POSSIBLE APPLICATIONS OF A HIGHLY DUCTILE SPRAYED CONCRETE AS A MEASURE FOR GROUND SUPPORT AND STRUCTURAL UPGRADE

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The possible impacts to our underground infrastructure that might occur during its operational phase are subsequently correlating with the types of goods we are transporting as well as the overall threats to our society. With that in mind, explosions and huge fires, resulting from terroristic attacks or huge accidents, have become valid threats to our tunnels and underground hubs, especially in countries like Great Britain, the United States or Germany. Unfortunately, there are only a limited amount of measures and technical systems available for the systematic upgrade of such underground facilities, especially when talking about combined scenarios (explosion plus fire). The problem is, that most of these protective systems are based on ultra-high performance concrete approaches with a huge amount of reinforcement and additional additives for increasing the explosion and fire resistance of the concrete. For reasons of manufacturing and fabricating such protective layers and shells, these systems can often only be applied to plane structures with simple geometries and clearly defined boundaries. This is not necessarily a typical description of an underground structure, where arches and curved planes are more or less common. Therefore, a highly ductile sprayed concrete, with high fibre or steel content, could help closing this gap, at least in theory.

This paper will show the development of a highly ductile sprayed concrete mixture. Based on a design for an ultra-high performance concrete, a recipe for a sprayed concrete was developed that provides a high resistance against fire and explosive loads. Carrying huge amounts of fibers (140 kg/m³ steel fibers as well as 3 kg/m³ PP-fibers) the sprayed concrete provides the required performances under the mentioned impacts but is still workable under the circumstance of a sprayed concrete application on a “normal” construction sites. The paper will show the developmental process as well as results from exposures to fire and explosives. We will then take a closer look into test of residual strengths of the damaged concrete, the energy absorption capability of our mixture and reachable compressive strengths. In addition, we will discuss how such a concrete can not only be used for the structural upgrade but also in situations where a highly ductile ground support is needed.

Figure 1: Backside of a concrete slab exposed to explosive impact without (left) and with (right) an 8 cm cover of the developed concrete mixture (by courtesy of Fraunhofer EMI)