Dear Readers,

We are pleased to share with you an edition themed on 'Fire safety of underground tunnel infrastructure' edited by Dr David Lange.

Dr David Lange is a senior lecturer in Structural and Fire Safety Engineering and Director of Higher Degree by Research training in the School of Civil Engineering at The University of Queensland (UQ). He has a Ph.D. degree in Structural Fire Engineering and a Master of Engineering in Structural Engineering with Architecture – both from the University of Edinburgh in the United Kingdom (U.K).). He is a chartered Fellow of Engineers Australia, a member of the national engineering register in Australia, a registered international Professional Engineer, an Asia Pacific Economic Co-operation Engineering (APEC) engineer, and a registered professional engineer in Queensland. He joined UQ in 2018 after 6.5 years in the research industry sector in Sweden. His research interests have two main tracks – fire safety engineering and resilience of infrastructure and communities - and he has been active in both fields of research for several years, participating in and leading a range of funded projects and other research activities of various scales. His work has had significant impact on policy and regulation of fire safety and fire safety engineering in Australia, through his role in the Warren Centre project to professionalise fire safety engineering and subsequent engagement with state governments and regulators; and in Europe through his work on crisis management, infrastructure resilience and fire safety. As well as a member of the editorial board of the ICJ he is also a member of the editorial boards of Fire Safety Journal and Fire Technology.

We hope you enjoy reading this edition.

Production Editor
Indian Concrete Journal

**Dear Readers,**

I'm pleased as a member of the editorial board of the Indian Concrete Journal (ICJ), as well as the guest editor of this edition, to be able to present to you these papers related to fire safety of underground tunnel infrastructure. The papers represent an exciting mix including a review of fire hazards for tunnels, detailed studies into the response of different concrete mixes to fire, a review of repair strategies for concrete structures following fire, and a review of numerical approaches to study the response of concrete linings to fire. As such, they can be seen to represent the entire lifecycle of concrete under fire conditions. They also present research related to concrete in fire as part of the wider issue of fire safety of underground infrastructure as well as from a very practical and detailed perspective for structural design and response to fire. This collection is a worthwhile and important overview of current research both in India and internationally in this exciting and challenging field.

Our first paper is an invited contribution from Professor Kodur of Michigan State University and Dr Bhatt of Pacific Structural Forensics LLC [1]. Their paper gives an overview of some of the key design considerations of tunnels for fire. It provides a summary of different fire scenarios and what these represent, some key safety systems in tunnels, and provides a road map for much needed future research in the field. This paper is undoubtedly not just a good introduction for readers who are not overly familiar with some of the challenges of fire safety design of tunnels but is also a valuable resource that may serve to influence future research directions.

Our second paper provides a summary of the response of concrete reinforced with High Density Polyethylene (HDPE) following heating [2]. Rao and Patro in their paper show that the addition of HDPE fibers to a concrete mix leads to minor alterations in residual capacity, elastic modulus and splitting tension after having been heated to 220°C. As well as valuable information for the design of concrete mixes which may rely on HDPE fibers as opposed to Polyethylene (PE) fibers, this conclusion also suggests that more work may be needed to understand the long-term response of tunnel structures following even a relatively minor fire.

Vidya and Rao [3] present a study of the response of high-strength concrete under cycles of heating and cooling to various temperatures. In their work they heated concrete specimens up to temperatures of between 100°C and 400°C for periods of 8 hours, followed by 16 hours of cooling and evaluated the compressive strength, tensile splitting strength and the flexural strength of the concrete after this cycle. They show that high-strength concrete experiences more strength loss compared with a standard concrete mix used as a benchmark in their work.

Das et al. [4] study the response of different mixes of steel and polypropylene fiber in fire resistant mortar mixes, heating samples up to 300°C and 600°C and testing their residual capacity and studying their microstructure under scanning electron microscopy. They show that mortar reinforced with both polypropylene and steel fibers has a reduced compressive strength compared with mortar reinforced with one or the other types of fiber. Steel fiber reinforced mortar is shown to have a higher compressive strength residually after exposure to high temperature – suggesting that steel fiber reinforced mortars demonstrate improved resilience to fire over polypropylene or hybrid fiber mixes.

In our 5th paper, Rathod et al. [5] report on an investigation into different strengthening techniques applied to a reinforced concrete frame damaged by fire. This research paper summarizes in situ testing approaches to determine the extent of fire damage to a reinforced concrete frame and then explores application of Carbon Fiber wrapped and steel plate jacketed reinforcement techniques to recover some of the structural properties of fire damaged reinforced concrete sections. They show that steel jacketing is more effective in recovering the original behavior of the steel element such that it more closely approximates the response pre-fire exposure.

Finally, a summary of numerical modelling approaches applicable to concrete tunnel linings exposed to fire is presented by Prakash [6]. In his paper, Prakash provides a holistic perspective that aims to contribute to filling an important gap in available design guidance.

Fire safety engineering internationally is at cross-roads. As a result of high-profile incidents around the world and the introduction of new techniques and materials in the built environment that are negatively impacting the level of safety provided by prescriptive solutions and codes the discipline is under intense scrutiny. It is a pleasure to be able to present this short summary of the state of the art in aspects related to fire safety of underground tunnel infrastructure.


[1] Kodur, V. K. R., Bhatt, P. P. (2022). "Fire hazard in tunnels: review, assessment, and mitigation strategies", *The Indian Concrete Journal*, Vol. 96, No. 3, pp. 5-17.

[2] Rao, M. M., Patro, S. K. (2022). "Behavior of high-density polyethylene fiber reinforced concrete exposed to elevated temperatures of about 220°C", *The Indian Concrete Journal*, Vol. 96, No. 3, pp. 18-23.

[3] Vidya, B., and Rao, K.S. (2022). "A study on thermo-mechanical behavior of concrete subjected to thermal cycles", *The Indian Concrete Journal*, Vol. 96, No. 3, pp. 24-34.

[4] Das, S. K., Sahoo, S., Patro, S. K., Syed, M. M. (2022). "Mechanical and micro structural studies of fiber reinforced mortar mixtures at elevated temperature", *The Indian Concrete Journal*, Vol. 96, No. 3, pp. 35-42.

[5] Rathod, J. D., Chauhan, P. S., and Anghan, V. R. (2022). "Case study of fire damaged industrial structure and an experimental investigation on structural performance of fire damaged retrofitted RC beams", *The Indian Concrete Journal*, Vol. 96, No. 3, pp. 43-50.

[6] Prakash, P. R. (2022). "Numerical modelling of damage in tunnels subjected to fire exposure", *The Indian Concrete Journal*, Vol. 96, No. 3, pp. 51-56.


Thank you,

**David Lange**

# CALL FOR GUEST EDITORS

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