iwtech- Production Tech of Foam Concrete of 300–900 kg/m^3

use, manufacture & properties

2014 - 2022

iwtech™ europe

Foam concrete technologies

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Briefly about our history

- ✓we date back to 1997,
- ✓by gradual development from the production of polystyrene - concrete on-site, the company iwtech europe ltd worked through the production of foam concrete (FC) on the construction site to the production of FC at the concrete plant: "foam concrete as concrete"
- ✓FC was manufactured on-site in patented automated equipment MS 1000 with the possibility of dosing cement from bags or silos
- ✓FC production technology at the concrete plant has been on the market since 2014
- ✓it is currently used successfully in the markets of SK, CZ, PL, UK and HR
- ✓ so far, several hundred thousand m^3 of FC has been produced using iwtech tech
- ✓FC is currently considered a proven building material

Introductory statement

- ✓all information, descriptions of realizations, experiences, and results of measurements contained in this presentation apply exclusively and only to foam concrete (FC) manufactured according to instructions and recommendations and the equipment and admixtures of iwtech europe ltd.
- ✓the above mainly means that there are several FC producers, each with its descriptions and measurement results and using its own, in some cases taken over, production technology and therefore it is not possible to assign the properties of FC produced by one technology to the properties of FC produced by another technology
- ✓for example, FC with a density of 400 kg/m^3 produced by one technology may not have similar properties as FC of 400 kg/m^3 produced by another technology

Input information about iwtech europe -Foam Concrete - Lightweight Concrete with natural setting

Lightweight Concrete with natural setting: Foam Concrete (FC)

FC: Density usually 300 - 900kg/m^3, in iwtech conditions mastered automated production at the concrete plant with verified repeatability and quality control, pumping with screw pumps, if the conditions are met, even large piston pumps, ideal aggregate 0-2mm, it can be used for the production of FC 300, fraction 0-4mm from FC 500 above, the condition is mastering the production of technical foam (TF) as well as its precise dosing, concrete plants as well as mixer trucks in the usual version
The production is managed when the produced material is a homogeneous mass, after maturing an even distribution of pores over a layer thickness of up to 1000mm.
The most common uses: levelling layers for civil engineering floors, replacement of compacted gravel in the industrial floor, filling of empty spaces in the underground - replacement of the Cement-Fly-Ash suspension, other geotechnical applications

In the case of FC, the value of λ depends mainly on its Density, the same applies to the strength characteristics.

foam concrete as concrete

The proven use of Foam Concrete

produced

according to the instructions and recommendations of iwtech europe ltd

Application of FC 300 – 400 kg/m^3: levelling layer of the floor

FC as a replacement for, for example, floorboard polystyrene

Descriptions and advantages: higher labour productivity than when laying EPS boards between pipes, unevenness of the subbase is not transferred to the upper layer, which brings, for example, a constant thickness of the screed layer, ultimately lower price of the entire floor layer, technological moisture gradually leaves the FC through the ceiling plate into the space below, additional layers already after 24 - 48 hours depending on the ambient temperature

Use of FC 400 - 500 kg / m^3: levelling layer of the vault structure

FC as a replacement for "heavy" backfills and thus lightening the load-bearing structure

Advantages: easy handling, retains the functionality of the supporting vault structure, homogeneous FC layer evenly carrying the load, technological moisture from the FC gradually leaves through the vault structure into the space below; other layers after 24 - 48 hours depending on the subbase temperature

Application of FC 600 - 900 kg/m^3: flat roof slope

slopes up to 2% on concrete or vapour barrier subbases

Description and advantages: high load-bearing capacity at low dead weight, easily compensates for unevenness of the subbase and does not transfer them to the coating layer, technological moisture from FC gradually leaves through the ceiling plate also through the micro-ventilation coating layer, rain-free weather at least 8 hours after application at air temperature min 15° C, further layers already after 72 hours

Use of FC 800 - 900kg/m^3: filling between the pool and the excavation

FC replaces backfills with homogeneous material with a significant increase in thermal resistance

Description and advantages: easy handling, does not require any compaction of the backfill, homogeneous layer ensures the stability of the pool body without surface deformations and evenly transmits the load, technological moisture from the FC gradually leaves into the surrounding soil; other layers after 24 hours

Use of FC 400 – 500 kg/m^3: sewer connection to a family house

FC as a replacement for the backfill of the sewer connection to the family house

Výhody: higher labour productivity than with backfills, FC creates a homogeneous excavation filling without surface deformations, cost savings for the implementation of excavation levelling, additional layers after 24 - 48 hours depending on the ambient temperature

Application of FC 400 - 500kg/m^3: filling between foundation strips

FC as a replacement for compacted gravel or frequently used building rubble

Advantages: higher labour productivity than with backfills, FC creates a homogeneous and thermal insulation base for the upper reinforced concrete plate, savings on heating costs in the order of 10%, further layers after 24 - 48 hours depending on the ambient temperature

Use of FC 500 - 800kg/m^3: stabilization of the pipe in the excavation

FC as a substitute for sand backfill and compacted backfill

Advantages: higher labour productivity than with backfills, FC creates a homogeneous filling between the pipe surface and the excavation wall, there is no risk of damaging the pipe during backfill compaction, FC-filling is stable in terms of volume and strength over time, i. there is no danger of consolidation of the subsoil and thus also the formation of surface deformations, e.g. roads, further layers after 24 – 48 hours depending on the ambient temperature

Application of FC 500 - 800kg/m^3: filling unnecessary pipes

FC as a barrier against uncontrolled soil and surface drops above the pipe

Advantages: higher labour productivity than with backfills, FC creates a homogeneous filling between the pipe surface and the excavation wall, there is no risk of damaging the pipe during backfill compaction, FC-filling is stable in terms of volume and strength over time, i. there is no danger of consolidation of the subsoil and thus also the formation of surface deformations, eg, roads; other layers after 24 - 48hours depending on the ambient temperature

Use of FC 500IF: subbase under the foundation slab of a multi-storey building

FC as a substitute for compacted gravel

Advantages: so far max. 28 m3/hour of installed FC 500IF, FC creates a homogeneous layer without the need for compaction with subsequent control of its size, FC-base layer is stable in terms of volume and strength over time, creates a flat surface for laying reinforced concrete foundation structure, another layer after 24 - 48 hours depending on temperature

Use of FC 500IF in an industrial floor

FC as a replacement for compacted gravel

Description and benefits: so far max. 28 m^3/hour of laid FC 500IF, FC creates a homogeneous layer without the need for compaction with subsequent control, FC-base layer is stable in volume and strength over time, creates a flat surface for laying the top plate, the next layer after 24 - 48hours depending from ambient temperature

Use of FC 500 - 800kg/m^3: filling an unnecessary sewer pipe

FC used to fill the sewer pipe under the body of the future tram line

Description and advantages: filling the pipe eliminates the need to dig it out with the subsequent implementation of loose subsoil layers, FC creates a homogeneous filling of the entire volume of the pipe, FC-filling is stable in volume and strength over time and therefore there is no risk of surface deformation above the pipe

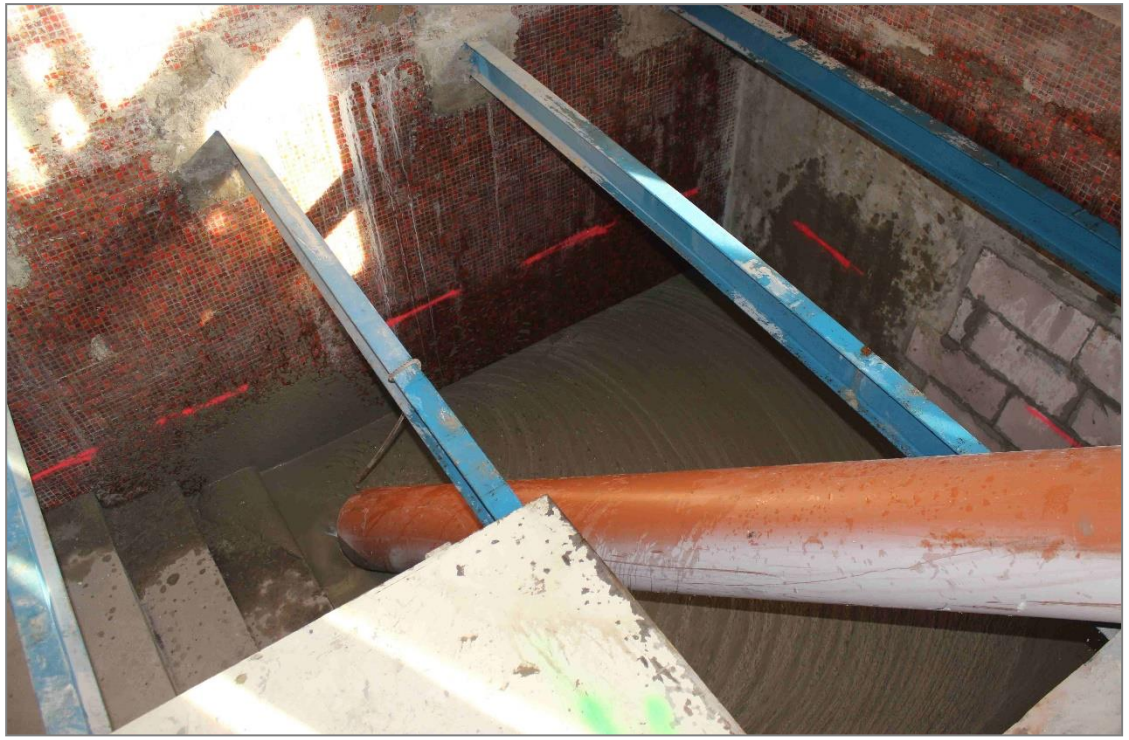
Application of FC 500 - 800kg/m^3: filling an unnecessary sewer pipe

FC used to fill the sewer pipe

Description and advantages: filling the pipe eliminates the need to dig it out with the subsequent implementation of loose subsoil layers, FC creates a homogeneous filling of the entire volume of the pipe, FC-filling is stable in volume and strength over time and therefore there is no risk of deformation of the terrain above the pipe

Use FC 500 - 800kg/m^3: filling unnecessary underground spaces

FC as a substitute for cement-fly ash suspension, or instead of backfilling with soil



Description and advantages: in times of growing fly ash shortage, FC is a suitable substitute for Cement-Fly-Ash suspension when filling underpasses and former Civil Defense or anti-aircraft covers, also mining works, usually poured directly from the gutter of the truck mixer, FC-filling is stable in terms of volume and strength over time, another layer after 24 - 48 hours

Use FC 500 - 800kg/m^3: filling unnecessary underground spaces

FC as a replacement for cement-fly ash suspension or backfilling with soil

Description and advantages: in times of growing fly ash shortage, FC is a suitable substitute for Cement-Fly Ash suspension, used for filling underground structures, also mining works, filling the space between the excavation and the tank body, usually poured directly from the gutter of the truck mixer, FC forms a homogeneous layer without compaction needs, FC-filling is stable in terms of volume and strength over time; the next layer after 24 - 48 hours

