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Weak-layer Deformation of Vertically Irregular Infilled Frames in Seismic Analyses

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ABSTRACT: Based on the SeismoStruct model of full-scale, four-story, 2D infilled reinforced concrete frame, this paper set the infill walls at different locations in the structure to obtain a vertical stiffness irregular frame and frames with a weak layer. In this paper, the response of different structures are studied when input the same seismic waves. The results show that the vertical stiffness of the infill wall frame structure will greatly affect the response and interlayer drift. When the bottom layer has no infill wall, the top displacement is larger than other cases. The presence of the infill wall can limit the interlayer deformation of the frame structure.

KEYWORDS: Weak-layer; Infill wall; Drift; Vertically Irregular

I.INTRODUCTION

The reinforced concrete frame structure has the characteristics of flexible layout, large indoor space and so on. It is widely used in building structures such as commercial and residential buildings, office buildings, hospitals, teaching buildings and hotels. In the frame structure, the infill wall is usually set due to the room layout. The generation of weak layers of the frame structure is strongly related to the placement of the infill walls. Due to structural stiffness of the lateral force components and bearing capacity is not continuous, the damage of the weak-layer is caused by the failure of the structural bearing capacity. The Code clearly specifies measures to avoid weakness. The actual damage shows that the emergence of weak-layers will lead to serious damage to the structure, even collapse.

The structures[1] studied are two-dimensional building frames with multiple stories. Irregularities are introduced by changing the properties of onestory or floor. The effects of the irregularities on shear forces and maximum ductility demands are studied. The seismic performance of one-side setback structures is investigated[2]. From this paper, values of area setback ratio is influential to the confidence levels of the one-side setback buildings. That means irregularity has a great influence on the structure. The seismic response of irregular(both in plan and in elevation) buildings subjected to bidirectional ground motions are assessed by bidirectional pushover analysis method[3]. The seismic demands for vertically irregular and regular frames are studied[4]. Considering irregular of stiffness and strength, three types of irregularities similarly influence the height-wise variation of story drifts.

II. SEISMOSTRUCT VERIFICATION

The modelling of a full-scale, four-story, 2D infilled reinforced concrete frame, which is representative of the design and construction practice of the 50s-60s in Southern Mediterranean countries. The frame includes infill walls with openings of different dimensions. The model was tested under two subsequent pseudodynamic loading at the ELSA laboratory (Joint Research Centre, Ispra)[5]. The Structural geometry is shown in Fig. 1. The analytical results, obtained with the FE analysis program SeismoStruct, are compared with the experimental results[6]. The comparison between experimental and analytical results is shown in Fig. 2.

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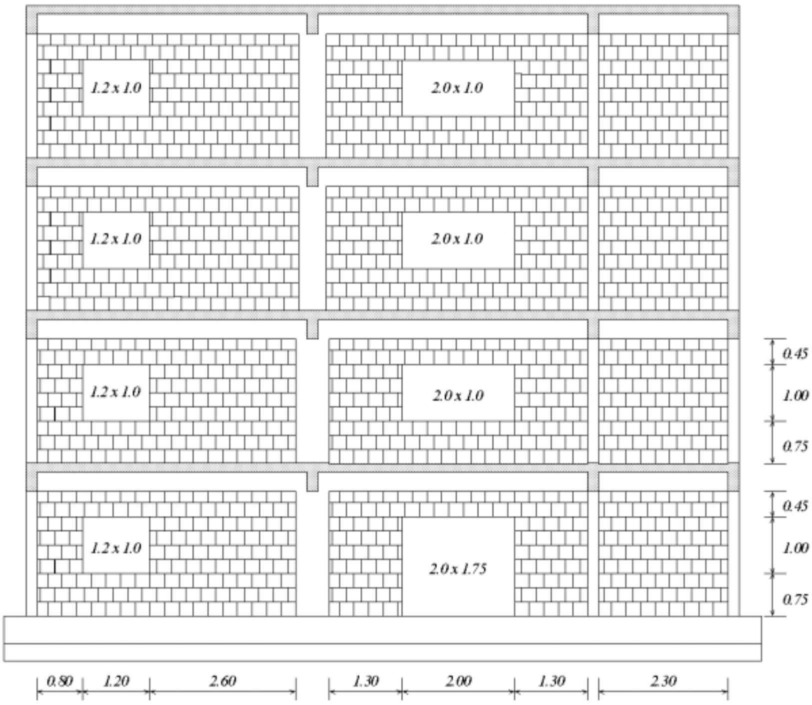

