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**SHOTCRETE  
FOR  
UNDERGROUND SUPPORT  
IX**

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*Edited by* **Koichi Ono**

**Japan Tunnelling Association**

# **SHOTCRETE FOR UNDERGROUND SUPPORT IX**

Kyoudai-Kaikan Kyoto, Japan  
November 17-20, 2002

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This proceeding consists of 35 papers presented at the SHOTCRETE FOR UNDERGROUND SUPPORT IX conference held in Kyoto, Japan, November 17-20, 2002. It covers the themes of materials, support mechanism and application concerning shotcrete. This book presents the state-of-the-art for the use of shotcrete in the world.

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## FOREWORD

Human beings have been realizing various advantages of underground space use for the long history and have been trying creation of tunnel and underground space at their every stage of development although these works have always been difficult. The most rapid increase in the use of tunnel and underground space appeared in the 19th and particularly in the 20th century. During these periods, tunnel and underground space use has been extended to various facilities such as road, waterway, railway, subway, underground infrastructure, car park, shopping mall, powerhouse, warehouse, sewage station, storage for oil, gas and radioactive waste, museum, concert hall, sport center.

Underground space has various fundamental characteristics, such as easier creation of new space, mechanical, thermal, acoustic and opaque isolation and no disturbance to the ground surface. Various advantages of tunnel and underground use have strongly encouraged human beings to go underground even with difficult conditions. Strong demand to conquer such difficult conditions has yielded various excavation and support technology in tunnel and underground works. Untiring efforts for construction of tunnel and underground space will continue.

The use of shotcrete in tunnel and underground excavation has been realized to be very efficient for rock support. The International Conference of Shotcrete for Underground Support has been making tremendous contributions to the development of tunnel and underground construction technology. It is a great honor for Japanese researchers and engineers in the tunnel and underground field to be able to host this professional conference in Japan.

The wide use of shotcrete for underground support in tunnel and underground works in Japan started only in 1970th. Since then, the use of shotcrete increased with a tremendous rate owing to the abrupt increase of tunneling works particularly for Shinkansen and highway constructions. The annual use of shotcrete for tunnel excavation in Japan reaches 2 million m<sup>3</sup> every year.

The tunnel and underground space use has wonderful and tremendous future. The role of shotcrete will also become more and more important. The 9th International Conference on Shotcrete for Underground Support, SUS9 contains many important information and developed technology. The contributions made by the authors of the papers are highly appreciated. I would also like to thank all the SUS9 preparation committee member for their unlimited voluntary efforts to make this conference a success.

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\* Manuscript not available at the time of printing.



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