$\lambda_h = h\left(\frac{E_m t.\sin 2\theta}{4E_c.I_c.h_m}\right)^{1/4} \tag{2}$$

where, h is height of column, E_m is young’s modulus of the infill material, E_c is young’s modulus of column, t is thickness of the infill wall, h_m is height of the infill, I_c is moment of inertia of the frame columns, θ is angle between diagonal of the infill and the horizontal.

Paulay and Priestley [15] suggested that the width of the strut should be one-fourth of the diagonal length of the infill, based on the geometry of the frame and infill. Liauw and Kwan [16] presented Eq. (3) for calculating the width of the diagonal strut based on the mechanics of interaction between the infill and the surrounding frame.

$$w = \frac{0.95h.\cos\theta}{\sqrt{\lambda_h}} \tag{3}$$

Mainstsone, Pauley and Priestley, and Liauw and Kwan used Eq. (4) to calculate the contact length of column-infill, as report by Crisafully [22].

$$z = \frac{\pi}{2\lambda_h}.h \tag{4}$$

Maidiawati and Sanada [18] developed a new single-strut model that considers the interaction between the RC frame and the masonry infill. In this model, the infill wall is replaced with a diagonal strut that has the same thickness and material as the original wall. Fig. 2 illustrates how the diagonal strut and distributed forces act at the interface between the column and the infill.

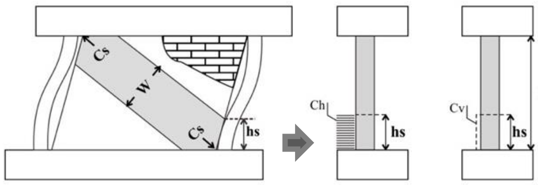


Fig. 2 Modeling of masonry infill and distributed strut forces at the column–infill interface

The strut width W, which corresponds to the frame-infill contact length, h_s, is provided in Eq. (5).

$$W = 2h_s \cos\theta \tag{5}$$

The frame–infill contact length (h_s) is determined by the intersection of the column's flexural displacement and the infill's shear deformation. The column displacement is calculated by Eq. (6) for column's height $y \leq h_s$ and Eq. (7) for $h_s \leq y \leq L$. The shear deformation of infill is obtained by Eq. (8)

$$\delta_c(y) = \frac{1}{EI}\left(\frac{1}{24}C_h y^4 - \frac{1}{6}Q_u y^3 + \frac{1}{2}M_u y^2\right) \tag{6}$$

$$\delta_c(y) = \frac{1}{EI}\left(\left(\frac{1}{6}C_h h_s - \frac{1}{6}Q_u\right)y^3 + \left(\frac{1}{2}M_u - \frac{1}{4}C_h h_s^2\right)y^2 + \frac{1}{6}C_h {h_s}^3 y - \frac{1}{24}C_h {h_s}^4\right) \tag{7}$$

$$\boldsymbol{\delta_{i(y)}} = \frac{\boldsymbol{\delta_{c(y=L)}}}{\boldsymbol{L}}\boldsymbol{y} \tag{8}$$

Where M_u is the ultimate moment at the base of the column (Eq. 9), Q_u is the ultimate shear force of the column (Eq. 10), and C_h is distributed strut forces at the column (Fig. 2) calculated by Eq. (11), f_m' is the factored compressive strength of the masonry infill.

$$M_u = 0.8\, a_t \sigma_y D + 0.5ND\left(1 - \frac{N}{bDF_c}\right) \tag{9}$$

$$Q_u = \frac{2M_u}{L} + C_h h_s - \frac{C_h {h_s}^2}{L} + \frac{C_h {h_s}^3}{3L^2} \tag{10}$$

$$c_h = t f_m{}' \cos^2\theta \tag{11}$$

The intersection of column–infill displacement can be evaluated by solving the $\delta_c(y) = \delta_i(y)$ from the Eqs. (6) or (7) and Eq. (8). The detailed methodology for determining the frame–infill contact length is described in reference [18]. The contact height between the column and the infill is measured on both the left and right columns. The smaller of the two values is then used to calculate W.

