DEVELOPMENT OF RADIATION SHIELDING CONCRETE UTILZING ELECTRONIC ARC FURNACE OXIDIZING SLAG

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Introduction

In general, magnetite or barite (density: more than 4.0ton/m^3) has been used in concrete for radiation shielding, and radiation tests have been performed to evaluate shielding performance. However, researchers have not studied concrete for radiation shielding that utilizes electric arc furnace oxidizing slag. Although much research is progressing on electric arc furnace slag, it has been researched for the purpose of replacing normal aggregate, and it has progressed on fine aggregate only due to a problem of expansibility of electric arc furnace slag. This research aims to utilize electric arc furnace oxidizing slag which depends on reclamation as environment-friendly concrete materials by using coarse and fine aggregates of electric arc furnace slag containing 30% ferrous metal and with a density of around 3.0~3.8 ton/m^3. Accordingly, this research has judged that the high density electric arc furnace oxidizing slag aggregate can be applied to X-ray shielding concrete. It has also examined the possibility of developing X-ray shielding concrete utilizing electric arc furnace oxidizing slag aggregate by comparing concrete utilizing all fine and coarse aggregate of electric arc furnace oxidizing slag with concrete using magnetite.

Experimental

Each mixture is based on W/C 40% and 45%, and iron powder was included to arbitrarily improve unit weight in case of W/C 45%. The iron powder was targeted to contain more than 3,500 kg/m^{3}of unit weight according to a calculation of weight ratio. In addition, when magnetite was mixed in W/C 40% and 45%, fine particles and self-density of magnetite were high, so the content of admixtures was increased. The planning of experiments of this research is the same as in Table 1, and experiments on slump, air content and unit volume weight in fresh concrete were progressed as items of experiments. Experiments on the compressive strength test, X-ray transmission test and unit volume weight were carried out on hardened concrete. Specimens were manufactured to have the size of Ø10×20cm, and because the criteria of specimens for X-ray transmission tests were not clarified, the test was progressed by arbitrarily manufacturing specimens with the size of 13.6×16×5cm.

Table 1 Experimental Plan

Experimental factors		Experimental level
Mixing	W/C(%)	40, 45
	Using aggregate	Normal aggregate, Magnetite, iron Powder, Dang-jin electric arc furnace oxidizing slag, In-cheon electric arc furnace oxidizing slag
	slump(mm)	150±25
Details	fresh	slump, air content, unit volume weight
	hard concrete	compressive strength, unit volume weight, X-rey transmission

Results and Discussion

The test results on slump, air content and unit volume weight of fresh concrete and the test results on compressive strength of hardened concrete are the same as in Table 2.

Table 2. test results

W/C (%)	Sample	Slump (mm)	air content (%)	Unit volume weight (kg/m^3)	Compressive strength (MPa)
40	N-40	160	1.8	2280	39.5
	DS-40	160	2.5	3210	60.2
	MA-40	155	3.5	3470	55.5
	DSMA-	155	2.8	3270	61.5
45	DS-45	160	2.2	3110	35.5
	IS-45	165	2.3	2910	32.1
	MA-45	145	3.3	3610	37.5
	DSSM-	155	2.1	3500	36.1
	DSSS-	155	2.4	3650	39.3
	N-45	170	2.3	2340	31.2

Fig. 1 is a comparison of the unit volume weight and compressive strength, so the increase of compressive strength according to increase of unit volume weight can be seen.

