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ORIGINAL PAPER

Formulation of Alumino-Silicate Polymer Mortar Using a Liquor Waste from Pulp Industries

Arun Murugesan[1] · Sasikumar Ramachandran[2] · Abdul Aleem Mohamed Ismail[1] · Alagar Muthukaruppan[2,3] · Deepasree Srinivasan[1]

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Abstract

Purpose Alumino-silicate(geo)polymer (ASP) has created a better alternative to conventional concrete and is being under continuous study owing to the environmental benefits. However, the ASP mortar possesses certain constraints of poor workability, whereas the workability and mechanical properties are inversely proportional to each other. On the other hand, a large amount of cellulose pulp filtrate (liquor waste) is generated from the pulp industries, which pollutes/exploits the land. To overcome the above issues, the present study aimed to utilize the cellulose pulp filtrate waste in the formulation of ASP mortar to study its influences in terms of workability and mechanical properties.

Methods The ASP mortar was developed by using fly-ash, a combination of sodium hydroxide and sodium silicate at a ratio of 1:2.5 along with different admixtures (systems 1–5) viz., liquor waste, NaOH, water, and anti-microbial (AM) filtrate. The physio-mechanical and anti-microbial properties of ASP mortars were studied.

Results From the analysis, the addition of cellulose pulp filtrate proportionating the workability by improving the slump value (28 mm) as well as enhancing the mechanical properties like compressive strength (37.74 MPa), and flexural strength (5.30 MPa) of about 1.5 times higher than the control.

Conclusion The present study paves an avenue to overcome the constraints of the ASP mortar by utilizing liquor waste, which also could provide zero discharge/wastage from pulp manufacturing industries.

Keywords Waste valorization · Liquor waste · Cellulose pulp filtrate · Alumino-silicate polymer · Proportionate · Physio-mechanical · Anti-microbial

Introduction

Owing to the sustainability and environmental benefits, alumino-silicate (geo) polymer (ASP) has created a possible breakthrough in the construction industry by replacing conventional (cement) concrete [1, 2]. The benefits associated with practicing ASP include reduced CO_2 emission, solid waste management, faster construction, and better properties [3, 4]. In addition, life cycle assessment on ASP yields high environmental benefits [5–7] and also reported the potential of using ASP to reduce global warming by 70% than that of conventional concrete [5]. Despite its immense benefit, the limitation of the ASP is poor workability. The materials of ASP include alumino-silicate such as fly-ash, Ground Granulated Blast Furnace Slag (GGBS), metakaolin, and alkaline activators viz., sodium hydroxide (SH) and sodium silicate (SS). The workability of the ASP is influenced by the alkaline activators due to their high viscosity and sticky

✉ Sasikumar Ramachandran
rskmsc@gmail.com

✉ Deepasree Srinivasan
deepuscool2@gmail.com

[1] Engineering Materials Laboratory, Department of Civil Engineering, PSG Institute of Technology and Applied Research, Neelambur, Coimbatore 641 062, India

[2] Polymer Engineering Laboratory, Department of Chemistry, PSG Institute of Technology and Applied Research, Neelambur, Coimbatore 641 062, India

[3] Centre for Advanced Materials, PSG College of Arts & Science, Coimbatore 641 014, India

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Summary of the Findings

ASP mortars were modified by cross-linking the admixtures to evaluate the performance on workability and mechanical characteristics. Among the different admixtures, NaOH and AM-filtrate played a vital role in the desired characteristics. In the case of NaOH, poor workability was observed due to the viscous medium, conversely, NaOH attained the highest strength in mechanical properties. In the second case (AM-filtrate), both the workability and mechanical properties were improved (proportionate) over the control. From the evaluation, considering the cost, properties and valorization, cellulose pulp filtrate would be the best to improve the deficient characteristics of ASP (workability) and as well proportionate the hardened properties.

Conclusion

The present work developed a method for an advancement of alumino-silicate polymer (ASP) by using liquor waste generated from paper industries. This approach gives an avenue for pollution control as well as improved the workability and mechanical properties of the ASP. Additional concentration of SH reduces the workability of ASP by increasing the viscosity, due to rapid cross-linking reaction. Whereas, the addition of filtrate and AM-filtrate consisting of lignin and hemicellulose delaying the cross-linking of alumino-silicate, consequently, controlling the viscosity results in improved workability of the ASP.

The density of the ASP mortar decreased to some extent owing to the presence of low-dense cellulosic materials with sustained mechanical properties. The AM-filtrate exhibits the slump value of 28 mm, the compressive and flexural strength of 37.74 MPa and 5.30 MPa, respectively, which are about 1.5 times proportionally higher than those of control. Further, the addition of an anti-microbial agent in cellulose pulp filtrate protects the ASP composite from microbial attack by lowering the colony units by 73.4% than that of the absence of the anti-microbial agent. Based on the observation, the valorization of cellulose pulp filtrate would benefit the pulp industries with zero wastage, in addition, the modified ASP helps in ease of construction and reduces environmental contamination.

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Data Availability Data will be made available on request.

Declarations

Ethics Approval and Consent to Participate Not applicable.

Consent for Publication Not applicable.

Conflict of Interest The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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