# $^{1}$H NMR APPLIED TO CEMENT SAMPLES

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Outline:

Measuring cement paste porosity is not an easy task due to the complexity of the material. It forms a complex network of pores, full of water, which is difficult to probe experimentally. C-S-H hydrate, the active component of cement, is known to be calcium silicate layers separated by nano-pores called “interlayer” and “gel pores”. Up to now, there has not been an experimental method available that is able to adequately characterise as-prepared C-S-H without removing the water: a procedure that damages the very nano-scale structures that are of interest.

$^{1}$H NMR has been used to quantify the primary reservoirs of water in hydrating cement pastes, including C-S-H. The method is able to separately quantify water in solid crystalline phases (Portlandite & Ettringite), C-S-H interlayer water, C-S-H gel water and capillary pore water.

The results show clear evidence of densification of C-S-H over the time with a transition from growth of low-density product containing gel pores to higher density product devoid of gel pores.

A careful analysis of the signals has lead to an updated version of Powers’ classical model from 1947. In contrast to the single “hydrate” of Powers, NMR differentiates between C–S–H and calcium hydroxide and separates out the interlayer water within the C–S–H. It shows a clear nonlinearity in the growth of the different fractions with degree of hydration (figure 1). In addition, C-S-H density and chemical equation can be work out at any time.

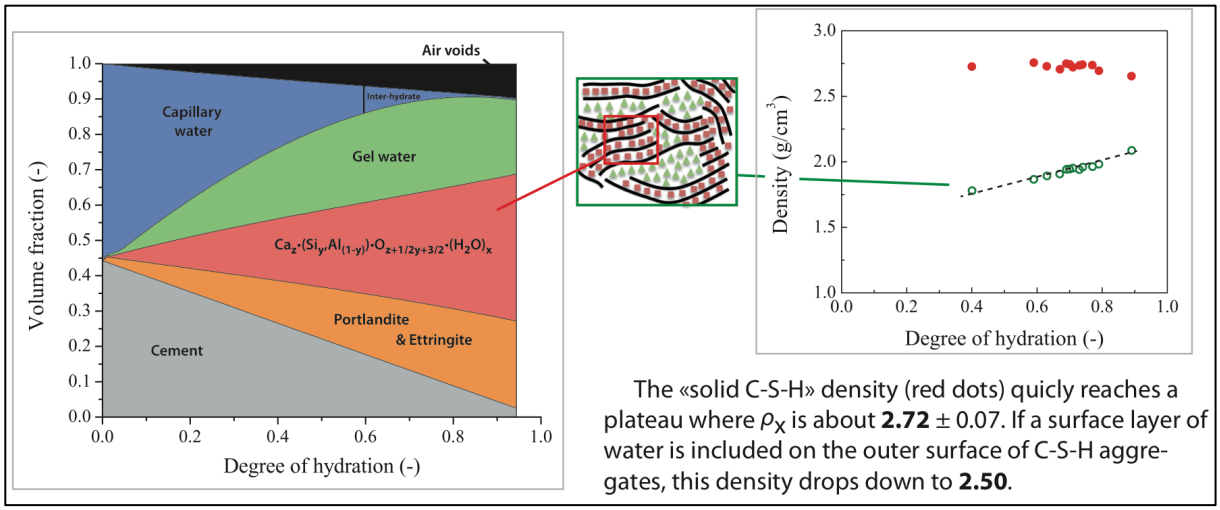


*Figure 1: Updated Powers’ model arising from NMR signal analysis.*