

Optimising cemented paste backfill through admixture technology: improving pumpability, stability and binder efficiency

By Teresa Bellver-Baca and Ignacio Aguilar-Sánchez, Sika

Cemented paste backfill (CPB) has become a key enabling technology in modern underground mining. By returning tailings underground as structural fill, CPB improves stope stability, reduces the environmental footprint of surface tailings storage and provides greater operational flexibility in increasingly complex geological environments.

Despite these advantages, CPB systems face significant technical and economic challenges. Paste mixtures must accommodate variable tailings characteristics while meeting strict requirements for pumpability, placement and strength development. At the same time, cost pressures remain substantial, with CPB typically representing 10–20% of mining operating costs and cementitious binder accounting for up to 3 quarters of backfill expenses.

Improving paste efficiency while maintaining operational reliability has therefore become a key focus for backfill engineers. In this context, admixture technologies are emerging as an important tool to optimise paste performance.

THE OPERATIONAL CHALLENGES OF CEMENTED PASTE BACKFILL

Producing a stable, pumpable and structurally reliable paste requires balancing several competing parameters. The mixture must remain fluid enough for pipeline transport and underground placement while maintaining sufficient stability to prevent segregation, bleeding or excessive settlement.

Paste performance is typically characterised by parameters such as yield stress (50–300 Pa), plastic viscosity (0.1–1.0 Pa.s), slump flow (180–250 mm), solids content (67–80%), bleed water (<3%) and compressive strength (0.5–5 MPa, depending on stope requirements).

Maintaining these parameters within a stable operating window can be challenging, as tailings mineralogy, particle size distribution and water chemistry may vary throughout mine life. Pumping distances and underground logistics further constrain workability and flow stability, requiring continuous optimisation of paste mixture design.

THE ROLE OF ADMIXTURES IN CEMENTED PASTE BACKFILL SYSTEMS

Traditionally, paste performance has been adjusted by modifying the binder, binder dosage or solids content. While effective in some cases, these approaches can increase operating costs or reduce transport efficiency.

Mineral additions, such as supplementary cementitious materials or fillers, can partially replace cement while contributing to long-term strength through hydraulic or pozzolanic reactions.

Chemical admixtures provide an additional degree of flexibility in CPB formulation. By modifying interactions between particles, water and binder phases, they influence rheology, stability, setting behaviour and strength development during mixing, pumping and curing. Examples include water reducers, stabilisers, viscosity-modifying agents, pumping aids, retarders and accelerators.

Together, these technologies allow engineers to tailor paste mixtures to the specific conditions of each mine site.

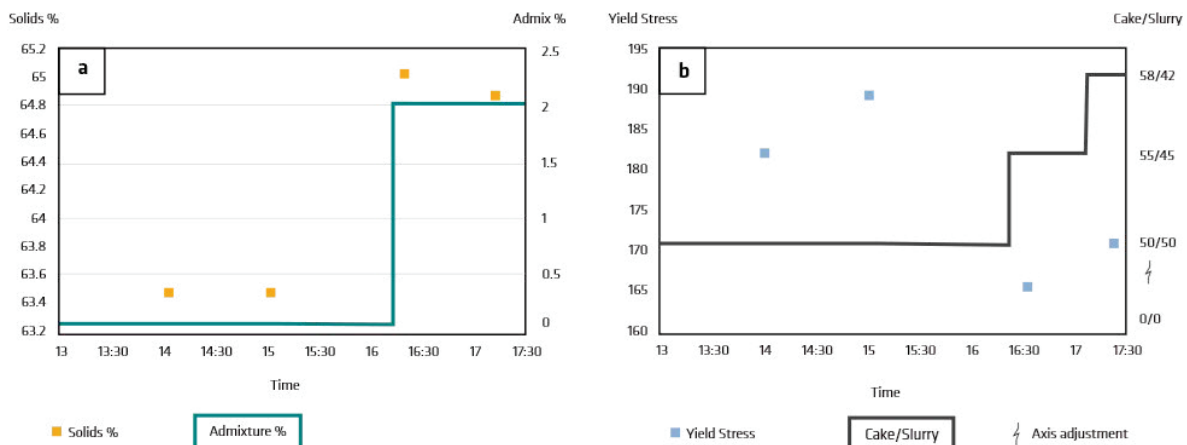


Figure 1 Relevant parameters during the industrial tests carried out in a gold mine. (a) Increment of the solids content in fresh paste when the admixture is added to the system. (b) Decrease of the yield stress (Pa) in fresh paste when admixture is added to the system. When adding the admixture, the yield stress decreases even though the solids content increases, easing the pumping pressure (modified from Aguilar-Sánchez et al. 2024)

IMPROVING RHEOLOGY AND PUMPABILITY

One of the most immediate benefits of admixtures in paste backfill is the 'improvement' of rheological behaviour. By dispersing fine particles and modifying interparticle interactions, water-reducing admixtures can significantly reduce yield stress and viscosity at a given solids content.

