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Structural Safety

Volume 35, March 2012, Pages 29 – 39

Climate change adaptation for corrosion control of concrete infrastructure

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http://dx.doi.org/10.1016/j.strusafe.2011.10.002, How to Cite or Link Using DOI

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Abstract

The durability of concrete is determined largely by its deterioration over time which is affected by the environment. Climate change may alter this environment, especially in the longer term, causing an acceleration of reinforcement corrosion that will affect the safety and serviceability of concrete infrastructure in Australia, US, Europe, China and elsewhere. This paper reviews advanced simulation procedures to predict increases in damage (corrosion) risks under a changing climate in Australia in terms of changes in probability of reinforcement corrosion initiation and corrosion induced damage due to (i) increase in the concentration of CO_2 in the atmosphere, and changes to (ii) temperature and (iii) humidity. These time and spatial variables will affect the penetration of aggressive agents CO_2 and chlorides into concrete, and the corrosion rate once corrosion initiation occurs. The effectiveness of adaptation measures for new and existing buildings, bridges, and other concrete infrastructure is then assessed. Carbonation-induced damage risks may increase by more than 16% which means that one in six structures will experience additional and costly corrosion damage by 2100. We show that the impact of climate change on infrastructure deterioration cannot be ignored, but can be addressed by changes to design procedures including increases in cover thickness, improved quality of concrete, and coatings and barriers. For example, an increase in design cover of 10 mm and 5 mm for structures where carbonation or chlorides govern durability, respectively, will ameliorate the effects of a changing climate.

Highlights

► Increased CO_2 levels and temperature can increase the corrosion of RC structures. ► Carbonation-induced damage risks may increase by an additional 16%. ► Climate impact reduced by an increase in design cover (5 – 10 mm) or strength grade.

Keywords

Climate change; Corrosion; Concrete; Risk; Climate adaptation; Damage; Deterioration; Infrastructure; Reliability

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Figures and tables from this article:

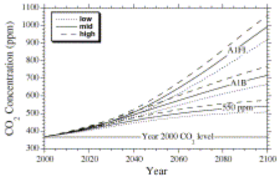

Fig. 1. Predicted low, mid and high estimates of CO_2 concentrations.

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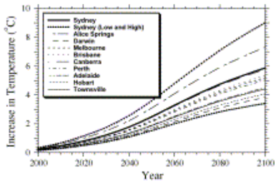

Fig. 2. Predicted median temperatures, and low and high estimates for Sydney, using CSIRO Mk3.5 climate model for the A1FI emission scenario.

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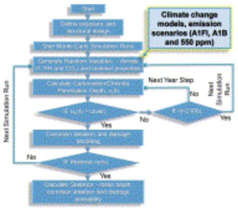

Fig. 3. Flowchart of simulation of concrete deterioration under climate change.

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Fig. 4. Environmental exposure of concrete structures in Australia.

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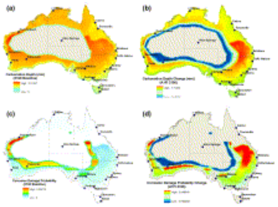

Fig. 5. Carbonation-induced corrosion of concrete structures by 2100: (a) Mean carbonation depth without consideration of climate change, (b) Change in carbonation depth for A1FI emission scenario, (c) Probability of corrosion damage without consideration of climate change, (d) Change in probability of corrosion damage for A1FI emission scenario [34].

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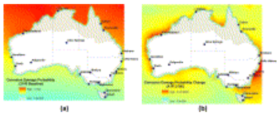

Fig. 6. Probability of chloride-induced corrosion damage of concrete structures by 2100: (a) Probability of corrosion damage without consideration of climate change (baseline), (b) change in probability of corrosion damage considering A1FI emission scenario [34].

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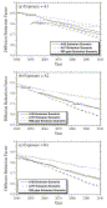

Fig. 7. Diffusion coefficient reduction factor for concrete structures to maintain the same probability of carbonation-induced corrosion damage at a given year for concrete structures that meet the requirement of AS3600 for exposures A1, A2 and B1 without consideration of climate change, for Sydney and Darwin.

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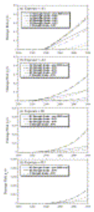

Fig. 8. Probability of carbonation-induced corrosion damage of concrete structures in exposure A1, A2, B1 and B2 in Darwin under climate change (A1FI emission Scenario), with a given strength grade of concrete that meets the requirement for higher exposure in AS3600 (The probability is represented by decimal numbers).

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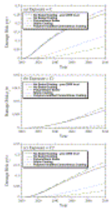

Fig. 9. Chloride-induced corrosion damage probability in Adelaide for different coatings, for exposures C, C1 and C2 and A1FI emissions scenario.

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Table 1. Durability design specifications for concrete structures in Australia and .

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Table 2. Minimum cover (mm) required to counteract the impact of climate change on carbonation-induced corrosion damage risks by 2100.

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Table 3. Minimum cover (mm) required to counteract the impact of climate change on chloride-induced corrosion damage risks by 2100.

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Table 4. Exposure indicator for the minimum strength grade required to counteract the impact of climate change on carbonation-induced corrosion damage.

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Table 5. Parameters selected for the simulation of surface treatment for chloride penetration [8].

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