



Evaluation of durability of concrete substituted heavyweight waste glass as fine aggregate

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HIGHLIGHTS

- Cathode ray tube (CRT) waste glass was recycled as fine aggregate of concrete.
- Durability of concrete containing CRT glass was investigated.
- As the mixing ratio of waste glass increased, durability is better in the concrete.
- This study showed that CRT waste glass can be used as fine aggregate in concrete.

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ABSTRACT

Concrete is the most widely used construction material, and huge amounts of natural resources are required to manufacture it. With relatively recent rapid industrial development as well as the improvement of people's living standards, the volume of domestic and industrial waste is increasing, and much of this waste is not recycled. Cathode ray tube (CRT) waste glass is an industrial waste material that has been studied by many researchers for use as fine concrete aggregate. As one example of its potential application, nuclear power plants and radioactive waste disposal sites are often located in areas vulnerable to attack by chloride and sulfate, and this may compromise the durability of the concrete structure designed to shield radiation. More durable concrete would therefore be desirable. We studied the durability of concrete mixed with waste glass through the following approach. Waste CRT glass containing heavy metals was recycled as fine aggregate for concrete; the durability of the concrete was investigated by performing freeze-thaw resistance, sulfate attack, and chloride ion penetration measurement. The test results showed that as the mixing ratio of waste glass increased, the freezing and thawing resistance, sulfate attack resistance, and chloride ion penetration resistance were all better in the concrete containing waste glass than in normal concrete. However, the compressive and the flexural strength of the concrete both decreased due to lower adhesion between cement paste and waste glass. In conclusion, it was confirmed that concrete substituted with heavyweight waste glass could be used in radiation shielding structures.

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1. Introduction

Concrete is one of the most widely used construction materials, and it is a fundamental material in nearly all structures. Alternative aggregates are, however, very much needed because aggregate shortages abound due to the exhaustion of natural aggregates and strict environmental restrictions placed on the construction industry. In addition, with rapid industrial development as well as the improvement living standard, the amount of domestic and

industrial waste is increasing. Treatment of such types of waste has become a serious issue, and a globally unified effort is needed to implement technologies for effective waste recycling and resource recirculation.

Against this context, several types of industrial waste are currently being used in the manufacturing of eco-friendly materials, which can replace existing construction materials. Among the various types of industrial waste, glass is considered to be the most suitable substitute as an aggregate due to its physical characteristics and chemical composition [1–3]. Furthermore, previous study has shown that recycled glass may be suitable for use in a wide range of applications, including concrete, bricks, and in highway engineering projects [4–7].

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In particular, since 2012, when analog TV broadcasting ended, and systems converted to digital TV broadcasting in South Korea, a large volume of cathode ray tube (CRT) TVs and monitors were discarded and replaced with LCD panels. The amount of electronic waste, including waste CRT glass from CRT TVs and monitors, increased from 910,000 ea. in 2012 to 970,000 ea., and is currently projected to increase to about 10 million ea. in 2020 [8,9]. Just as notable is that most of the old CRT TVs and monitors are not recycled despite the fact that parts, including the CRTs, can be. CRT glass products are classified into panels and funnels, wherein the panels may be reused as glass after washing, but the funnels, containing a large number of heavy metals such as iron and lead, are difficult to treat using conventional recycling technology. Heavyweight waste glass has therefore frequently been illegally dumped or buried in landfills, leading to serious environmental pollution [10]. As a result, it is important to find effective recycling methods for heavyweight waste glass that contains heavy metals. One possible option that has been studied includes applying waste glass as an alternative concrete aggregate [2,10–21], however, studies specifically on the durability of concrete are lacking.

Many of the existing studies involve mortar [11,14,21]. Most studies also used treated waste glass in the form of crushed glass in which heavy metals were removed [15–19]. Such waste glass treatment process is very complicated. In South Korea, a study was conducted to investigate the applicability of heavyweight waste glass crushed solely by a jaw crusher [10,21]. In this paper, heavyweight waste glass was simply crushed by jaw crushers,

and not all of the heavy metal in the waste glass was removed, making it a very simple process.

