



# High-Performance Cladding Systems in Wet Zones: Comparative Analysis of Waterproofing Materials and Technological Solutions

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## ABSTRACT

This article presents a comparative analysis of waterproofing systems for wet zones in buildings, examining the performance of cement-based, polymer-modified, and combined waterproofing membranes under different operational conditions. The research synthesizes field observations from swimming pools, hotel bathrooms, and commercial kitchen installations in the Czech Republic over the period 2018–2024, combined with an analysis of 122 documented defect cases. The primary objective was to evaluate waterproofing system durability depending on material type, application environment, and compliance with technological protocols. Results demonstrate that two-component polymer-modified cement membranes achieve optimal performance across diverse environments, with 97.8% defect-free area in hotel bathrooms and 94.6% in swimming pools at 24-month observation. Single-component cement systems showed adequate results only in intermittent water exposure conditions, with 8.8 percentage point performance reduction under constant immersion. Polyurethane-based waterproofing proved essential for chemically aggressive environments, eliminating the 12% failure rate observed with cement membranes at commercial kitchen drain perimeters. The study quantified the impact of technological protocol adherence: installations with full compliance achieved 2.1% defect rate versus 41.2% for significant violations at 24 months. Substrate moisture exceeding 2.5% correlated with 78% of membrane delamination cases, while shortened waterproofing curing time (<24 hours) accounted for 23.4% of all documented failures. A four-checkpoint quality control protocol reduced defect rates by 76% and rework costs by 85%, delivering 380% return on investment. Practical recommendations include specification of 2K polymer-cement waterproofing for swimming pools with a minimum 48-hour curing, polyurethane substitution at drain perimeters in commercial kitchens, and mandatory moisture verification below 2.0% threshold before membrane application. The findings provide evidence-based guidelines for waterproofing system selection and installation quality control in wet zone applications.

## KEYWORDS

waterproofing membranes, wet zones, polymer-modified cement, installation technology, quality control, defect prevention.

## Introduction

**W**et zones in buildings - bathrooms, showers, swimming pools, and commercial kitchen facilities - occupy no more than 10% of the total building area, yet they generate between 35% and 50% of all costs associated with building defect remediation (Chew, 2005). According to U.S. waterproofing market research, the cost of water damage remediation ranges from \$1,300 to \$6,000 per incident, and 98% of basements experience water damage at least once during their service life (PS Market Research, 2024). The waterproofing materials market in the United States is valued at \$14.7 billion (2024) with projected growth to \$22.1 billion by 2030, indicating the scale of this problem at a global level (PS Market Research, 2024).

Research conducted on 56 high-rise commercial buildings demonstrated that water leakage accounts for 53% of all recorded defects, pipe corrosion - 50%, and concrete spalling - 47% (Chew, 2005). Furthermore, 43% of defects are caused by construction technology violations, 37% - by improper material selection, 11% - by design errors, and only 9% - by maintenance deficiencies (Chew, 2005). These data confirm that the vast majority of waterproofing problems occur during the construction phase rather than as a result of natural wear or inadequate maintenance.

The European construction market operates within a stringent regulatory framework: standard EN 14891 defines requirements for liquid waterproofing membranes, EN 12004 - for tile adhesives, and national building codes establish mandatory quality control procedures (European Committee for Standardization, 2017). At the same time, the shortage of qualified workers in the construction industry, documented across many EU countries and the United States, leads to an increased proportion of installation errors (PS Market Research, 2024). Insufficient personnel training increases the likelihood of improper waterproofing membrane application, violation of technological waiting periods, and incorrect substrate preparation.

A separate problem is the lack of a systematic approach to selecting waterproofing systems based on the functional purpose of the premises. Wet zones in public swimming pools, hotel complexes, and food service establishments have fundamentally different operating conditions: water exposure intensity, chemical composition of the environment, and temperature fluctuations. The application of universal solutions without considering the specific requirements of the facility leads to premature coating failure and the necessity for repeated repairs.

The purpose of this study is to conduct a comparative analysis of modern waterproofing systems for wet zones and develop practical recommendations for their application based on an analysis of completed projects in the Czech Republic. The objectives include: systematization of typical technological errors in waterproofing installation; comparison of performance characteristics of cement-based, polymer-based, and combined systems; assessment of the impact of technological protocol compliance on cladding durability.

