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EFFECT OF INFILL WALLS AND PLASTER FOR A FOUR STOREY R/C BUILDING

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Infill walls are non-structural elements, which are mainly used for architectural purposes. Besides contribution of infill walls is ignored during the structural analysis, the effect of the infill walls are usually taken into account through the application of additional loads and masses appropriately distributed along the interfaces between the surrounding frame and the infill walls. In doing so, the stiffness and strength contribution of the latter elements as well as their interaction with the members of the Reinforced Concrete (RC) frame are also ignored. Practically some of the earthquake design codes like Turkish code neglect the effects of the non-structural infill walls. However the presence of infill walls significantly increases the stiffness and the strength of a frame. The reasons of this increment are high in-plane stiffness of infill and the composite action of the infill and the frame. On the other hand, plastering significantly affects the behaviour of infill walls. Thus, the dynamic characteristics of a building also affected by the infill walls of building having plaster or not.

The objective of this study is selected to compare the behaviour of infill walls with and without plaster by focusing on dynamic characteristics of a 4-storey residential R/C building in Eskisehir, Turkey. Natural periods, mode shapes and damping ratios of the building were determined for two different construction stages by using ambient vibration test. To obtain experimental dynamic characteristics, Enhanced Frequency Domain Decomposition (EFDD) technique was used. These 4-storey residential R/C building is located in Eskisehir, Turkey. The investigated building in which seismic loads are jointly resisted by frames and structural walls. There are only one shear wall along x-direction and four shear walls along y-direction. The floor area of the building is 400 m^2 and story heights are 2.83 m. Total area of infill walls for one storey are 5.44 m^2 and 10.75 m^2 at x-direction y–direction, respectively..

As a result of this study, vibration measurements are established that, plaster significantly changed the dynamic characteristics of building. Decrease in the periods both x and y directions and also torsional period showed that the plaster increases the lateral stiffness of the infill walls and thereby it increased the lateral stiffness of the building.

Keywords: Operational, Modal, Analysis, Vibration, Ambient, Infill, Plaster, Period

1. INTRODUCTION

Infill walls, in framed buildings are generally considered as non-structural components. Therefore, the contribution of infill walls in resisting lateral loads has been neglected in the design of the framed structures. The effect of the infill walls are usually taken into account just as masses and loads. But it is very well-known fact that, infill walls significantly affect the lateral load resisting capacity of the building and also remarkable change is observed at the dynamic characteristics of a building in presence of infill walls. Most of the earthquake design codes neglect the rigidity effects of the infill walls. Turkish Earthquake Code 2007 (TEC 2007) also neglect the effects in design process. Besides, section area of infill walls are just considered to calculate the weak story irregularity according to TEC 2007 [1]. Additionally, another important point is the effect of plaster. As it is known, infill walls are commonly plastered in practice. Plastering significantly affects the behaviour of infill walls. Thus, the dynamic characteristics of a building also affected by the infill walls of the building having plaster or not.

Infill effect is a well-studied topic in literature. On a pioneer study about the infills, Smith (1967) proposed an equivalent diagonal strut concept, in which, infill replaced by diagonal bracing struts. This approach is so common in literature that most of researchers and engineers use these approximation on their studies and/or designs. According to this approach, if diagonal stiffness and strength of the infills could be established, it would be possible to predict the lateral stiffness and strength of an infilled frame [2]. Abdul-Kadir (1974) carried out series of small-scale experiments. In this investigation the detailed behavior of brickwork infilled frames with and without opening has been described and discussed. On the basis of an equivalent diagonal strut, the infilled panels have been analyzed for stiffness prediction [3]. Saneinejad and Hobbs (1995) also studied equivalent diagonal strut approach. Authors proposed a new design and analysis method, which considers the nonlinear behavior of infilled frames [4]. To determine the effects of infills on the global behavior of reinforced-concrete (RC) frames, Negro and Verzeletti (1996) carried out a series of tests on a full-scale 4-storey RC building [5]. Cavaleri and Papia (2003) established a new system identification technique, it is possible to determine stiffness and dissipation parameters of a system with a very low level of excitations like environmental noise with this technique. Authors used this technique for the designation of the equivalent strut for infilled frames [6].

