

Delayed ettringite formation in concrete (DEF)

Introduction

DEF has caused cracking in some heat cured precast concrete components many years after the concrete was produced. There is a concern that cracking has also occurred in larger in-situ concrete structures as a result of the build up of heat of hydration in the early life of the structure.

What is delayed ettringite formation (DEF)?

DEF is expansion and cracking of concrete associated with the delayed formation of the mineral ettringite (a hydrated calcium sulfoaluminate) which is a normal product of early cement hydration. DEF is a result of high early temperatures (above 70°C - 80°C) in the concrete caused either by application of accelerated (heat) curing or by the build-up of heat of hydration in a massive in-situ concrete pour, which prevents the normal formation of ettringite. Cooling followed by prolonged exposure to moist conditions can, in some circumstances, cause the slow formation of ettringite.

Where has DEF been found?

The most common occurrence of DEF worldwide has been in heat cured precast concrete components, such as railway sleepers. It is estimated that DEF may also have occurred in around 60 in-situ concrete civil engineering structures in the UK, such as bridges and foundations.

What are the consequences of DEF?

DEF in already hardened concrete leads to expansion with visible displacement and cracking. Structural collapse without the warning signs of displacement and cracking is most unlikely. DEF can, however, increase the risk of secondary forms of deterioration such as freeze/thaw attack or reinforcement corrosion. Each case of suspected DEF should be assessed individually.

How can DEF be prevented?

As stated in the British Standard for Concrete BS 8500-1, where the heat of hydration of accelerated curing is likely to take the concrete temperature above 70°C the potential for DEF should be considered. Limiting the internal concrete temperature to 70°C during its early life will minimise the risk of subsequent DEF. This can be achieved either by direct specification, or indirectly by limiting the cement content or specifying the use of low or very low heat cement.

Where can I find out more?

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Further reading

BRE IP 11/01, 2001, *Delayed ettringite formation: in-situ concrete*.

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