4. NUMERICAL STUDY

4.1 Structural Models of Infilled RC Frame

The finite element models were developed using the SeismoStruct program [25] to estimate the nonlinear performance of RC frames with partial infills. Three one-story structural models—one RC frame with full brick masonry infill (IFFW) and two RC frames with partial masonry infills (IFPW-1 and IFPW-2)—were constructed based on experimental test models by Tanjung et al. [19] and Maidiawati and Tanjung [20]. Table 1 presents the dimensions of the IFFW, IFPW-1, and IFPW-2 models.

A numerical study was conducted to assess the seismic capacity of the IFFW, IFPW-1, and IFPW-2 structures using the pushover method. In this process, the diagonal strut width and contact length of column-infill were employed to apply infill characteristics to the pushover technique. A schematic of diagonal strut models for RC frames with partial infills is presented in Fig. 3. The seismic performance of RC frame structures with full and partial infills (IFFW, IFPW-1, and IFPW-2) is expressed in terms of the lateral force–drift ratio relationship.

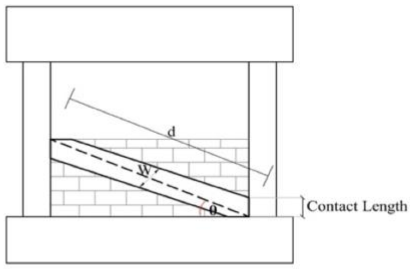


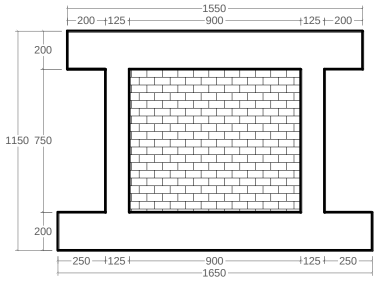
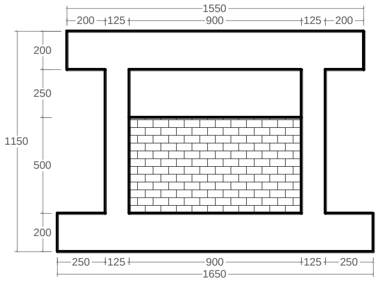
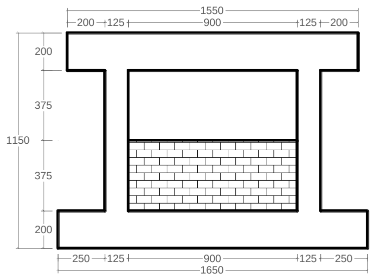
Fig. 3 Diagonal strut model for partial infill

4.2 Material Properties of Models

The material properties and parameters of the RC frames and masonry walls used in the numerical study are summarized in Table 2, based on experimental test results by Tanjung et al. [19], and in accordance with Crisafulli [22] and Smyrou [24], except for the equivalent contact length and strut width of the infill.

The strut widths and contact lengths at the column–infill interface for the IFFW, IFPW-1 and IFPW-2 models, calculated using the models of Holmes, Mainstone, Pauley–Priestley, Liauw–Kwan, and Maidiawati–Sanada, are given in Table 3.

Table 1. Dimensions of structural models

Model Type	Columns (mm)	Masonry Infills (mm)	Beams (mm)	Drawing of models
IFFW	Cross section:125×125 Main bar 4D10 Hoop: Ø4-50	Length: 900 Height: 750 Thickness: 50	Upper beam: 200×200 Main bar: 4D13 Hoop: Ø 6-50 Lower beam: 700×200 Main bar: 12D13 Hoop: Ø 6-50	
IFPW-1	Cross section:125×125 Main bar 4D10 Hoop: Ø4-50	Length: 900 Height: 500 Thickness: 50	Upper beam: 200×200 Main bar: 4D13 Hoop: Ø 6-50 Lower beam: 700×200 Main bar: 12D13 Hoop: Ø 6-50	
IFPW-2	Cross section:125×125 Main bar 4D10 Hoop: Ø4-50	Length: 900 Height: 375 Thickness: 50	Upper beam: 200×200 Main bar: 4D13 Hoop: Ø 6-50 Lower beam: 700×200 Main bar: 12D13 Hoop: Ø 6-50	

