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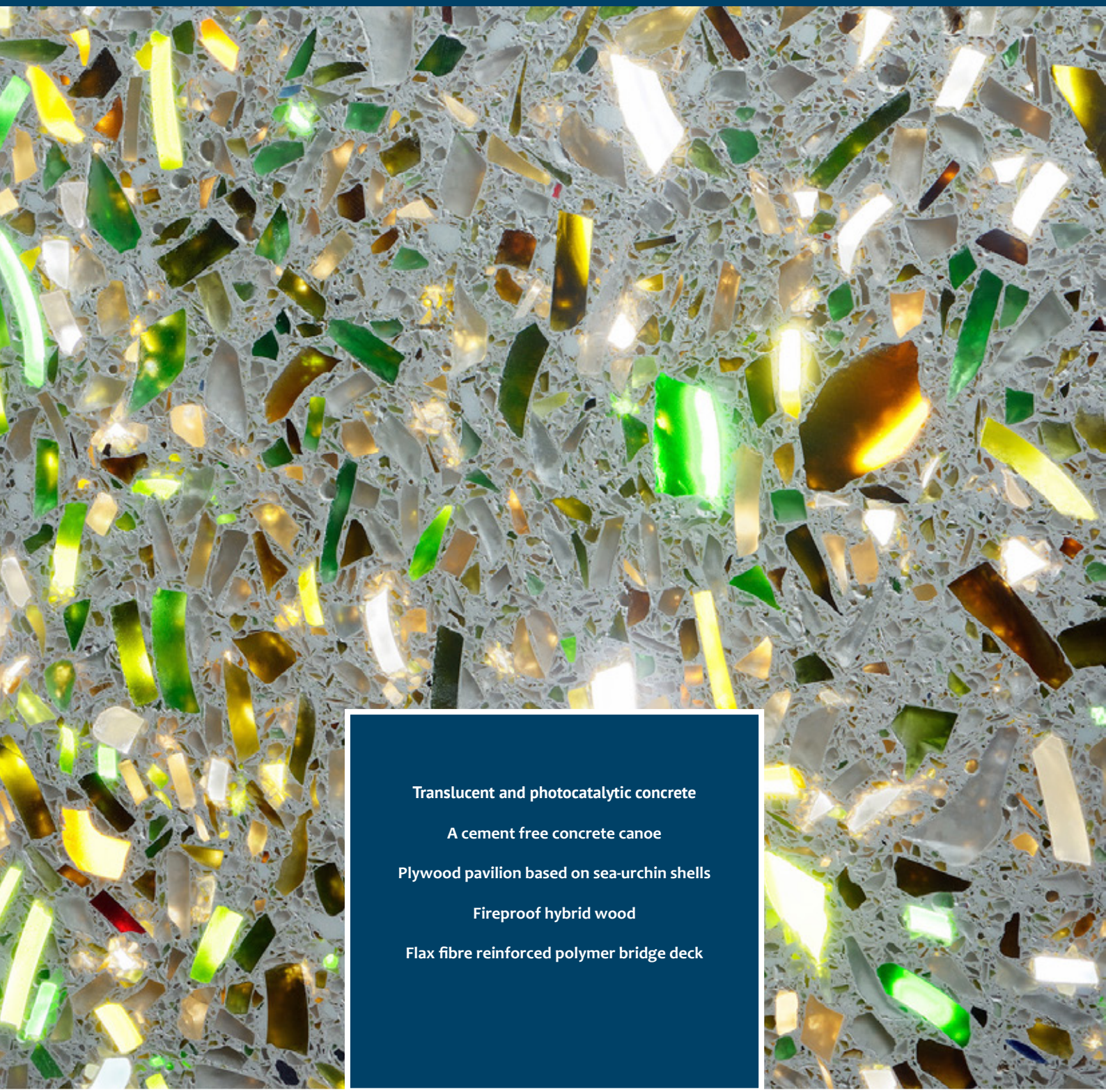
INNOVATIVE MATERIALS



Translucent and photocatalytic concrete

A cement free concrete canoe

Plywood pavilion based on sea-urchin shells

Fireproof hybrid wood

Flax fibre reinforced polymer bridge deck

MATERIAL INNOVATION IN ENGINEERING, CONSTRUCTION AND INDUSTRIAL DESIGN

COLOFON

About

Innovative Materials (Innovatieve Materialen) is a digital, independent magazine about material innovation in the fields of engineering, construction (buildings, infrastructure and industrial) and industrial design.