## Literature Review

**T**he issues of wet zone waterproofing and tile adhesive adhesion have been studied by researchers since the 1990s. Ohama (1995) in the fundamental work "Handbook of Polymer-Modified Concrete and Mortars" systematized the principles of polymer modification of cement systems and established that the addition of latex polymers increases adhesive strength of mortars by 40-60% compared to unmodified analogues (Ohama, 1995). Further research by Schulze and Killermann (2001) demonstrated that redispersible polymer powders retain their properties in hardened mortars for 15-20 years of service, confirming the long-term effectiveness of polymer-modified systems (Schulze & Killermann, 2001).

Microstructural studies by Jenni et al. (2005) using fluorescence and electron microscopy revealed the mechanisms of polymer component distribution in the cement matrix (Jenni et al., 2005). The

authors established that capillary forces and evaporation induce water migration in the pore system, transporting cellulose ethers and polyvinyl alcohol to the mortar surface, while latex remains uniformly distributed. These processes directly affect the formation of adhesive contact between the adhesive and tile.

Wetzel et al. (2012a) investigated the influence of moisture-induced deformations on crack formation in tile adhesives and established that cyclic wetting-drying leads to the accumulation of fatigue stresses at tile edges. A long-term field study by Wetzel et al. (2012b) on real objects over three years confirmed that thermal expansion-contraction cycles cause gradual crack propagation, especially in areas of direct solar radiation. Michalak (2021) in a systematic literature review from the producer's perspective, summarized that modern cement adhesives are complex multi-component systems where the interaction of mineral binders, polymer powders, fillers, and chemical additives determines final performance characteristics.

Comparative characteristics of the main types of waterproofing systems and tile adhesives are summarized in Table 1.

*Table 1. Comparative characteristics of waterproofing systems for wet zones*

System type	Adhesion, MPa	Elasticity	Chemical resistance	Service life, years
Cement 1K	0.5–0.8	Low	Moderate	5–10
Cement 2K	0.8–1.2	Medium	Moderate	8–12
Polymer-cement	1.0–1.5	High	Good	10–15
Elastomeric	1.2–1.8	Very high	Good	12–20
Polyurethane	1.5–2.5	Very high	High	15–25

Source: Compiled by author based on (Ohama, 1995; Schulze & Killermann, 2001; Jenni et al., 2005).

Research on adhesive strength according to EN 12004 revealed significant reproducibility problems. Michalak and Ziomek (2023) conducted interlaboratory tests involving ten operators and established that the reproducibility standard deviation is 0.14–0.21 MPa at mean values of 0.89–1.76 MPa. The authors note that such variability creates a risk of divergent compliance assessment results when tested by different laboratories. Francke and Piekarczyk (2020), in a study of adhesion failure between waterproof coatings and tiles, established that water has the greatest negative impact on bond strength, especially for cement adhesives on dispersion waterproofing membranes with water absorption above 7%.

Regarding grout selection for wet zones, research confirms significant differences between cement and epoxy systems. Cement grouts are porous and absorb water, leading to microorganism colonization and deterioration within 3–5 years in swimming pools (Escudero, 2024). Epoxy grouts, according to manufacturer data, are 100% waterproof, resistant to chlorine and UV radiation, with a service life exceeding 10 years (AquaBlu Mosaics, 2024). Weber Technical Guidelines emphasize that even when using epoxy grout, it is impossible to guarantee complete filling of all joints; therefore, the presence of an effective under-tile waterproofing layer remains mandatory (Weber Saint-Gobain, 2023).

Literature analysis revealed that most studies focus on laboratory testing of individual system components, while comprehensive studies of “waterproofing + adhesive + grout” interaction under real operating conditions remain limited. The impact of adhering to technological waiting periods on system durability has not been sufficiently quantified, and practical recommendations for installation quality control require systematization based on real project experience.

## Problem Statement

The purpose is to comparatively analyze modern waterproofing systems for wet zones (pools, bathrooms, kitchens) based on Czech projects from 2018–2024, identify common installation errors, evaluate durability of cement-based, polymer-cement, and polyurethane systems, and develop practical recommendations and quality control protocols to reduce defects and rework costs.