In this method, the infill is modeled with two struts having areas A_1 and A_2. A_1 is the product of the strut width (W) multiplied by the wall thickness. The tensile strength of the masonry wall (f_t) is small and can be assumed to be zero [22]. The diagonal compressive strength of masonry ($f_{m\theta}$) is obtained by Eq. (12), and the bond shear strength of masonry is calculated using Eq. (13), where f_m is the compressive strength of masonry. The maximum shear stress (τ_{ma}) is obtained by Eq. (14), where V_s and A_m are the shear force and the cross-sectional area of masonry infill, respectively. The reduction shear factor (α_s) of 1.43 represents the average shear force in the range of 1.4 to 1.65 [22].

$$f_{m\theta} = f_m . sin^2\theta \qquad (12)$$

$$\tau_0 = 0.03\ f_m \qquad (13)$$

$$\tau_{max} = 1.43\ \frac{V_s}{A_m} \qquad (14)$$

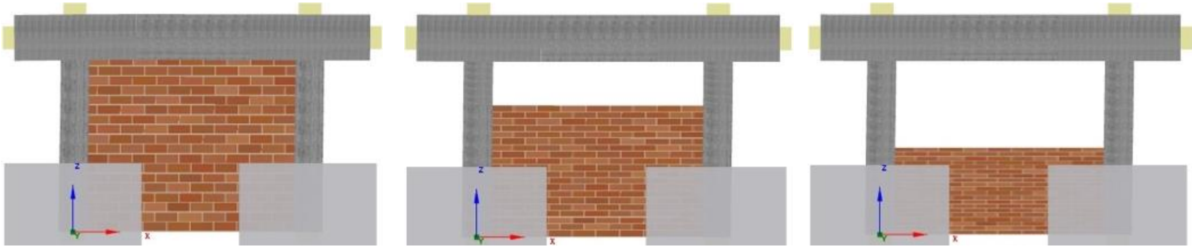
Fig. 4 shows a structural model created in SeismoStruct. In this model, the lower beam is fixed at the base, while the upper beam and columns are allowed to move only in the lateral direction. All parts of the frame are restrained from out-of-plane movement. Fig. 5 shows the model used for nonlinear static analysis. In this setup, the load and displacement are applied and measured at the top of the left column, and the base is fixed. No shear connectors were used between the masonry infill and the surrounding frame.

