Science for Environment Policy
DG Environment News Alert Service
European Commission

30 June 2011

Reinforced concrete more liable to damage under climate change

Higher atmospheric carbon dioxide levels and temperatures under climate change are likely to increase the rate of corrosive damage in reinforced concrete structures, according to a recent study. This could result in costly repairs in the future, unless structures are suitably adapted.

Concrete structures, such as buildings, bridges and harbours, reinforced with internal metal bars for added strength are an integral part of social and economic activities in modern societies, with some infrastructures built to last hundreds of years. However, it is thought that higher atmospheric CO_2 and rising temperatures projected under a changing climate could increase the rate of corrosion of the reinforcing metal resulting in serious cracking of reinforced concrete structures. Weakened infrastructure will cost more to repair and disrupt the use of facilities in the future.

This study investigated climate change impacts on the risk of corrosive damage to concrete structures over 100 years, from 2000 to 2100, by modelling changes in CO_2 concentration, temperature and humidity in two Australian cities: Sydney (representative of a temperate climate) and Darwin (representative of a tropical climate).

Three scenarios were compared with a baseline of keeping CO_2 concentrations at 2000 levels: 1) high CO_2 emissions, 2) medium CO_2 emissions and 3) reduced CO_2 emissions brought about by policy measures to mitigate climate change, but still higher than baseline levels. Concrete structures were located in different types of sites exposed to a range of water impacts, for example, submerged, in a tidal zone and dry inland. Corrosion impacts were modelled from two sources: exposure to CO_2 in the atmosphere ('carbonation') and exposure to chloride, from salty water and air.

It was found that reinforced concrete structures were more susceptible to corrosion by carbonation, affected by increased CO_2 levels in the atmosphere, than by chloride-induced corrosion under all three future scenarios. By 2100, it is likely that 20-40 per cent of all concrete infrastructure, in these two cities representing two climate types, will be damaged, requiring maintenance or repairs.

For the worst case scenario, with the greatest CO_2 emissions, carbonation damage is up to 460 per cent higher than for the base case (where emissions remain the same as year 2000 levels) for dry inland regions or temperate climates. Structures here would need extra attention to adapt to the more damaging environment.

Although higher temperatures under climate change will increase chlorine-induced corrosion under all emission scenarios, the risk of corrosive damage will increase by a maximum of 15 per cent under the worst case scenario, compared with the base case scenario. Nevertheless the risk of corrosion is already high for marine structures located in tidal splash areas, so these structures especially require further protective measures to adapt to the extra risk of damage caused by climate change.

In planning future infrastructure using reinforced concrete, the costs associated with adaptations (such as extra concrete cover or special coatings) to mitigate anticipated increases in corrosion damage should be factored into the design of the structures.

Source: Stewart, M.G., Wang, X., Nguyen, M.N. (2011) Climate change impact and risks of concrete infrastructure deterioration. *Engineering Structures*. 33: 326–1337.
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Theme(s): Climate change and energy, Urban environments