Production of foam concrete according to iwtech europe ltd

FC: basic admixtures and production method

Cement: I - IV from 42.5R, N, 32.5R or various other types, but not types of cement containing hydrocarbon residues intended for the production of waterproof concrete
Water: just clean, not recycled water from the concrete plant, it can also be from a well, mineral turbidity is usually not a problem, it must not contain organic solvents - even their traces because they disrupt the pre-formed bubbles
Aggregate: ideally mined or crushed fractions 0-2mm for FC with bulk densities of 300 - 900kg/m^3, fractions 0-4mm, preferably mined, for a density from 500kg/m^3 higher, other fractions not tested in our country
Admixtures: other fine inorganic wastes - limestone, finely ground slag, fly-ash only verified
Technical foam (TF): under iwtech conditions, the best foam-forming concentrate based on hydrolyzed proteins so far, its unsurpassed advantage is the stability of quality, which synthetic concentrates usually do not achieve, the TF optimal density is 80 g/l; precisely calculated TF amount is dosed into the mixture, dosing the TF is continuous and its properties are the same throughout the dosing period
Production procedure: according to the supplied recipe, the concrete plant produces cement milk/slurry and pours it in the prescribed quantity into the mixer truck‘s drum.
The generator marked GFM 8 or 10 fills the technical foam into the mixer truck drum rotating at increased speed.
Then he leaves for the construction site with the set transport speed of the drum.
2-minute-homogenization at a speed of approx.10 rpm is recommended before starting to pump FC to the installation site.
Production capacity: approx. 26 - 28m^3/hour including the installation

Production equipment

Concrete plant:	the same as for the production of concrete, before the production of cement slurry for FC after the previous production of concrete, it is necessary to wash up the mixing core of the plant
Mixer truck:	the same as for transporting concrete, before the production of foam concrete after the previous transport of concrete, it is necessary to wash its mixing drum
Generators:	of technical foam for industrial FC production GFS 8, 10 - stationary - without chassis, GFM 8 alt. 10 - mobile, for transfers on public roads, GFS LabE - generator for the production of test specimens,
Pump:	screw, e.g. Estrich Boy FHS 200 piston, e.g. Putzmeister P 715 or another conventional one

FC 300 - 900kg/m^3: at the concrete plant

Description: for the production of cement slurry for the production of FC, any concrete plant that meets the current requirements for the accuracy of dosing components can be used, for the transport of concrete to the construction site, a standard mixer truck is suitable, technical foam is produced and dosed into the drum in the required amount by the technical foam generator GFM 8 alt. 10, the mixture is homogenized while driving + 2 min. after reaching the construction site before the start of pumping, the driving time of the truck mixer should not exceed 120 min. A screw pump is the most suitable for pumping FC to the installation site, the use of a piston pump must be verified mainly in relation to its condition.

FC: pre-formed / technical foam (TF)

Description and advantages: iwtech uses its own foaming concentrate with the designation FC1 for the production of TF; the setting of the foaming agent concentration and the TF density are checked before FC production; the production of TF according to the set parameters and the dosing of the specified amount of TF into the drum of the truck mixer is provided by the TF generator GFM 8 alt. 10 produced by iwtech europe ltd

FC 300 - 900 kg / m^3: quality control on site

the density and its consistency is checked

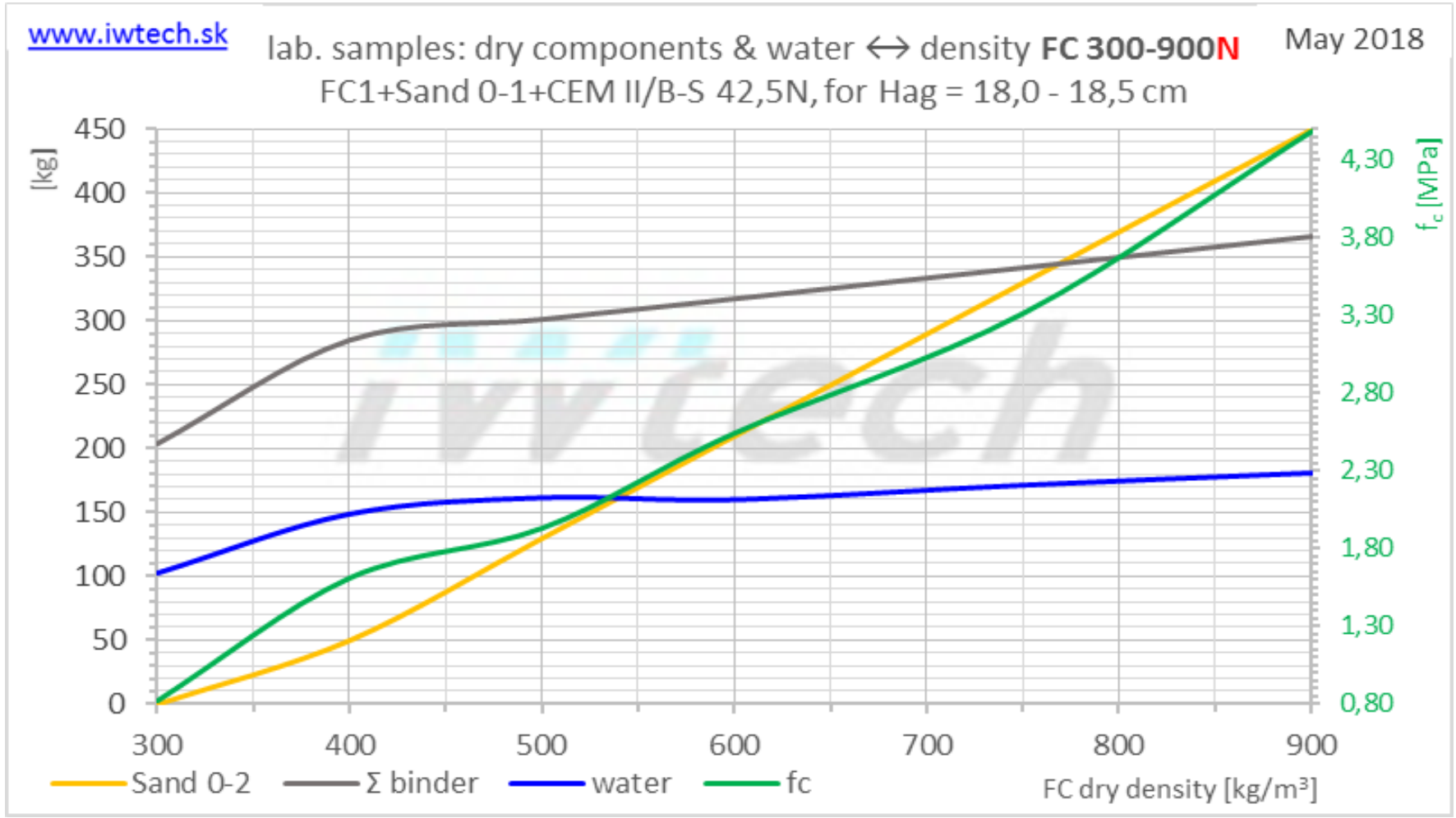
&

Description: the quality control of the produced FC is from the technologist's point of view as simple as possible - the density (D) and consistency are measured on the construction site; A sample for measuring both control parameters is always taken at the end of the transport hose; fresh density and consistency/flow values are given in the production procedure for the respective density; for passing the probative test, test specimens are made - usually 150 mm cubes in accordance with the Control and Test Plan

Component mix design and examples of guidelines for FC 300 - 900kg/m^3

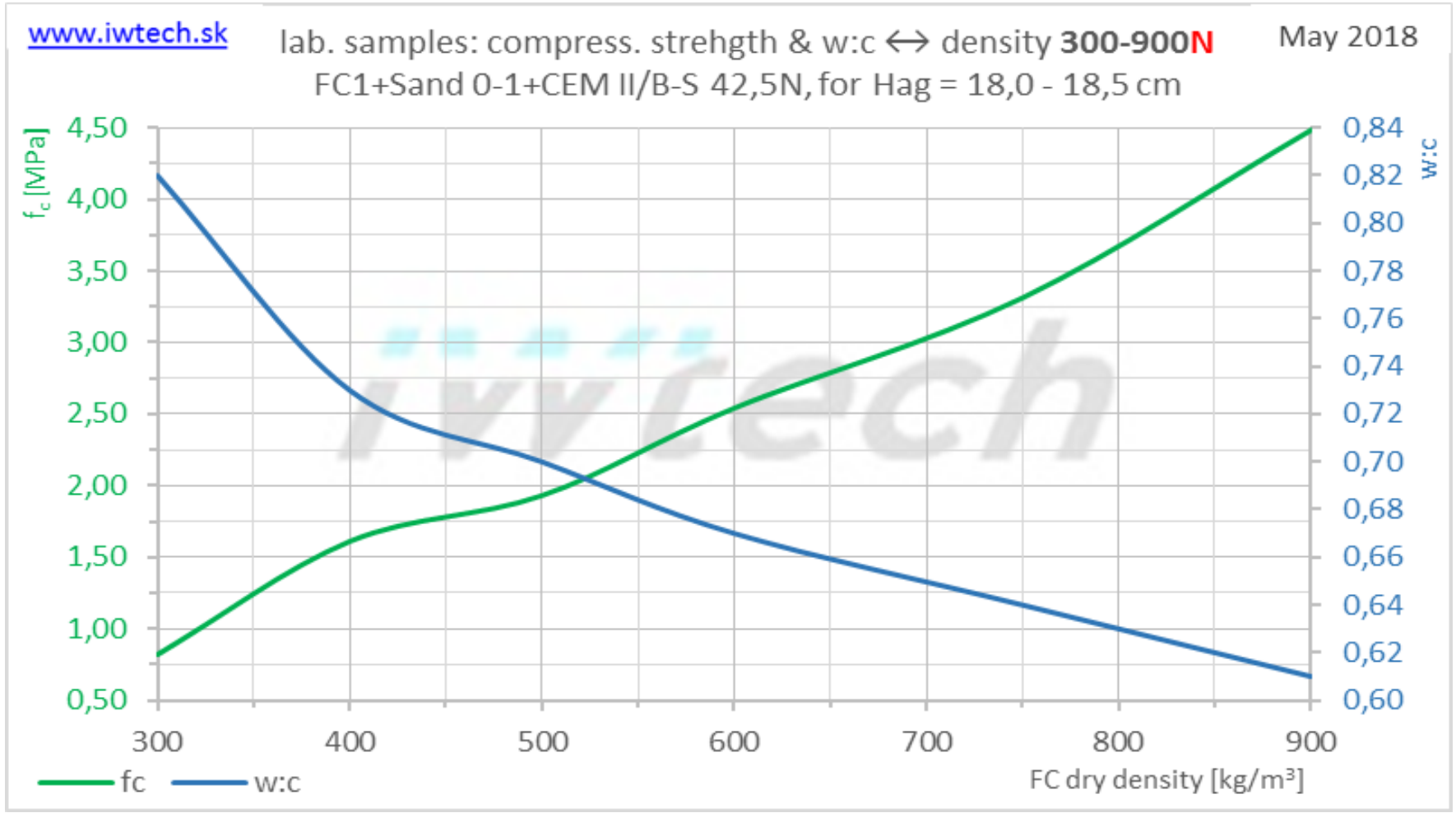
FC: component doses for variant N - diagram I

- **The density (D) of FC is always shown in the diagrams for the dry state !!!**
- for quick orientation in component batches for different FC densities
- the read doses are entered into iwtech-FC Calc, which calculates the TF dose
- also available for E (Economy) and H (Hard) versions