Table 2. The material properties of the models

Properties of models	Unit	Models		
		IFFW	IFPW-1	IFPW-2
Yield strength of rebars (f_y)	N/mm^2	Ø4 = 390.2 Ø6 = 346.8 D10 = 462.0 D13 = 421.1	Ø4 = 390.2 Ø6 = 346.8 D10 = 462.0 D13 = 421.1	Ø4 = 390.2 Ø6 = 346.8 D10 = 462.0 D13 = 421.1
Compressive strength of concrete ,f_c'	N/mm^2	49.9	49.9	49.9
Young modulus of column, E_c	N/mm^2	33201	33201	33201
Initial Young Modulus, E_m	KPa	4467213	1612426	3061798
Compressive Strength, $f_{m\theta}$	KPa	4467.2	1612.4	3061.8
Strain at Maximum Stress, ε_m		0.0012	0.0012	0.0012
Ultimate Strain, ε_u		0.04	0.04	0.04
Closing Strain, ε_{cl}		0.004	0.004	0.004
Strut Area Reduction Strain, ε_1		0.004	0.004	0.004
Residual Strut Area Strain, ε_2		0.005	0.005	0.005
Starting Unloading Stiffness Factor, γ_{un}		1.5	1.5	1.5
Strain Reloading Factor, αre		0.2	0.2	0.2
Strain Inflection Factor, α_{rh}		0.7	0.7	0.7
Complete Unloading Strain Factor, βa		1.5	1.5	1.5
Stress Inflection Factor, β_{ch}		0.9	0.9	0.9
Zero Stress Stiffness Factor, γ_{plu}		1.0	1.0	1.0
Reloading Stiffness Factor, γ_{plr}		1.1	1.1	1.1
Plastic Unloading Stiffness Factor, ex_1		3	3	3
Repeated Cycle Strain Factor, ex_2		1	1	1
Shear Bond Strength, τ_0	Kpa	327.0	327.0	327.0
Friction Coefficient, μ		0.62	0.62	0.62
Maximum Shear Resistance, τ_{max}	KPa	467.6	467.6	467.6
Reduction Shear Factor, α_s		1.43	1.43	1.43
Panel Thickness, t_w	m	0.05	0.05	0.05
Out of Plane Failure Drift	%	5.0	5.0	5.0
Strut Area 1, A_{m1}	m^2	0.0154	0.0137	0.0145
Strut Area 2, A_{m2}	%	100	100	100
Equivalent Contact Length, h_z	%	13.35	19.84	15.20
Horizontal Offset, x_{oi}	%	13.89	13.89	13.89
Vertical Offset, y_{oi}	%	26.67	53.33	35.56
Proportion of Stiffness Assigns to Shear, γ_s	%	20	20	20
Specific Weight, W	KN/m^3	17	17	17

Table 3. Contact length and the strut width of infill

Authors	Contact length (mm)			Strut width (mm)		
	IFFW	IFPW-1	IFPW-2	IFFW	IFPW-1	IFPW-2
1. Holmes [10]	486.6	572.6	509.0	390.5	325.0	353.8
2. Mainstone [13]	486.6	572.6	509.0	143.8	125.7	132.0
3. Pauley &Priestley [15]	486.6	572.6	509.0	292.0	243.8	265.3
4. Liaw & Kwan [16]	486.6	572.6	509.0	351.8	229.3	297.9
5. Maidiawati & Sanada [18]	200.3	148.8	171.1	307.8	274.7	290.0



(a) IFFW (c) IFPW-1 (d) IFPW-2

Fig. 4 Analytical structural models for RC frames with full and partial infills

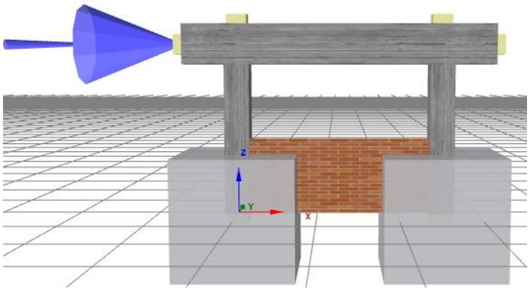


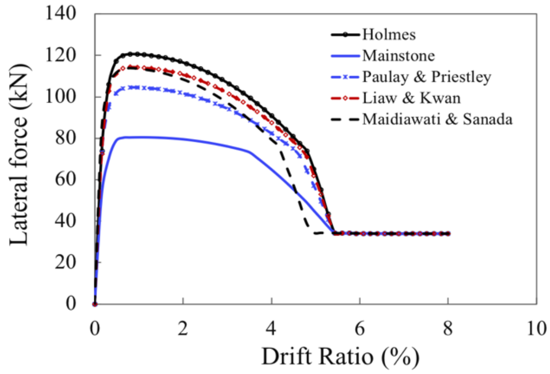
Fig. 5 Schematic model for nonlinear static analysis of an RC-filled model

