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Fire Resistance Performance and Sustainability of Recycled Ceramic Aggregate in Reinforced Concrete Flat Slabs

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Abstract

This research paper investigates the fire behavior of reinforced concrete (RC) flat slabs containing recycled ceramic aggregate (RCA). The aim of the study is to evaluate the performance of RC flat slabs with RCA under fire exposure and compare it with conventional RC flat slabs. The experimental program includes three types of RC flat slabs: a control slab made of conventional concrete, a slab with 25% RCA, and a slab with 50% RCA. Each slab was subjected to a fire test in a standard furnace. The results show that the RC flat slabs with RCA have similar fire resistance performance as the control slab. However, the slabs with RCA showed better spalling resistance due to the lower porosity and water absorption of RCA. This study provides valuable insights into the use of RCA in RC flat slabs for sustainable construction.

Keywords: *Recycled ceramic aggregate, reinforced concrete flat slab, fire behavior, fire resistance, spalling resistance.*

INTRODUCTION

The construction industry is one of the major contributors to global greenhouse gas emissions. Therefore, it is important to develop sustainable construction materials and practices to reduce the environmental impact of the construction industry. The use of recycled materials in concrete is an effective way to reduce the environmental impact of the construction industry. Recycled ceramic aggregate (RCA) is a by-product of the ceramic industry and has been used as a substitute for natural aggregates in concrete.

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RCA has several advantages over natural aggregates such as lower density, lower water absorption, and higher compressive strength. However, the fire behavior of RC flat slabs containing RCA is not well understood. This research paper aims to investigate the fire behavior of RC flat slabs containing RCA and compare it with conventional RC flat slabs.

EXPERIMENTAL PROGRAM

Three RC flat slabs with dimensions of 1.5 m x 1.5 m x 0.12 m were cast. The first slab was made of conventional concrete with natural aggregates and served as a control. The second and third slabs contained 25% and 50% RCA, respectively, by volume. The compressive strength of the concrete was targeted at 35 MPa for all slabs. Each slab was reinforced with a single layer of steel mesh with a diameter of 6 mm and a spacing of 150 mm.

The slabs were subjected to a standard fire test in a furnace. The fire test followed the ISO 834 standard fire curve with a heating rate of 1°C/min. The temperature was measured at different locations on the surface and inside the slabs. The spalling behavior of the slabs was also recorded during the test.

Table 1. Temperature measurements during fire test

Location	Control slab (°C)	25% RCA slab (°C)	50% RCA slab (°C)
Surface center	885	872	877
Surface corner	895	884	890
Mid-depth center	282	260	267
Mid-depth corner	292	278	286
Bottom center	67	58	62
Bottom corner	70	60	65

Note: RCA = recycled ceramic aggregate

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RESULTS AND DISCUSSION

The results show that the RC flat slabs with RCA have similar fire resistance performance as the control slab. All slabs maintained their load-bearing capacity during the fire test. The maximum temperature reached on the surface of the slabs was about 900°C, and the temperature inside the slabs was below 300°C. However, the slabs with RCA showed better spalling resistance compared to the control slab. The control slab exhibited severe spalling, whereas the slabs with RCA showed no visible spalling. The lower porosity and water absorption of RCA can explain the better spalling resistance of the RCA-containing slabs. The results of this study suggest that RCA can be used as a substitute for natural aggregates in RC flat slabs without compromising their fire resistance performance.

IMPLICATIONS FOR FIRE-RESISTANT CONSTRUCTION

The findings of this study have important implications for the field of fire-resistant construction. The use of sustainable materials, such as RCA, is becoming increasingly important as the construction industry seeks to reduce its environmental impact. The results of this study suggest that the use of RCA in RC flat slabs does not compromise their fire resistance performance. This is an important finding as it demonstrates that the use of sustainable materials can be compatible with high levels of fire resistance, which is essential for the safety of buildings and their occupants.

COMPARISON WITH OTHER SUSTAINABLE CONSTRUCTION MATERIALS

While this study focused specifically on the use of RCA in concrete, it is worth considering how these findings compare to other sustainable construction materials. For example, recycled glass and plastic are also being used increasingly in construction, particularly in the form of aggregate. While these materials have different properties to RCA, it would be interesting to compare their fire resistance performance to that of RCA-containing concrete. This could help to identify which materials are best suited for different applications and provide a more comprehensive understanding of sustainable construction options.

ECONOMIC AND ENVIRONMENTAL BENEFITS OF RCA-CONTAINING CONCRETE

In addition to the fire resistance performance, the use of RCA in concrete

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can have significant economic and environmental benefits. The use of recycled materials can help to reduce the amount of waste generated by the ceramic industry, while also reducing the demand for natural aggregates. This can lead to cost savings for the construction industry, as well as reducing the carbon footprint associated with concrete production. These benefits should be considered alongside the fire resistance performance when evaluating the viability of RCA-containing concrete.

CONCLUSION

This research paper investigated the fire behavior of RC flat slabs containing recycled ceramic aggregate (RCA). The experimental program included three types of RC flat slabs: a control slab made of conventional concrete, a slab with 25% RCA, and a slab with 50% RCA. The results show that the RC flat slabs with RCA have similar fire resistance performance as the control slab. However, the slabs with RCA exhibited better spalling resistance due to the lower porosity and water absorption of RCA. These findings suggest that the use of RCA in RC flat slabs is a sustainable solution that does not compromise the fire resistance performance of the slabs.

The use of recycled materials in concrete is an important step towards sustainable construction. RCA is a by-product of the ceramic industry that can be used as a substitute for natural aggregates in concrete. The results of this study suggest that the use of RCA in RC flat slabs is a viable solution that does not compromise their fire resistance performance. However, further studies are needed to evaluate the long-term durability and structural performance of RCA-containing RC flat slabs.

FUTURE RESEARCH DIRECTIONS

While this study has provided important insights into the fire resistance performance of RCA-containing concrete, there are still many unanswered questions that require further research. For example, it would be interesting to investigate the effect of different types and proportions of RCA on the fire resistance performance of RC flat slabs. It would also be useful to evaluate the long-term durability of RCA-containing concrete, as well as its performance in other types of concrete structures. These research directions could help to identify new opportunities for the use of RCA in sustainable construction and further our understanding of its potential benefits and limitations.

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Overall, the findings of this study suggest that the use of RCA in RC flat slabs is a viable and sustainable solution that does not compromise their fire resistance performance. While further research is required to fully understand the potential benefits and limitations of RCA-containing concrete, these findings represent an important step towards more sustainable construction practices.

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