In practice, this allows operations to achieve several potential improvements, such as:

- lower pumping pressures and reduced energy consumption
- improved pipeline transport reliability
- the ability to increase solids content without sacrificing pumpability
- greater operational robustness under varying tailings conditions.

These effects can be particularly valuable in deep mines or operations with long transport distances, where pumping constraints often limit paste formulation.

ENHANCING MIX DESIGN STABILITY

Paste stability is equally critical for reliable backfill placement. Excessive bleeding or segregation can result in inconsistent stope filling, loss of

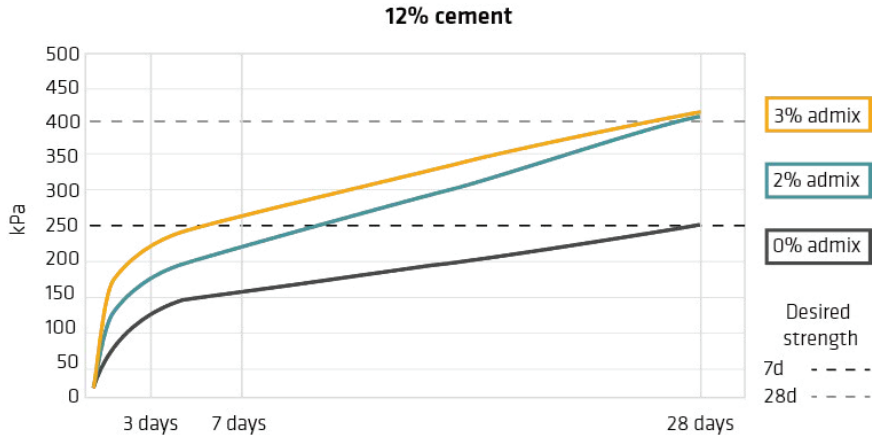


Figure 2 Uniaxial compressive strength test results after 3, 7 and 28 days in a mix with 12% cement and different admixture concentrations (0, 2 and 3% by weight of cement). The dotted lines reflect the desired strengths after 7 (black) and 28 days (grey). Gold mine case study (field trials)

structural performance, or operational delays.

Stabilisers and viscosity-modifying admixtures can help control particle settlement and water separation, maintaining paste homogeneity during transport and placement. This ensures that the paste arriving at the stope maintains the intended solids distribution and binder concentration. Maintaining stability also improves the

predictability of strength development and reduces the risk of operational variability.

BINDER EFFICIENCY AND STRENGTH DEVELOPMENT

Reducing binder consumption while maintaining mechanical performance is a key objective in CPB optimisation. Admixtures contribute to this by reducing water demand, improving