Previous studies about infill walls show that the presence of infill walls affects the dynamic characteristics of a building like natural period, damping etc. Natural period of a building could be determined by means of eigenvalue analysis or empirical code predictions. It is obvious that natural periods, which are established with any of these methods longer than the measured periods of the buildings because the effects of non-structural elements like the infill walls are not considered in structural modeling [7]. Actually, infill walls increase the lateral stiffness and shorten the natural period of the building. In addition, if infill walls have been plastered, the lateral stiffness and strength of the infills also increase. Thereby, if a building has plastered infill walls, lateral stiffness and strength of the building increase and the natural period of the building decreases relative to the case of the buildings infill walls without plastering. Marjani and Ersoy (2002) stated the effect of plaster by a series of 1/3 scaled experiments. Infilled R/C frames examined under reversed cyclic loading. According to their findings, the strength increase of the infilled frame due to the plaster is about 25% and increase in initial stiffness is about 50 to 80% [8]. Arslan and Durmus (2014) conducted experiments to full scale one bay and one story frames, in which, bared, infilled and plastered infilled in laboratory conditions. Authors determined the natural periods, damping ratios and mode shapes of frames by ambient vibration measurements. Results showed that, fundamental period of infilled frame with plastered 16% shorten than the infilled frame without plastering [9].

The dynamic evaluation of existing structures can be carried out by means of either ambient or forced vibration tests. In ambient vibration test, the structural response is tied to the ambient noise present in the environment (see Meyyappa et al., 1980; Diehl, 1986) [10,11]. Ambient noise, which occurs in a wide range of frequencies, can be caused by micro tremors, wind, traffic etc. Forced vibration tests

believed to provide more accurate results compared to the ambient vibration test due to the larger amplitudes of vibrations (Memari et al., 1999) [12]. Guler at al. (2008) conducted ambient vibration measurements on a 12-storey R/C building, which was designed according to Turkish Earthquake Code 1975 (TEC 1975), during three different construction stages. According to their findings, the periods of the building shorten between 20-35% when the infill walls with plastered [13]. Bikce at al. (2011) carried out ambient and forced vibration measurements on a 6-storey, ribbed slab R/C building, when the infill walls of the building with and without plaster. Results of the study indicates that, plastering decreases the periods 25-35% [14].

In this study a comparative study has been made to assess the effect of infill walls and plaster on dynamic characteristics of a 4-storey residential R/C building. For this purpose, during its two different construction stages, the results captured by using ambient vibration measurements. Initially, a measurement was applied when the building have infill walls without plaster. After the infill walls have been plastered, another measurement was applied. Results of these two measurements were compared with each other.

2. BUILDING DETAILS

The view of the building with infill walls and plastered infill walls are shown in Fig. 1. The building is located in Eskisehir, Turkey. It is a 4-storey residential RC building, in which, seismic loads are jointly resisted by frames and structural walls. As seen in the Fig. 2 there are only one structural wall along x-direction and four structural walls along y-direction. The floor area of the building is 400 m2 and story heights are 2.83 m. Total area of infill walls at x-direction is 5.44 m2 and y-direction is 10.75 m2. Tested building was designed according to TEC 2007.