Heavyweight aggregates can be used in heavyweight concrete, and most of the concrete used in radiation shielding in nuclear power plants and radioactive waste disposal involves heavyweight concrete. Nuclear power plants are mainly located on the coast and are susceptible to attack by chlorides, while radioactive waste disposal plants are often located deep underground and are vulnerable to sulfate attack, so these factors need to be considered. In addition to heavyweight aggregate, many researchers have studied the properties and radiation shielding performance of concrete mixed with lead mine waste, waste marble, recycled aggregate, electric arc furnace slag, ferrochromium slag, barite, and minerals [22–30]. Our research confirms that heavyweight waste glass can be used as a fine aggregate of concrete by previous study [21] and improve radiation shielding performance.

In summary, the development of alternative resources is required due to the depletion of natural resources, and efforts to use industrial wastes as alternative resources are continuing. Much research has been conducted on waste glass, which is an industrial waste, as concrete aggregate, and we conducted this study to apply heavyweight waste glass as an ingredient of radiation shielding concrete. In previous studies, lead mine waste, barite, and so on have been used as aggregate in a radiation shielding concrete, and studies on heavyweight waste glass are insufficient.

Thus, this study was conducted to investigate the durability of concrete prepared using heavyweight waste glass containing

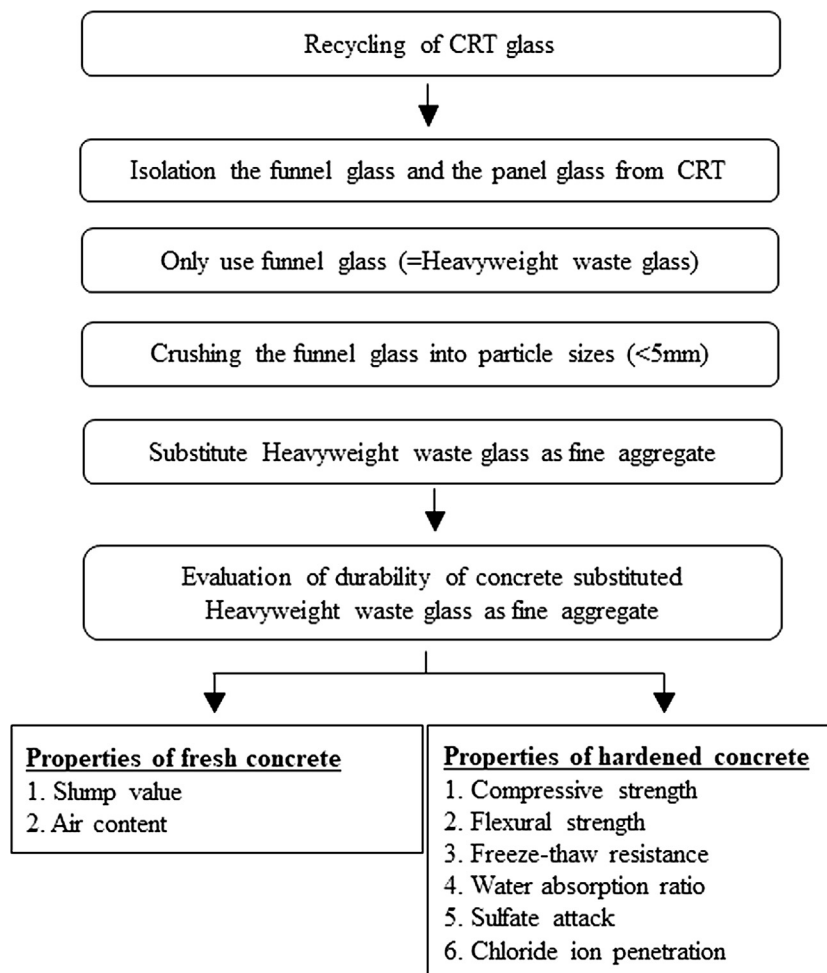


Fig. 1. Research Framework.

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