Fire analysis of reinforced concrete precast tunnel lining considering the spalling effect

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Tunnel construction with the Tunnel Boring Machine (TBM) is, today, the most extensively adopted method both in soft soil and rock. During the excavation process, the TBM places the tunnel lining, usually made of precast reinforced concrete segments, and uses these elements as contrast in the advancing process.
Behaviour of a tunnel under fire conditions has become a relevant topic, during the last years, due to several accidents that have occurred. Fire behaviour of a tunnel excavated with the TBM can be of interest since the lining thickness can be relatively small (from 250 to 500 mm).
Fire analysis of precast segmental tunnels involves several problems, mainly related to the soil-structure interaction during fire exposure, coupled with material degradation. Temperature increase in the tunnel is the cause of thermal expansion of the lining, which is resisted by the soil pressure. Furthermore, the increase of temperature in the lining leads to severe damage to the reinforced concrete precast elements, which can jeopardise structural safety.
This problem has been analysed using an ideal case of a precast segmental tunnel excavated in a stratified soil. Initially, excavation of the tunnel was modelled in order to predict stresses in the lining due to the soil pressure and eventually fire exposure was considered. The reinforced concrete lining was modelled with a crack model in order to simulate the actual behaviour.
Furthermore, the effect due to concrete spalling have been modelled. The spalling phenomena can leads to a reduction of the concrete section. The structural effect of the spalling are two folds: a reduction of the concrete section leads to a decrease of the bearing capacity of the lining but also a stiffness decrease leading to a reduction of the actions due to thermal expansion.
Results show the importance of considering the interaction with the soil and the degradation of the concrete lining.