USE OF PLASTIC MATERIAL FOR PROVIDING THERMAL AND ACOUSTICS COMFORTS IN RESIDENCE CONSTRUCTED WITH RC TUNNEL FORM SYSTEM

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Summary

Producing structural members using plastic space former which is the newest method on structural members, was developed in Europe and found application area. Researches on this concept have focused on shear and punching strength of RC section. In this study, to eliminate thermal and acoustics insulation deficiencies especially in tunnel form buildings, to lighten structural system, to reduce concrete consumption and to keep lateral and horizontal load carrying capacities of structural members at optimum level, experimental studies have been conducted on reinforced concrete members produced with plastic material having circular section. In this scope, a series research has been performed on feasibility of plastic balls having 6 cm diameter in reinforced concrete systems. Reinforced concrete members have been produced with/without balls to analyze structural behavior under loading, and also to investigate thermal conductivity coefficient and sound absorption behavior of the members.

In this study, structural parameters have been mentioned on reinforced concrete members such as floor and shear wall produced with/without balls, also making some explanation on feasibility of the research and findings discussed in comparative way. Results obtained from experimental studies shows that plastic balls used in reinforced concrete with the suitable position, do not cause to decrease on strength and rigidity but some improvement on thermal and acoustic features has been observed.

Keywords: tunnel form building, reinforced concrete, plastic ball, experimental study

1 Introduction

Tunnel form systems are primary monolithic housing systems of many countries due to their fast construction technique where in-situ concrete is poured into shear-walls and floor slabs, simultaneously. The economical gains due to the faster construction type than conventional system increased the demand of this type of construction.

In these buildings, all the vertical-carrying members are made from shear-walls and the slab system is flat plate therefore the lateral rigidity of the system higher than classical frame and shear wall – frame structures. In all studies based on lessons from earthquakes [1–2], researchers mentioned the importance of larger cross sectional area such as shear wall in a structural system. For this reason, tunnel form buildings are known as high seismic safety building type in earthquake prone regions such as Turkey, Greece and Italy. The

seismic advantage of the tunnel form building, this type of system has some disadvantage especially on acoustic and thermal comfort. Besides these, non-structural components such as facade walls, stairs, landings and partition wall which are produced as precast members to expedite construction phase causes some comfort problems in the tunnel form buildings. Producing structural members using plastic space former have found an application area especially tunnel form buildings due to their weak acoustic and thermal comfort. In the literature researches on this concept have focused on shear load capacity and punching strength of RC section since the space former causes the strength of shear capacity. In this study, to eliminate thermal and acoustics insulation deficiencies especially in tunnel form buildings, to lighten structural system, to reduce concrete consumption and to keep lateral and horizontal load carrying capacities of structural members at optimum level, experimental studies have been conducted on reinforced concrete members produced with plastic material having circular section (in other words "plastic ball").

2 Method and Theoretical Background

In the literature, there have been some researches on using recycled plastic waste which used in concrete production, recently. The main aim of these researches is to reduce concrete production cost and limit using the natural sources by using plastic waste. In this study, the main objective is the similar with the other studies. However, in this study plastic balls which produced from plastic waste are used into reinforced concrete section. The main mechanical behavior of reinforced concrete section under loading is to be known to understand the concept of the ideas of using plastic balls. The Figure 1 (***Fig. 1***) represents the bending behavior of a typical reinforced concrete section. Stress distribution and deformation shape is given in the figure. As seen from the figure the dotted line is pointed the natural axe of the section. In the other words, the natural axe and its surroundings have no effect on the loading capacity of a beam. Therefore, the related zero stressed section can be dropped from the section. In reinforced concrete buildings beams and slabs are mainly subjected to the bending moment. The other inertia forces can be ignored. When thinking on a tunnel form building, shear wall and slabs are subjected to especially bending moment. The main objective of this study is using plastic ball in the reinforced concrete section and its effects.