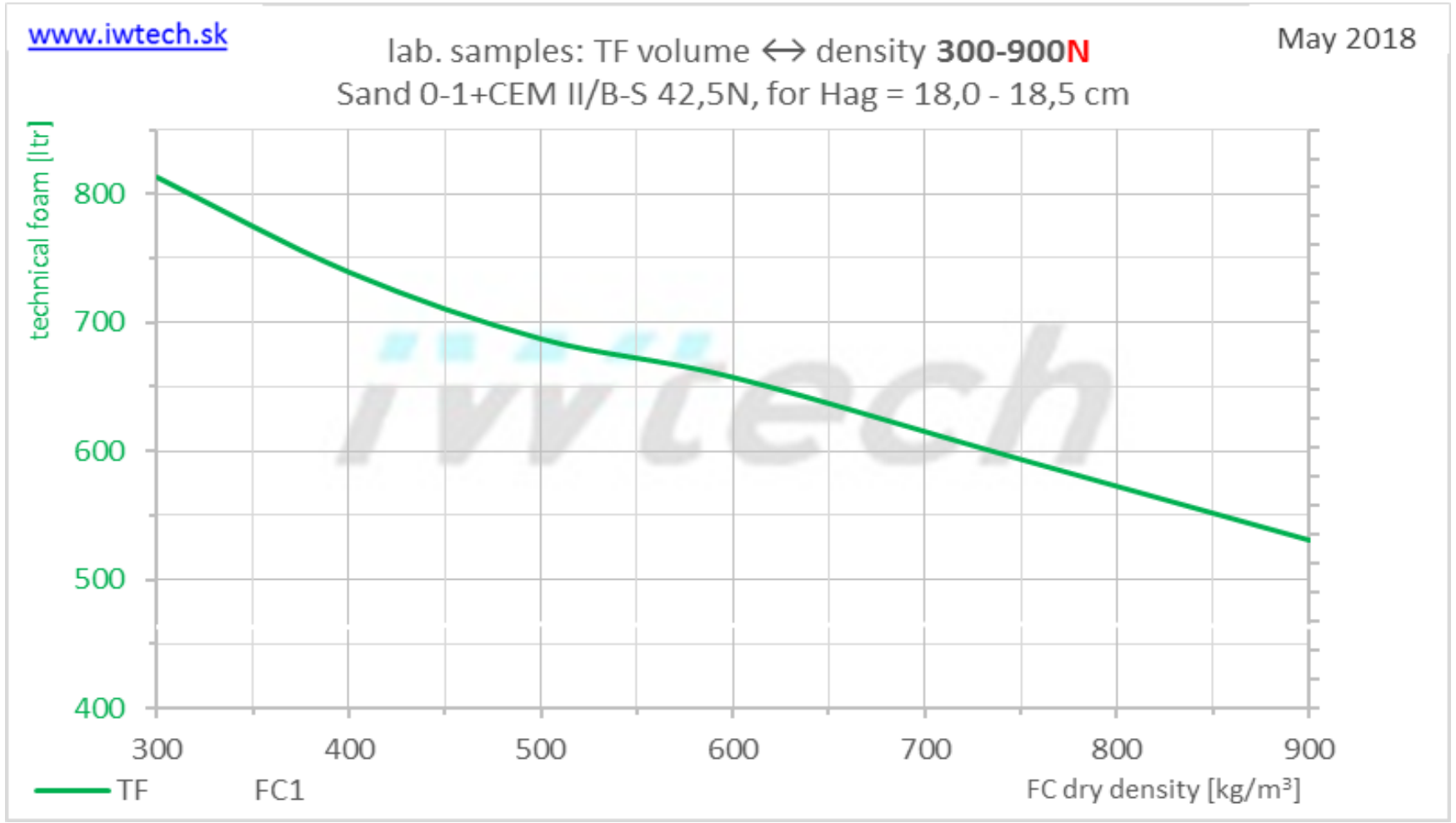
FC: batches of components of variants N - diagram II

- relationship between D, w/c ratio and fc+28
- spilling on a Hagermann cup is important
- practice suggests that it is more advantageous to control the water dose so that a pour in the range of 17 to 18.5cm is achieved
- the diagram applies to version N, still available for versions E (Economy) and H (Hard)
- iwtech is currently developing a plasticizer that will reduce the w/c ratio and thus also increase the strength



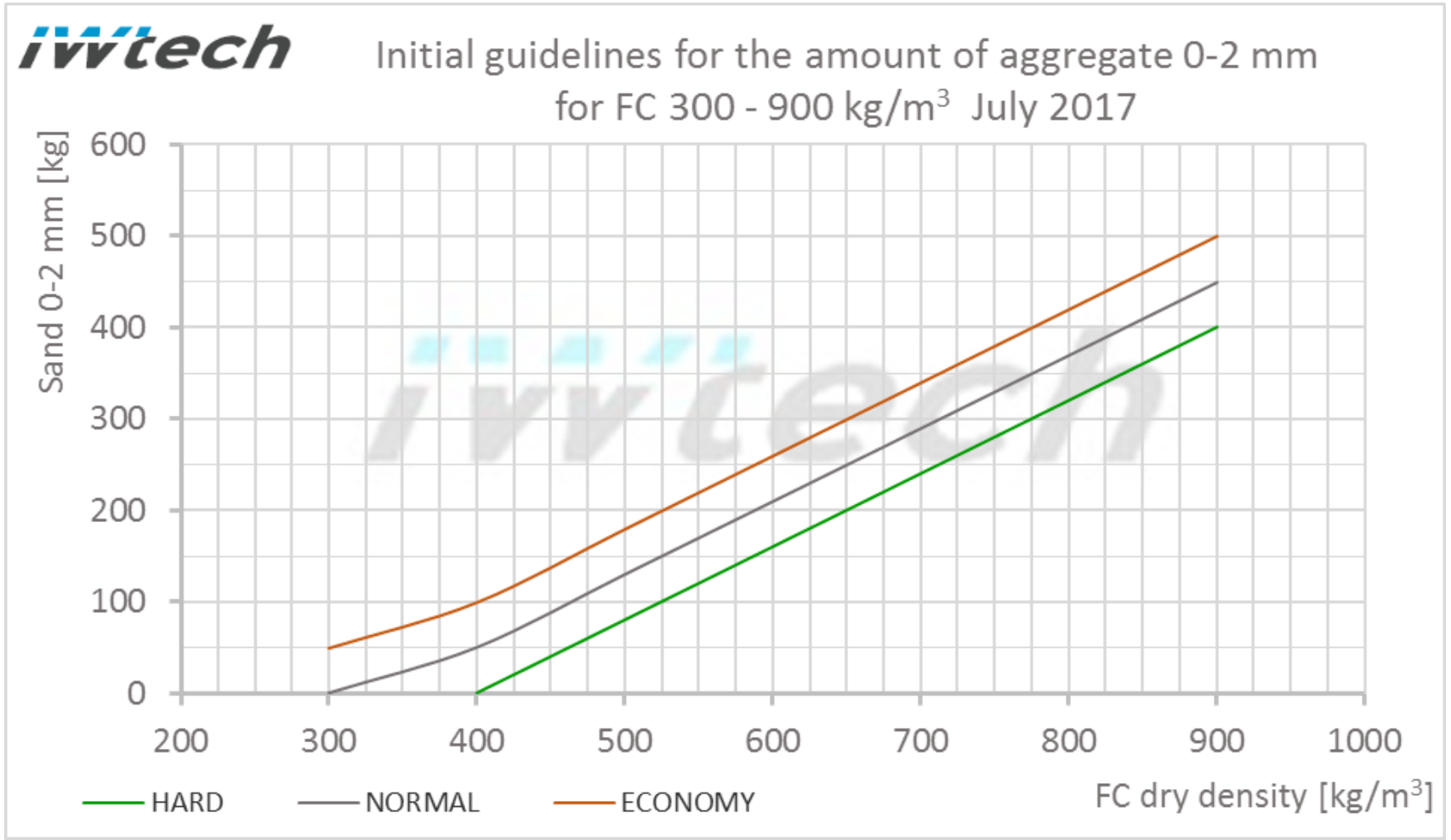
FC: batches of components of variants N - diagram III

- the diagram shows the amount of TF delivered for different FC Densities
- for version N, still available for versions E (Economy) and H (Hard)
- **the amount of TF per unit volume of FC is a determining factor for achieving the projected D**
- TF is used as a filler in iwtech technology, even if it is only suitably pre-formed air
- for comparison: EPS granules are also a filler and it is also basically just formed air



FC: aggregate batches - diagram IV

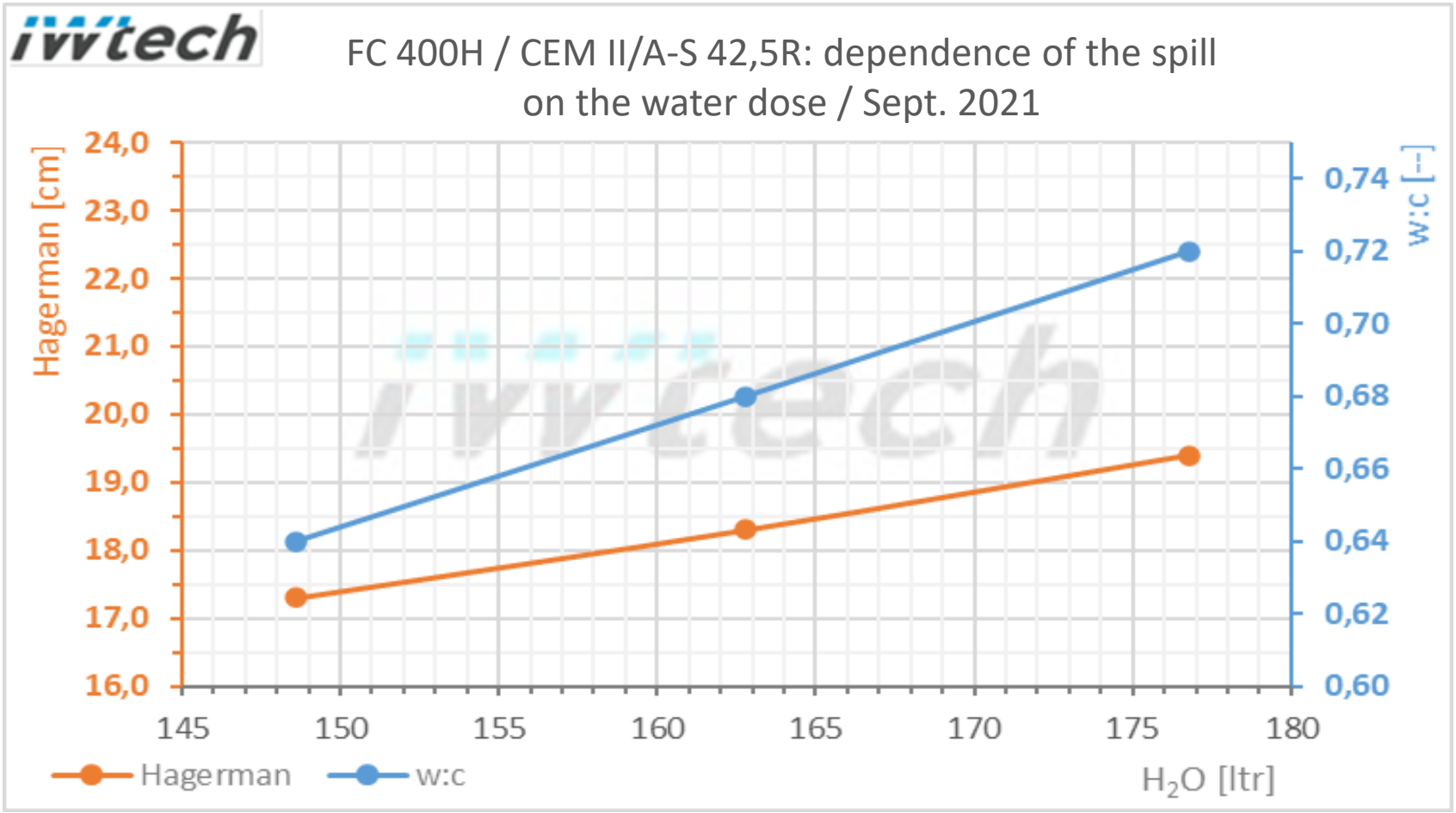
- standardized aggregate doses for variants E, N and H
- there may be differences between fractions among different aggregate producers
- the aim was to get batches of aggregate into the system, which, among other things, allows you to easily navigate when setting the recipe for each Density



FC 400H: effect of water dose on flow

It is important for the technologist to know before entering into production the range of water in relation to the resulting flow.

