DEVELOPMENT OF SEISMIC DESIGN AND ANALYSIS METHOD FOR RC FRAMES WITH INFILL WALLS

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1. INTRODUCTION

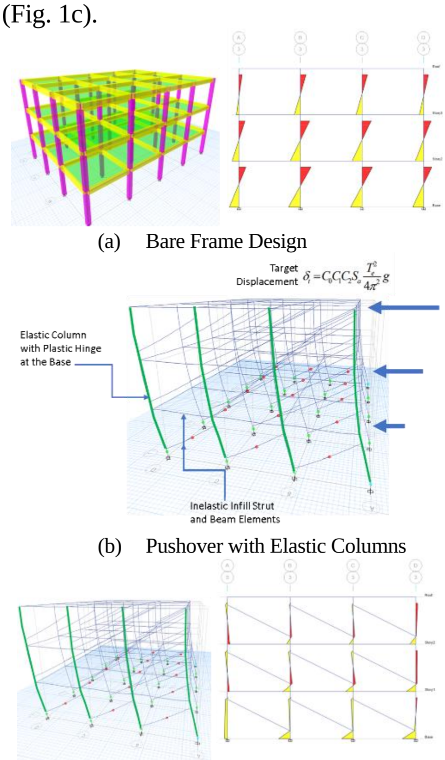
Low-rise RC frames with Infilled walls are widely used in many areas around the world including Thailand. It is well known that the presence of infill walls can have adverse effects on the seismic response of the frame due to infill-frame interactions [1-2]. Despite their widespread usage, clear design strategies to prevent undesirable failure modes due to the infill-frame interactions are not normally given in design codes. Typically, these frames are designed based on elastic analysis without considering the infill walls. It is well recognized that structures designed with elastic analysis may result in uncontrolled inelastic response. Together with complexed infill-frame interactions, theses RC frames may develop undesirable, and potentially dangerous, failure modes such as soft-story mechanism and brittle shear failure.

The undesirable response modes can be mitigated by controlling the response mechanism and using realistic inelastic internal force distribution for design. This paper proposes a practical design method for RC with infilled frames. The method focuses on controlling failure mechanism of the frame. The inelastic internal force distribution is obtained from push-over analysis using a structural model that can capture infill-frame interactions. By ensuring that the frame develops a pre-selected mechanism and preventing all the undesirable local failures, the RC frame with infill walls can be one of the most seismically robust structural systems for low-rise structures.

2. DESIGN STRATEGY

In this study, the following design method is proposed. The design consists of 3 main steps as follows.

1. The frame is first designed following a governing code procedure without considering the infill walls. This first step ensures that the frame will have the minimum required frame strength stipulated by the governing code (Fig. 1a).
2. A computer model is developed with the infill modeled as struts. The beams and infill walls are modeled using inelastic elements. However, the columns are modeled as elastic elements except the at the bases of the columns where plastic hinges are assigned and allowed to form. By doing so, the model ensures that the column will remain elastic except at the base. This is the pre-selected mechanism with elastic column and inelastic activities confine to only the beams and infill walls only (Fig. 1b).
3. The final design forces for the columns are obtained by push-over analysis. The frame can be pushed up to a selected target drift. In this study, the target drift calculating using DPW1303 standard [3] is used as the basis for the design. The column forces obtained at the target drift from the push-over analysis are used to determine final column sizes and reinforcement. These include the moment shear in the columns induced by the infill walls. If the column sizes and reinforcement from step (1) are insufficient, column design revision is carried out (Fig. 1c).



(a) Bare Frame Design

(b) Pushover with Elastic Columns

(c) Inelastic Force Distribution for Final Design Check

Fig. 1. Summary of Design Steps

3. TARGET DISPLACEMENT

In the proposed method, the structure is pushed up to the target displacement given by DPW1303 [3]. Figure 2 shows the results from nonlinear dynamic analysis of single-degree-of-freedom systems with negative post-yield stiffness and with varying strength ratios (R=2.5 and R = 4) under 20 ground motions. The negative post-yield stiffness represents a typical hysteretic characteristic of an RC-Infill frame where significant strength degradation occurs after infill wall failure. The results show that by taking the yield strength as 60% of the peak system strength, the target displacement given by DPW1311 is reasonably accurate for design purpose except at very short period ranges.

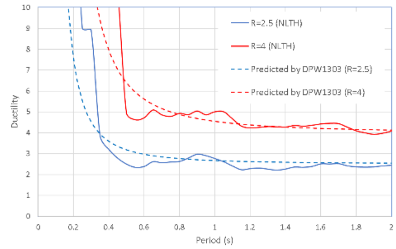
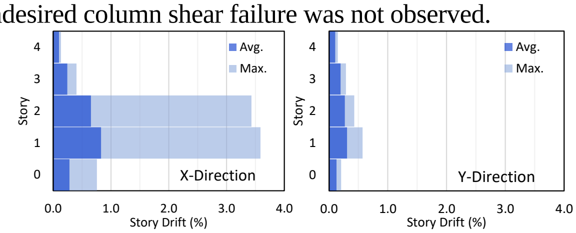


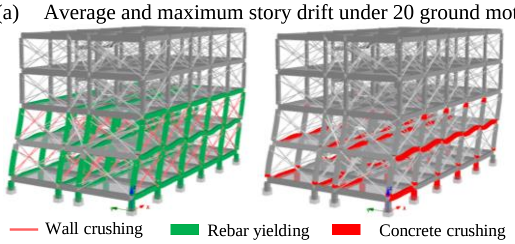
Fig. 2. Comparison between DPW1303 target displacements and results from non-linear dynamic analysis of SDOF systems.

4. EXAMPLE

The above design method was applied to a four-story RC-infill frame. The effectiveness of the design method was assessed by performing a non-linear dynamic analysis using an accurate FEM model with multi-strut infill elements [4]. The results are shown in Fig. 3. Under 20 MCE ground motions, the average drift of the building in X- and Y-directions is lower than 1.0% and distributed in a desirable shape, as indicated in Fig. 3(a). Only one ground motion caused the maximum story drift in the X-direction up to 3.5%. The structural damage state corresponds to the maximum drift shown in Fig. 3(b). The concrete crushing was observed on the lower stories. The undesired column shear failure was not observed.



(a) Average and maximum story drift under 20 ground motions



(b) Snapshot of the deformed shape and structural damage

Fig. 3. Analytical results of the example building

5. CONCLUSIONS

This paper proposes a practical design method for RC with infilled frames. The method is based on controlling failure mechanism of the frame and using realistic non-linear internal force distribution from pushover analysis for design. The results show that, properly designed, RC frame with infill walls can behave in a predictable manner resulting in satisfactory and robust seismic response behavior.

6. ACKNOWLEDGEMENT

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7. REFERENCES

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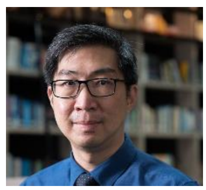

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