Innovative Materials is published in a digital format, although there is a printed edition with a small circulation. Digital, because interactive information is attached in the form of articles, papers, videos and links to expand the information available.

Scope

The digital edition is sent to engineers, scientists, students, designers, decision makers, innovators, suppliers and appliers working in civil engineering, construction, building, architecture, design, government and industry (both manufacturing industry and end users).

Innovative Materials has entered partnerships with several intermediate organisations and universities, all active in the field of material innovation.
More information (in Dutch):
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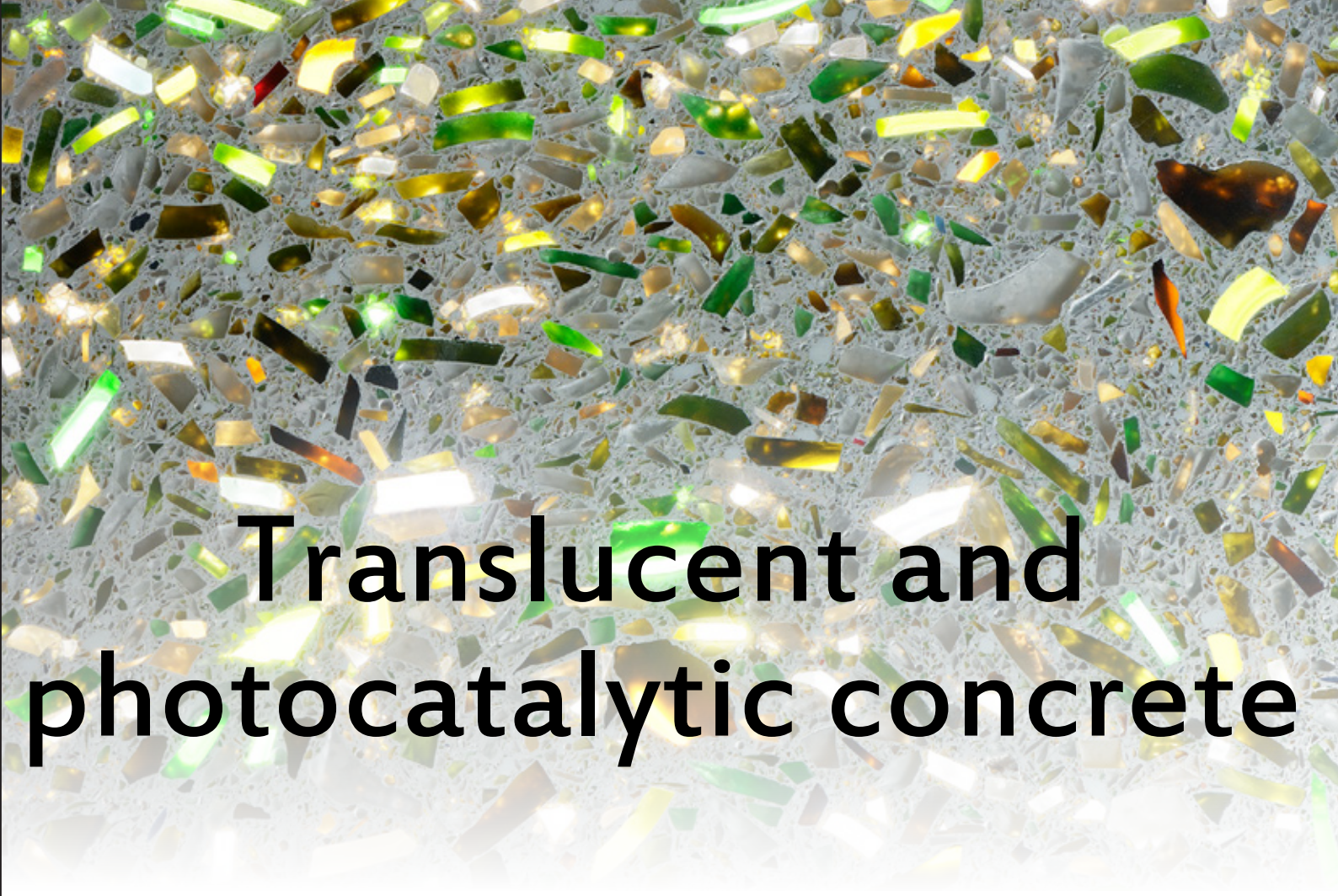
CONTENTS



Translucent and photocatalytic concrete

Last year Rotterdam-based artist Jan Eric Visser was presenting a new outdoor project called 'Ruins of Desire'. The sculpture pedestals are made of a new type of concrete developed by the University of Technology Eindhoven. In this new material, aggregates have been replaced by waste materials, such as glass waste. Also a mineral has been added to render the concrete self-cleaning and eliminate air pollution. Thus it uses UV light to prevent the growth of algae and degrade small particles in the air we breathe known as nitrogen oxides. Its performance is increased by 40 % as the various glass particles used in the concrete intensify the UV light.