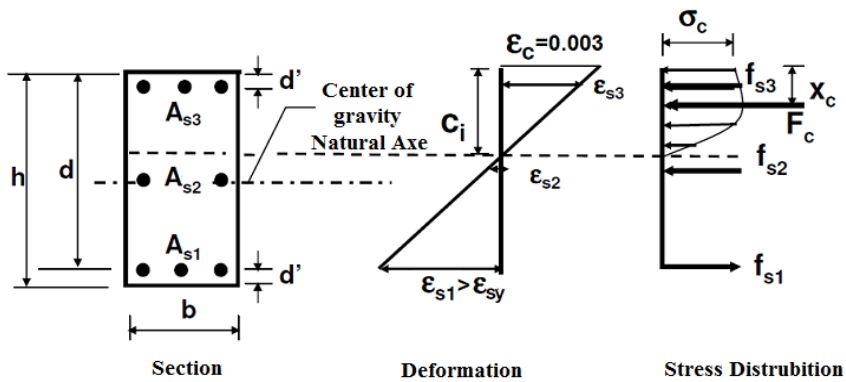

Fig. 1 *Stress distribution in a reinforced concrete section under bending moment*

In the literature, using the ball in flat slab which thicknesses is changed between 20 and 50 cm is common. Figure 2 (***Fig. 2***) and Figure 3 (***Fig. 3***) shows some examples from this

kind of slabs application from Europe [3]. However, in a tunnel form buildings the flat slab thickness is about 15 cm and therefore the ball radius must be smaller.

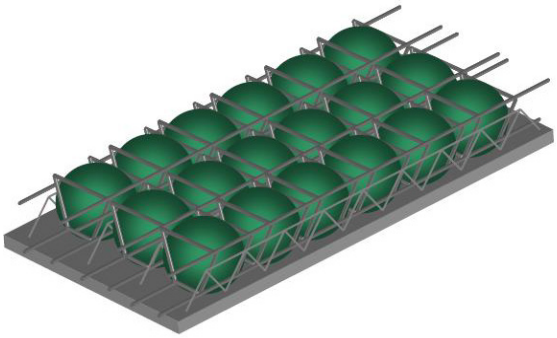

Fig. 2 *Plastic balls in slabs*

Fig. 3 *Some examples from application*

3 Studies about Plastic Balls Application in Turkey

The mentioned plastic ball application in Europe has not met the producers in Turkey, so far. The main reason of this situation is based on building type in Turkey. In Turkey, general reinforced concrete building type is framed, shear wall-framed and tunnel form. The average slab thickness differs from 12 cm to 20 cm, based on the loading and span length [4]. Therefore, the ball diameters must be smaller. In tunnel form building, the average slab thickness and shear wall width is about 15 and 20 cm, respectively. In Figure 4 (***Fig. 4***), some examples of tunnel form buildings in Turkey are given.

Fig. 4 *Some examples from application*

4 Experiments

In the experimental stage of the study, first of all full scale reinforced concrete shear wall and slab tested the loading. The shear walls with 15 cm thickness have produced with and without balls. The ball diameter was selected as 6 cm. The balls replaced to the natural axe of the sections. The specimens and load-displacement curves of the shear walls are given in Figure 5 (***Fig. 5***).

