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Engineered Backfill Materials for Enhanced Corrosion Mitigation of Buried Pipelines

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Extended Abstract

Pipelines are crucial for transporting essential commodities such as water, gas, oil, and sewage. Worldwide, about 3.5 million kilometres of such pipelines are predominantly buried. For example, water utilities in Australia manage around 260,000 kilometres of pipelines and about 80% of them are buried underground [1]. A large part of such essential urban infrastructures are located at shallow depths (1 – 5 m) and they are mainly constructed with ferrous materials. These materials are susceptible to underground electrochemical corrosion. The key factors influencing underground corrosion include soil moisture content, soil air permeability and soil resistivity [2, 3]. These factors are significantly affected by the soil's degree of saturation (S_r), which is defined by the water-occupied voids.

While mitigation methods such as cathodic protection are available to reduce pipeline corrosion in some cases, they require regular maintenance and can potentially lead to corrosion of nearby pipelines [4]. Engineered backfill material can also provide an effective and low-maintenance solution for preventing pipeline corrosion.

Before the 1960s, pipeline trenches were backfilled with excavated natural soils, resulting in older cast iron pipes being surrounded by these natural soils [5]. However, from the early 1960s, there was a significant shift towards using specific types of backfill, such as sand and various granular materials, to improve pipeline support [6]. A key feature to note here is that all backfill specifications attempt to provide adequate support to pipelines, but less consideration is made on the resulting corrosion process [3]. Recent studies have shown that factors like backfilling have been less explored in pipeline corrosion studies [7].

This present study aims to address this gap by developing innovative engineered backfill materials designed to electrically isolate buried pipelines, thereby protecting them from electrochemical corrosion while also providing robust mechanical support for the pipeline. We conducted an online survey across Australia, United States of America, United Kingdom and Canada to gather insights from pipeline industry professionals on the requirements, challenges, and current remedial measures for buried pipeline backfills. The survey has highlighted the concerns about cost and the importance of finding affordable and innovative backfill solutions. Therefore, when selecting proper backfill materials, we must consider their cost in addition to their hydro-electrochemical and mechanical properties.

Given the global shift towards net-zero carbon emissions, the initial strategy involves incorporating recycled materials into the backfill blends. The literature shows that various recycled material blends have emerged as viable alternatives to traditional backfills. These blends, including crumb rubber and crushed glass are noted for their low moisture sensitivity and reduced compaction requirements, making them suitable for sustainable construction [8, 9]. Therefore, we used soil-crumb rubber mixtures with varying percentages of crumb rubber (5%, 20%, and 25%) to investigate the impact on pipeline corrosion. These engineered mixtures demonstrated high resistivity values, indicating a potential reduction in corrosion for buried pipelines. Furthermore, we developed a numerical model to assess the corrosion rate of ferrous pipes buried in the composite mixtures under typical Melbourne climatic conditions. Overall, this study offers experimental and numerical insights towards the feasibility of using recycled materials for backfilling buried pipelines

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