SOIL REINFORCEMENT WITH SYNTHETIC FIBRES

Ernst-Dieter Hornig

Technical University Bergakademie Freiberg, Germany, Geotechnical Institute, hornig@ifgt.tu-freiberg.de

ABSTRACT. This report describes a laboratory program where the shear strength of a mixture of soil and mixed-grained soils with short synthetic fibers has been studied. The influence of the quantity of fiber on the shear strength of reinforced soils in the frame shear device and the triaxial shear device according to DIN 18137 was investigated. There have been non-reinforced and reinforced soil samples under loose and under medium-density storage, and in dry (sand only) and in a fully saturated condition comparatively studied. The results in relation to the shear strength are clear: fiber reinforcement increases the shear resistance substantially. The shear resistance of the soil increased with the increase in the proportion of fiber. The investigations show that the maximum fiber content is 0.25% to 1.0%. A larger proportion of fiber can mix the fibers with the soil not more homogeneous. An increased segregation during the sample preparation at higher fiber content is also observed.

ЗАЗДРАВЯВАНЕ НА ПОЧВАТА СЪС СИНТЕТИЧНИ ВЛАКНА

Ърнст-Дитер Хорниг

Технически университет „Минна академия", Фрайберг, Германия, Геотехнически институт, hornig@ifgt.tu-freiberg.de

РЕЗЮМЕ. Настоящият доклад описва лабораторна програма, която изследва якостта на срязване при смес от почва и смесено-зърнеста почва с къси синтетични влакна. Проучено е влиянието на количеството влакна върху якостта на срязване на укрепени почви в рамково устройство за изпитване на срязване и триосно устройство за изпитване на срязване според DIN 18137. Направени са сравнителни изследвания на неукрепени и укрепени почвени проби при хлабаво съхранение и при съхранение със средна плътност и при сухо (само пясък) и напълно наситено състояние. Резултатите по отношение на якостта на срязване са очевидни: заздравяването с влакна значително увеличава устойчивостта на срязване. Устойчивостта на срязване на почвата се увеличава с нарастването на дела на влакната. Изследванията показват, че максималното съдържание на влакна е от 0.25% до 1.0%. По-голямата част от влакната могат да се смесят с влакна и почва, която не е по-хомогенна. Наблюдава се също увеличено отделяне по време на подготовката на пробите с по-високо съдържание на влакна.

1. Investigated Soils

With the examined ground it concerns a narrow-graded sand with the grain size from 0.06 to 2.0 mm (see. Fig. 1).

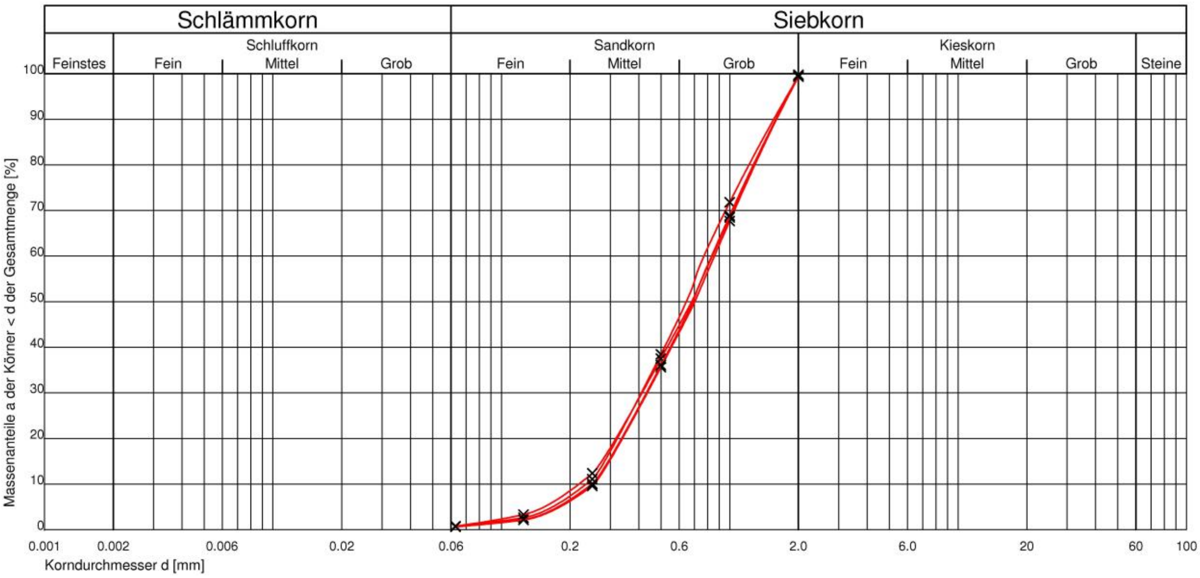

Fig. 1. Grain-size curve, coarse sand, strong medium sandy, low fine sandy

Investigated fiber

With the investigations plastic fibers from Polypropylen were used.

