



## Development of Fire Resistant Shotcrete with Olivine Aggregates

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### Summary

The objective of this research was the development of shotcrete mixtures with olivine aggregates that could act as protective coating in case of high temperature exposure, such as fire inside a tunnel. Workability, unit weight, porosity, modulus of elasticity and compressive and flexural strength at the age of 7, 28 and 90 days of olivine-based concrete mixtures were tested and compared with reference mixtures with limestone aggregates and river sand. The residual mechanical properties of shotcrete mixtures were also measured after exposure to 400, 550, 750 and 850°C. Results showed that the replacement of limestone with olivine led to concrete superior in terms of strength at all temperatures of strain, indicating that the utilization of olivine-based shotcrete enables production of a fire resistant shotcrete at temperatures up to 850°C. The experimental procedure was completed with a successful pilot application of olivine-based shotcrete on concrete panels.

**Keywords:** olivine aggregates; shotcrete; tunnels; fire safety; elevated temperatures; mechanical properties.

### 1. Introduction

Concrete material in structures is likely to be exposed to high temperatures during a fire incidence. Thus, the resistance of concrete against high temperatures is of great importance in terms of safety and serviceability, especially for underground structures such as road and rail tunnels, which are increasingly significant to present day traffic infrastructure [1]. Apart from a major threat to public safety, tunnel fires can also cause costly damage to surrounding infrastructure [2]. Serious tunnel fires that have occurred in Europe in recent years (Channel Tunnel - UK/France 1996, Mont Blanc Tunnel - France/ Italy 1999, Great Belt Tunnel - Denmark 1994) have highlighted this issue and shown the devastating effect of such fires in terms of loss of life, damage to facilities and destruction of vehicles [3,4]. The EU Directive 2004 on minimum safety requirements for tunnels in the Trans-European Road Network states that the main structure of all tunnels shall ensure a sufficient level of fire resistance [5]. A great deal of research has been done on improving fire safety in new and existing tunnels, including the addition of polypropylene fibres in the concrete mix and the application of cementitious coatings or panels to the concrete ceiling and walls [6,7].

In the present report, olivine has been used as aggregate in the development of fire resistant shotcrete mixtures that could be applied on concrete ceiling in order to upgrade the fire resistance of tunnels. The mechanical and physical properties of shotcrete mixtures with olivine aggregates, before and after exposure to elevated temperatures, were measured and compared with reference mixtures with limestone aggregates and river sand. The experimental procedure also comprised a pilot application of olivine based shotcrete on existing concrete panels and residual mechanical properties to high temperatures were examined.