



## **Introduction to this Special Issue on Tunnels and Underground Structures and the Best of Copenhagen**

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# Introduction to This Special Issue on Tunnels and Underground Structures and the Best of Copenhagen

One of the challenges faced by societies globally is to accommodate an ever-increasing population while ensuring adequate mobility and quality of life for all. In order to achieve this goal, it is necessary to provide the basis for societal development, including the development of infrastructure, habitation and production facilities.

Structural engineering has a significant role in designing structures and infrastructure to meet the challenge of urbanization, which is resulting in increasing numbers of megacities all over the world.

Tunnels and underground structures provide a solution to make the best use of the available land and to develop green, liveable cities. In addition, underground structures may be used as a means to mitigate the effects of climate change and extreme weather, for instance by providing sustainable storm-water management systems.

In France, the “Grand Paris Express” is the largest urban project in Europe, with 200 km of automated lines—as much as the current metro—and 68 stations. Essentially underground, the new metro will cross the territories of Greater Paris to connect them to each other and to the capital. Once completed, it will be easier to get from one point to another in the region without going through central Paris, but also to reach the heart of the capital more quickly from its outskirts. Offering an alternative to the car, the Grand Paris Express will reduce

pollution and congestion and help to create a metropolis that is more respectful of the environment. Construction started in 2016, and at the beginning of this year, 2020, 15 tunnel boring machines were in service around Paris.

In 2019, a new metro line opened in Copenhagen, the capital of Denmark—and ranked as one of the most liveable cities in the world—providing 15.5 km of new underground metro and 17 stations and improving mobility in and around the city centre. The year before, in the summer of 2018, IABSE held a mid-year conference in Copenhagen under the heading “Engineering the Past to Meet the Needs of the Future”, with the overall objective of discussing the operation, maintenance, sustainability and upgrading of existing structures to meet future demands.

For the first time, a special issue of *Structural Engineering International* has been dedicated to tunnels and underground structures, which are presented together with a selection of the best papers from IABSE’s Copenhagen conference. The papers present a wide variety of topics, from recently completed and ongoing projects to scientific papers and innovative solutions. The White House Station of the Grand Paris Express project and the shaft design for the Rijnlandroute bored tunnel give an insight into the challenges of designing and constructing major infrastructure in urban areas. The load-bearing capacity of the permanent shotcrete lining of the Brenner Base Tunnel is analysed considering

time-dependent and nonlinear material behaviour. The record-breaking and award-winning Hong Kong–Zhuhai–Macao link is presented in a paper focusing on construction of the artificial islands that form the important link between the immersed tube tunnel section and the bridges. A paper on submerged floating tube bridges offers an insight into what may be the future of deep-sea crossings. Various applications of fibre strengthening are presented, both as fibre-reinforced sprayed concrete used as permanent tunnel lining and as a review of flexural design of concrete slabs strengthened with textile-reinforced mortar. The effects of fire are analysed in three papers, covering fire resistance for underground reinforced concrete ducts, a practical approach for tunnel fire verification and the fire protection of bridge cables. Finally, this issue includes a paper on cable-supported bridges for both rail and road traffic and one on the bearing capacity of thin, transversely prestressed concrete deck slabs from the 1960s and 1970s and how they may be demonstrated to be safe and reliable for modern traffic demands to optimize the use of existing infrastructure.

We hope you will enjoy reading this selection of unique papers!

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