- the recommended diameter of the flow is 17 - 18.5cm
- it is advisable to check the consistency of fresh FC
- before changing the type or supplier of cement
- water in technical foam is always included in the w/c ratio



FC: calculation of doses of individual components

iwtech-FCCalc:

- sw is intended for the FC production technologist used to design the quantities of components
- the concrete plant receives the doses listed at the very bottom, the generator operator sets the calculated dose of technical foam

FoamConcrete Calculator v1.2.8

Name of recipe

FC 500IFs - MedArt etapa VI_2 17Okt19 - znizena voda o 4 l oproti rec z 16.10 s cielom zmensit rozliv y 19 na 18 cm, co sa i podarilo

Requirements

CEM : GGBS in CEM	100: 0
CEM : GGBS in CEM : GGBS added	100:0:0
Fine dry component	0.0 kg
Sand	130.0 kg
Water	144.0 kg
Density in dry state	500.0 kg/m3

Result

CEM	301 kg
GGBS in CEM	0 kg
GGBS added	0 kg
Fine dry component	0 kg
Sand	130 kg
Water	144 kg
Foam	56.8 kg <--> 709.8 ltr
Foam added	0 kg <--> 0 ltr
Water in total	200.8 kg
Concentrate consuption	1.59 l <--> 1.82 kg
w : c	0.667
Density in dry state	500 kg/m3
Fresh density	631 kg/m3
Density in natural moisture	550 kg/m3
Volume:	999.8 l

Mixing volumes

	CEM	GGBS added	Fine dry component	Sand	Water	Foam
6000.0 ltr	1806.42 kg	0.00 kg	0.00 kg	780.18 kg	864.20 ltr	4259.78 ltr
7000.0 ltr	2107.49 kg	0.00 ltr	0.00 kg	910.21 kg	1008.23 ltr	4969.75 ltr

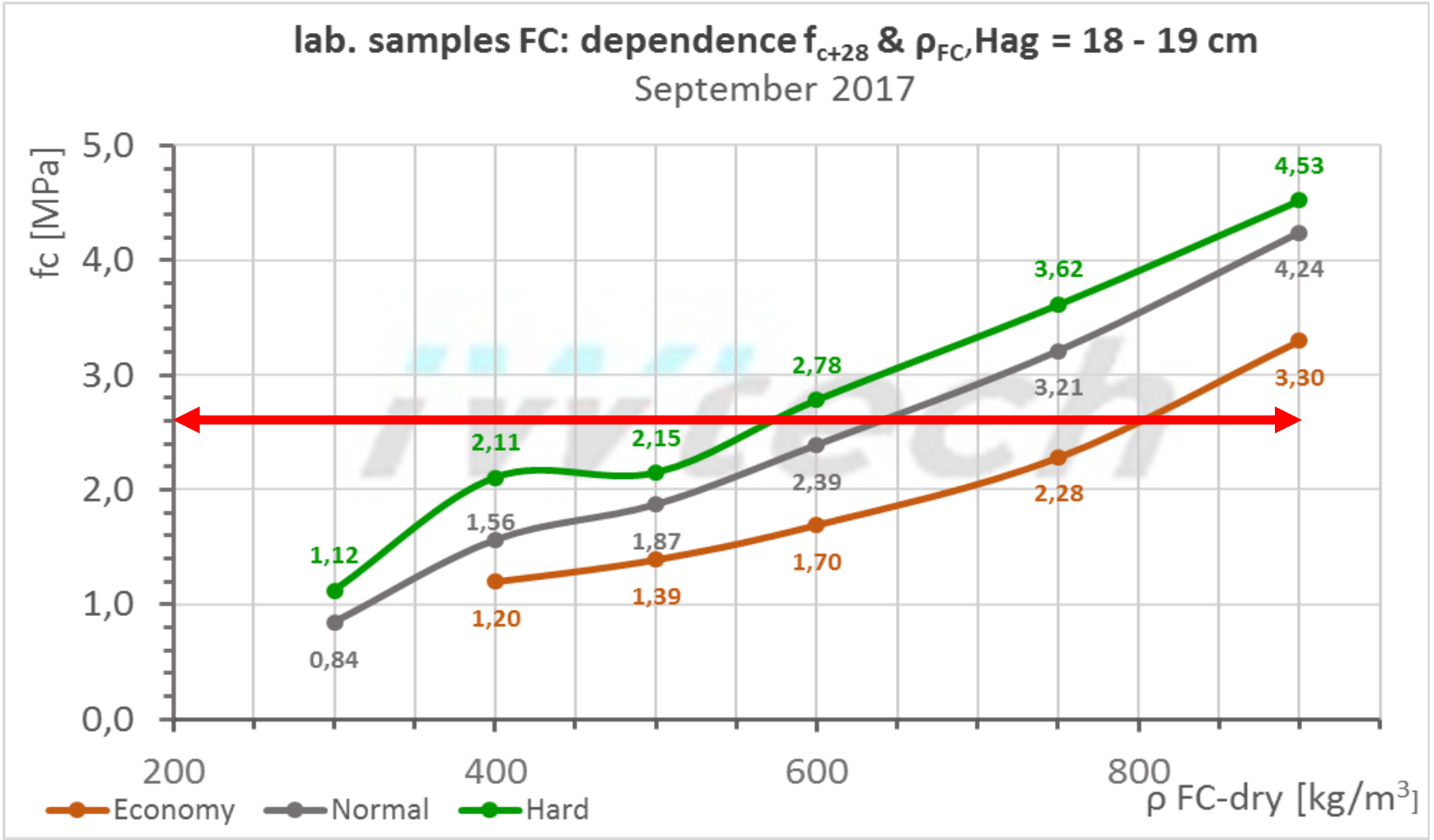
Examples of strength characteristics

FC 300 – 900 kg/m^3

FC: compressive strengths for variants E, N and H

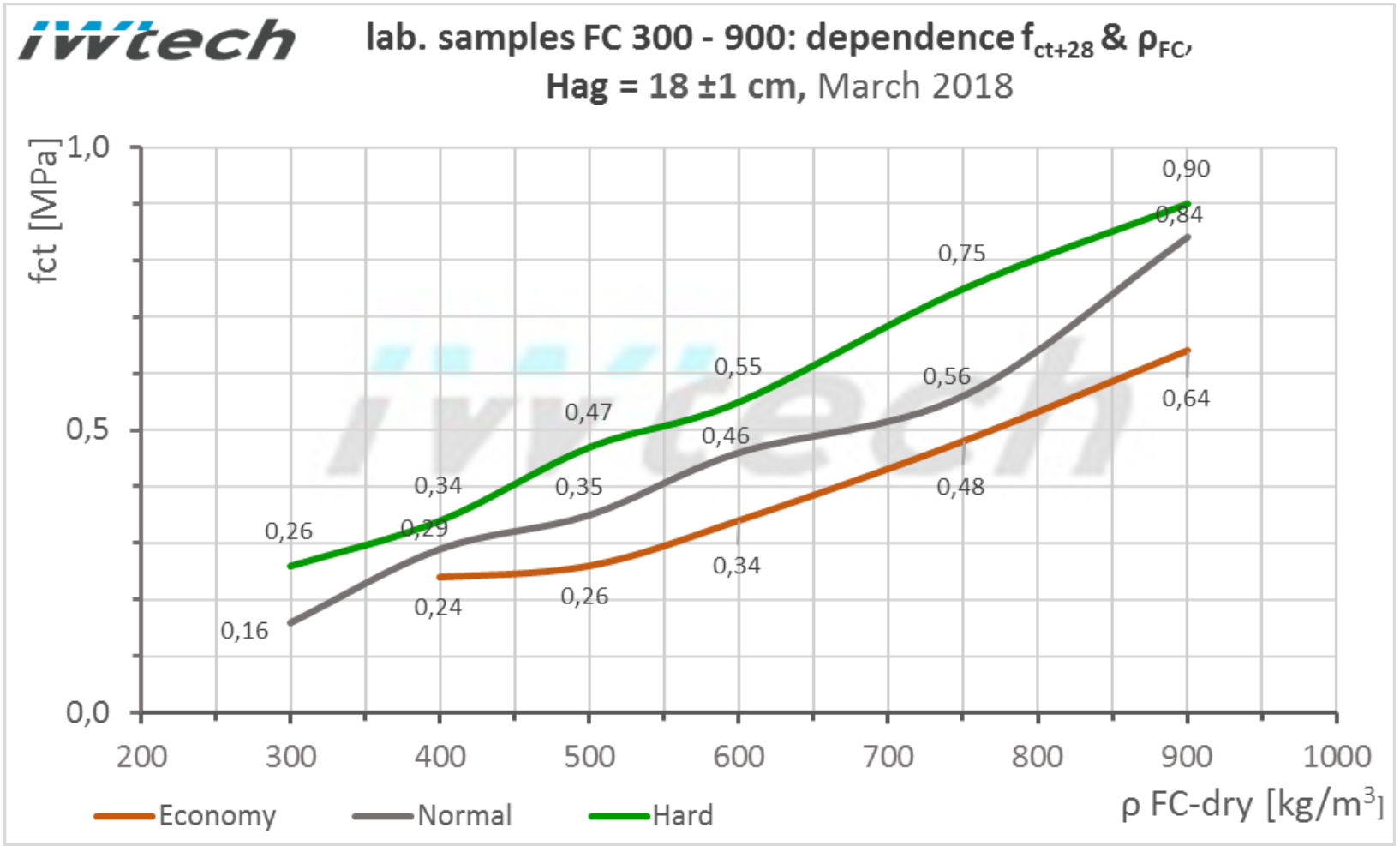
- FCs with smaller air bubble diameters always show higher strengths than FCs with larger pore diameters
- the condition for comparing the compressive strength (fc) is the same flow measured by a Hagermann cup

The diagram shows that different FC densities can be used to transfer the same load - see the red line.
The more and more demands appear, when the customer requires a certain fc, the density and λ do not decide, only the price per 1 m³ is decisive.