Fig. 1 Four-storey 2D infilled frame (ICONS frame) [3]

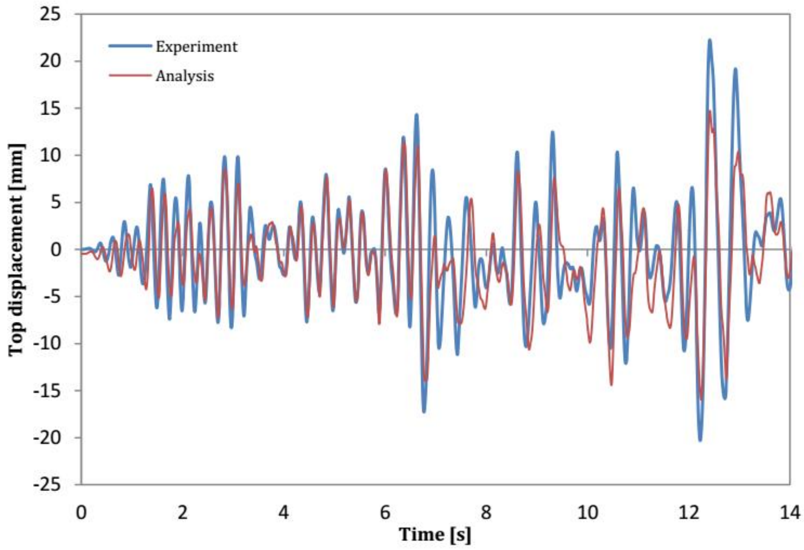

Fig. 2 Experimental vs. Analytical results – top displacement-time (975yrp) [4]

III. FINITE MODELS

The four-story and three-span 2D frame is used as the analysis object. Non-linear analysis is done on SeismoStruct[7]. The material used in the analysis was based on the Mander uniaxial nonlinear constant confinement model (con_ma) and the steel based on Menegotto-Pinto model (stl_mp). The fiber section was used to simulate the bipolar bending characteristics of the column. Columns and beams are modelled through 3D force-based inelastic frame elements (infrmFB) with 4 integration sections. The number of fibres used in section equilibrium computations is set to 200. The infill walls can be seen as equivalent diagonal oblique support bar model, and being modelled through a four-node

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masonry panel element (inelastic infill panel element). Considered a variety of infill wall vertical arrangement form, the number and corresponding model is shown in Fig. 3.