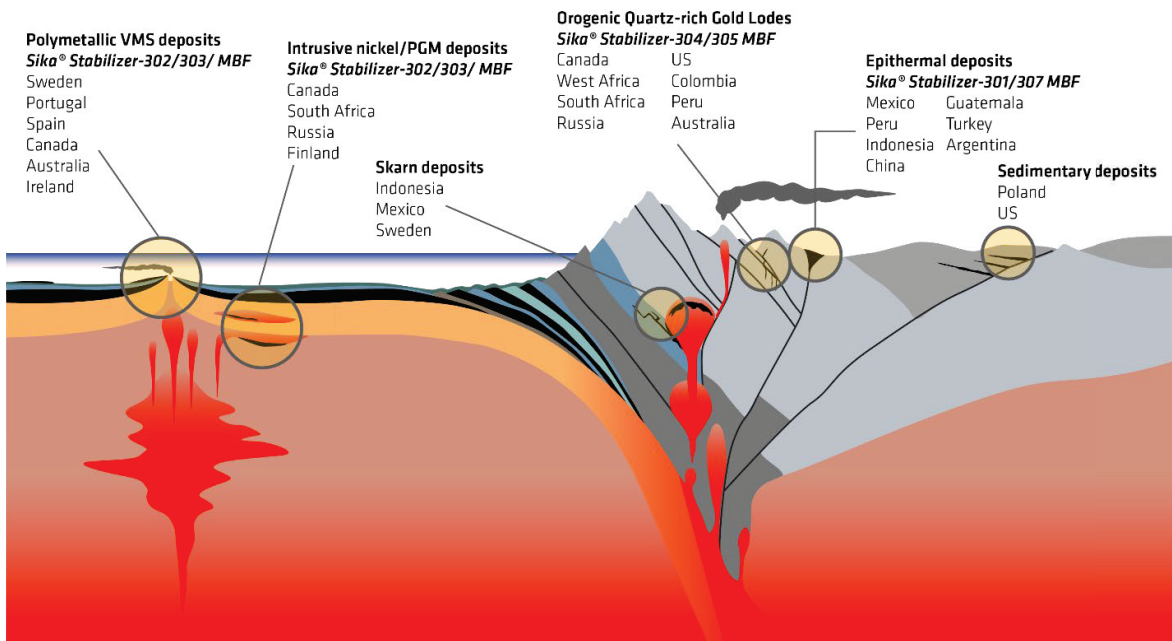


Figure 3 Schematic representation of geological environments associated with mineral deposit formation and the subsurface systems that give rise to economically exploitable ore bodies. These settings also influence the mineralogical and chemical characteristics of tailings, which determine the suitability and performance of chemical admixtures and binder systems used in cemented paste backfill (source: Sika Services AG. [n.d.]

particle dispersion and lowering the effective water-binder ratio, allowing equivalent or higher strengths at lower binder dosages. Improved rheology can also enable higher solids contents, further enhancing strength development without increasing cement consumption.

An underground gold mine case study illustrates these effects (Aguilar-Sánchez et al. 2024): the field trials compared reference paste mixtures with enhanced mix designs incorporating an admixture, while maintaining different binder levels. The addition of the admixture significantly reduced yield stress in the fresh paste, even as solids content increased (Figures 1a and b). Compressive strength testing at 3, 7 and 28 days also showed consistent improvements across different cement dosages (e.g. 12% binder, Figure 2).

These results indicate that admixture-enhanced paste mixtures can improve both fresh and cured paste performance, enabling optimisation of binder usage without compromising structural requirements.

TAILORING SOLUTIONS TO EACH OPERATION

Despite these benefits, CPB systems remain highly site-specific (Figure 3). Tailings characteristics, mine layout, climate and operational constraints all influence paste behaviour.

Successful implementation of admixture technologies therefore relies on close collaboration between mine operators, backfill engineers and material specialists. Laboratory testing, field trials and onsite validation are essential to develop reliable paste formulations.

Through systematic testing, mines can define operating envelopes that account for variations in tailings and processing conditions, ensuring consistent long-term performance.

FUTURE OUTLOOK AND KEY TAKEAWAYS

As underground mining operations become deeper and more complex, the optimisation of CPB systems will remain essential to improving both operational efficiency and environmental performance.

Advances in admixture technologies, combined with alternative and/or more sustainable binders and improved process monitoring, are expanding the flexibility of paste formulations and enabling more efficient use of available materials.

By improving rheology, stability and strength development, these solutions allow mines to increase solids content, reduce pumping constraints and optimise binder consumption.

However, achieving reliable performance ultimately requires solutions tailored to the specific characteristics of each operation, supported by close collaboration between stakeholders and validated through laboratory and onsite trials.

The successful optimisation of CPB lies in combining geological understanding, materials science and operational experience to deliver reliable and efficient backfill systems.

REFERENCES:

Aguilar Sánchez, I, Bellver Baca, MT, Barahona, W, Arcila-Gut, S, Erisman, F, Avilés, E, Weinkauf, A, Hansson, M & Contador, R 2024, 'Enabling sustainability in mining case study: mine backfill', in AB Fourie & D Reid (eds), *Paste 2024: Proceedings of the 26th International Conference on Paste, Thickened and Filtered Tailings*, Australian Centre for Geomechanics, Perth, pp. 373–384, https://doi.org/10.36487/ACG_repo/2455_30

Sika Services AG. (n.d.), *Geological deposits and Sika® Stabilizer solutions*, brochure, Sika Services AG, Baar, <https://www.sika.com/dam/dms/corporate/a/glo-sika-technologies-tunneling-mining.pdf>



Dr Maria Teresa Bellver Baca
Sika Services AG, Switzerland



Ignacio Aguilar Sanchez
Sika Services AG Switzerland

Call for ACG Paper Reviewers

Become a peer reviewer and play an integral role in ensuring the quality and relevance of conference presentations.

Your insights on submitted papers are vital to our shared success.

We invite you to contact publications-acg@uwa.edu.au to join our valued reviewer community.

PROFESSIONAL DEVELOPMENT HOURS	
UP TO XX	PD Hours

Participation in Paste 2026 may contribute towards your professional development accreditation. Please contact info-acg@uwa.edu.au for details.