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Shear Capacity of Biaxial Hollow Slab with Donut Type Hollow Sphere

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Abstract

This paper presents the shear capacities of biaxial hollow slab with donut type hollow sphere. Recently, various types of slab systems which can reduce self-weight of slabs have been studied as the height and width of building structures rapidly increase. A biaxial hollow slab system is widely known as one of the effective slab system which can reduce self-weight of slab. According to previous studies, the hollow slab had low shear strength, compared with solid slab and the shear capacities of biaxial hollow slab are influenced by the shapes and materials of hollow spheres. In addition, the present code does not provide a clear computation method for the shear strength of hollow slab. To verify the shear capacities of this hollow slab, shear tests were performed. Four test specimens were used for test parameters. One was conventional RC slab and others were hollow slabs. The test parameters included two different shapes and materials of plastic balls. The shape parameters were donut and non-donut forms. And the material parameters were general plastic and glass fiber plastic

Keywords: Hollow slab; Shear strength; Floor system; Donut type hollow sphere

1. INTRODUCTION

In building, the slab is very important structural member to make a space. And the slab is one of the largest member which is made by concrete. In a general way, the slab was designed only to resist vertical load. However, deflection and vibration of slab are also considered recently because people are getting more interest of residential environment. In addition, when span of the building is increasing, deflection of slab is more important. Therefore, the slab thickness is on the increase. The increasing of slab

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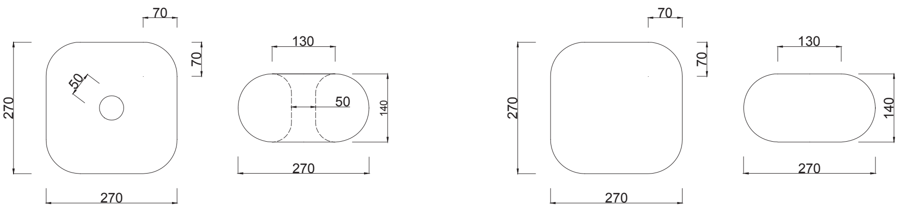
thickness makes slab heavier, and it leads to increase column and base size. Thus, it makes building consume more materials such as concrete and steel. To avoid these disadvantages which were caused by increasing of self-weight of slabs, the biaxial hollow slab system, also known as void slab, was suggested. This slab system could optimize the size of vertical members like walls and columns by lightening the weight of slabs. According to previous studies, the hollow slab had low shear strength, compared with solid slab and the shear capacities of biaxial hollow slab are influenced by the shapes and materials of hollow spheres. In addition, the present code does not provide a clear computation method for the shear strength of hollow slab. To verify the shear capacities of this hollow slab, shear tests were performed. Four test specimens were used for test parameters.

2. EXPERIMENT PROGRAM

Test specimens were designed of four types of slabs, one was conventional RC slab and others were hollow slabs. The test parameters included two different shapes and materials of plastic balls. The parameters are such as following. First, the shape parameters were donut and non-donut forms which were shown Fig 1. Second, the material parameters were general plastic and glass fiber plastic which details were shown Table 1. Details of test specimens were illustrated in Table 2 and Fig 2. The load was applied by displacement control at the mid-span of the slab by a 2000kN hydraulic actuator. The a/d ratio was 1.7 and parallel two line load was applied. Loading speed was 0.03mm per second. And the load was applied until the load bearing capacity of specimens was declined 50% of their peak capacities. The hinge and roller were used to minimize fixed end moment and other errors from support condition.



a)Donut Type b)Round Box Type

Figure 1: Hollow Sphere Shape

Table 1: Properties of Plastic

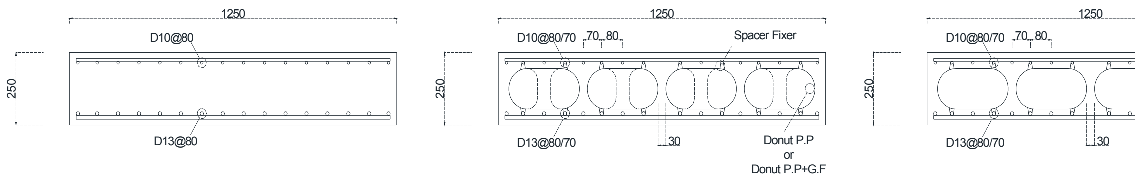
Material	Fu (MPa)	Elongation(%)	$E_{plastic}$(MPa)	Density(g/cm^3)
P.P	29.4	300	1323	0.91
P.P+G.F	117.6	3	8330	1.22

3. EXPERIMENTAL RESULTS

To find out the effect of hollow sphere shapes and materials, the results of tests were divided into 2 classes of each parameter. Figure 4 and Figure 5 illustrate the shear capacities of specimens of each parameter and crack patterns. And Table 3 shows the results of tests.

