A17: Water penetration in brick masonry: Impact of brick type and workmanship

Seyedmohammad Kahangi Shahreza*[a], Nathan Van Den Bossche[b]

a Department of Building and Environmental Technology, Division of Structural Engineering, Lund University, Lund, Sweden
b Building Physics Group, Faculty of Engineering and Architecture, Ghent University, Ghent, Belgium

* Corresponding author: mohammad.kahangi@kstr.lth.se

How to cite: Shahreza, S. K., Van Den Bossche, N. (2025) Water penetration in brick masonry: Impact of brick type and workmanship. In: Abstracts of *the 3rd International Conference on Moisture in Buildings 2025*, 23-24 Oct 2025, Portugal. *UCL Open Environment*: UCL Press; 2025. Pp 1-3. DOI: 10.14324/111.444/ucloe.icmb25.a17

Peer review statement
This abstract has undergone single blind review by the ICMB25 Conference Scientific Committee.

About the conference
The following abstract is from the 3rd International Conference on Moisture in Buildings (https://ukcmb.org/icmb25) held in UM Guimarães, Portugal, on the 23-24 Oct 2025. All abstracts published here underwent single blind review by the Conference Scientific Committee.

Abstract
This study investigates the impact of brick types and workmanship on water penetration in brick masonry veneer walls. Masonry specimens, built by two masons using solid and perforated bricks with two different laying methods, were subjected to an average water spray rate of 28 $l/m^2 \cdot h$. Results indicate that, on average, the water penetration rate was approximately twice as high in solid bricks as in perforated bricks. The workmanship could significantly influence the penetration rate in solid bricks, with rates varying up to eightfold depending on the mason's skill and technique. However, workmanship variations had negligible effects on penetration rates for perforated bricks. These findings emphasize the significance of workmanship, particularly in the case of solid bricks, in ensuring the hygrothermal performance and durability of masonry walls.
Keywords: water infiltration; moisture ingress; workmanship; perforated brick; solid brick

---

1. Introduction/Background

In Northern Europe, wind-driven rain (WDR) is the dominant moisture source affecting masonry façades and may lead to water penetration. Such moisture ingress influences the hygrothermal performance of building envelopes, leading to increased moisture accumulation, which may result in mold growth, wood decay, and a reduction in insulation performance. However, quantifying water penetration remains a challenge due to the interplay of multiple factors, including WDR characteristics, material properties, and workmanship quality [1].

Among these, workmanship is frequently identified as the most critical factor [2, 3], encompassing aspects such as joint thickness, bricklaying technique, mortar joint profile, use of a separate pointing mortar, and the tooling method. While best practice recommendations regarding workmanship emphasize achieving full bed and head joints, head joints can be formed using different techniques, with the most common being "pushing" and "buttering". In the pushing technique, mortar is placed on the bed joint and formed into a head joint by pushing the brick into place. In the buttering technique, mortar is directly applied onto the brick's head face before placement [3]. Previous studies [1, 4] identified head joints as the primary pathway for water penetration, prompting a detailed investigation of these techniques in the current study.

2. Material and methods

Two brick types were evaluated: solid and perforated bricks, both conforming to the Swedish standard format of 250 × 120 × 62 mm^3. The solid bricks exhibited an average IRA of 2.1 kg/m²·min, classifying them as medium-suction bricks, with a water absorption coefficient (A_w) of 0.284 $kg/m^2 \cdot s^{0.5}$. The perforated bricks had a lower IRA of 1.53 kg/m²·min and an A_w of 0.178 $kg/m^2 \cdot s^{0.5}$. A factory-mixed dry mortar M 2.5, supplied by Weber Saint-Gobain, which is a cement-based mortar containing Portland cement, lime filler, natural sand (0–3 mm), and additives, including an air-entraining agent, was used for preparing masonry specimens. In accordance with common Swedish practice, the specimens were constructed without prewetting.

A total of 16 masonry specimens, each with approximate dimensions of 0.8 m × 0.5 m and with nominal mortar joint thickness of 15 mm, were prepared (see Figure 1 (left)) by two masons, referred to as Mason A and Mason B. Mason A, who had comparatively less experience, constructed six specimens using the pushing technique. Among these, three specimens were built with solid bricks and three with perforated bricks. Mason B prepared ten specimens, divided into four groups. Six of these specimens were built using the buttering technique, with three constructed from solid bricks and three from perforated bricks. The remaining four specimens were built using the "pushing" technique, with an equal split between solid and perforated bricks.

The setup, developed by Kahangi Shahreza et al. [4], equipped with two scales, was used to measure water absorption and penetration continuously. Specimens (initially dry masonry stored at controlled laboratory conditions) were exposed to a spray rate of around 28 l/m²·h for 23 hours with no air pressure difference applied. This setup mimics real-world conditions better than widely used standards, such as ASTM E514 (138 l/(m²·h)) and EN 1027 (120 l/(m²·h)), which employ higher spray rates to represent (very) extreme WDR events.