4.3 Numerical Results

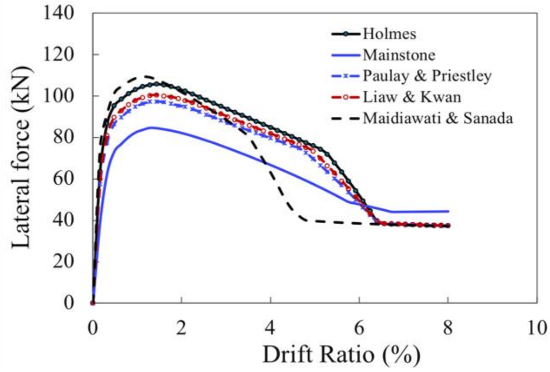
Fig. 6 shows the relationship between lateral force and drift ratio of structural models IFFW, IFPW-1 and IFPW-2 based on several diagonal strut models using the pushover method. It can be seen in Figs. 6a and 6b that the performance of IFFW and IFPW-1 is almost similar across all diagonal strut models, except that the strength evaluated by the Mainstone model is relatively lower compared to other models. The RC frame with partial half infill (IFPW-2) exhibits comparable performance when assessed using all diagonal strut models, including the Mainstone model (Fig. 6c).

The lateral strength and stiffness of an RC frame with full brick infill are greater than those of an RC frame with partial infill walls. However, the strength of the IFFW model decreases immediately after reaching its peak. This response indicates a non-ductile structural behavior. The lateral strength and stiffness of masonry-infilled RC frame structures decrease with the inclusion of partial brick infill. In particular, for the structure with half-height infill (IFPW-2), the lateral strength was significantly reduced when compared to the RC frame with full infill, as evidenced by the test results reported in the literature [19,20].

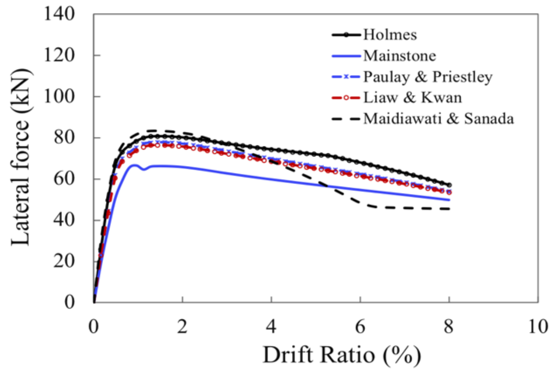
The IFPW-1 structure exhibits behavior similar to that of the IFFW structure, with a significant reduction in lateral strength following the attainment.



a. IFFW model



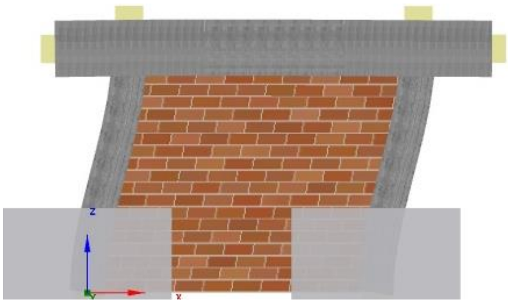
b. IFPW-1 model



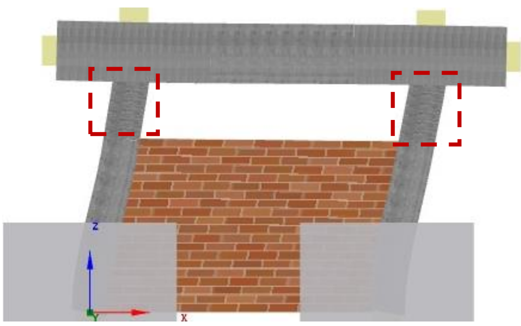
c. IFPW-2 model

Fig. 6 Lateral force vs. drift ratio of models

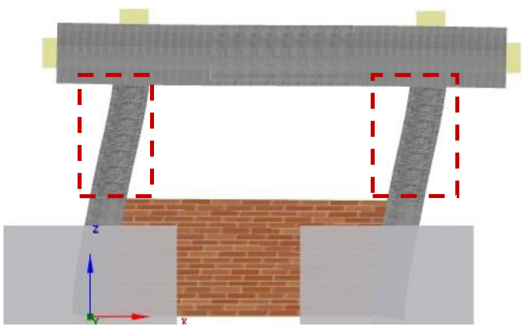
In contrast, the IFPW-2 structure shows only a slight decrease in lateral strength. This behavior indicates that structures with half-height infill walls possess greater ductility compared to those with full- or three-quarter-height infill walls. It is observed that as aspect ratio of infill walls increases, the lateral strength and stiffness of the infilled frame structures decrease, while their displacement capacities tend to increase.