FC: flexural tensile strengths for variants E, N and H

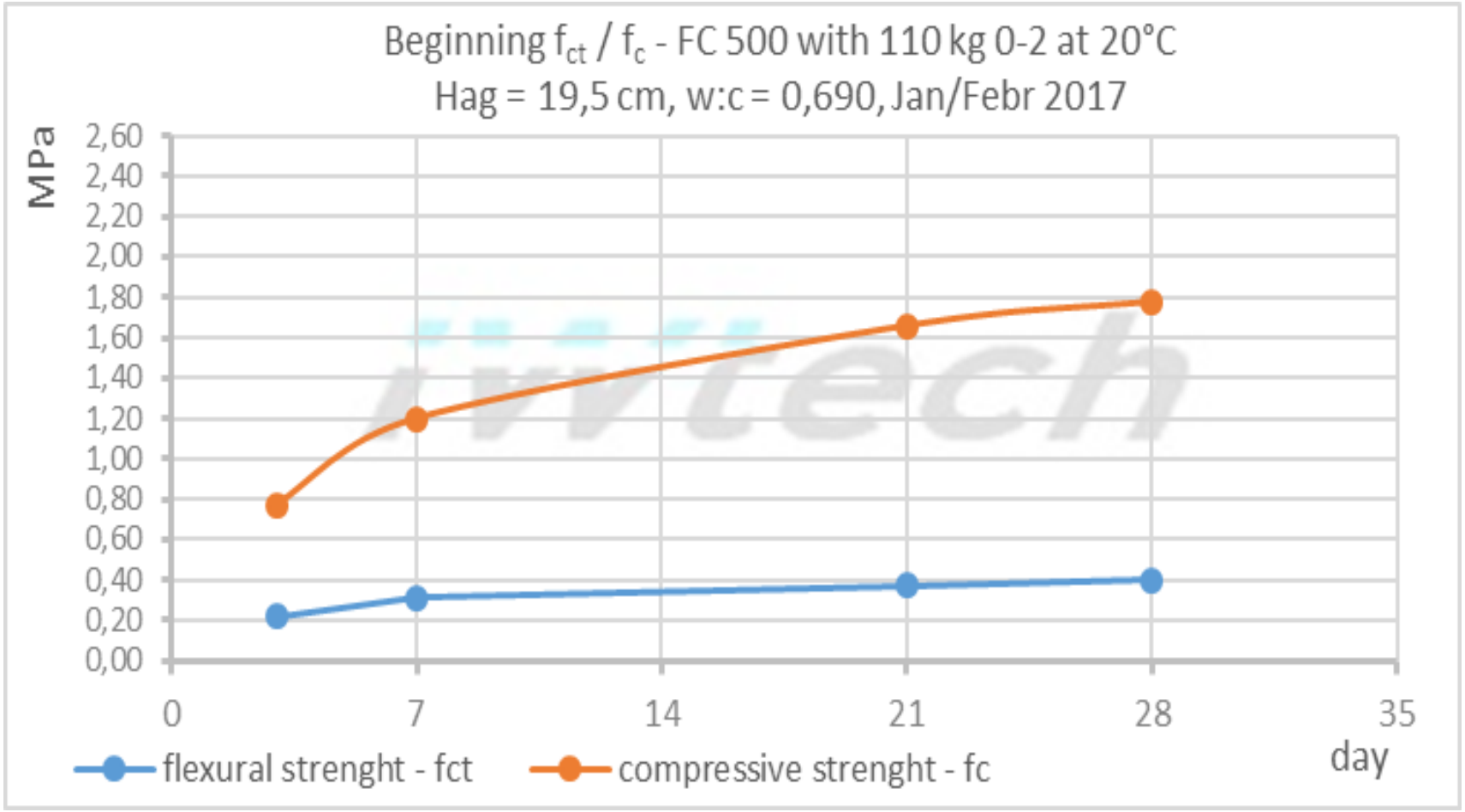
- flexural tensile strength (f_{ct}) was measured to select the FC variant for layers replacing compacted gravel in industrial floor construction
- f_{ct} can be increased by suitable reinforcement, especially in the drawn area of the layer
- we use geotextiles for reinforcement, in justified cases also Orlitech®
- basalt meshOrlitech® basalt reinforcement does not corrode in FC environments



FC 500N: rate of compressive & flextural strength gain

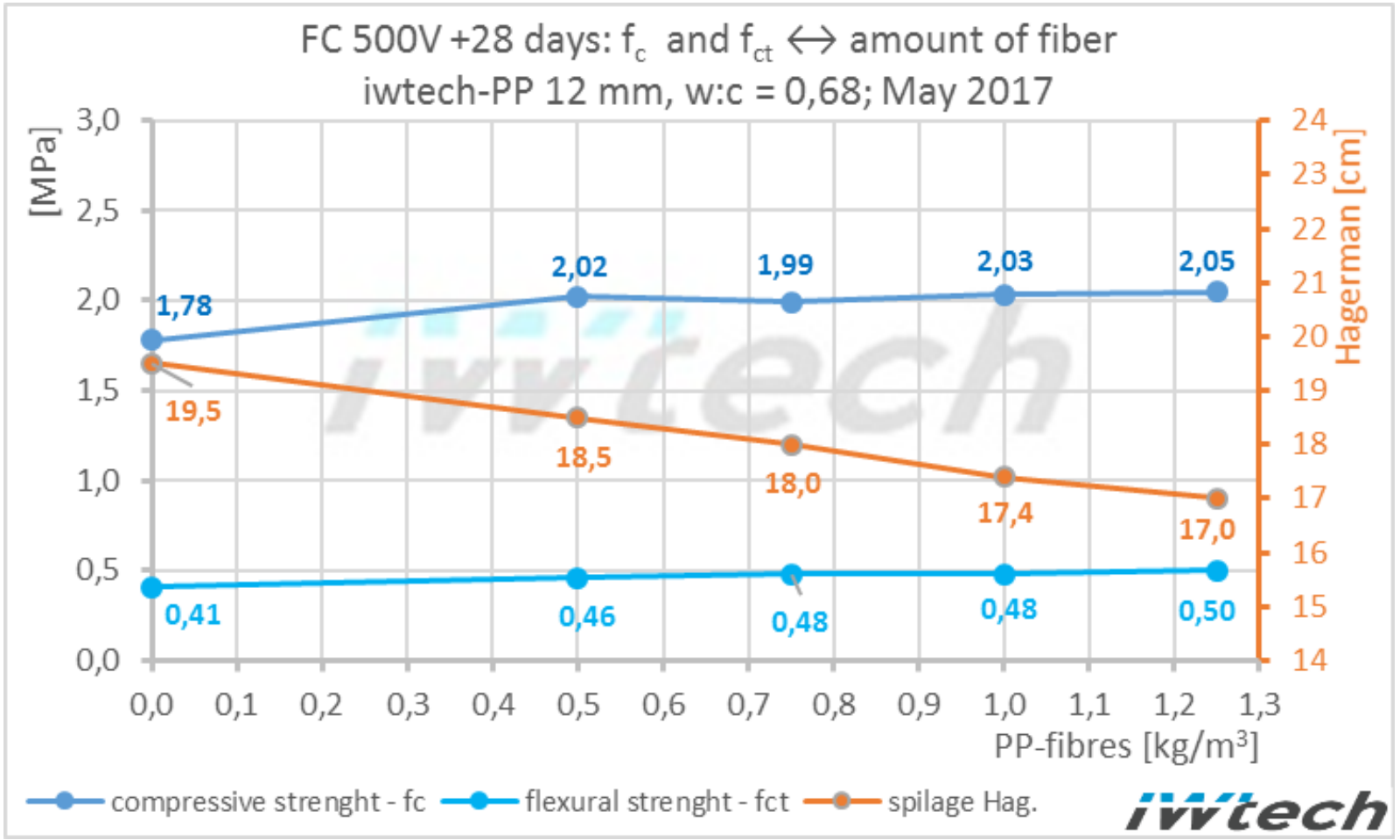
Rises of strengths:

- after +3 days at least 40% of fc + 28
- all FC densities have a similar course of the rise of the strength, they differ in absolute values of strength at a given time

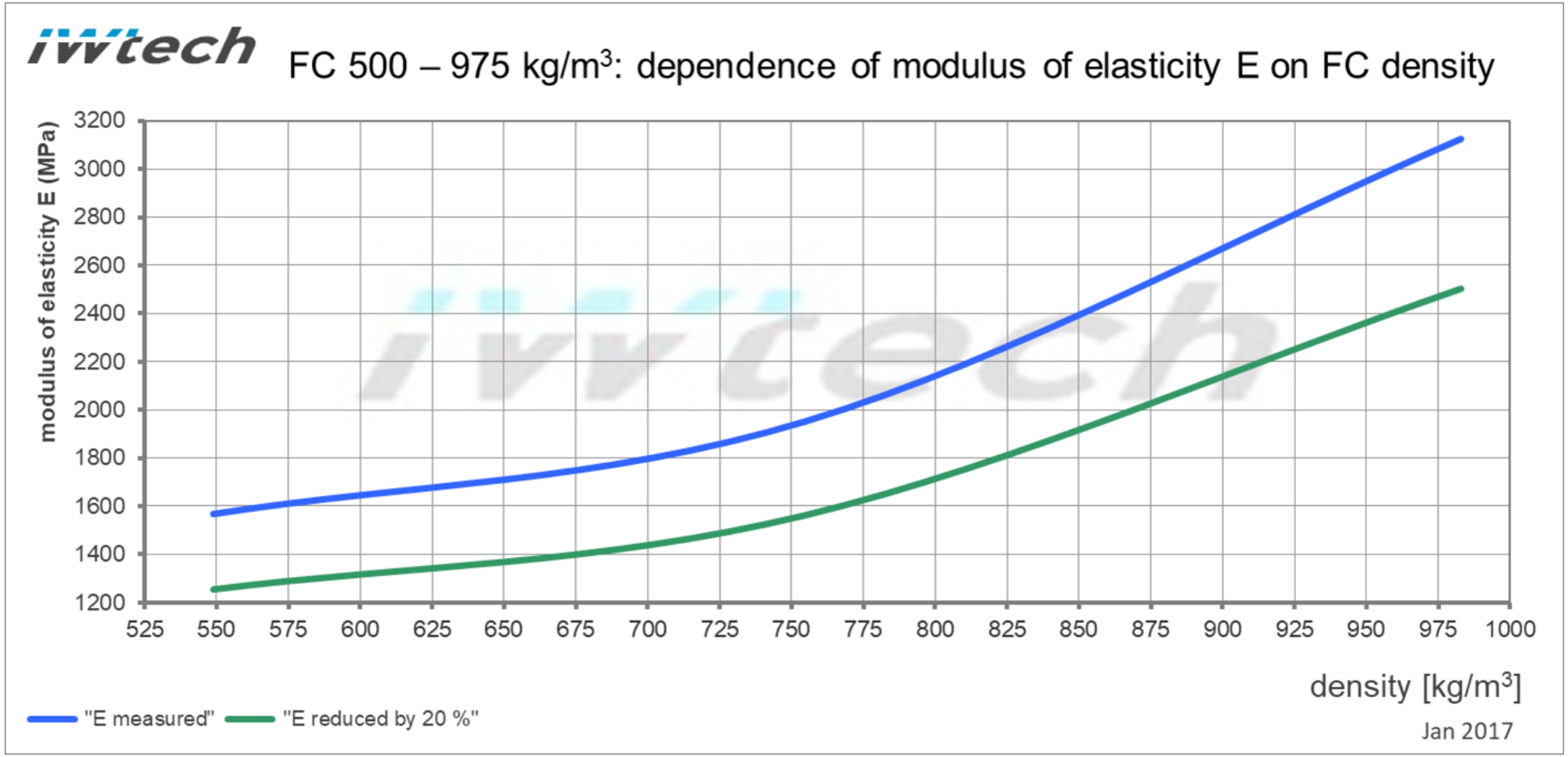


FC 500NV: PP-fiber reinforcement

- the increase in f_{ct} over fiber-free test specimens was not noted as significant
- increasing the dose of 12 mm PP-fiber did not even bring a significant increase in f_c
- However, PP fiber contributes to increasing frost resistance
- after 100 cycles the following was measured:
  decrease in fc 10.5 %
  mass loss 0.5 %



