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Sustainable construction for Singapore's urban infrastructure – some research findings

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Abstract

Many cities around the world can afford the old model of urban sprawl, where the city boundary grows outwards. However, in small city states like Singapore, evolving the city of the future will be very different. Singapore requires development of holistic sustainable technologies and solutions for sustainable infrastructure to meet future social and economic needs. This includes adopting building designs, construction methods and materials that are environmentally-friendly, as well as using materials and resources that have sustainable supplies. A brief update of some research findings to address Singapore's infrastructural sustainability needs is presented.

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Keywords: Sustanable; construction; urban; infrastructure; microwave-assisted beneficiation, design for disassembly.

1. Introduction

More than half the world lives in cities and this is expected to grow. Many cities can afford the old model of urban sprawl, where the city boundary grows outwards. However, in city states like Singapore, evolving a city of the future will be very different. Singapore as a city state with virtually no natural resources has unique needs to be met in developing a holistic model and infrastructural solutions for future sustainable urban development. This includes adopting building designs, construction methods and materials that are environmentally-friendly, as well as using materials and resources that have sustainable supplies.

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Research on sustainable infrastructural development in Singapore is on-going. A number of interesting projects are targeted at developing sustainable solutions to meet challenges, unique to Singapore. One such project involves using microwaves to increase the yield and quality of recycled materials. This novel technique utilizes microwave heating to separate the components of recycled concrete aggregate (RCA) for reuse. Heating causes the cementitious mortar adhering to the surface of the RCA particles, to delaminate from the granitic aggregates. Another project briefly described in this paper involves partnering the Housing Development Board, to design high-rise buildings that, like building blocks, can be disassembled and re-used. Such work aims to provide a sustainable supply of construction materials available locally, which can reduce over-reliance on imported sand and aggregates.

2. Microwave-assisted beneficiation of recycled aggregate concrete

The use of recycled aggregates in structural applications is limited due to the presence of adhering cementitious mortar on the individual recycled aggregate particles. The adhering mortar has been reported to result in higher porosity, higher water absorption, lower modulus of elasticity and weaker interfacial zone (ITZ) between the newly cast cementitious mortar and the recycled aggregates [1, 2, 3]. The microwave-assisted beneficiation method takes advantage of the differences between the electromagnetic and thermal properties [4, 5, 6] of the coarse aggregate, granite, and adhering cementitious mortar to cause delamination at the ITZ, separating the granitic aggregate from the adhering cementitious mortar. The results of both experimental and analytical studies show that microwave heating is effective in increasing the yield and quality of the recycled concrete aggregates compared to more traditional methods of recycling [4, 5, 6].

2.1. Analytical results

Analytical modeling was used for the microwave-assisted beneficiation system shown in Fig. 1. The system utilizes three frequencies 2.45, 10.6 and 18 GHz representative of the characteristics of typical low, intermediate and high frequencies together with a constant incident microwave power of 1.1 MW /m^2. Typical results obtained are presented in Fig. 2 and 3. For clarity, Fig. 2 and 3 show only the temperature developed within the first 10 cm thick surface layer of the concrete block when subjected to microwave heating. The amount of energy dissipated in the concrete specimen varies significantly with its electromagnetic properties. The electromagnetic properties of concrete are a function of factors including concrete constituent materials and mix proportions, water content, microwave frequency, temperature, etc. The significant effects of concrete water content (Fig. 2 and 3) and microwave frequency on the heating process have been confirmed [4, 5, 6].

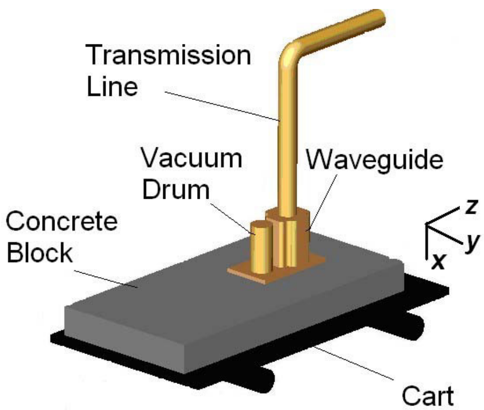

Fig. 1. Sketch of the microwave heating system

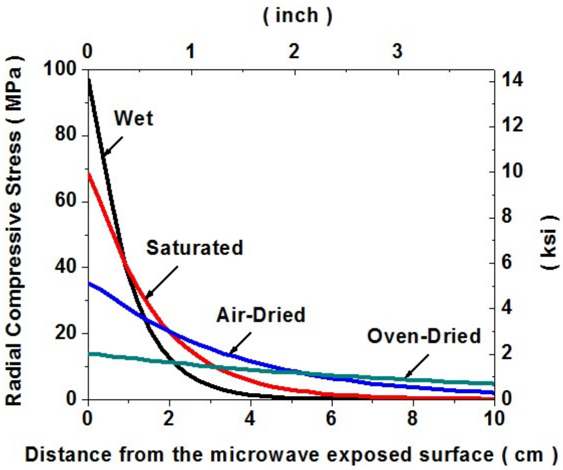

Fig. 2. Radial compressive stress in concrete after 2 seconds of microwave heating at 10.6GHz frequency