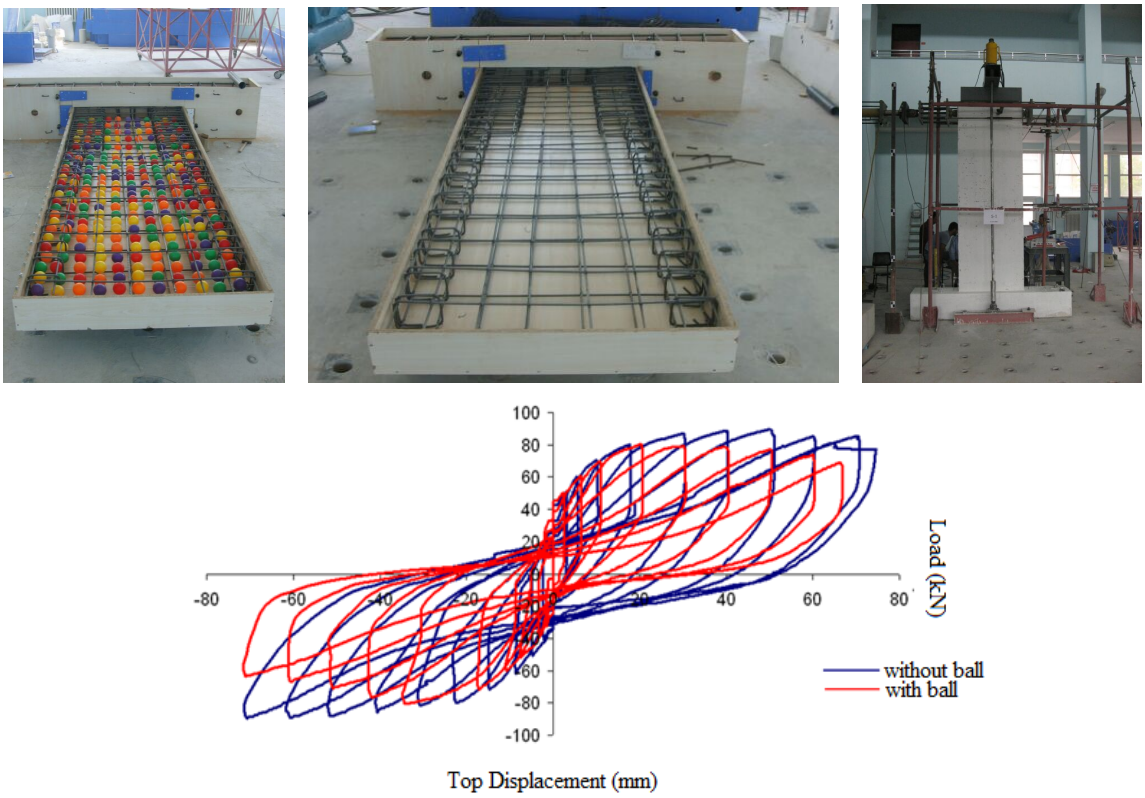

Fig. 5 *Shear wall tests and load-displacement curves of specimens.*

The specimens and vertical load- vertical displacement curves of the flat members are given in Figure 6 (***Fig. 6***).