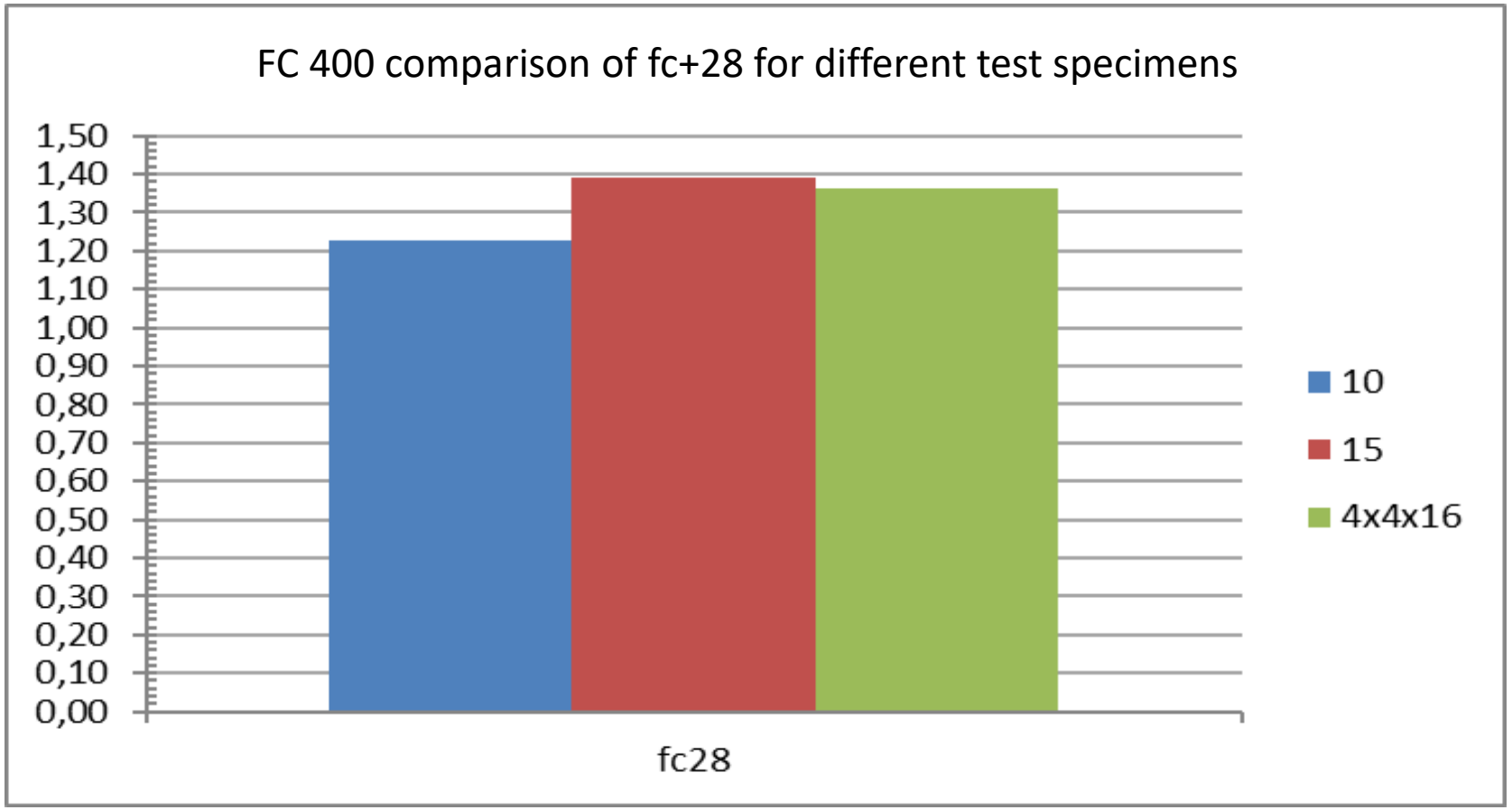
FC 500N: modulus of elasticity



FC: compressive strength - comparison of specimen shapes

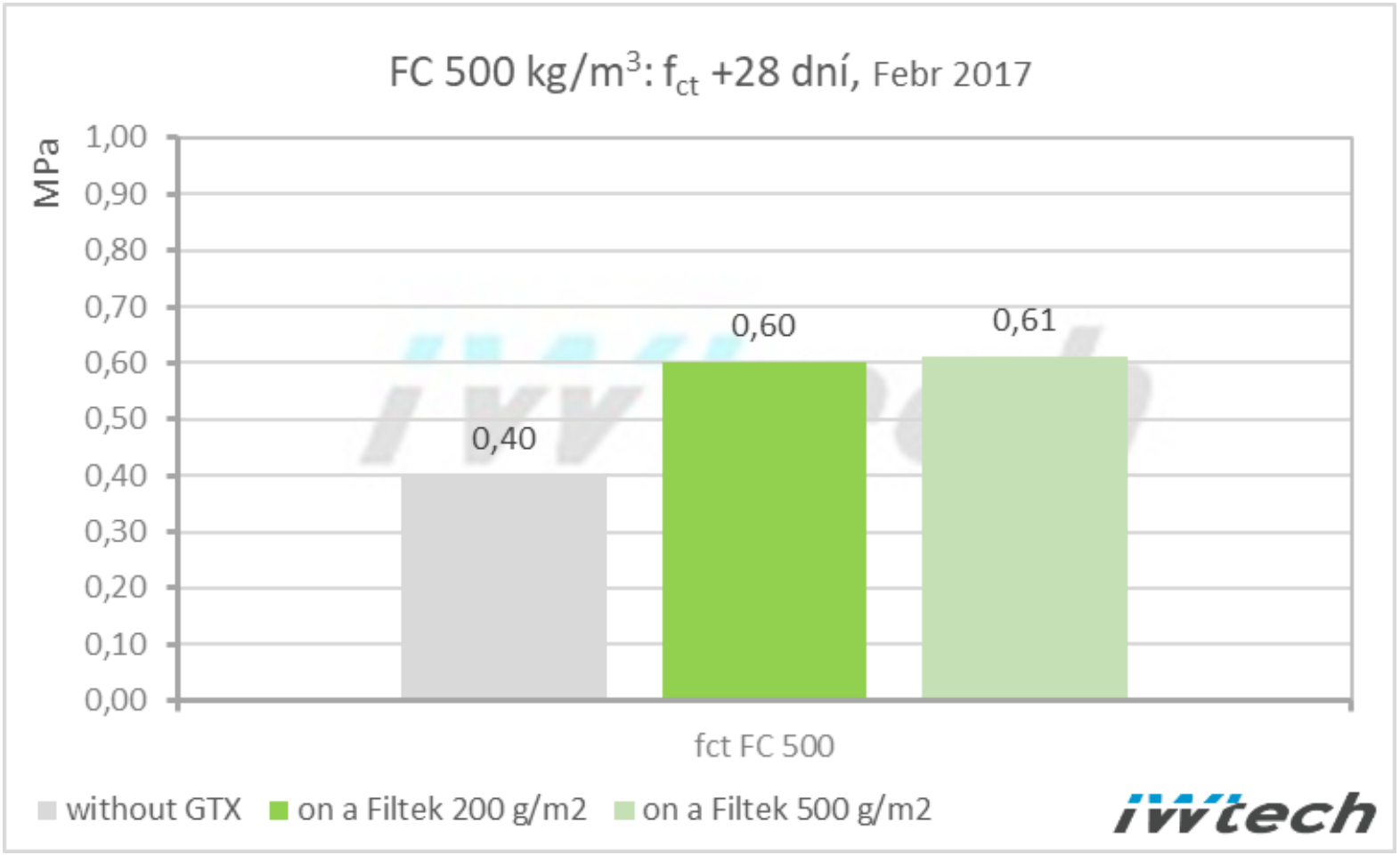
Influence of the test specimen shape on the measured value fc+28

- in iwtech, we use cubes of 100 mm
- the ratios of the values may differ for different densities, but the proof tests performed so far confirm the differences mentioned here



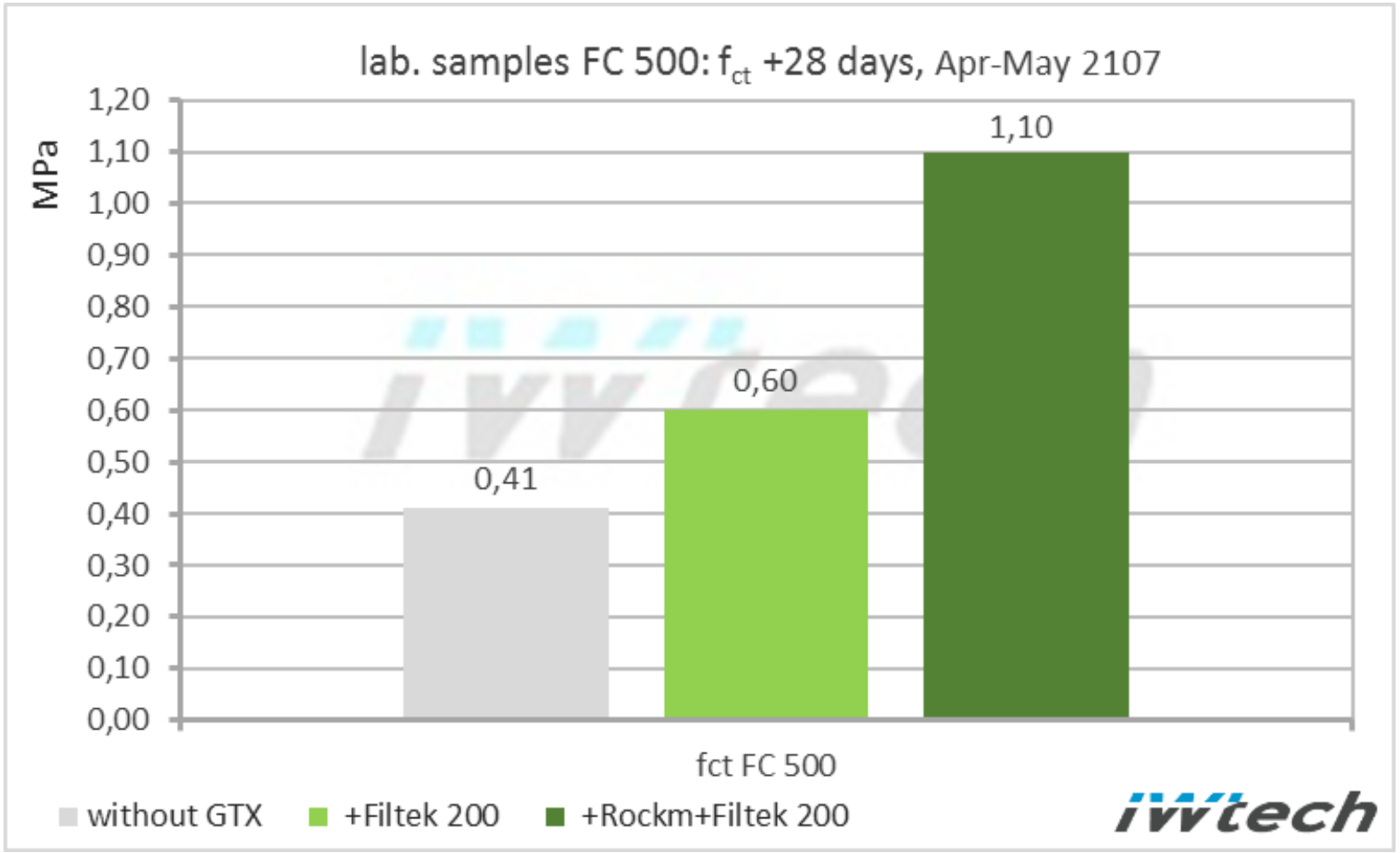
FC 500: GTX reinforcement - various basis weights

- Geotextile (GTX) is always placed on a level surface with a joint overlap of 15 - 20 cm and after its wetting, FC is poured directly on it
- the increase in f_{ct} when using the GTX Geofiltex 500 was not significant compared to the Geofiltex 200in the case of replacing Geofiltex 200 with a GTX from another manufacturer, the working diagram of the given GTX is decisive, comparing the strength values MD - along and CMD - across the strip



FC 500N: GTX and Orlitech® basalt mesh reinforcement

- the purpose of using reinforcing mesh is to increase the flexural tensile strength – f_{ct}
- Orlitech® mesh is laid directly on the GTX and poured with FC
- Orlitech® is supplied by WIL&DERS ltd to SK markets
- the basic material is basalt fibre fixed in special resin
- basalt reinforcements are stainless