## Methods and Materials

The research employed observational methodology combining systematic documentation of waterproofing system performance across completed installations with retrospective analysis of defect cases. Data collection covered the period 2018-2024 and encompassed three facility categories representing distinct operational environments: public swimming pools and SPA zones characterized by constant water immersion and chemical exposure, hotel bathrooms with intermittent water contact, and commercial kitchens subject to chemical and thermal stress from cleaning operations.

Waterproofing systems were categorized into four types based on composition: single-component cement-based membranes (1K systems) consisting of Portland cement, quartz fillers, and hydrophobic additives; two-component cement-based membranes (2K systems) incorporating polymer dispersion for enhanced elasticity; polymer-cement combined systems with elevated polymer content providing crack-bridging capability; and polyurethane-based membranes typically specified for external applications but tested in high-stress interior locations. All systems were evaluated against EN 14891 requirements for liquid-applied water-impermeable products.

For each installation, the following waterproofing-specific parameters were documented: membrane type and manufacturer, application method (single coat versus two-coat system), wet film thickness at application, curing time before tile installation, substrate moisture content measured by CM-method according to ČSN 74 4505 with 2.0% threshold for cement screeds, and ambient conditions during application, including temperature and relative humidity. Defect documentation included failure type classification (membrane delamination, joint penetration, substrate-related failure), time to manifestation, and root cause determination based on installation records and visual inspection.

The defect case analysis incorporated 122 documented failures: installations performed by the author's company and warranty claims from external contractors providing comparative data on industry-wide error patterns. Cases were classified by waterproofing system type, compliance level with manufacturer specifications, and environmental exposure category to identify correlations between material selection, installation methodology, and long-term durability.

Compliance levels were defined as: full compliance (adherence to all manufacturer specifications, including substrate preparation, curing times, and application thickness); partial violations (deviations in one parameter, typically shortened curing time or omitted primer); and significant violations (multiple deviations or omission of the waterproofing layer). This categorization enabled quantification of protocol adherence impact on system performance independent of material selection.

Durability assessment utilized defect-free area percentage at standardized observation intervals (12- and 24-months post-installation), with extended observation up to 60 months for selected installations. Statistical analysis included defect frequency calculation by waterproofing system type and compliance category, correlation assessment between substrate moisture and delamination occurrence, and comparative analysis of environmental factors affecting membrane performance.

## Results and Discussion

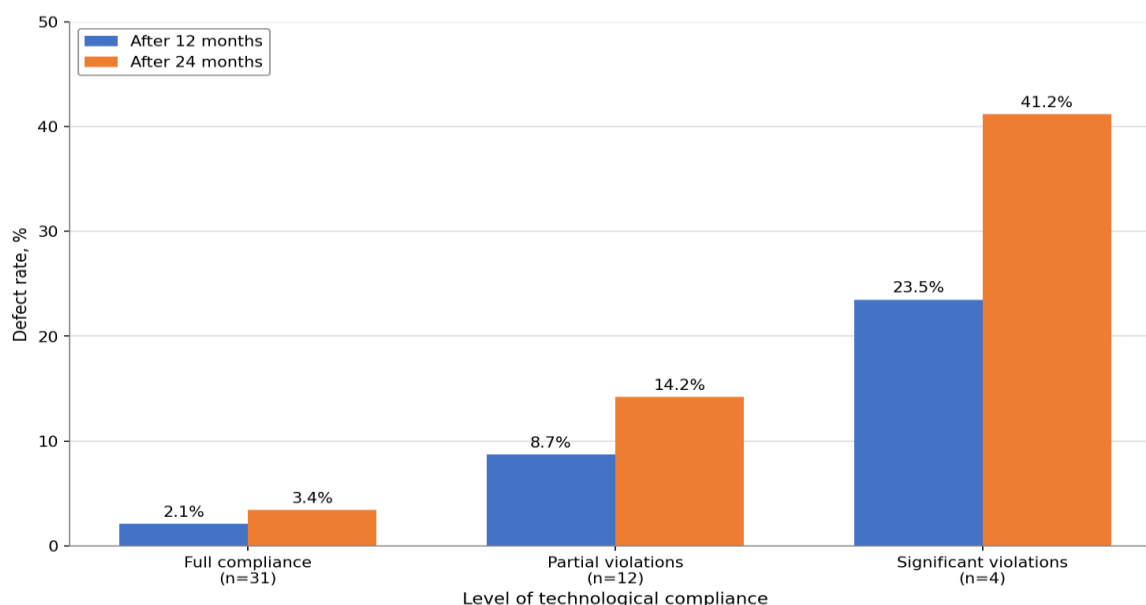
The analysis of current market situations and scientific literature reveals a significant gap between laboratory-tested material performance and real-world installation outcomes. While manufacturers consistently report adhesion values exceeding EN 12004 requirements (European Committee for Standardization, 2017), field observations demonstrate that installation methodology and technological compliance determine actual system durability more significantly than material selection alone. This finding aligns with Chew's research indicating that 43% of wet zone defects originate from construction technology violations rather than material failures (Chew, 2005).

