

Multi-Layer Shotcrete Design for Tunnel Construction

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ABSTRACT

Shotcrete is an essential support element for conventionally driven tunnels. Traditionally shotcrete is applied in multiple layers for construction reasons, but for the design the lining is considered as monolithic. This is acceptable, in case the time lag between the application of each shotcrete layer is short, corresponding to one construction step. A different situation occurs, when an additional shotcrete layer is applied with a large delay. In that case the system consists of a pre-loaded and a stress-free layer and needs to be designed accordingly. Currently there is no explicit design procedure incorporated in the design codes, but only recommendations for design, such as relevant codes to be applied and the requirement to consider the pre-loading conditions of the first shotcrete layer. The paper presents and discusses a standard-conform (Eurocode 2) method for design of a concrete cross section consisting of two layers. The method is based on the assumption of full bond between the layers allowing full transfer of shear stress. The design procedure includes the check of strains in the relevant fibres of cross section, i.e. top and bottom fibres of the combined cross section, as well as the interface fibre between the layers. As result a bending moment – axial force interaction diagram of additional bearing capacity of the two layer cross section can be drawn for specific pre-loading conditions of the first shotcrete layer. Parametric study of pre-strain conditions of the first shotcrete layer confirmed, that a strengthening of the cross section is reasonable only for cases, when the capacity of the first shotcrete layer is not highly utilized. The additional bearing capacity of a two layer cross section with highly utilized first layer is very limited.