Concrete is one of the most used materials in construction. The main reasons are its low price, high mechanical strength, high durability and variety of its form due to on-site casting or prefab design. Unfortunately it is highly unsustainable in terms of CO_2-emissions and resource efficiency. To make the concrete mixture more sustainable, aggregates can be replaced (partially or completely) by container waste glass. In research by the University of Technology Eindhoven, these products are incorporated in self-compacting concrete (SCC) mixtures, replacing conventional aggregates and fine powders. The SCC mixtures were designed using a particle packing optimization algorithm in order to obtain good properties in both fresh and hardened states.
The addition of a photocatalyst was studied, to render the material self-cleaning and to promote photocatalytic oxidation (PCO) of NO_x.

This research was done by students Bart van Lieshout and Spiros Rouvas, coworkers dr. Dipl.-Eng. MSc.-Eng. Przemek Spiesz, dr. Qingliang Yu MSc., MSc. Xu Gao and prof.dr.ir Jos Brouwers, Eindhoven University of Technology, Faculty of the Built Environment, section Building Physics and Services.

ASR

In concrete some harmful reactions can occur, such as alkali-silica reactions (ASR) in which a formed gel expands over a longer period of time, damaging the concrete. Even though extensive research has already been done on the alkali-silica reaction issue in concrete, it is still not completely clear how this reaction takes place. Most of the proposed ASR mechanisms are based on the same principle: a reaction between the alkalis (Na_2O and K_2O) originating from the cement with silica originating from aggregates. As the product of this reaction, a gel of alkali-silicate is formed. This gel binds water and can expand to about twice its initial

volume. This reaction only takes place if the amount of Na_2O and K_2O is high enough and when water is present.

Reactivity

Knowing how reactive different mixtures and materials are, is very important because the expansion can deteriorate concrete in the long term. Therefore, the application of low-alkali cements and/or non-reactive aggregates is crucial from the durability point of view. Different properties of materials used in concrete have an effect on the ASR reactivity. In the case of glass this comes to its particle size and chemical composition. For container waste glass, differences in ASR reactivity can be ascribed to different colors of the glass, i.e. different chemical compositions of the glass. Besides the composition, also the particle size plays a role in the reactivity of the glass. It is found that larger particles have higher long-term reactivity (deterioration capacity) than smaller particles. When particles smaller than sieve mesh #50 (ASTM) are used, the produced mixtures have very low reactivity. In general, the ASR is a very slow reaction (it can take years). When reactive fine materials (for instance glass powder) are added, a large reactive surface is available. The larger the area, the faster the reaction takes place and completes. If enough fine material (sufficient surface area) is available, the ASR can be finished before the hardening of concrete finishes. This means that the long-term expansion due to the ASR can be prevented.