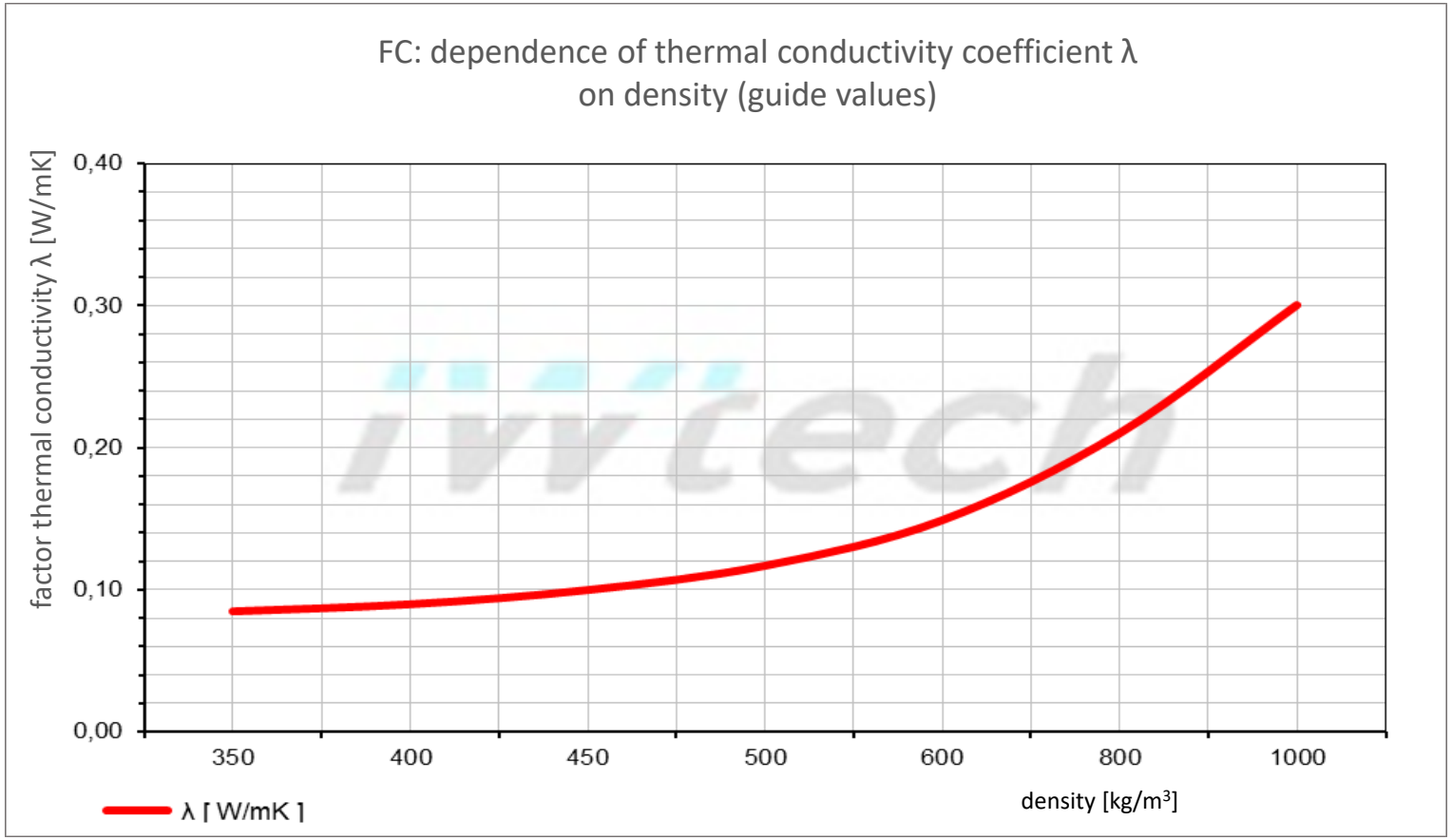
FC 500IF and ORLITECH® MESH on the test field

Description: Orlitech® stainless steel reinforcement mesh is basalt-based; a steel mesh without corrosion protection is not suitable for FC reinforcement due to its possible corrosion resulting from the high volume of air in the FC; the Orlitech® network is always placed on a base consisting of a separation geotextile of at least class Geofiltex 63/20 or equivalent

Thermal engineering and moisture content of FC 300 - 900 kg/m³

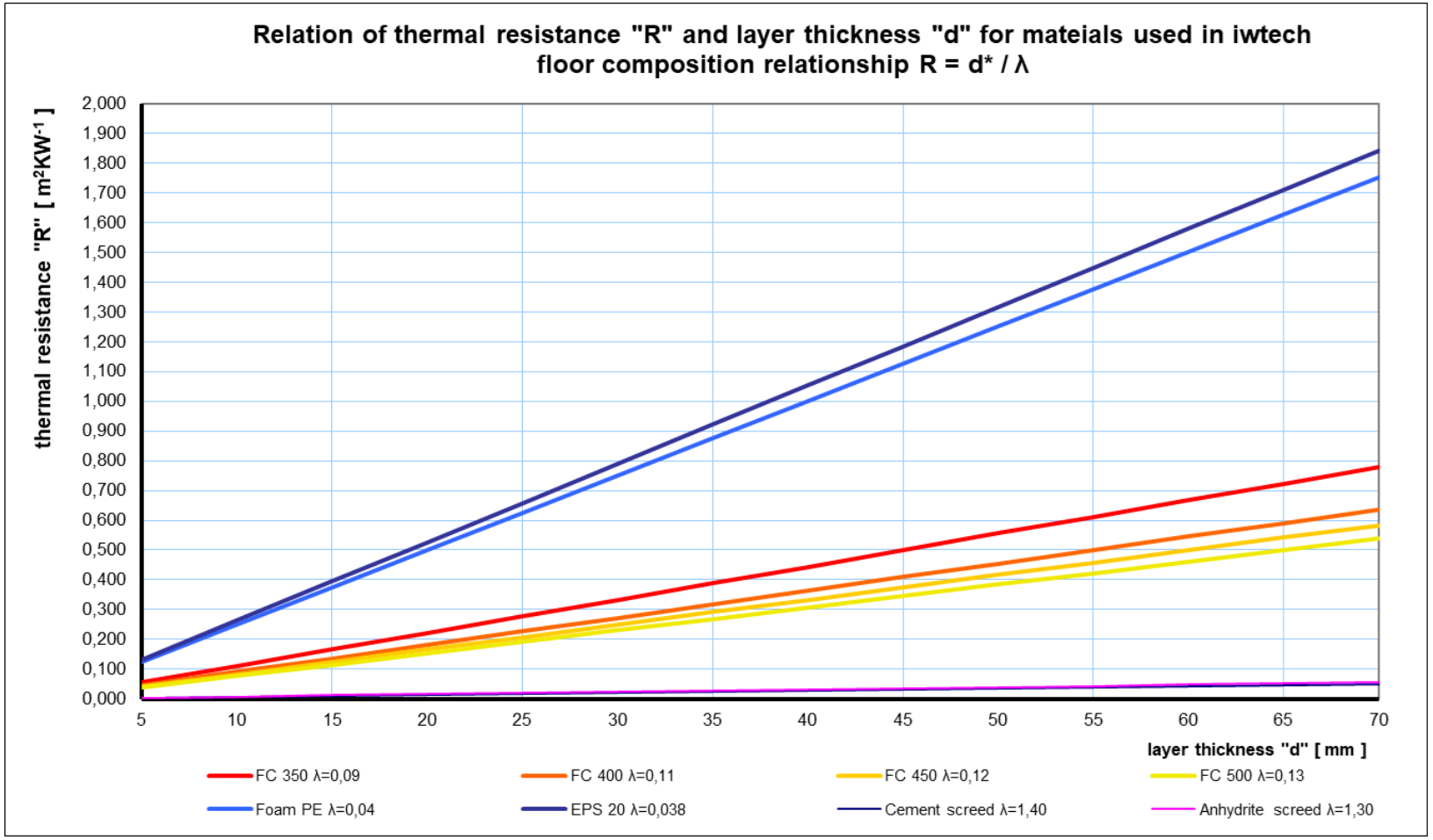
FC: coefficient of thermal conductivity and density

- λ values apply to dry FC
- practice and measurements confirm that the determining factor for the value of λ is the bulk density together with the humidity
- the FC layer can be a suitable addition to increasing the thermal resistance of the building structure
- The FC layer is absorbent, but as it absorbs water, it easily releases it
- after the end of the water supply to the FC layer, the physical properties of the FC gradually reach the values before the start of the water supply



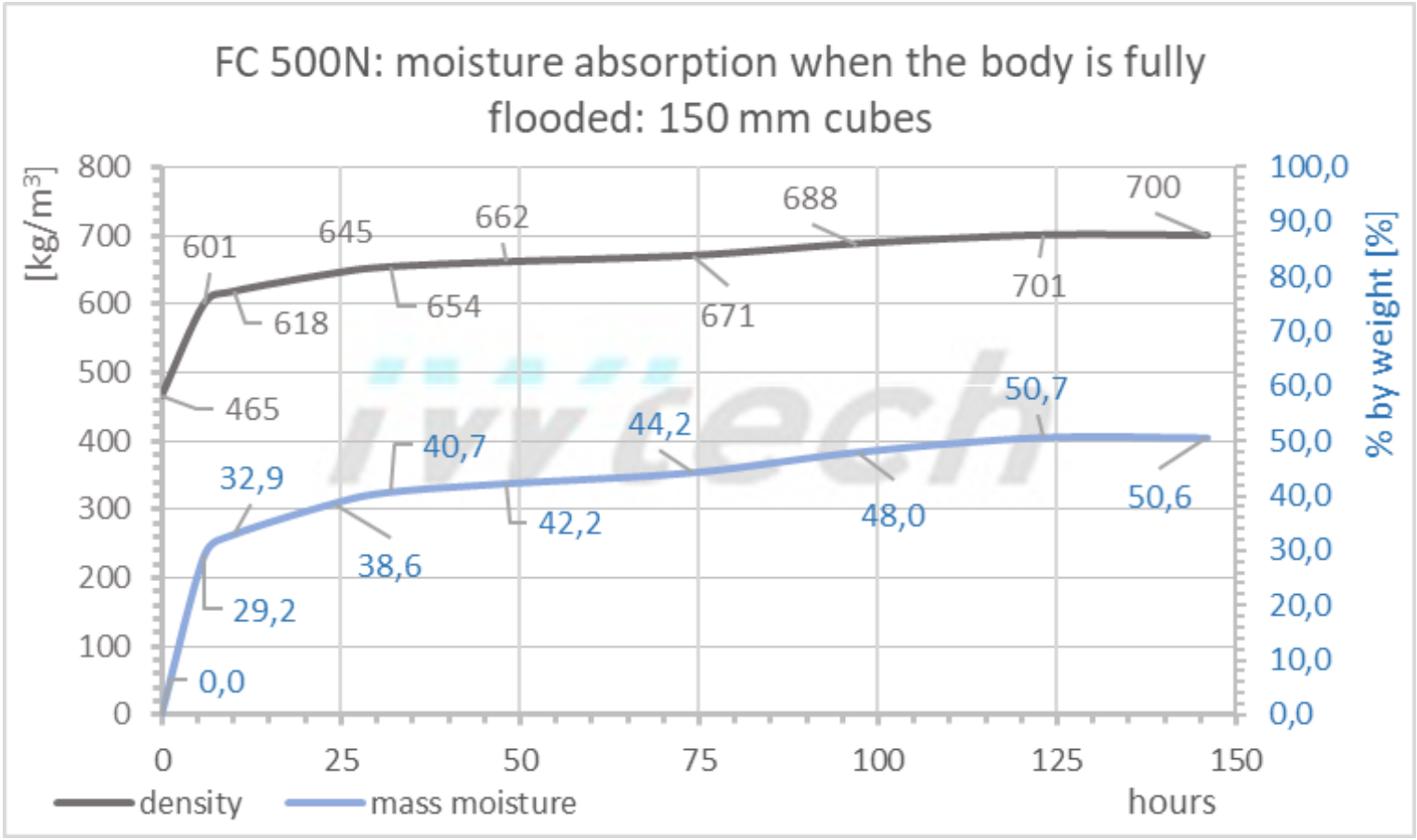
FC: thermal conductivity coefficient and thermal resistance