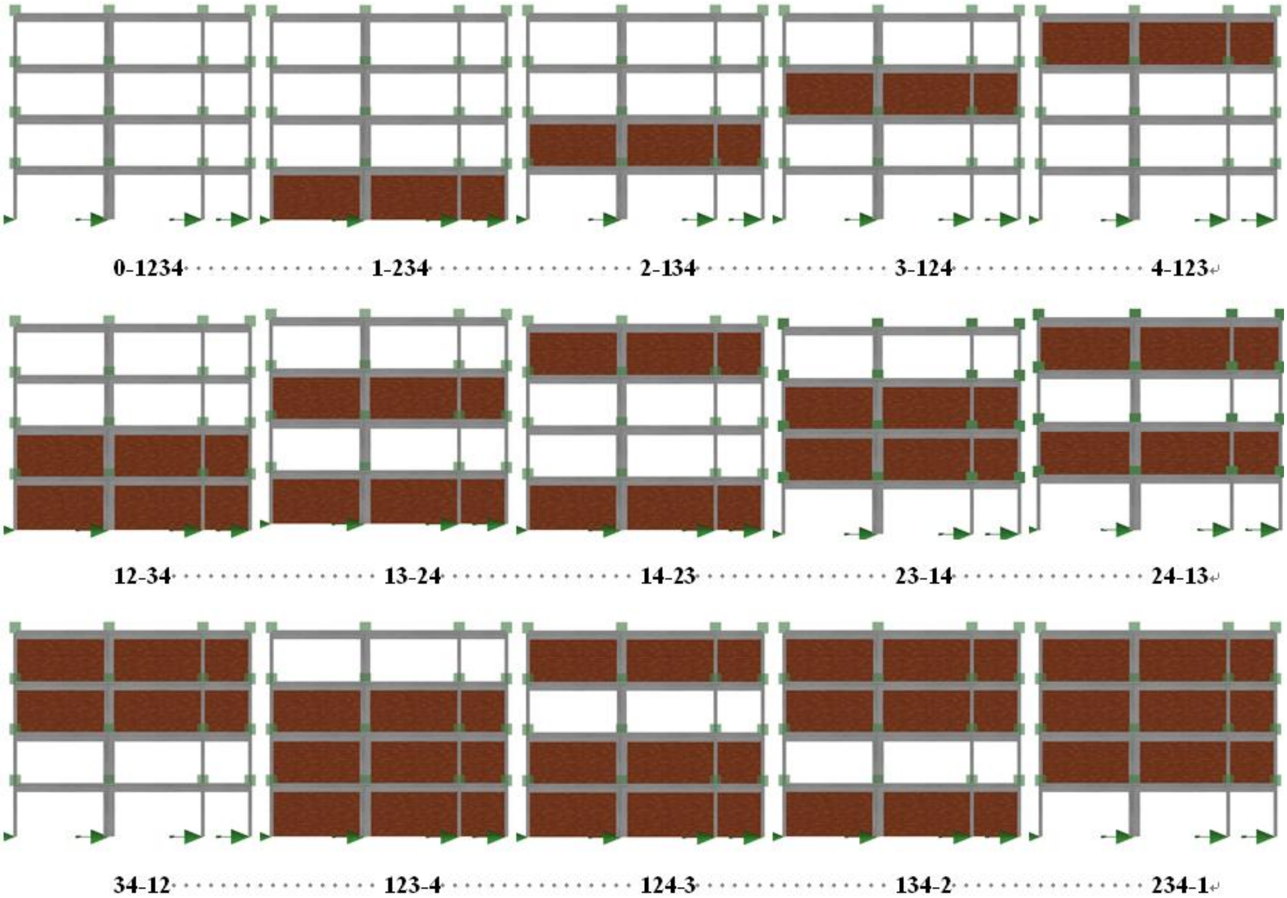

Fig. 3Number and the corresponding model

IV. EARTHQUAKE INPUT

The input earthquake wave selected in this paper is The Imperial Valley (USA) earthquake. The wave is shown in Fig. 4. The Imperial Valley (USA) earthquake is October 15, 1979. It is from PEER Strong Motion Database. The recording stations is USGS STATION 5115. The frequency range is 0.1-40.0Hz. The first 20 seconds interception is used in the seismic analyses.

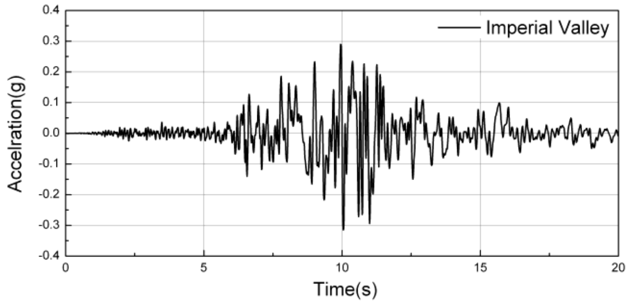

Fig. 4The input earthquake wave

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V. EXPERIMENTAL RESULTS

The maximum of top displacement is shown in Table 1, Table 2, Table 3. Under the same seismic input, when there is no infill wall (0-1234), the frame has the largest displacement. When there is one layer of infill wall, the infill wall is located on the fourth floor (4-123) is the largest displacement. That means the infill wall of the upper layer leads to structural response. When there are two layers of infill wall, the infill wall is located on the adjacent floor (12-34,34-12) is the larger displacement. Overall, when the bottom has no infill wall, the top displacement is larger than other cases. When the frame is full of infill walls, the top displacement is the minimal. That illustrates the effect of the infillwall on the structural response.

