Hall's Notes and Queries

NQ4

Hirschwald redux

Julius Hirschwald (1845–1928) was a German crystallographer and mineralogist. He was of the generation that developed the theory of geometrical crystallography after the principles were set out by Haüy and others. His Dr. phil. dissertation at Tübingen in 1868 was about the orthorhombic crystal system. In 1875 Hirschwald went as professor to the Königliche Gewerbeakademie in Berlin, a technical institute that soon became a part of the Technischen Hochschule and later the Technische Universität Berlin. From the 1880s Hirschwald devoted his professional life to the scientific study of building stones, and eventually in 1912 published his monumental book *Handbuch der Bautechnischen Gesteinsprüfung*[1], the cover of which is shown in Fig 1.

This NQ is to remember him as a pioneer of what we now call physical properties measurement, the source of foundational data for all construction materials. Hirschwald developed many of the standard test methods for properties such as porosity, density and water absorption, and applied these methods to a huge range of building stones, for the purpose of understanding weathering behaviour and frost damage. Hirschwald's data and know-how were later trans-

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[1] J Hirschwald (1912), Handbuch, Bornträger, Berlin

Handbuch Der Bautechnischen Gesteinsprüfung Für Beamte Der Materialprüfungsanstalten Und Baubehörden, Steinbruchingenieure, Architekten Und Bauingenieure

Sowie Für Studierende Der Technischen Hochschulen

Scholar SELECT

JULIUS HIRSCHWALD

Figure 1: Hirschwald's *Handbuch* of 1912.

ferred to the German federal materials testing laboratory in Berlin, the organisation that we know today as BAM.

Hirschwald's name appears several times in WT3e[2]. This is partly because we wished to revive the use of the *Hirschwald coefficient* to describe the amount of air-trapping in simple capillary absorption. Hirschwald himself called this property the Sättigungskoeffizient (saturation coefficient), denoted it S, and defined it as the ratio of the weight of water absorbed in a capillary absorption test to the weight absorbed under high pressure. Today the weight absorbed under high pressure would be replaced by the weight absorbed under vacuum. Hirschwald tabulated the saturation coefficient of around three hundred German stones (*Handbuch*, pp. 779ff). The range in S is large, for example in limestones from 0.30 (Rüdersdorf) to 0.94 (Limburg). Fig 2 shows Hirschwald's S data on 164 sandstones. It should be noted in passing that the trapping of air during capillary absorption had been observed and reported earlier by Bloxam in a Scottish sandstone[3]. However Hirschwald's data showed that air is trapped universally in primary capillary imbibition, and that the amount varies greatly from stone to stone. Even today, we lack a simple predictive model for this process.

The fractional Hirschwald saturation coefficient (which we now denote h) has been largely superseded in the literature of construction materials by the *capillary moisture content*[4] usually denoted w_{cap}. This quantity is the weight of water at the end of primary imbibition per unit bulk volume of material. We argue that w_{cap} is less informative than h since it does not directly show what fraction of

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[2] C Hall & W D Hoff (2021) Water transport in brick, stone and concrete, third edition, CRC Press.

[3] T Bloxam (1857) The analysis of Craigleith sandstone. Proceedings of the Royal Society of Edinburgh, **3**, 390–395.

[4] See H Hens (1976) Die hygrischen Eigenschaften von Ziegel. Proceedings of the 4th International Brick Masonry Conference, Bruges, Belgium.

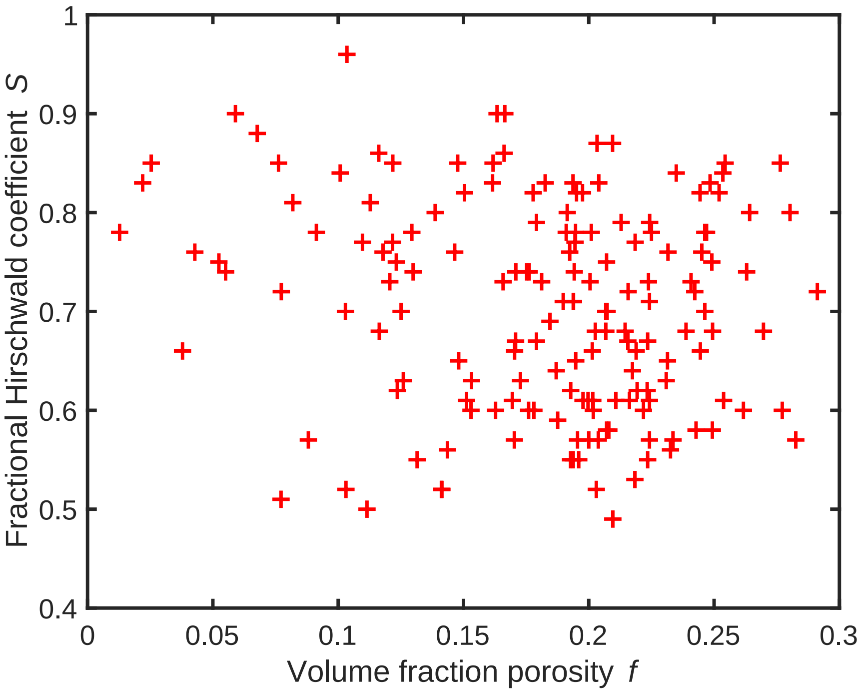

Figure 2: Hirschwald's saturation coefficient S plotted against his measured porosity for 164 sandstones, from *Handbuch*. The mean of S is 0.71 (s.d 0.11). The porosity is used only for purposes of display – it clearly has no explanatory value.

the porosity is filled with residual air. For a fuller explanation of the merit of using h rather than w_{cap}, see WT3e, p176, note 22.

A second reason for the appearance of Hirschwald's name in WT3e is that in that edition we coin the term the *Hirschwald state* to describe the *moisture state* of a sorptive material following simple capillary imbibition. We find it helpful to have this term to use descriptively or even qualitatively for the state of unsaturation at the end of primary imbibition. Because of the presence of trapped air, the water content $\theta = \theta_{\mathsf{h}} < \theta_s$, where θ_s is the saturated water content.

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30 April 2024