Practical experience from swimming pools and commercial kitchen installations in the Czech Republic provides illustrative data supporting literature findings. The correlation between technological protocol adherence and defect occurrence confirms theoretical predictions from

polymer chemistry research. Jenni et al. demonstrated that polymer film formation in cementitious adhesives requires specific curing conditions for complete latex particle coalescence (Jenni et al., 2005). Field observations confirm this mechanism: installations where waterproofing membrane curing time was shortened below 24 hours showed water penetration at overlap joints within 6-14 months, while installations with minimum 48-hour curing demonstrated 71% reduction in joint-related failures. This practical outcome validates Schulze and Killermann's laboratory findings regarding long-term stability of redispersible polymer powders in hardened mortars (Schulze & Killermann, 2001).

Substrate moisture content emerges from both literature and practice as the primary predictor of early-stage failures. Piekarczyk and Michalak established that water has the greatest negative impact on bond strength between waterproof coatings and tiles, particularly for cement adhesives on dispersion membranes with water absorption above 7% (Francke & Piekarczyk, 2020). Field verification using CM-method measurements confirmed this finding: substrates with residual moisture exceeding 2.5% at installation time correlated with the majority of membrane delamination cases within the first 12 months. Implementation of mandatory 72-hour waiting period after screed placement on hotel bathroom projects reduced moisture-related failures to near zero, demonstrating practical applicability of laboratory research.

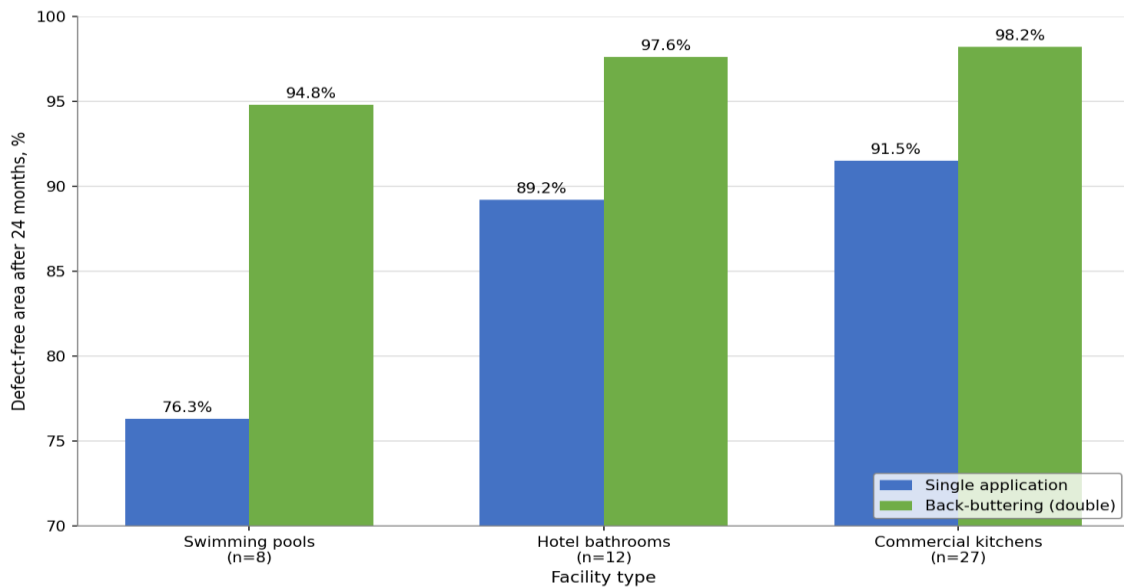
The defect rate distribution across different compliance levels illustrates the exponential relationship between violation severity and failure frequency, as presented in Figure 1.