a. IFFW model



b. IFPW-1 model



c. IFPW-2 model

Fig. 7 Crack patterns of models at the 2% drift ratio

In RC frames with partial infills, the walled portion of the column becomes stiff, causing increased cracking and damage to short columns (Figs. 7b and 7c). This condition is consistent with the short-column damage commonly observed in structures affected by earthquakes, as reported in the referenced literature [3]. It has been shown that partial masonry infill contributes to the lateral strength and stiffness of RC frame structures; however, it also alters the cracking patterns and failure modes of boundary columns, as discussed in references [19–21].

5. VERIFICATION OF NUMERICAL STUDY

5.1 Experimental Works and Results

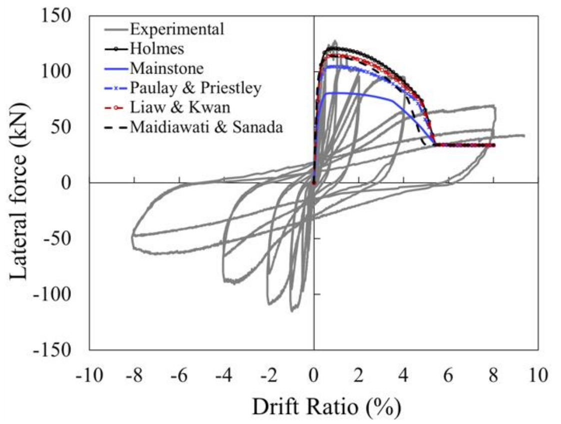
Experimental studies conducted by Tanjung et al. [19] and Maidiawati and Tanjung [20] on RC frames with full infill (IFFW) and partial brick infills (IFPW-1 and IFPW-2) were used to verify the numerical results. The structural specimens were subjected to static cyclic lateral loading throughout the experimental study. Fig. 8 shows the hysteresis loops representing the relationship between lateral force and drift ratio, as obtained from experimental tests on the IFFW, IFPW-1, and IFPW-2 structures.

5.2 Seismic Performance Comparison of Numerical to Experimental Results

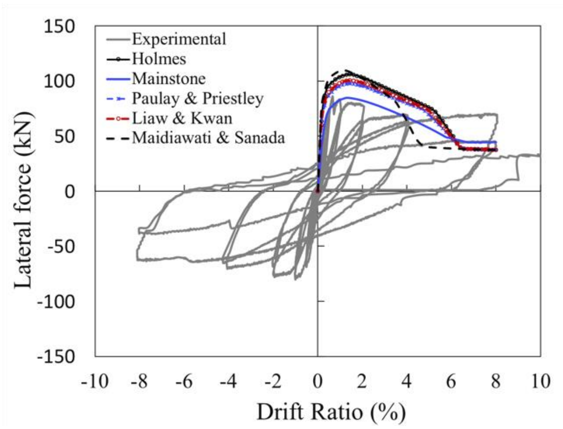
A comparison of the seismic performance of RC frames with full and partial infill walls is shown in Fig. 8, highlighting both experimental and numerical findings. As shown in Fig. 8, the seismic performance of the three structures demonstrates close agreement between the numerical analysis and the experimental data. Based on both sets of results, the lateral strength of the RC frame with full masonry infill is reduced by approximately 29% and 46% when compared to frames with three-quarter- and half-height infills, respectively. With the exception of the Mainstone model (Fig. 8a), the numerical and experimental results for the RC frame with full brick infill show strong agreement.

All of the methods used to evaluate the implemented strut models for RC frames with partial infills (IFPW-1 and IFPW-2) produced results that closely matched the experimental findings, as shown in Figs. 8b and 8c. This demonstrates that the seismic performance of RC frames with both partial and full masonry infill can be effectively evaluated using diagonal strut models.

