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Exercise 6: Comparative analysis of UHPFRC fibrous mixes

We consider the use of a horizontally poured UHPFRC to create a thin, 25 mm-thick protective coating on an industrial reinforced concrete slab (thickness of 150 mm), in an aggressive environment.

1) Propose a fibrous mix (straight fibers according to options in table 1 and vol. % dosage) and justify it. Assume a bond strength τ of the fibers = 7 MPa and the strength of the UHPFRC matrix (elastic limit) f_{Ute} =8 MPa.

   Table 1 below shows different types of steel fiber available on the market.

   Table 1

L_f [mm]	d_f [mm]
6	0.16
10	0.2
10	0.16
13	0.175
13	0.16
14	0.20
20	0.30

   The fiber efficiency coefficient μ_1 can be estimated according to the data in Appendix 1, based on the selected orientation coefficient μ_0.

2) What would be the tensile strength f_{Utu} in a laboratory test, on molded specimens, with an orientation coefficient μ_0 of 0.8 for the selected UHPFRC?

3) What is the effect of the f_{Utu}/f_{Ute} ratio required on the fibrous mix needed for this application?

   Calculate the fibrous mix required for the application for f_{Utu}/f_{Ute} ratios of 1.1 and 1.2.

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Appendix 1:

The fiber efficiency coefficient (pull-out force for a given angle of incidence compared to that for a pull-out in the fiber axis) depends on the angle of incidence of fibers Θ, as shown in Figure 1, which presents a simplified model according to Jungwirth (2006).

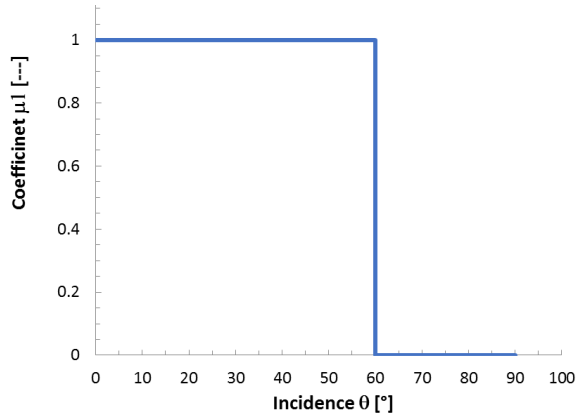

Figure 1: The effect of fiber incidence on pull-out efficiency.

Moreover, fiber orientation, which is characterized by the orientation coefficient, can also be reduced to a domain of angles defining cones in space within which the fibers are randomly oriented. It is therefore possible to calculate by integration the average value of the fiber efficiency coefficient for a given orientation coefficient, in space, defining a certain domain of angles, Bastien-Masse et al. (2016). Figure 2 below illustrates the result obtained for the model presented in Figure 1.

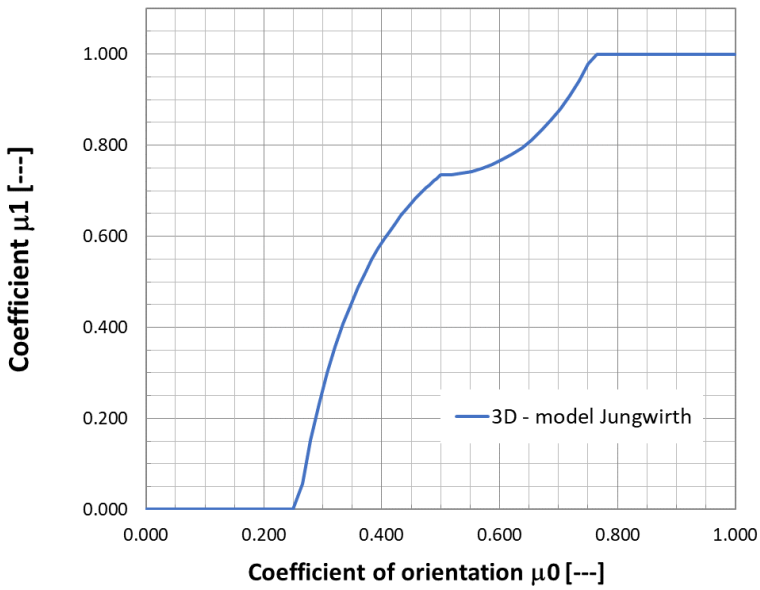

Figure 2: Effect of fiber orientation coefficient on average pull-out efficiency.

References:

Jungwirth J., (2006), "Zum Tragverhalten von Zugbeanspruchten Bauteilen aus Ultra-Hochleistungs-Faserbeton", EPFL thesis, No. 3429, Lausanne.

Bastien-Masse M., Denarié E., Brühwiler E., (2016), "Effect of fiber orientation on the in-plane tensile response of UHPFRC reinforcement layers", Cement and Concrete Composites, 67, 111-125.

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