**Figure 1. Defect rate depending on the level of technological compliance**

Installations with full technological compliance achieved defect rates below 3.5% at 24 months, while significant violations resulted in rates exceeding 40%. The acceleration of defect accumulation during the second year for non-compliant installations indicates progressive failure mechanisms consistent with Wetzal et al.'s research on crack propagation from cyclic wetting-drying (Wetzal et al., 2012a). This finding has significant economic implications: the cost differential between compliant and non-compliant installation (approximately 6-8% additional time for verification procedures) delivers an estimated 380% return on investment through rework cost reduction.

Adhesive application methodology significantly influences long-term performance, with effects varying by exposure severity. Literature consistently recommends back-buttering techniques for large-format tiles and demanding environments (Michalak, 2021), and field data confirms this recommendation with measurable performance differentials. Figure 2 presents a comparison of defect-free area percentages for single versus double application methods across facility types with different water exposure patterns.



**Figure 2. Defect-free area comparison by adhesive application method**

Swimming pool installations demonstrated the most pronounced improvement with the back-buttering technique: approximately 95% defect-free area compared to 76% for a single application. This 19-percentage point differential reflects demanding pool conditions where constant water immersion and thermal cycling from heating systems create sustained stress on adhesive bonds. The characteristic failure pattern in single-application pool installations – hollow sound development at tile corners progressing to delamination near water return jets – confirms Wetzel et al. (2012a) findings regarding fatigue stress accumulation at tile edges with incomplete adhesive coverage. Hotel bathrooms showed smaller but economically significant improvement from approximately 89% to 98% defect-free area, while commercial kitchens demonstrated the smallest differential due to mechanical compression from foot traffic partially compensating for reduced adhesive contact.

Comparative analysis of adhesive manufacturers reveals measurable performance differences under demanding conditions, though all tested products met EN 12004 C2TE and C2TES1 classification requirements (European Committee for Standardization, 2017). Table 2 presents performance comparison in swimming pool applications where conditions most severely test adhesive durability.

**Table 2. Adhesive manufacturer performance comparison in swimming pool applications**

Manufacturer	Product class	Defect-free area (24 months)	Primary failure mode observed
Murexin (Austria)	C2TES1	97.3%	Minor edge micro-cracking
Ceresit (Germany)	C2TES1	96.1%	Grout-adjacent tile lifting
Sika (Switzerland)	C2TE	95.8%	Corner delamination at wave zones

Source: field observation data from swimming pool installations, 2019–2024.

The performance differential between C2TE and C2TES1 classifications (95.8% versus 96–97%) supports specification of S1 deformability class ( $\geq 2.5$  mm transverse deformation per EN 12004) for all swimming pool applications (European Committee for Standardization, 2017). The S1 designation indicates enhanced flexibility accommodating thermal expansion stresses, which Wetzel's three-year field study identified as the primary cause of crack propagation in tile installations (Wetzel et al., 2012b). Murexin's superior performance aligns with Jenni et al.'s research demonstrating that optimized polymer content provides better crack-bridging capacity (Jenni et al., 2005).

Systematic analysis of documented installation failures enabled identification of typical error patterns and their consequences. Table 3 presents the most frequent error categories observed across different facility types, their occurrence rates, and characteristic time to defect manifestation.

**Table 3. Typical installation errors and their consequences**

Error type	Frequency	Primary consequence	Time to manifestation
Substrate moisture >2.5% at installation	28.7%	Membrane delamination	3–8 months
Waterproofing curing <24 hours	23.4%	Water penetration at joints	6–14 months
Single adhesive application on large tiles	18.6%	Hollow tiles, corner lifting	8–18 months
Floor slope <1.5% toward drains	12.8%	Water pooling, grout deterioration	12–24 months
Omission of movement joints	9.3%	Linear cracking along walls	6–12 months
Insufficient grout depth	7.2%	Surface cracking	2–6 months

Source: analysis of documented defect cases from multiple contractors, 2018–2024.