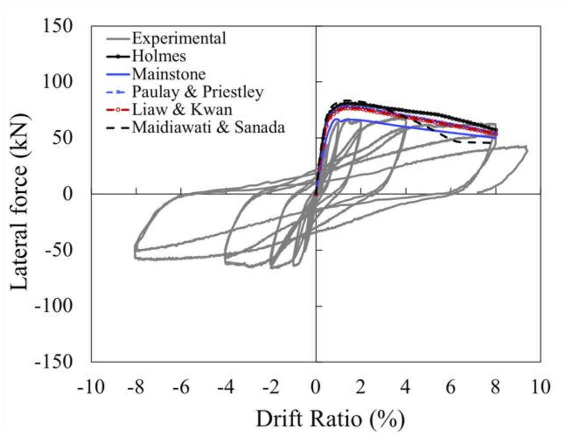
The RC frame structures with full infill and partial three-quarter infill exhibit brittle behavior, as seen in Figs. 8a and 8b. Their lateral strength decreases significantly after reaching peak values at drift ratios of 0.93% and 0.7%, respectively. In contrast, the IFPW-2 specimen shows a more gradual reduction in lateral strength after reaching its peak (Fig. 8c). This suggests that when partial masonry infill occupies only half of the panel area, it has a less significant impact on the seismic performance of the frame structure.



a. IFFW model



b. IFPW-1 model



c. IFPW-2 model.

Fig. 8 Comparison of lateral force-drift ratio between numerical and experimental study results

6. CONCLUSION

The numerical results were validated against experimental data, confirming that the diagonal strut model is effective for assessing the seismic behavior of RC frames with both full and partial masonry infills. The findings suggest that this model can serve as a practical analytical tool for predicting the lateral strength and overall seismic performance of existing buildings with masonry infill.

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8. REFERENCES

[1] Maidiawati and Sanada Y., Investigation and Analysis of Buildings Damaged during the September 2007 Sumatra, Indonesia Earthquakes. Journal of Asian Architecture and Building Engineering (JAABE), Vol. 7 Issu 2, 2008, pp. 371-378.
[2] Yuan F., Xiaobin W., and Shulu Z., Failure Modes of Masonry Infill Walls and Influence on RC Frame Structure Under an Earthquake. Tenth U.S. National Conference on Earthquake Engineering, Frontiers of Earthquake Engineering, 2014, Alaska
[3] Maidiawati, Tanjung J., Sanada Y., Nugroho F., and Wardi S., Seismic Analysis of Damaged Buildings Based on Post-Earthquake Investigation of the 2018 Earthquake. International Journal of GEOMATE, Vol. 18, Issue 70, 2020 , pp. 116-122.
[4] Maidiawati, Sanada Y., Konishi D. and Tanjung J., Seismic Performance of Nonstructural Brick Walls Used in Indonesian R/C Buildings. Journal of Asian Architecture and Building Engineering (JAABE) Vol. 10 Issue 1, 2011, pp. 203-210.
[5] Tanjung J., and Maidiawati, Experimental Study on the Effect of Brick Masonry Walls on the Lateral Strength of the Reinforced Concrete Structures (in Indonesian), Jurnal Teknik Sipil ITB, Vol 23 Issu 2, 2016, pp. 99-106.
[6] Tanjung J., and Maidiawati, The Experimental Investigation on Beneficial Effects of the Local Brick Masonry Infills to Seismic Performance of R/C Frame Structures in West Sumatera. International Journal of Civil Engineering and Technology (IJCIET), Vol 8, Issue 10, 2017, pp. 687–697.
[7] Al-Chaar G., Evaluating Strength and Stiffness of Unreinforced Masonry Infill Structures, Research Report ERDC/CERL TR-02-1, U.S. Army Corps of Engineers, 2002.
[8] Cavaleri L., and Trapani F.D., Cyclic response of masonry infilled RC frames: Experimental Results And Simplified Modeling. Soil Dynamics and Earthquake Engineering, Vol. 65,

2014, pp. 224-242.

