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Rapid changes in the physical properties of rock and concrete during intertidal exposure; implications for weathering and engineering durability

Martin A. Coombes (1), Larissa A. Naylor (1), and Alejandra Feal-Pérez (2)

(1) School of Geography, University of Exeter in Cornwall, Penryn, Cornwall, UK (correspondence: mac215@exeter.ac.uk),
(2) Departamento de Xeografía, University of Santiago de Compostela, Galicia, Spain

Water absorption is an important parameter affecting the susceptibility of rocky shore substrates and construction materials to wetting-drying, salt weathering and dissolution processes exposed in the intertidal zone. Strength is also an important determinant of durability and resistance to erosion processes such as abrasion. Here we examine changes in the water absorption properties and strength of representative materials used in the construction of coastal defences after 8 months exposure in the intertidal zone.

Blocks of Portland limestone, Cornish granite and marine concrete were attached to shore platforms in Cornwall, UK, at Mean Tide Level. After 8 months exposure, Water Absorption Capacity (WAC) was determined (in both fresh water and synthetic seawater) for exposed and control samples, and strength was measured using Point Load and Equotip surface hardness tests. Differences between exposed and control samples were examined with ANOVA, using material type (3 levels; limestone, granite and concrete) and treatment (2 levels; control and field exposed) as fixed factors.

There were significant differences in the WAC of field exposed materials compared to unexposed controls after 8 months ($p = 0.02$). Post-hoc Student Newman Kuels (SNK) tests also revealed significant material x treatment combinations in both fresh and synthetic seawater ($p < 0.01$). Field exposed concrete had lower water absorption compared to controls ($p < 0.05$), which was associated with the development of a surface bio-chemical crust (observed using SEM) and an increase in surface hardness (Equotip test, Student's t-test $p = 0.05$). In contrast, WAC of limestone in fresh and synthetic seawater was higher for exposed samples compared to controls, but was only significant in fresh water ($p = 0.05$). SEM examination suggests that extensive borehole erosion of exposed limestone probably explains these differences. Surface hardness of exposed limestone was lower than controls, which may also be associated with boring activity, but this was not statistically significant after 8 months. Water Absorption Capacity and surface hardness were no different between controls and field exposed granite samples. Point Load tests showed no detectable changes in bulk material strength of any material after 8 months exposure.

Results are discussed with respect to early-stage physical changes of natural rock and artificial materials exposed in the intertidal zone during the construction of hard coastal defences. In particular, the role of material composition in determining responses to exposure, and temporal changes in the susceptibility of natural rock and concrete to different intertidal weathering and erosion processes, are discussed.