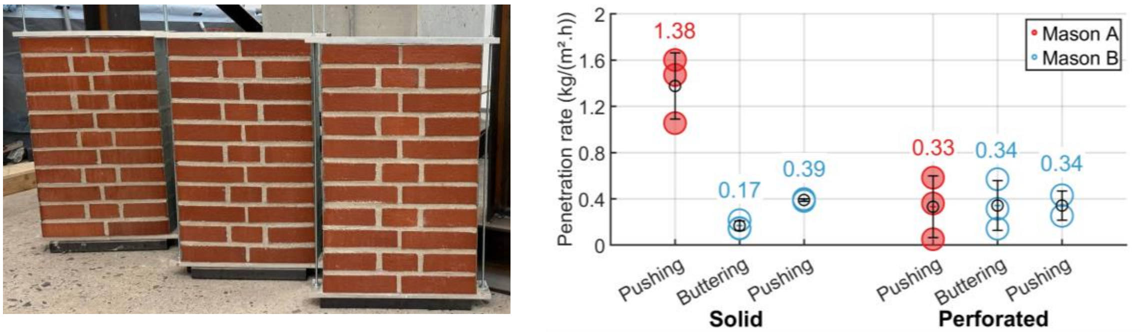

Figure 1. Representative masonry specimens prepared (left), and water penetration rate (kg/(m²·h)) in brick masonry grouped by brick type (solid and perforated), workmanship technique (pushing and buttering), and mason (Mason A and Mason B) (right).

3. Results and discussion

The results in terms of water penetration rate for individual specimens are shown in Figure 1 (right). On average, specimens built with solid bricks exhibited a penetration rate of approximately 0.65 kg/(m²·h), nearly twice the rate observed for perforated brick specimens, at around 0.34 kg/(m²·h). In terms of leakage—defined as the ratio between the water penetration rate and the water spray rate—this corresponds to 2.3% and 1.2%, respectively. The highest average penetration rate, 1.38 kg/(m²·h), corresponding to a leakage of 4.9%, was recorded for specimens built from solid bricks by Mason A using the pushing technique. Conversely, the lowest average rate of 0.17 kg/(m²·h)—equivalent to a leakage of 0.6%—was observed in solid-brick specimens prepared by Mason B employing the buttering technique. These findings highlight the important role of mason skill in achieving watertight masonry, particularly when working with solid bricks. In the case of specimens built with perforated bricks, differences in mason skill and workmanship technique were negligible. All groups showed comparable average penetration rates around 0.34 kg/(m²·h), equivalent to a leakage of roughly 1.2%.

Building on these results, a comparison using the same technique shows clear differences due to mason experience. Even when employing the same workmanship technique, the penetration rate for solid bricks built by Mason A (1.38 kg/(m²·h)) was approximately 3.5 times higher than that achieved by Mason B (0.39 kg/(m²·h)). This notable difference can primarily be attributed to Mason A's comparatively lower experience. Due to Mason A's inexperience, insufficient pressure was applied when pushing bricks into the mortar to adequately form/fill the head joints, resulting in higher penetration rates. Additionally, the longer construction time per specimen by Mason A may have negatively impacted the overall quality of the masonry. It should also be noted that each mason prepared mortar batches according to their preferred consistency and flow; although not quantified here, this variable likely influenced the observed results.

4. Conclusions

The results highlight the substantial influence of workmanship on water penetration in solid brick masonry. Mason's skill and chosen masonry technique significantly affected water penetration rates, with specimens prepared using the pushing technique by Mason A exhibiting penetration rates eight times higher than those constructed using the buttering technique by Mason B. Conversely, in perforated brick masonry, variations in workmanship and mason skill showed negligible impacts, indicating inherent resistance to water penetration irrespective of laying methods.

References

[1] S. Van Linden and N. Van Den Bossche, "Review of rainwater infiltration rates in wall assemblies," *Building and Environment,* vol. 219, p. 109213, 2022.

[2] K. Calle, C. Coupillie, A. Janssens, and N. Van Den Bossche, "Implementation of rainwater infiltration measurements in hygrothermal modelling of non-insulated brick cavity walls," *Journal of Building Physics,* vol. 43, no. 6, pp. 477-502, 2020.

[3] F. Slapø, T. Kvande, N. Bakken, M. Haugen, and J. Lohne, "Masonry's Resistance to Driving Rain: Mortar Water Content and Impregnation," *Buildings,* vol. 7, p. 70, 08/09 2017, doi: 10.3390/buildings7030070.

[4] S. Kahangi Shahreza, J. Niklewski, and M. Molnár, "Novel water penetration criterion for clay brick masonry claddings," *Construction and Building Materials,* vol. 353, p. 129109, 2022/10/24/ 2022.