

Smart Nanomaterials Technology

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Applications of Nanomaterials in Civil and Environmental Engineering

Towards Sustainable Development and
Environment Remediation

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Contents

Application of Nanomaterials in Structural Engineering and Concrete Technology	
Effect of Nano-TiO₂ Admixed Cement Slurry Coatings on Corrosion of Steel	3
Md Daniyal, Sabih Akhtar, and Mohammad Asif Raja	
Influence of Nano-Fe₃O₄ and Nano-SiO₂ on the Microstructural, Mechanical, and Durability Properties of Cement and Concrete Composites	29
Md Arif, Sabih Akhtar, and Ameer Azam	
Impact of Graphene Oxide on the Mechanical Properties of Portland Cement Composites	47
Mohd. Sufian Abbasi, Noureen Ansari, Mohd. Azhar, Mohd. Samiullah, Neda Tabassum, Syed Aqeel Ahmad, and Qazi Inamur Rahman	
Application of Nanomaterials in Structural Engineering and Technology for Industry 4.0 in the Era of Digital Twin	61
Azhar Khan, Nadeem Akhtar, Mohd Sayeed Ul Hasan, Mohammad Shariq, Md Anwar, and Juveiria Khan	
Impact of Nano-Zinc Dioxide, Nano-Calcium Carbonate, and Nano-Chromium Oxide on the Properties of Cementitious Materials	79
Pappu Kumar, Ajay Kumar, Amrendra Kumar, and Rahul Kumar	
Impact of Nanomaterials on the Characteristics of Cementitious Composites	87
Suresh Kumar Verma, Md Daniyal, and Dulal Goldar	

Impact of Graphene Oxide on the Mechanical Properties of Portland Cement Composites



Mohd. Sufian Abbasi, Noureen Ansari, Mohd. Azhar, Mohd. Samiullah, Neda Tabassum, Syed Aqeel Ahmad, and Qazi Inamur Rahman

Abstract This chapter investigates the transformative influence of Graphene Oxide (GO) on the strength properties of Portland Cement composites, delving into the realm of nanomaterial reinforcement for advanced construction materials. Focusing on the enhancement of compressive, flexural, and tensile strength, Impact and Fracture Toughness, the study explores the multifaceted interactions between GO and the cementitious matrix. Beginning with an overview of the essential characteristics of GO, the chapter provides insights into synthesis and incorporation techniques for GO in Portland Cement composites, setting the stage for understanding its potential as a reinforcement agent in Portland Cement composites. The findings from this chapter contribute to the evolving landscape of nanomaterial-modified cementitious systems, offering a deeper understanding of how GO can be harnessed to propel the strength performance of Portland Cement composites. As the construction industry seeks sustainable and high-performance solutions, this chapter provides a valuable resource for scholars, engineers, and practitioners aiming to advance the frontier of modern construction materials.

Keywords Graphene oxide · Portland cement · Advanced cement materials · Mechanical properties

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31. Yao, X., Shamsaei, E., & Wang, W. (2020). Graphene-based modification on the interface in fiber reinforced cementitious composites for improving both strength and toughness. *Carbon*, *170*, 493–502.
32. Sharma, S., Kothiyal, N. C., & Chitkara, M. (2016). Enhanced mechanical performance of cement nanocomposite reinforced with graphene oxide synthesized from mechanically milled graphite and its comparison with carbon nanotubes reinforced nanocomposite. *RSC Advances*, *6*, 103993–104009. <https://doi.org/10.1039/C6RA23421F>