Sprayed Optimised Concrete (SpOC)

CO_2-reduced shotcrete and optimised spray technology: towards a durable, homogeneous construction material

Shotcrete is of immense importance in underground construction and engineering and thus heavily influences the environmental impact and life-cycle costs of underground buildings such as tunnels. An improved shotcrete technology has significant potential for future applications. Therefore, we propose the present collective research project „Sprayed Optimised Concrete" (SpOC) with support from the Austrian Construction Association (ÖBV).

Goals and expected results

In this project, research in the fields of primary materials, spraying and pumping technology, sustainable shotcrete construction, quality testing and life-cycle guidance are conducted for the benefit of members of the entire shotcrete industry sector (building owners, planers, machine producers, material suppliers, building companies) on the path to a more climate-friendly, durable and efficient construction method.

1. New raw materials for low-CO_2 hydraulic binders

Initial works show the usability and promising properties of new supplementary cementitious materials such as siderite, ankerite, calcined clays, artificial slags, rock powder fillers, etc. In this work package, the reaction mechanisms and usage of such supplementary cementitious materials shall be investigated to reduce CO_2 emissions of the shotcrete construction method. The most important goals comprise increasing the early strength using alternative raw materials, further reducing the sinter potential (< 0.3 kg Ca/t shotcrete) and increasing the durability and sustainability of shotcrete.

2. New technologies and methods for quality assurance of the spraying process

Existing shotcrete machines and pumping and/or spraying equipment shall be characterised concerning the undesirable formation of layers and inhomogeneities during the spraying process. Such layering can for example be caused by accelerator overdosing due to the discontinuous pumping of the concrete flow, resulting in accelerator layers in the finished product. The detection and characterisation of such layers allows suggesting possible technological improvements by the associated industry partners, which can then be tested in large-scale spraying tests. For example, installation of sensor equipment (*e.g.* pressure sensors in the concrete feed pipes and hoses, tracers in the raw materials) can be used to evaluate the layer-formation potential of shotcrete machines, which provides the machine producers with approaches for new pumping and controlling equipment which can in turn be tested again.

The overall goals are improving the application process of shotcrete by avoiding pulsation in the concrete flow, installing flow sensors and controlling equipment and developing robust mix designs to form a homogeneous sprayed concrete with less accelerator usage. In addition, testing procedures are developed and improved to evaluate the spraying process and the homogeneity of the hardened material.

3. Prospecting new construction possibilities for shotcrete as a durable, impermeable building material

Shotcrete shall be investigated regarding its usability for efficient and durable construction and building repair methods. Suitable mix designs with favourable binder composition are used to optimise (early) strength development and deformation behaviour. Methods for crack reduction are investigated and tried in practical applications; in this regard the application of different types of fibres is also tested. At the end of this developments the improved durable shotcrete should be practically tested for constructive tasks, e.g. for tunnel linings, crosscuts or escape galleries. In the long run, this can enable more efficient and durable building methods based on improved, permanent shotcrete; for example, permanent shotcrete linings could allow tunnels with lower life-cycle costs.

4. Supply assessment criteria for shotcrete as "life-cycle guidance" and develop suggestions for guidelines, contracts and awarding

Diverging requirements shall be considered as early as the planning stage to gain a transparent comparison between all important parameters (*e.g.* early strength, durability, CO_2-equivalent emissions, environmental impact, cost, application security, etc.). The stepping stones towards evaluating the "best option" regarding sustainability, technical performance and life-cycle costs are prepared in guidelines and decision tools. Thus, proposed shotcrete mixes can be tailored for the planned construction site and its requirements (*e.g.* durability due to local geology and groundwater chemistry). To secure a found database for the decision-making process, testing methods regarding durability and spray quality shall be improved.

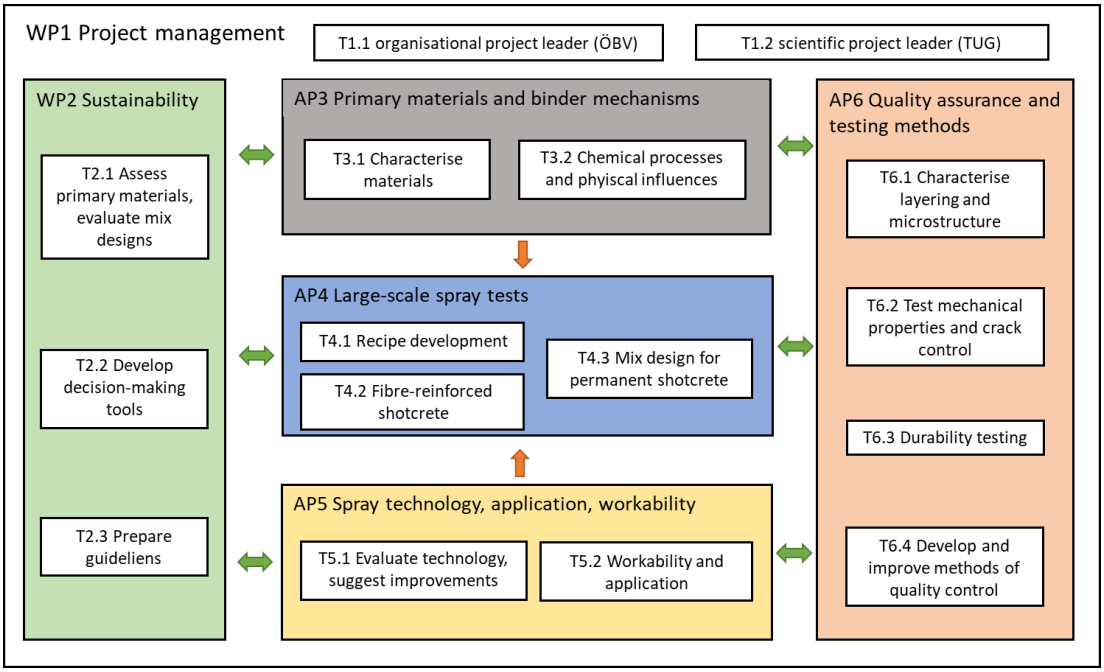

Figure 1: Overview of the work packages (WP) which are subdivided into specific tasks (T).