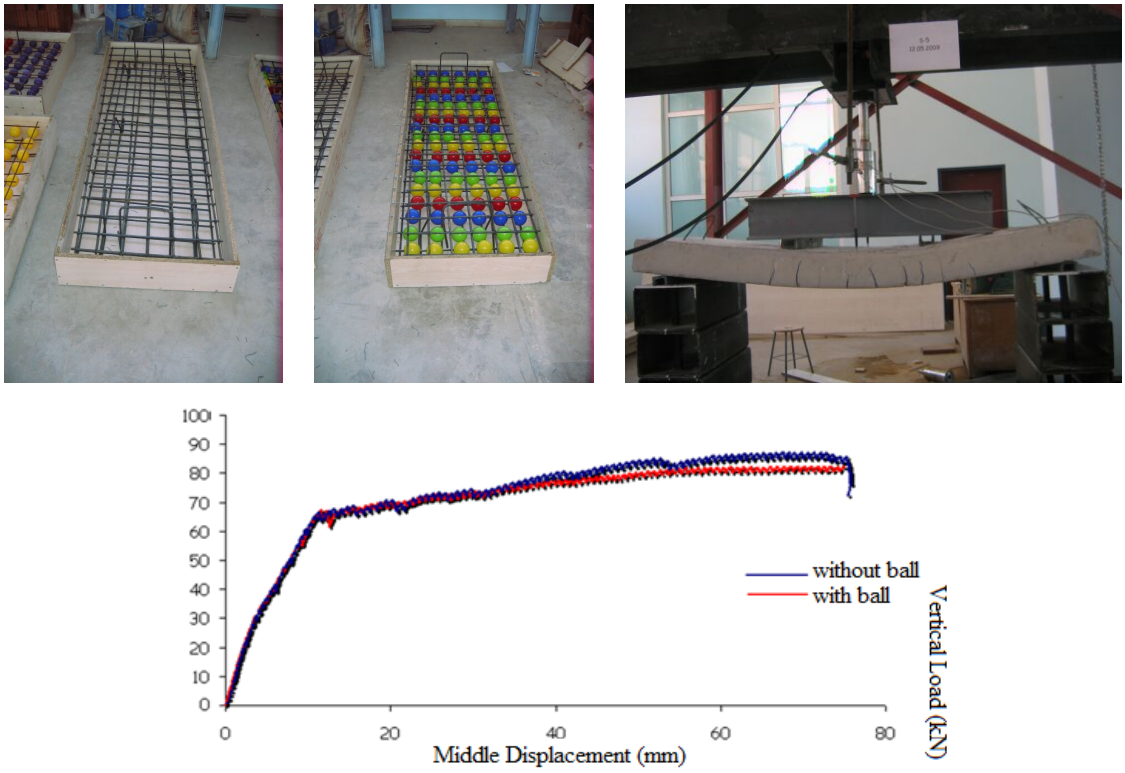

Fig. 6 *Shear wall tests and load-displacement curves of specimens.*

In the second phase of the experimental study, the acoustic and thermal characteristics of the specimens have been obtained. The produced members with and without ball is given in Figure 7 (***Fig. 7***).

Fig. 7 *The specimens for thermal and acoustics tests specimens.*

5 Experiment Results

Structural results;

- With the using 6 cm in diameter plastic ball in reinforced concrete shear wall with 15 cm thickness, the lateral load carrying capacity of the specimens has decreased about 9 % on the maximum loading level. The ductility level of the balled specimen is same as the reference reinforced concrete frame without ball. The vertical load

carrying capacity did not change with the using ball in slab members. The inertia rigidity and seismic energy absorption of the two sections is same in slabs and shear walls. The crack mechanism and plastic hinge behavior is same in two reinforced concrete shear walls.

Comfort results;

- The sound absorption level is high different in two members. For instance, the reference section produced without ball this coefficient is about 54 decibels (dB). However in the section with ball this coefficient is obtained 74 dB. The thermal conductivity coefficient also known as the "Lambda Value" in reference section is calculated as 1.974 W/m^2K, the same coefficient in balled section is obtained 0.626 W/m^2K. The concrete using in reinforced concrete section decreased about 12 %, in other words the weight of the section and the inertia force from dead load will decrease about the same level.

6 Conclusions

In this study, structural and comfort parameters have been investigated in reinforced concrete sections such as slab and shear wall produced with/without balls. Results obtained from experimental studies shows that 6 cm in diameter plastic balls used in reinforced concrete shear wall and slabs with the suitable position, do not cause to significant decrease on strength and rigidity but important improvement on thermal and acoustic features has been observed.

Acknowledgement

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References

[1] ARSLAN, M. H., KORKMAZ H. H., What is to be Learned from Damage and Failure of Reinforced Concrete Structures During Recent Earthquakes in Turkey?, Elsevier Publication, Engineering Failure Analysis, (2006), Vol. 14, pp. 1–22.

[2] JHONSON, C., What's The Big Deal About Temporary Housing Planning? Considerations for Temporary Accomodation After Disasters: Example of The 1999 Turkish Earthquakes. Report, Canada, 2001.

[3] BubbleDeck Test Report from Ian Sharland Ltd Airborne and Impact Sound Insulation. November (2005).

[4] BAL, I., E CROWLEY, H., PINHO, R., Structural Characteristics of Turkish RC Building Stock in Northern Marmara Region for Loss Assessment Applications, IUSS Press, 2007.