The delivery fibrillated fibers from Polypropylen or Technofiber in straight form and the nominal lengths of 12.7 millimetres occurred from a German manufacturer. The specific identity values can be taken from the table 1.

Table 1: *technical product data – fibre proberty*

characteristic	unit	value
material		plastic fiber
density	[g/cm^3]	0,91
E-Modul	[N/mm^2]	4.900
tensile-strength	[N/mm^2]	400
melting point	[°C]	160 - 170
diameter	[mm]	0,004 - 0,15
length	[mm]	12,7 (Typ 310)
strain of failure	[%]	6-20
flammability temperature	[°C]	600

Fig. 2. PP-fibre (*Oubelkas 2008*)

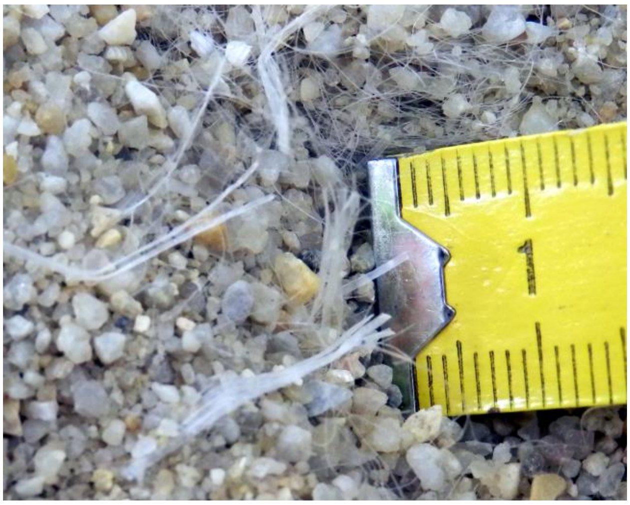

Fig. 3. Sand-fibre-mixture

Testing program und results

The frame shear device (RS) and triaxial shear device (Triax) became comparative, in loose as well as in dense stored sand, carried out. The sand was examined first only without fiber in the dry and in the state saturated with water for his shear behaviour. Then gradual plastic fibers were given to the sand. Were covered to the mass of the sand In terms of percentage different amounts in fibers added, namely: 0.06, 0.1 and 0.25 Gew. -%. with 0.25 Gew. -% a maximum fiber amount was reached with regard to a homogeneous mixture from sand and fiber. With higher fiber shares and with the examined sand a too strong demixing appears in the test production or while mixing the fiber.

The following pictures show an clearly trend with the cohesion: with increasing fiber portion this of C´ = 0 kN/m ² increases with 0% of fiber on at most C´ =14 kN/m ² with 0.25 Gew. -% of fiber.

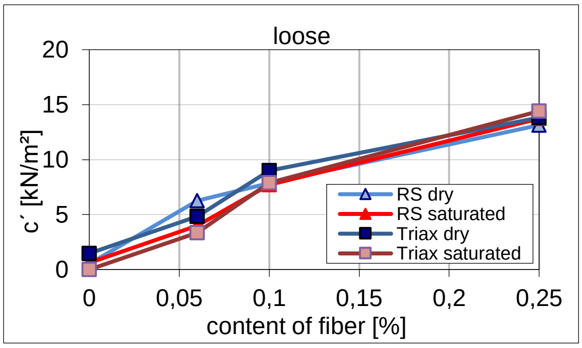

Fig. 6. content of fibre – cohesion (loose)

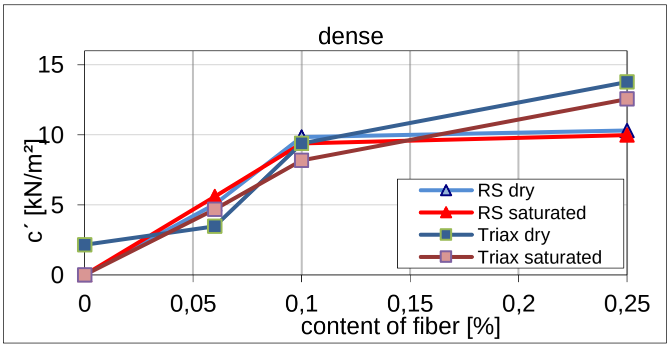

Fig. 7. content of fibre – cohesion (dense)

In contrast to the trend of the cohesion the development of the friction angle does not present itself in dependence of the fiber portion clearly: With the tests in the triaxial shear device the development of the friction angle is in dependence of the content of fiber comparably with the change of the cohesion – he rises with increasing content of fiber from approx φ´ = 38° to 45° (dense and dry).