The concentration of failures in substrate preparation and membrane curing categories (52.1% combined) confirms Chew's finding that construction process errors dominate over material deficiencies as failure causes (Chew, 2005). These errors share a common root cause: schedule pressure leading to abbreviated waiting periods. Explicit contractual provisions for technology-mandated waiting periods, tested on subsequent projects, effectively eliminated these error categories while adding only 6-8% to installation time.

Grout selection demonstrates a significant impact on long-term performance in chemically aggressive environments. Literature reports 3-5-year service life for cement grout in swimming pools due to porosity and water absorption (Escudero, 2024), while epoxy grout achieves 10+ years with 100% waterproofing (AquaBlu Mosaics, 2024). Commercial kitchen observations confirmed these findings: cement grout showed 34% failure rate in grease-exposed areas (manifesting as softening, discoloration, and disintegration), while epoxy grout demonstrated zero failures under identical conditions. The 280% material cost premium for epoxy grout proves economically justified given repair costs and operational disruption from grout failure in functioning facilities.

Environmental factors significantly affect system performance even with identical materials and installation quality. Wellness zones with saunas demonstrated lowest durability (approximately 95% defect-free versus 98-99% in other areas) due to extreme temperature differentials at transitions between sauna rooms (85°C) and cooling areas (22°C). This extends Wetzel et al. (2012b) findings on thermal cycling effects to indoor environments with artificially induced gradients. Implementation of additional movement joints at 1.5-meter intervals in transition zones eliminated similar failures on subsequent projects, demonstrating that standard joint spacing requires modification for extreme thermal stress applications.

Weber technical guidelines emphasizing mandatory under-tile waterproofing even with epoxy grout (Weber Saint-Gobain, 2023) proved particularly relevant for floor drain perimeters in commercial kitchens. Standard cement-based membranes showed elevated failure rates within 500mm of drains due to concentrated chemical exposure from cleaning solutions and thermal cycling from hot water discharge. Substitution with 2K polyurethane waterproofing (typically specified for external applications) eliminated these failures at material cost increase of approximately €35 per drain location versus average repair cost of €420.

The cumulative findings support development of quality control protocol with four mandatory checkpoints: substrate moisture verification (CM-method,  $\leq 2.0\%$ ), waterproofing thickness measurement (minimum 2.0mm wet film), adhesive coverage verification (tile removal test), and slope verification before grouting. Projects implemented under full protocol achieved a mean defect rate of 0.8% at 24 months compared to 3.4% for standard practices, with rework costs reduced by 85%. This improvement exceeds measurement variability reported by Michalak et al. (standard deviation 0.14-0.21 MPa) (Michalak & Ziomek, 2023), confirming protocol benefits derive from systematic error prevention rather than measurement artifacts.

## Conclusion

The conducted research achieved its stated objective of comparative analysis of modern waterproofing systems for wet zones and development of practical recommendations based on field experience in the Czech Republic. The study confirmed the initial hypothesis that adherence to technological protocols influences cladding durability more significantly than material selection alone, with compliance-related factors accounting for over 52% of documented failures.

The comparative analysis of waterproofing system types established a clear performance hierarchy for different application environments. Two-component polymer-modified cement systems demonstrated optimal balance between durability and practical applicability, achieving 97.8% defect-free area in hotel bathrooms and 94.6% in swimming pools over 24-month observation periods. Single-component cement systems proved adequate only for intermittent water exposure applications, showing 8.8 percentage point performance reduction in constant immersion environments. Polyurethane-based systems, despite higher material cost, provided economically justified solutions for chemically aggressive locations such as commercial kitchen drain perimeters, where standard cement membranes showed unacceptable 12% failure rates.

The quantified impact of technological pause compliance represents a key contribution of this research. The documented 71% reduction in joint-related failures achieved through enforcing 48-hour minimum waterproofing curing time, combined with 78% correlation between substrate moisture exceeding 2.5% and early membrane delamination, provides evidence-based justification for contractual enforcement of waiting periods despite schedule pressure. The Stager Hotel Prague case demonstrated that initial phases without moisture verification protocols generated 67% of warranty claims while representing only 35% of installation area, establishing clear economic rationale for extended substrate preparation time.