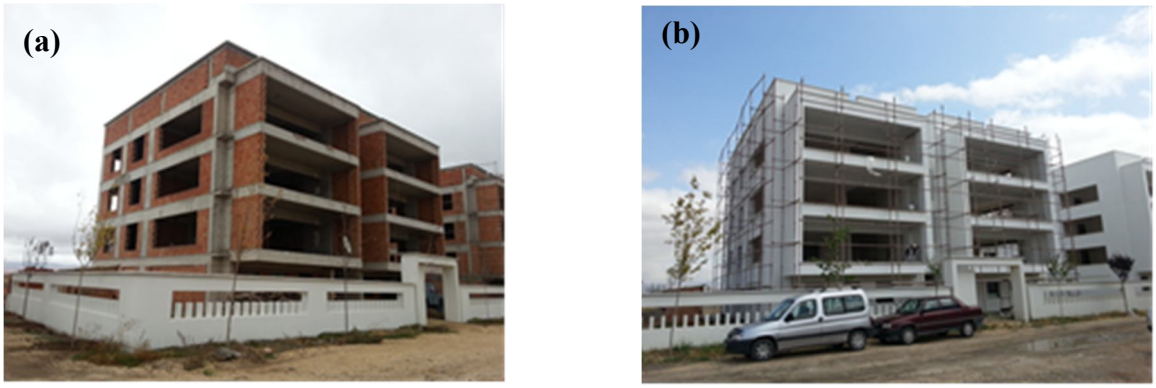

Fig. 1 (a) Building with infill walls, (b) Building with plastered infill walls

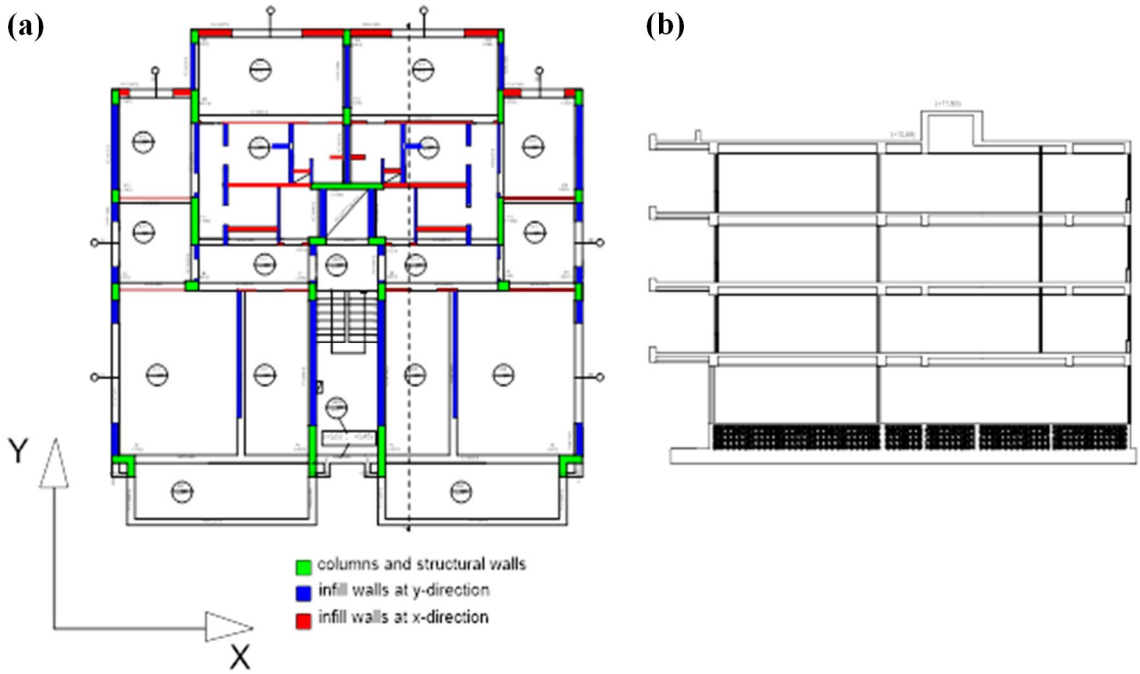

Fig 2. (a) Plan view of the building, (b) section cut of the building [15]

3. THE DETAILS OF TESTS AND INSTRUMENTATIONS

Four broadband accelerometers (Guralp CMG-5TCDE) were used as testing equipment. The CMG-5TCDE's are fully digital, tri-axial, force-feedback accelerometers with a large dynamic range. It has full-scale sensitivity from ± 0.1 to ± 4.0g. CMG-5TCDE has an integrated CD24 digitizer and a CMG-EAM embedded acquisition module.

Ambient vibration tests were carried out. Two measurements were conducted. One of them was applied when the building has infill walls. This measurement was named as MIW, in which, the accelerometers were located at the top floor to the 4 corners of the building. Second measurement was named as MPIW. MPIW was applied after the infill walls were plastered. Accelerometers were located in the same configuration with MIW at the top floor. Test layout is shown in Fig.3

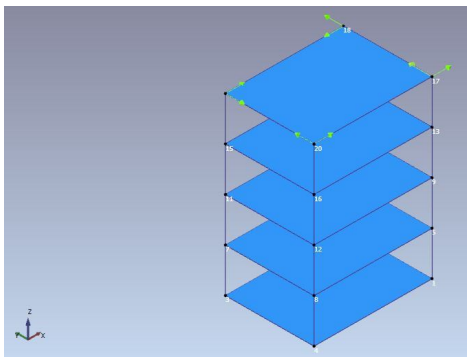

Fig. 3 Test layout for MIW and MPIW

4. DISCUSSION OF THE RESULTS

Measurement records were operated in Artemis Modal Software. In order to obtain the dynamic characteristics of the building "Enhanced Frequency Domain Decomposition Technique" (EFDD) was used. In MIW 3 modes were observed, first one was translation at x-direction with a period of 0.2348s, the second one was torsional with a period of 0.1802 and the third one was translation at y-direction with a period of 0.1689s. Spectral density function of MIW is shown in Fig. 4. When the results of MIPW was analyzed, three modes were observed, first one was translation at x-direction with a period of 0.2047s, the second one was torsional with a period of 0.1569s and the third one was translation at y-direction with a period of 0.1500s. Spectral density function of MIPW is shown in Fig. 5.

