PERFORMANCE ASSESSMENT OF SPECIALTY CEMENTS FOR MANHOLE CONSTRUCTION IN AUSTRALIAN SEWER INFRASTRUCTURE

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ABSTRACT

Civil infrastructure assets such as underground pipes, manholes, access chambers, and pumping stations are frequently exposed to aggressive environments including sulphates, chlorides, and biogenic sulphuric acid. Traditional general-purpose (GP) and blended (GB) cements often lack the chemical resistance required, resulting in reduced service life and higher maintenance costs. This study evaluates commercially available specialty binders—calcium aluminate cements (CAC) and geopolymers—as durable alternatives for precast sewer infrastructure, with potential to support lower-carbon construction compared with conventional GP systems. Assessment followed Australian standards AS 4198 and AS 3600, together with WSAA specifications WSA 160 and WSA 161. Durability was evaluated through in-situ exposure across sewer corrosivity environments and complementary accelerated corrosion testing. Casting suitability was assessed using mixes representative of Australian precast supply chains. Results demonstrate that selected specialty binders satisfy both durability and casting requirements across multiple sewer environments, supporting their application in resilient and lower-carbon wastewater infrastructure.

INTRODUCTION | BACKGROUND

Sewer infrastructure is highly susceptible to microbiologically induced corrosion (MIC), driven by sulphur-oxidising bacteria that generate sulphuric acid on concrete surfaces.[1–3] These conditions are particularly severe in manholes and access chambers due to gas-phase exposure and cyclic wetting environments. Conventional GP and GB cement concretes often exhibit limited resistance, leading to premature deterioration and increased lifecycle costs.[3], [4] Recent work has proposed classification of sewer gas-phase corrosivity based on environmental parameters such as H_2S concentration, temperature, and humidity, enabling differentiation of exposure severity and improved linkage between environmental conditions and material durability. Specialty binders such as calcium aluminate cement

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(CAC) and geopolymer systems offer enhanced resistance to acidic environments due to stable hydration products and modified microstructures.[5–7] In addition to durability benefits, improved service life may contribute to reduced lifecycle carbon impacts compared with conventional GP systems. This study evaluates specialty binders for manhole construction across sewer corrosivity environments while assessing compatibility with precast manufacturing requirements.

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METHODS

Standards, Exposure Classification, and Compliance

The evaluation was conducted in accordance with AS 3600 and AS 4198, with sewer durability aligned to WSAA specifications WSA 160 and WSA 161.[8,9] Durability assessment was structured using a sewer gas-phase corrosivity classification framework (Table 1), where environments were categorised based on measured H_2S, CO_2, temperature, and relative humidity—parameters known to drive microbiologically induced corrosion.[1–3] This classification enables comparison of material performance across exposure severities and links durability outcomes to service-life relevance.

Table 1. Sewer gas-phase corrosivity classification (C1–C5 severity levels)

Environmental Conditions				Predicted Depth of Corrosion (mm)		Corrosion Impact	Corrosion Classification
H_2S (ppm)	CO_2 (ppm)	T_g(°C)	RH (%)	10 years of service	100 years of service		
>155	<2500	15-30	95-99	>30	>180	Very High	C5
135-155	2500-4400	15-30	95-99	21-30	166-180	High	C4
70-135	4400-7600	15-30	95-99	14-21	120-166	Medium	C3
15-70	7600-9400	15-30	95-99	6.7-14	55-120	Low	C2
0-15	>9400	15-30	95-99	<6.7	<55	Very Low	C1

Durability Assessment

Durability was evaluated using both field and laboratory methodologies structured around the corrosivity classification. In-situ exposure trials were conducted in operational sewer assets representing multiple severity classes, supported by accelerated acid exposure testing.[2,3] Durability assessment considered chemical stability, microstructural integrity, mechanical performance, and acid resistance.

Corrosion model

To relate durability results to service-life relevance, a semi-empirical corrosion model was applied:

$$t_i = fn(k_{tiG}\ C_{ti}\ F_{tiG}) \qquad (1)$$

where environmental corrosivity (C_{ti}) reflects gas-phase drivers such as H_2S, CO_2, humidity, and temperature, and the material term (F_{ti}) captures binder chemistry and microstructure. The model was used to interpret durability differences between binder systems across corrosivity classes.

Casting Compliance

Casting suitability was evaluated using precast-representative mixes, focusing on workability, early strength, demoulding, and handling performance.

KEY FINDINGS

Durability Across Corrosivity Classes

Both CAC and geopolymer binders demonstrated improved resistance compared with conventional GP systems (Figures 1 and 2). Performance differentiation increased with corrosivity severity. CAC binders exhibited strong resistance across moderate to high severity environments, attributed to stable alumina-rich hydrates and reduced calcium hydroxide availability.[5], [6] Geopolymer systems showed formulation-dependent behaviour influenced by binder chemistry and microstructural densification[7]. Microstructural stability emerged as a key determinant of corrosion resistance across corrosivity classes. The observed durability trends were consistent with corrosion model predictions, with CAC systems exhibiting longer estimated initiation periods under equivalent exposure conditions.

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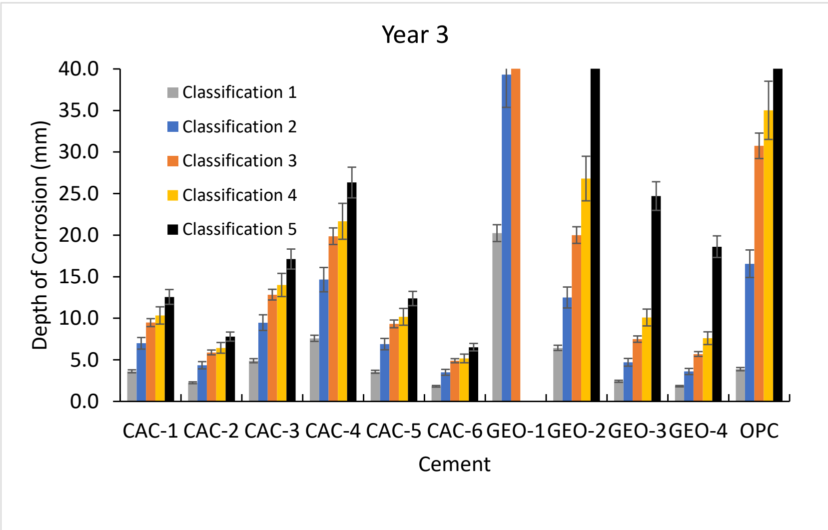

Figure 1. Comparative corrosion depth of CAC, geopolymer, and OPC systems after 3 years across sewer corrosivity classifications

Casting Compliance

Specialty binder mixes demonstrated production characteristics consistent with precast manufacturing requirements, including workability, early strength development, and demoulding behaviour. Observations are reported qualitatively due to confidentiality constraints but indicate compatibility with conventional precast workflows. Representative precast access chambers produced using specialty binders are shown in Figure 2, illustrating compatibility with standard casting and handling practices.

Figure 2. Precast access chambers manufactured using specialty binder concrete during pilot-scale casting trials.

IMPLICATIONS FOR MANHOLE CONSTRUCTION AND CONCLUSIONS

The combined durability and casting results indicate that specific specialty binders met both performance and manufacturability requirements across sewer corrosivity environments. Selected calcium aluminate cement (CAC) and geopolymer systems demonstrated improved resistance compared with GP cement while remaining compatible with precast manufacturing workflows, supporting practical implementation.

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