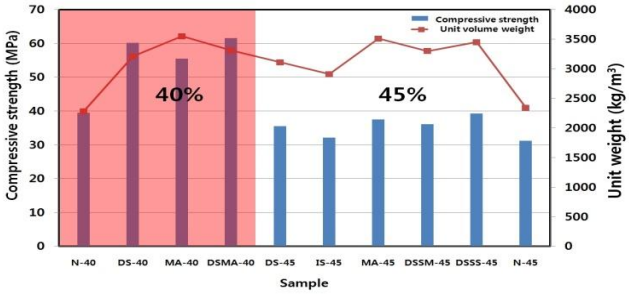

Fig 1. unit volume weight – compressive strength

Table 3. Concrete mixing table

W/C	Water	Cement	Fine aggregate 1	Fine aggregate 2	Coarse aggregate	AD compound	Density of fine aggregate	Density of coarse aggregate	Materials	Sample
40%	165	413	904	-	875	3.3	2.59	2.61	normal aggregate	N-40
			1287	-	1240	3.3	3.68	3.70	Dang-Jin slag	DS-40
			1570	-	1508	4.1	4.5	4.5	Magnetite	MA-40
			1287	-	1508	3.3	3.68	4.5	S1(Dang-Jin slag)+G1(Magnetite)	DSMA-40
45%	180	400	1223	-	1387	3.3	3.68	3.70	Dang-Jin slag	DS-45
			1123	-	1287	3.3	3.38	3.42	In-cheon slag	IS-45
			1496	-	1686	4.0	4.5	4.5	Magnetite	MA-45
			1199.7	133.3	1686	3.3	4.01	4.5	S1(Dang-Jin slag) + S2 (iron Powder 10%) G1(Magnetite)	DSSM-45
			997.2	664.8	1387	3.3	5.0	3.70	S1(Dang-Jin slag) + S2 (iron Powder40%) G1(Dang-Jin slag)	DSSS-45
			844	-	959	3.3	2.59	2.61	normal aggregate	N-45

As the density is high and the atomic number brings it higher, the radiation shielding ratio performs well, so this research aimed to perform radiation shielding tests on each material. The X-ray transmission test has used a LaBr3(Ce) Scintillator measuring instrument, and 150 kVp X-ray was used to find out the precision of the X-ray spectrum. Table 3 shows calculation results of I_O/I, μ_t (effective attenuation coefficient) and shielding ratio by using Spectrum Data through the X-ray transmission test.

Table 4. X-ray calculated transmission data

Sample	Unit volme weight (kg/m3)	Spectrum Data	IO/I	μ_t	Shielding ratio (%)
Source	-	1712234	1	-	-
N-40	2280	450588	3.8	0.267	73.68
DS-40	3100	148117	11.56	0.490	91.35
MA-40	3600	105174	16.28	0.558	93.86
DSMA-	3310	127588	13.42	0.519	92.55
DS-45	3100	153289	11.17	0.483	91.05
IS-45	2700	199097	8.6	0.430	88.37
MA-45	3550	114073	15.01	0.542	93.34
DSSM-	3220	133873	12.79	0.510	92.18
DSSS-	3420	119653	14.31	0.532	93.01
N-45	2300	449405	3.81	0.268	73.75

The Fig. 2 shows the shielding ratio on μ_t and the shielding performance according to each material was compared on the basis of Spectrum Data. It could be confirmed that magnetite showed the highest as 93%, and that normal concrete shows performance below 73%. The shielding ratio of electric arc furnace oxidizing slag appeared as 91%, so it could be confirmed once more that there is a correlation between the shielding ratio and unit volume weight.

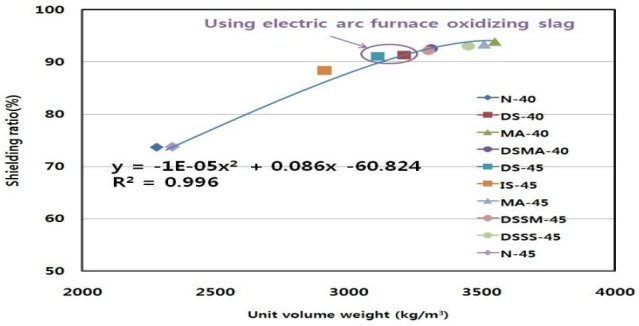

Fig 2. Unit volume weight-shielding ratio results

Conclusion

The electric arc furnace oxidizing slag had a liquidity similar to that of concrete using general aggregate in case of mixing, and showed high unit volume weight. Its specific gravity was lower than concrete using magnetite, but the specific gravity of electric arc furnace oxidizing slag could be raised by using iron powder. It was confirmed that the compressive strength and X-ray shielding ratio were increased by increasing its specific gravity, and the difference of W/C was not seen.

Acknowledgements

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