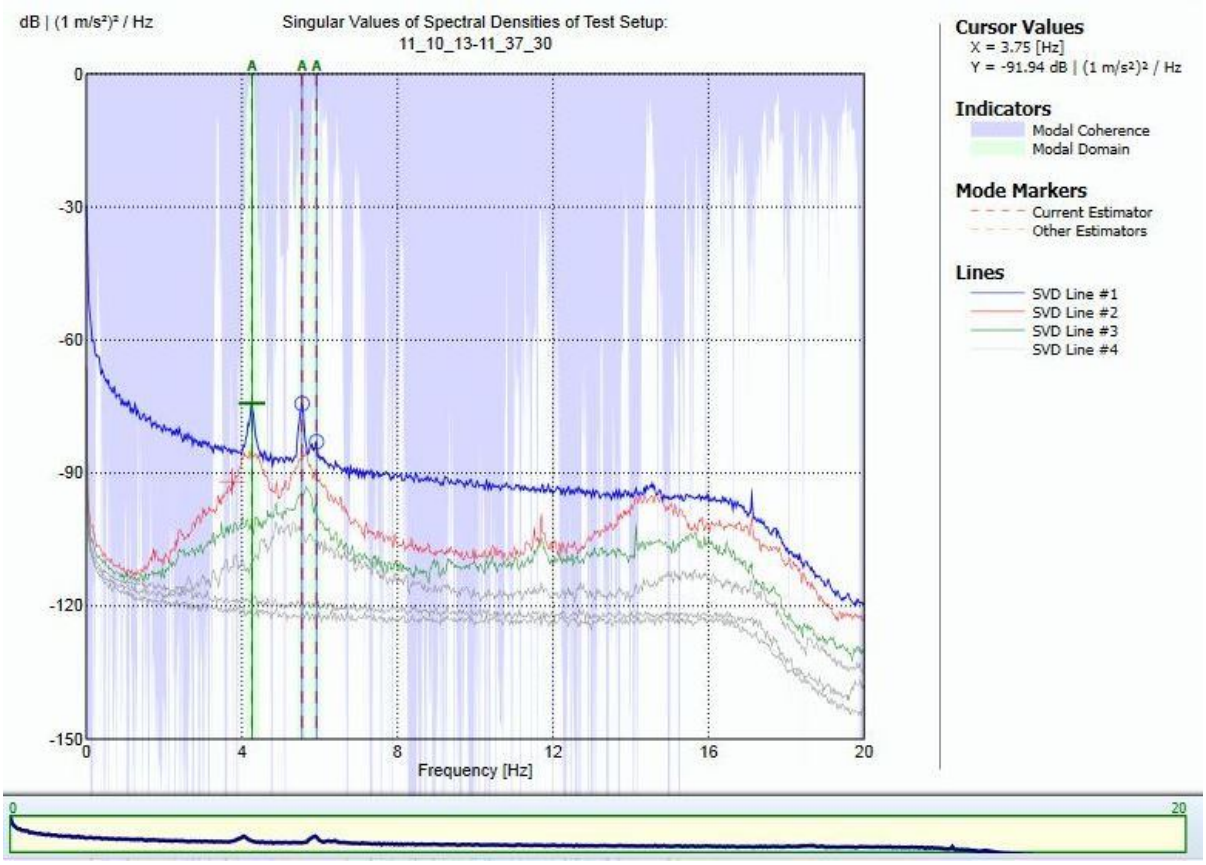

Fig. 4 Spectral density function of MIW

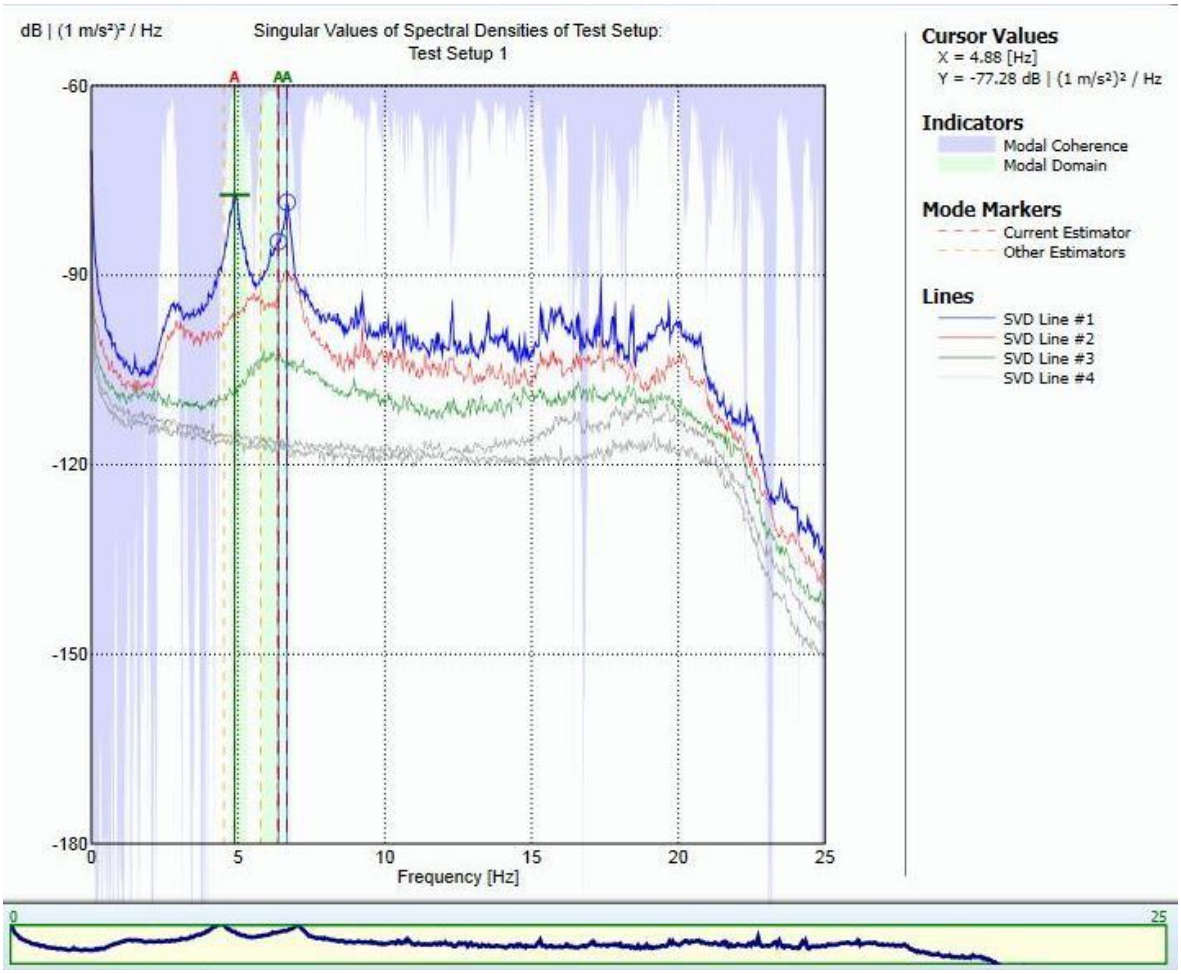

Fig. 5 Spectral density function of MPIW

According to results, which are stated at Table 1, period of x-direction of the building decreased 12.8% and the period of y-direction decreased 11.2% and the torsional period decreased 12.9% when the infill walls were plastered. It is seen that all the period decrease ratios are near to each other. It indicates that the plastering change the dynamic characteristics of the building in same manner for all directions. Nevertheless results were showed that, the plastering decreased the vibration periods of the building, and the decrease in periods indicated that plastering significantly increased the lateral stiffness of the building. As a conclusion, presence of plaster significantly effects the dynamic characteristics of a building and should be taken into consideration in structural modeling.

Table 1.
Comparison of field test results

	Period of x-direction (s)	Period of y-direction (s)	Torsional Period (s)
(a) MIW	0.2348	0.1689	0.1802
(b) MPIW	0.2047	0.1500	0.1569
(%) (b-a)/a	- 12.8	- 11.2	- 12.9

5. CONCLUSION

As a result of this study it is clearly showed that, the presence of infill walls and having plaster or not significantly increase the lateral stiffness of a building and so affects the dynamic characteristics of the building and should be taken into account in structural analysis.

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