Against it appears in the frame shear device partially a reverse behaviour: the friction angele remains in the dense, flooded sand with increasing fiber portion nearly constant with φ´ = 43°. The friction angle of the dense, dry sand increases from φ´ = 37° to 40°. With the loose built-in sand the friction angle from φ´ = 38° decreases to 35° in the dry state and from φ´ = 36° to 33° in the saturated state.

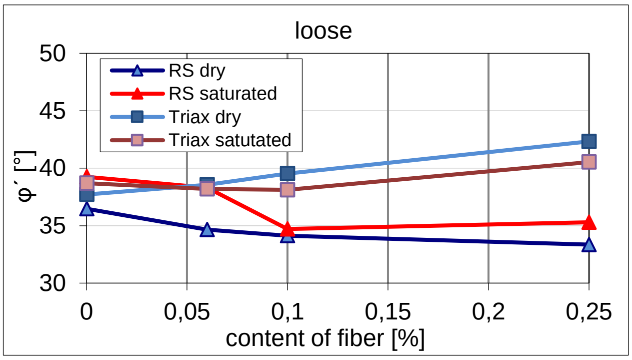

Fig. 6. content of fibre – friction angle φ (loose)

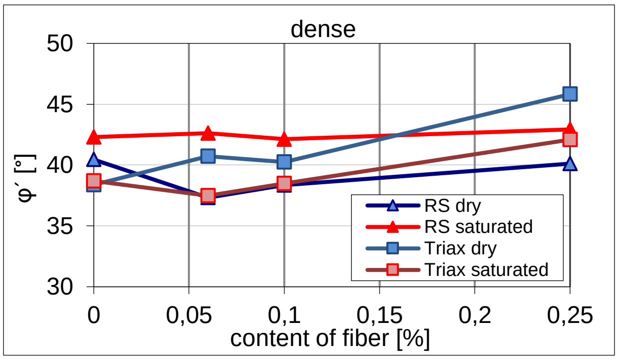

Fig. 7. content of fibre – friction angle φ (dense)

Summary und outlook

The first investigations shown in this article of the shear strength one with art material fibers of reimbursed cohesionless soil, here sand, have shown that with increasing fiber portion the cohesion clearly increases from C´ = 0 kN/m ² to approx. 14 kN/m ².

The friction angle increases by the addition of plastic fibers in the triaxial shear device on average around φ´ = 7°. In the frame shear device the friction angle hardly changes on average, partially he increases by the fibers around up to φ´ = 3° and partially he gets smaller around at most φ´ = 3°.

In future different sand should be still examined by the grain gradation in combination with different fiber kinds on the frame shear device. In particular there should be use a little stronger fibers with a higher specific weight which can be better mixed with ground in general and especially with sand, or with those no demixing appears in the test production. Besides possibilities should be examined for the industrial production of the ground-fiber mixture without appreciable demixing. Particularly application possibilities of the sand fiber mixture should be thereby shown also in the traffic routes and sports field construction.

References

[1] Oubelkas, M., Hornig, E.-D.: Verbundverhalten von bindigen Böden mit Kunststofffasern; Seite 95-112, Statusbericht 2008, Veröffentlichungen des Institutes für Geotechnik der TU Bergakademie Freiberg, Heft 2008-1

[2] Oubelkas, M.: Innovationen in der Bodenverbesserung - Kunststofffasern & Bindemittel -, Dissertation, Institut für Geotechnik, TU Bergakademie Freiberg, 2008.

[3] Consoli, N. C., Heineck, K. S., et al.: Shear Strength Behavior of Fiber-Reinforced Sand Considering Triaxial Tests under Distinct Stress Paths, Seite 1466, Journal of Geotechnical and Vol. 133, No. 11, November 1, 2007. ©ASCE, ISSN 1090-0241.

Recommended for publication by Editorial board.