Self-cleaning

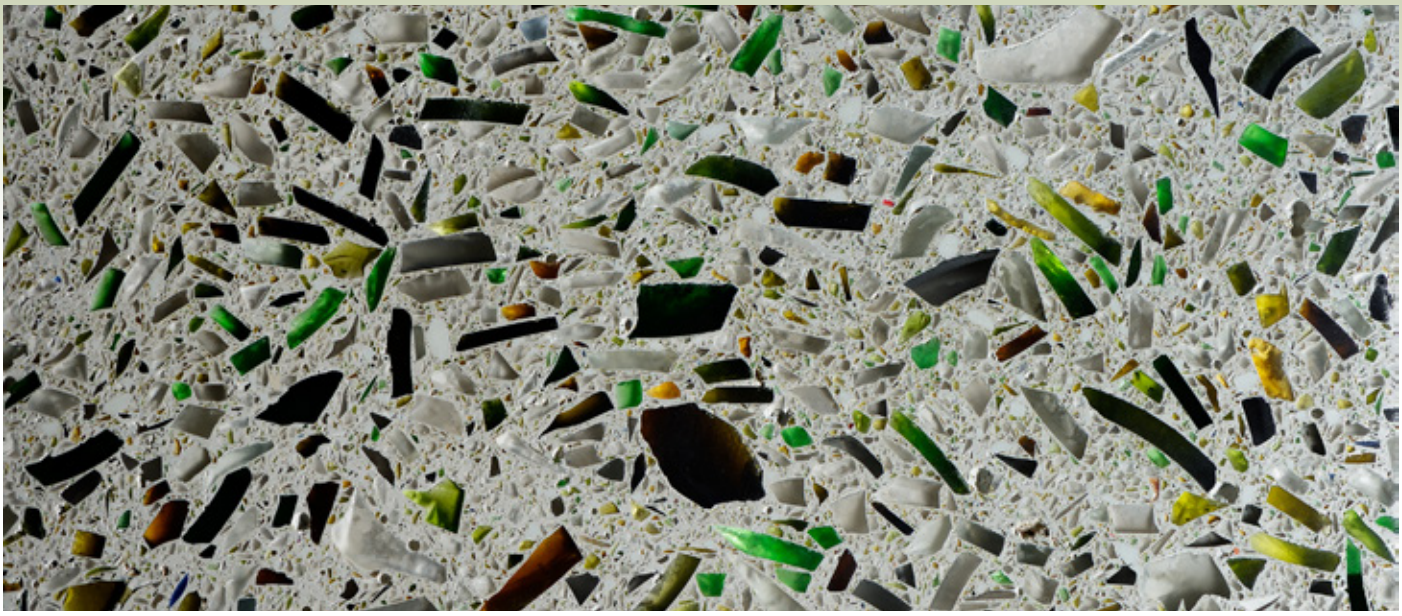
Because of the TiO_2-based photocatalytic oxidation (PCO) activated with the UV light, concrete may become a self-cleaning material. Additionally, if the right type of TiO_2 is applied, concrete can be used as an active air purifying material in both outdoor (activated by the UV-light) and indoor (activated by the visible light) applications. Due to the applied glass, it might be possible that even more UV light is transferred to the TiO_2 particles, making their activation more efficient and therefore this effect is also investigated by the TUE.

Results

Different mixtures were tested for their strength, alkali-silica reaction (ASR), translucency to the visible light and photocatalytic oxidation (PCO) properties. Results show that the strength of the SCC mixtures containing the waste glass, compared to a reference mixture prepared with conventional aggregates and sand, is slightly lower in all the investigated mixtures, bur still very suitable for structural applications. With respect to ASR test results, mixtures with glass aggregates can be classified as highly reactive, but the glass powder can suppress the ASR.

Jan Eric Visser, Untitled, 2015, IP 1, Translucent beton, Aquadyne and wood,105 x 34 x 28 cm. Photo: W. Vermaase

Jan Eric Visser, Untitles (Ruins of Desire I) 2015, Translucent beton en Aquadyne, 100 x 24 x 22 cm. Photo: W. Vermaase



Translucent beton

The PCO test results show an improvement of the NO_x degradation up to 40 % compared to the reference samples without glass particles. Finally, it is shown that the translucency of the product can be an attractive feature for concrete containing glass aggregates.

Showcase

The innovative, translucent concrete was applied and showcased for the first time by Jan Eric Visser. He used the university's standard test molds to cast pedestals as an initial step in the collaboration between artist and science. The sculptures in the project are made of Aquadyne, an innovative material produced of 100% postconsumer waste plastics. Micro and macro pores allow for the rooting of plants, even vegetables may be grown on it. The shapes were found as leftovers in the production machine and slightly adapted by the artist.

According to the artist both materials embody the new aesthetics of a post-industrial future in which valuable resources will be cherished and no longer incinerated as 'waste'. As such Ruins of Desire may be seen as a call for a new connection between man and matter, at the same time aspiring an artistic reconciliation of concept and matter.

This article is based on the publication 'Application of waste glass in translucent and photocatalytic concrete': Van Lieshout, B.; Spiesz, P.; Brouwers, H.J.H., and Utilization of waste glass in translucent and photocatalytic concrete'': Rouvas, S.,Spiesz, P.; Brouwers, H.J.H.

Also visit Eindhoven University of Technology Building Physics and Services TUE>

More about Jan Eric Visser at www.janericvisser.nl>