Table 2: Properties of Specimen

	Length (mm)	Width (mm)	Height (mm)	Fck (MPa)	Fy (MPa)	P (%)	Shape	Material
Solid							-	-
HS-D-0	2850	1250	250	24	400	0.54	Donut	P.P
HS-D-40							Donut	P.P+G.F
HS-R-0							Round Box	P.P



a) Solid b) HS-D-0/ HS-D-40 c) HS-R-0

Figure 2: Specimen details and section properties

3.1. Shear strength and stiffness

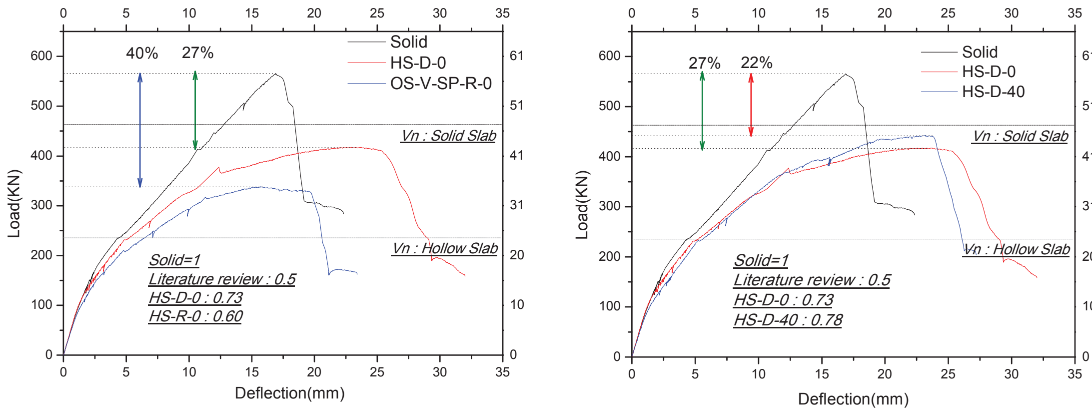
Figure 3-a) showed the load-deflection curves of the sphere shapes such as Solid, Donut, Round box. It showed small differences of load-deflection relationship before the shear crack was occurred about 25KN. However, as the shear crack width was increased, the stiffness of hollow slabs was dramatically decreased. Solid specimen has enough shear strength over the nominal strength 228KN but hollow slabs such as HS-D-0 and HS-R-0 specimens showed lesser shear strength than Solid Specimen. Because shear strength was influenced by its cross section area and the hollow slab specimens have much lower cross section area than the solid specimen. (52%) However, they have much higher shear strength than the theoretical strength 118kN calculated by their minimum cross section area. And HS-D-0 specimen which applied donut type hollow sphere has 19% higher ultimate shear strength than HS-R-0 even though they have same minimum cross section area. As the result, the shape of hollow sphere was significantly influenced shear strength and stiffness of the slab. As seeing the Figure 3-b), HS-D-40 specimen which applied a higher strength plastic(glass fiber reinforced plastic) hollow sphere has better ultimate shear strength (221.4kN) than HS-D-0 specimen(208.7kN). However stiffness of HS-D-40 was similar to that of HS-D-0 specimen. As the result, material strength of hollow sphere somewhat influenced shear strength of the slab.

3.2. Crack pattern and Failure mode

The crack patterns of the hollow slabs and the solid slab were very similar, even though they had different shapes and materials of hollow spheres. For low a/d ratios (1.7), as the shear load carried by a direct compression strut between the loading point and the support. So, all specimens were failed when diagonal shear cracks occurred and broaden out. Solid and HS-R-0 specimens showed brittle failure after the ultimate strength, however strength of donut type specimens such as HS-D-0 and HS-D-40 dropped more gradually.

Table 3: Test results

	Vn (kN)	Vu (kN)	Deflection (mm)	Vu/Vn (%)	Ratio (%)
Solid	228.3	282.39	16.95	124	100
HS-D-0	118.5	208.72	22.94	176	73
HS-D-40	118.5	221.38	23.17	187	78
HS-R-0	118.5	169.22	15.72	143	60



a)Load-Deflection by shapes b)Load-Deflection by materials

Figure 3 : Load-Deflection relationship

4. CONCLUSIONS AND SUMMARY

Based on the results of test, I conclude that shape and materials of hollow sphere might be influence the shear capacities of slabs. Especially, shapes of hollow sphere is very important factor for shear capacity. It can be increasing the shear strength about 20% rather than hollow slab which is applied non-donut shape hollow sphere. There are summaries about this study.

1) The hole in the center of hollow sphere like figure 1-a) might be performed to increases the shear strength of hollow slab.
2) The strength of hollow sphere material might be the one of the factor for the shear strength of hollow slab.
3) It tends to underestimate the shear strength to measure the shear strength of hollow slab by using minimum cross section area.

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REFERENCES

[1] J.H. Chung, N.K. Ahn, H.K. Choi. and C.S. Chang (2009). An analytical study of optimal hollow sphere shapes in hollow slab. Journal of the Korea institute for structural maintenance. 159-162