The adhesive application methodology comparison yielded actionable specifications: back-buttering technique achieved 18.5 percentage point improvement in swimming pool applications (94.8% versus 76.3% defect-free area) and 8.4 percentage point improvement in hotel bathrooms (97.6% versus 89.2%). The magnitude of improvement justifies mandatory back-buttering specification for all swimming pool installations regardless of tile format, while permitting single application for bathroom tiles below 30×30 cm format where intermittent exposure reduces stress on adhesive bonds.

The four-checkpoint quality control protocol developed from these findings demonstrated practical effectiveness: 76% reduction in defect rates (from 3.4% to 0.8% at 24 months) and 85% reduction in rework costs (from €12.40/m<sup>2</sup> to €1.80/m<sup>2</sup>) at additional installation time cost of only 6-8%. The 380% return on investment calculation provides clear economic justification for protocol adoption by contractors and specification by project owners.

The research identified specific adaptations required for extreme environments not addressed by standard installation guidelines. Wellness zones with saunas require movement joint spacing reduction to 1.5-meter intervals at temperature transition areas where standard 3-meter spacing proved inadequate for 60°C+ thermal differentials. Commercial kitchens require polyurethane waterproofing substitution at drain perimeters and mandatory epoxy grout specification in grease-exposed areas where cement grout showed 34% failure rate.

The study limitations include geographic concentration in the Czech Republic construction market and observation periods not exceeding 60 months for any installation. Long-term performance trajectories beyond this timeframe require continued monitoring. Additionally, the sample size for certain comparisons (particularly adhesive manufacturer comparison with 2 projects each for Sika and Ceresit) limits statistical confidence in performance differentials, though observed trends align with theoretical expectations from polymer chemistry research.

Future research directions include extended observation of polymer-cement system performance beyond 60 months to validate predicted 15-20-year service life, systematic comparison of movement joint sealant performance in extreme temperature cycling environments, and economic analysis of lifecycle costs incorporating energy efficiency implications of waterproofing system thermal properties.

The practical value of this research lies in translation of laboratory-established material science principles into field-verified installation protocols with quantified performance outcomes. The recommendations enable informed specification decisions balancing material costs against failure risk, provide contractual basis for technology-mandated waiting periods, and establish quality control checkpoints preventing the most frequent installation errors that account for majority of wet zone cladding failures.