[9] Korkmaz H.H., and Taciroglu E., Experimental Investigation of Contribution of Brick Infill Walls to The Seismic Response of Reinforced Concrete Frames. Proc. Of Int. Conf. on Structural Arch. and Civil Eng., Dubai, 2015, pp. 222-227

[10] Holmes M., Steel Frames with Brickwork and Concrete Infilling. Proceeding of The Institution of Civil Engineers, Vol. 19, Issue 4, 1961, pp. 473-478.

[11] Smith B.S., Methods for Predicting The Lateral Stiffness And Strength of Multi-Storey Infilled Frames. Building Science Vol. 2, Issue 3, 1967, pp. 247-257.

[12] Smith B.S, Carter C., A Method Of Analysis For Infilled Frames. Proceedings of The Institution of Civil Engineers, Vol. 44, Issue 1, 1969, pp. 31-48.

[13] Mainstone R.J., On The Stiffness And Strength Of Infilled Frames. Proceedings of the Institution of Civil Engineers, Vol. 49, Issue 2, 1971, pp. 57-90.

[14] Leuchars J.M., and Scrivener J.C., Masonry Infill Panels Subjected To Cyclic In-Plane Loading. Bulletin of the New Zealand National Society for Earthquake Engineering, Vol.9, Issue 2, 1976, pp. 122-131.

[15] Paulay T., and Priestley M.J.N., Seismic Design of Reinforced Concrete and Masonry Buildings. John Wiley & Sons: New York, 1992.

[16] Liauw T.C., and Kwan K.H., Nonlinear Behavior Of Non-Integral Infilled Frames." Comp. and Struct., 18, 1984, pp.551-560.

[17] El-Dakhakhni W.W., Elgaaly M., and Hamid A.A., Three-Strut Model for Concrete Masonry-Infilled Steel Frames. Journal of Structural Engineering, Vol. 129, Issue 2, 2003.

[18] Maidiawati and Sanada Y., R/C Frame–infill Interaction Model and Its Application to Indonesian Buildings. Earthquake Engineering & Structural Dynamic, Vol 46, 2017, pp. 221–241.

[19] Tanjung, J., Ismail F.A., Maidiawati, Nur O.F., and Mahlil, Experimental Study for Evaluating the Seismic Performance of RC Frame Structure with Partially Infilled by Brick Masonry. International Journal of GEOMATE, Vol. 16, Issue 57, 2019 , pp. 189-194.

[20] Maidiawati and Tanjung J., The Seismic Responses of RC Frames Infilled with Full and Partial Masonry Wall under Cyclic Lateral Load. in Proc.2nd Int. Conf. on Disaster and Management, 2021, pp. 1-8.

[21] Pradhan P.M., Pradhan P.L., and Maskey R.K., Lateral Strength of Partial Masonry infill Wall in Concrete Frame under Static Load. Journal of Civil Engineering (IEB), Vol. 40, Issue 1, 2012, pp.67-77

[22] Crisafulli F.J., Seismic Behaviour of Reinforced Concrete Structures with Masonry Infills. University of Canterbury, New Zealand, 1997, pp. 1-367

[23] Carvalho E.C., Coelho E., and Campos-Costa A., Preparation of the Full-Scale Test on Reinforced Concrete Frames. Characteristics of the Test Specimens, Material and testing Conditions. ICONS Report, Innovative Seismic Design Concepts for New and Existing Structures, European TMR network, LNEC, 1999.

[24] Smyrou E., Blandon C., Antoniou S., Pinho R., and Crisafulli F.J., Implementation and Verification of A Masonry Panel Model for Nonlinear Dynamic Analysis of Infilled RC Frames. Bulletin of Earthquake Engineering, Vol. 9, 2011, pp. 1519-1534.

[25] Seismossoft, Seismostruct 2024 – A computer program for static and dynamic nonlinear analysis of framed structures, 2024. https://seismosoft.com