Table 1Top displacement of infill wall frame model

Description		No Infill Wall	One Layer of Infill Wall			
Number		0-1234	1-234	2-134	3-124	4-123
Displacement	Negative	-72.31	-74.84	-55.43	-48.6	-53.01
	Postive	142.58	76.55	71.52	67.97	115.35

Table 2Top displacement of infill wall frame model

Description		Two Layers of Infill Walls					
Number		12-34	13-24	14-23	23-14	24-13	34-12
Displacement	Negative	-57.63	-51.18	-64.27	-40.56	-37.39	-41.02
	Postive	76.51	62.52	60.16	51.11	55.45	69.79

Table 3Top displacement of infill wall frame model

Description		Four Infill Walls	Three Layers of Infill Wall			
Number		1234-0	123-4	124-3	134-2	234-1
Displacement	Negative	-15.73	-42.46	-54.71	-53.15	-28.07
	Postive	20.5	25.85	22.92	34.01	52.12

The story drift is shown in Fig. 5. From Fig.5, the layer set the infill wall is not deformed. The presence of the infill wall can limit the interlayer deformation of the frame structure. When set one layer of infill wall, the interlayer deformation suddenly becomes smaller. When set two layers of infill wall, the interlayer deformation becomes larger when the floor with no infill wall. In this case, if the infill wall set interval, the floor between the infill walls become the weak layer. From Fig.5, there is obviously sudden change when weak layer appear in 13-24. 14-23.

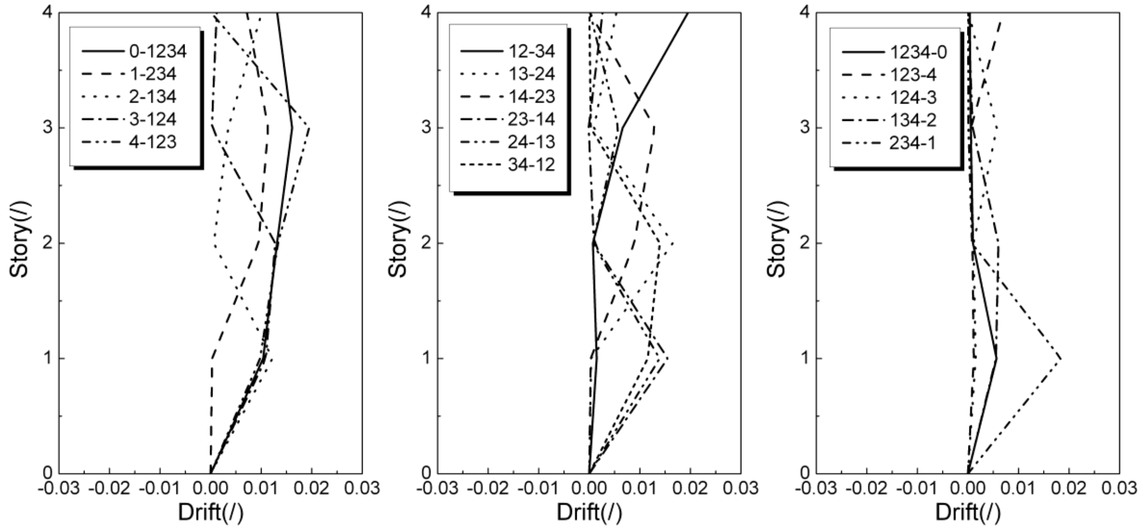

Fig. 5Story Drift

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VI.CONCLUSION AND FUTURE WORK

The influence of the vertical irregular arrangement of the infill walls on the seismic response of the reinforced concrete frame is studied, and the deformation of the weak-layer is studied in this paper. The results show that the vertical stiffness of the infill wall frame structure will greatly affect the response and interlayer drift. When the bottom layer has no infill wall, the top displacement is larger than other cases. The presence of the infill wall can limit the interlayer deformation of the frame structure.

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