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The RAAC Crisis – How Engineering Analysis and Simulation Can Help Prevent a Reoccurrence

Using engineering modelling, analysis, and simulation to make buildings as safe as they can be at the design stage.

Remedial work being carried out at Mayflower Primary School in Leicester, which has been affected with sub standard reinforced autoclaved aerated concrete (RAAC). Picture date: Monday September 4, 2023. Source: Alamy / PA

GLASGOW, UK, September 15, 2023 /EINPresswire.com/ -- Like all materials, RAAC (Reinforced Autoclaved Aerated Concrete) has a finite operating life. Lightweight and cheap, this aerated alternative to traditional concrete was widely used in UK public buildings from the 1950s to as recently as the 1990s. Given its high strength, low density, and excellent thermal insulation properties, RAAC allowed construction at scale whilst keeping costs down. When properly maintained and cared for, RAAC, or "Aerobar," as it is sometimes referred to, has an estimated lifespan of 30 years, after which it can deteriorate and potentially become unstable.

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> *Ab van den Bos, NLyse*

In September 2023, the UK government moved to close several schools due to fears that RAAC used in their construction could be at risk of partial collapse. There have been calls for action to investigate where the material has been used and to replace time-expired RAAC since the collapse of a school roof in Kent in 2018, with the Office of Government Property (OGP) issuing a warning notice that the material was now "life-expired".

"It is important to recognise that these structures are likely to have been designed using many conservative simplifying assumptions." commented Carl Brookes, structural engineer at Thorp Precast. "Assessing such structures' actual strength using techniques such as the FE method can often show improved strength as well as flagging the position of weaknesses. Prediction of crack patterns and damage can also be invaluable in interpreting site observations. Assessments based on FE techniques then provides a more reliable datum before the impact of any deterioration is considered."

Crucially, these assessments can also be used to identify whether any failure is brittle or ductile. Ductile behaviour is gradual and provides evidence of distress, concrete cracking, spalling, and excessive member deflections before any failure. Providing inspections are regularly carried out, the onset of ductile failure generally gives plenty of warning of collapse and should be easily identifiable. On the other hand, brittle behaviour occurs suddenly and often with little warning, which has major safety implications. Understanding whether a potential structural failure is brittle or ductile is therefore a priority and can help prioritise interventions, any repairs and strengthening, and where necessary, replacement.

The use of better strength assessment techniques requires reliable input data. For instance, actual geometry and support conditions, past and current loading, actual concrete and reinforcement material parameters and conditions. Visual inspection, non-destructive testing and material sampling can provide this information, however, it is often impossible to obtain sufficient information. To mitigate, a sensitivity approach can be used to consider ranges of parameters, for instance lower and upper bound material strengths. Simulation based on the FE method, including non-linear behaviour such as concrete cracking and reinforcement yielding, is ideally suited for this type of strength assessment.

In 1996, the UK's Building Research Establishment (BRE) recommended that RAAC be removed from the structural concrete British Standard as it gave the impression that "it can be used for permanent structures". Given that the material had been used in the construction of thousands of buildings across the UK already, this was cause for concern. Of course, no material lasts forever, but it helps when assessing the suitability of a construction material to have a sound idea of how long it's likely to last in the given environment. As Carl Brookes explains, "The service life of reinforced concrete structures is determined principally by the grade of concrete, how strong it is, and the depth of concrete cover which is the distance from the concrete surface to the steel reinforcement. RAAC is no different although additional protection is required. Design codes prescribe these values for different environmental conditions and for different minimum service lives. Reinforcement will eventually corrode as concrete cover protection degrades with time. Design rules aim to ensure minimum service lives are achieved."

"It's a fact that RAAC is particularly vulnerable to moisture changes and is brittle. Given the national scale of the recently revealed issues in the UK, and the critical nature of some of the affected buildings, i.e., schools, employing FEA in finding solutions to enhance the panels without replacing them would be useful," Commented Ab van den Bos, Director at Dutch engineering consultancy NLyse Consultants, a company specialising in, amongst others materials, reinforced concrete.

In this regard, engineering analysis and simulation tools very much have a role to play in the current situation by, van den Bos tells us, "...solving the problem at hand: FEA and simulation can help calculate enhancement, strengthening and or mitigation measures for the problems that have arisen."

By using the analysis and simulation tools we have available and being up to date with advanced technologies and best practices through organisations such as NAFEMS, the International Association for the Engineering Modelling, Analysis, and Simulation Community, engineers can ensure that the right materials are used appropriately and that material lifespans are predicted as accurately as possible. Learning from the experience of others across industry is key to ensuring that structural analysis is accurate and useful, leading to a greater understanding of the materials we use, their limitations, the maintenance required, and when materials will need to be replaced.

According to Nawal Prinja, Head Assessor of NAFEMS' PSE scheme, "The issue is not only with RAAC, but traditional reinforced concrete will also have limited useful life. Analysis and assessment methods now exist to allow computer simulation to predict durability. "

He tells us that for durability assessments, ageing and its impact on degradation of material properties needs to be considered. "In the case of concrete reinforced with steel, there are data and simulation tools like Finite Element Analysis available to estimate degradation of the yield stress of steel reinforcement at various corrosion rates and changes in the compressive strength of the concrete at various levels of corrosion penetration, geometric configuration and mechanical reinforcement ratios."

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