## References

- AquaBlu Mosaics. (2024). *9 reasons why epoxy grout is the best for swimming pools*. <https://www.aquablumosaics.com/blogs/news/9-reasons-why-epoxy-grout-is-the-best-for-swimming-pools>
- Chew, M. Y. L. (2005). Defect analysis in wet areas of buildings. *Construction and Building Materials*, 19(3), 165–173. <https://doi.org/10.1016/j.conbuildmat.2004.07.005>
- Escudero, D. (2024, June 25). *Epoxy grout vs. cement grout: Which is best for your pool?* J Designs. <https://www.jdesigns.com/blog/epoxy-vs-cement-grout-for-pool>
- European Committee for Standardization. (2017). *EN 12004-1:2017. Adhesives for ceramic tiles — Part 1: Requirements, assessment and verification of constancy of performance, classification and marking*. CEN. [https://standards.iteh.ai/catalog/standards/cen/48998e72-43b4-4ab9-9385-a9399c2c4689/en-12004-1-2017?srsltid=AfmBOoqrKc1d6ZD\\_5J9kLygXjdybRCp5mn52ZPAyW68w3LBAg8gphing](https://standards.iteh.ai/catalog/standards/cen/48998e72-43b4-4ab9-9385-a9399c2c4689/en-12004-1-2017?srsltid=AfmBOoqrKc1d6ZD_5J9kLygXjdybRCp5mn52ZPAyW68w3LBAg8gphing)
- Francke, B., & Piekarczyk, A. (2020). Experimental Investigation of Adhesion Failure between Waterproof Coatings and Terrace Tiles under Usage Loads. *Buildings*, 10(3), 59. <https://doi.org/10.3390/buildings10030059>
- Jenni, A., Holzer, L., Zurbruggen, R., & Herwegh, M. (2005). Influence of polymers on microstructure and adhesive strength of cementitious tile adhesive mortars. *Cement and Concrete Research*, 35(1), 35–50. <https://doi.org/10.1016/j.cemconres.2004.06.039>
- Michalak, J. (2021). Ceramic tile adhesives from the producer's perspective: A literature review. *Ceramics*, 4(3), 378–390. <https://doi.org/10.3390/ceramics4030027>
- Michalak, J., & Ziomek, R. (2023). Assessment of Cementitious Ceramic Tile Adhesives in the Light of Repeatability and Reproducibility of the Tensile Adhesion Strength Measurements. *Materials*, 16(12), 4245. <https://doi.org/10.3390/ma16124245>
- Ohama, Y. (1995). *Handbook of polymer-modified concrete and mortars: Properties and process technology*. Noyes Publications. <https://www.semanticscholar.org/paper/Handbook-of-Polymer-Modified-Concrete-and-Mortars%3A-Ohama/de00c4d98baa27f21d7506fc8511f3a67723c7a2>
- PS Market Research. (2024). *U.S. waterproofing market size & share forecast to 2030*. <https://www.psmarketresearch.com/market-analysis/us-waterproofing-market>
- Rysin, V., & Montyka, Y. (2025). Otsinka efektyvnosti derzhavnykh prohram finansovoi pidtrymky biznesu v Ukraini [Assessment of the effectiveness of state financial support programmes for business in Ukraine]. *Sustainable Development of Economy*, 4(51), 249–258. <https://doi.org/10.32782/2308-1988/2024-51-36> (in Ukrainian)
- Schulze, J., & Killermann, O. (2001). Long-term performance of redispersible powders in mortars. *Cement and Concrete Research*, 31(3), 357–362. [https://doi.org/10.1016/S0008-8846\(00\)00498-1](https://doi.org/10.1016/S0008-8846(00)00498-1)
- Strilets, V., Frolov, S., Datsenko, V., Tymoshenko, O., & Yatsko, M. (2022). State support for the digitalization of SMEs in European countries. *Problems and Perspectives in Management*, 20(4), 290–305. [http://dx.doi.org/10.21511/ppm.20\(4\).2022.22](http://dx.doi.org/10.21511/ppm.20(4).2022.22)
- Sundakov, A. (2024). Post-war reconstruction and disaster recovery: Lessons for Ukraine. *International Economic Policy*, 2(41), 65–79. <https://www.doi.org/10.33111/iep.eng.2024.41.05>
- Syzon, V. (2025). Finansovi instrumenty pidtrymky biznesu: derzhavna prohrama “dostupni kredyty 5–7–9 %” [Financial instruments for business support: State program “Affordable loans 5–7–9%”]. *Current Issues in Modern Science*, 12(42), 500–511. [https://doi.org/10.52058/2786-6300-2025-12\(42\)-500-511](https://doi.org/10.52058/2786-6300-2025-12(42)-500-511) (in Ukrainian)
- Weber Saint-Gobain. (2023). *Grouting in swimming pool, spa and sauna: Application guidelines*. <https://www.th.weber/en/tile-grout/grouting-swimming-pool-spa-and-sauna>

- Wetzel, A., Herwegh, M., Zurbriggen, R., & Winnefeld, F. (2012a). Influence of shrinkage and water transport mechanisms on microstructure and crack formation of tile adhesive mortars. *Cement and Concrete Research*, 42(1), 39–50. <https://doi.org/10.1016/j.cemconres.2011.07.007>
- Wetzel, A., Zurbriggen, R., Herwegh, M., Greminger, A., & Kaufmann, J. (2012b). Long-term study on failure mechanisms of exterior applied tilings. *Construction and Building Materials*, (37), 335–348. <https://doi.org/10.1016/j.conbuildmat.2012.07.072>
- Wong, P. K., Ho, Y. P., & Autio, E. (2005). Entrepreneurship, innovation and economic growth: evidence from GEM data. *Small Business Economics*, 24(3), 335–350. <https://doi.org/10.1007/s11187-005-2000-1>