- The informative diagram shows that dry FC has a relatively good value of the thermal conductivity coefficient λ compared to conventional thermal insulators, but the difference is significant when compared to conventional concrete or gravel.
- FC is in a dry state only in laboratory conditions, after installation in the construction of the building is always in a humid state, which is determined by the humidity of the surrounding materials
- after incorporation into the gravel, the mass humidity of **FC 500** stabilized at a level corresponding to the value **λ = 0.18 - 0.19**W/mK for comparison:
  reinforced concrete 2300kg/m3 has **λ = 1.58**W/mK
  grown clay-sandy soil 1800kg/m3 has **λ = 1.4**W/mK
  gravel 1650kg/m3 has **λ = 0.93**W/mK



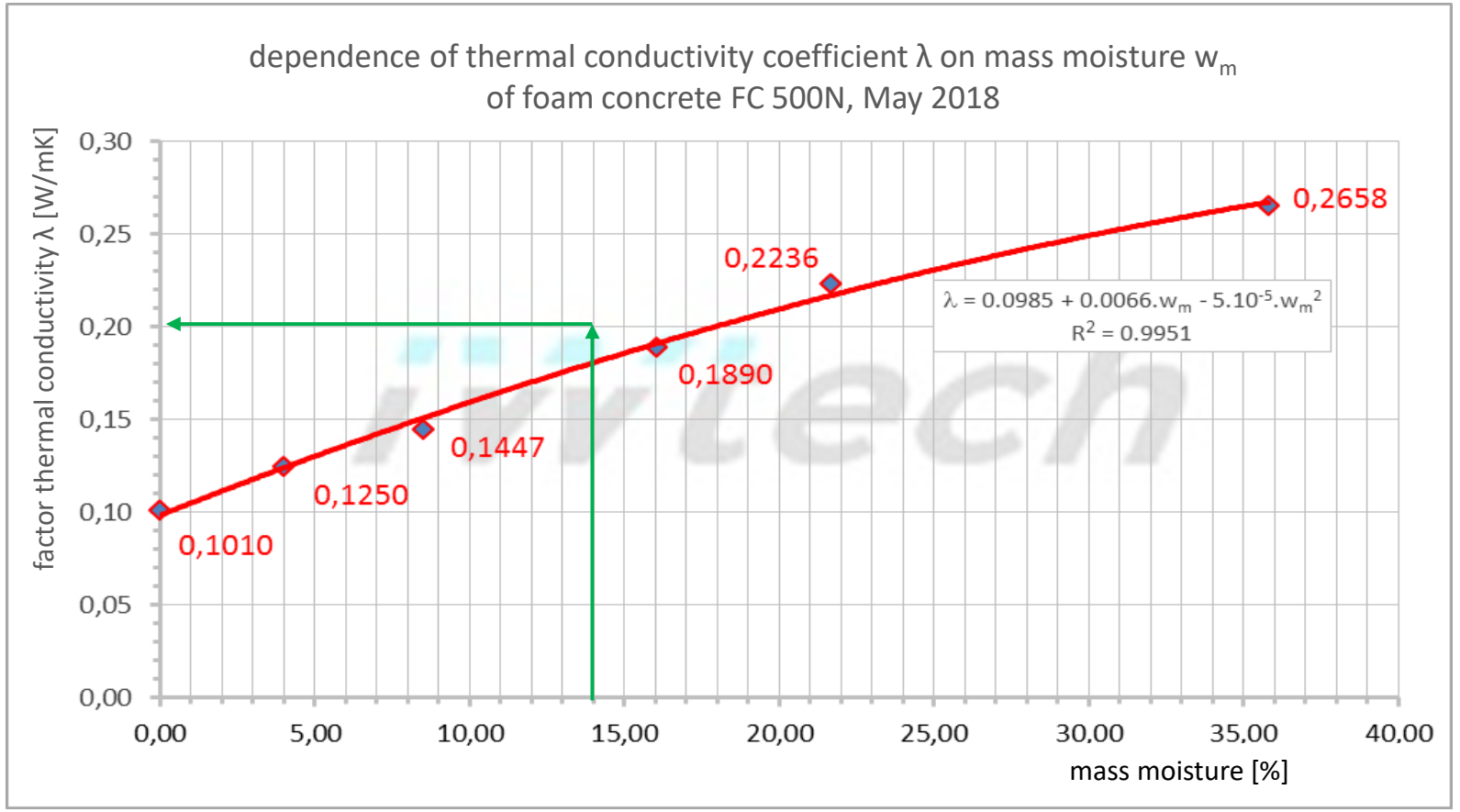
FC 500N: course of moisture rise during flooding

- for FC 500, the highest water absorption is about 50% by weight, which represents about 248 l H_2O (volume of saturated H_2O),
- that is, for example, a 10 cm thick layer of fully soaked FC 500 contains 24.8 l/m^2
- the release of moisture takes approximately the same time as the saturation time under the same conditions
- it is clear that the water absorption decreases with increasing density

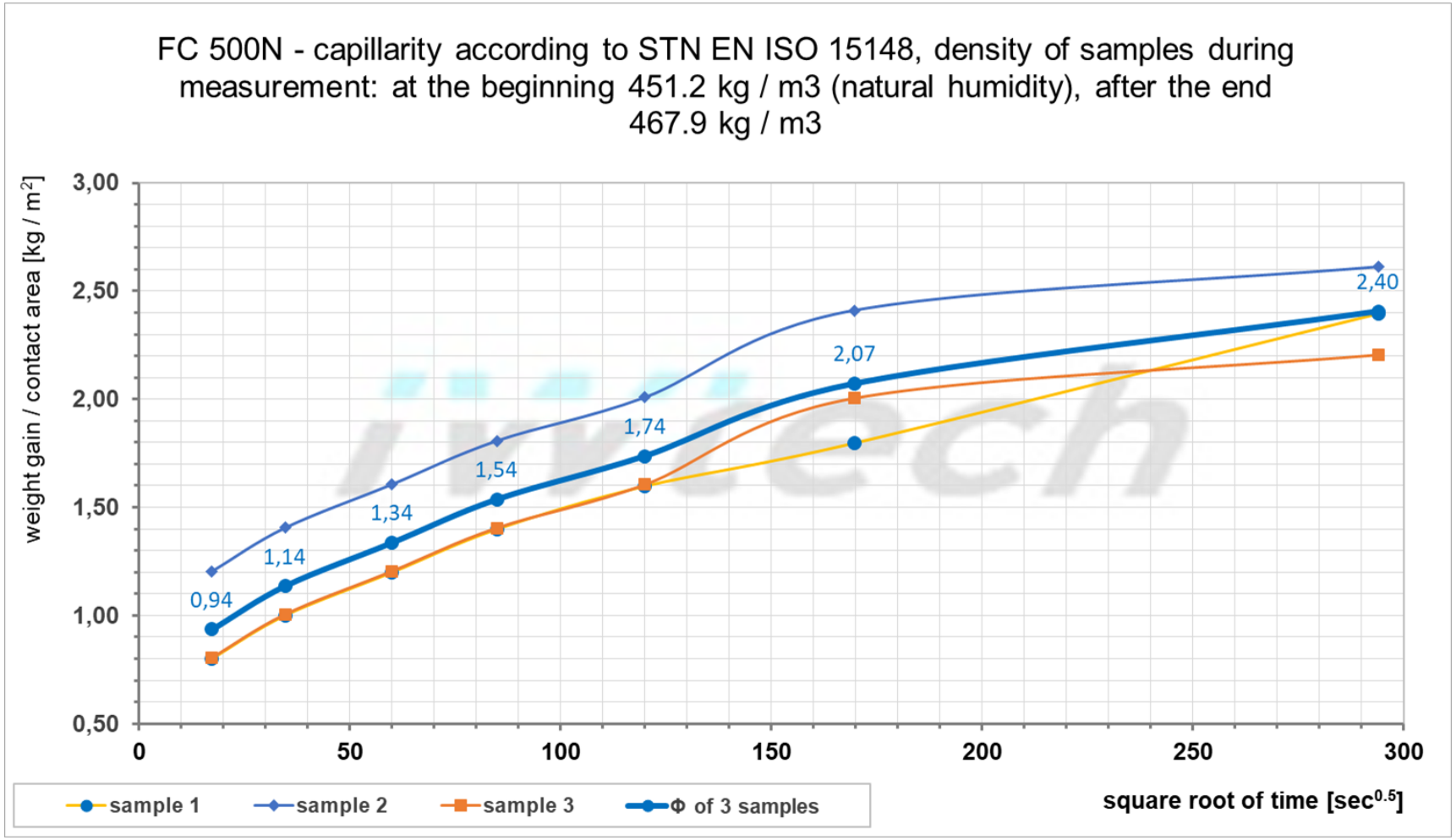


FC 500N: dependence of λ on mass moisture

- measurements were performed by Applied Precision s.r.o., Bratislavain a gravel environment with natural humidity, FC 500N stabilized at w_m = 13 - 14% by weight, which corresponds to a value of λ = approx. 0.18 [W / mK], and this value is taken for calculation - to determine the thermal resistance of the foam concrete base layer



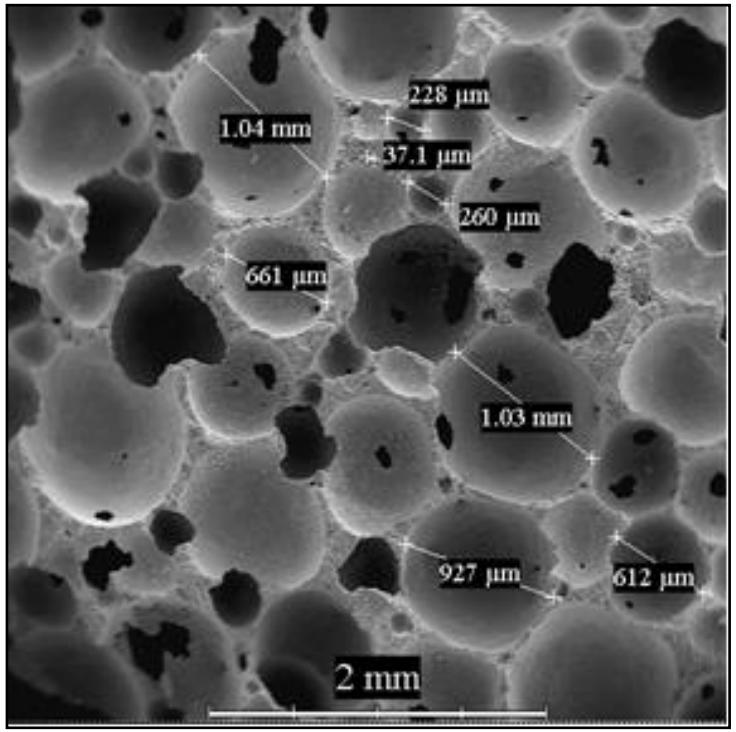
FC 500N: capillary capillarity



Interesting examples from practice

Buildings: FC 350 - resistance when pumping to a height of +85 m

as a levelling layer for building floors Bratislava,
Panorama Building, December 2014 - June 2015



Buildings: FC 350 - resistance to pumping to heights

floor area, transport height:
apartments ≈ 36,000m², max. +85m

density of foam concrete FC 350:
fresh / steady / dry / measured (ϕ out of 6 samples):
477 / 361 / 328 / **464 kg/m³**
realized thickness FC 350: **55 - 65mm**
pump: **Estrich Boy FHS 200/3**
hose length / hose diameter: **157m / 50mm**
FC volume loss in 78.0m: **<5%**
pumping time of 1m3 to a height of 78.0m: **<7 min**
place of production / place of installation / transport distance:
Břeclav (CZ) / **Bratislava (SK)** / **85km**

implementation date: **Dec 2014 - June 2015**

Construction - example: FC 500IF in an industrial floor

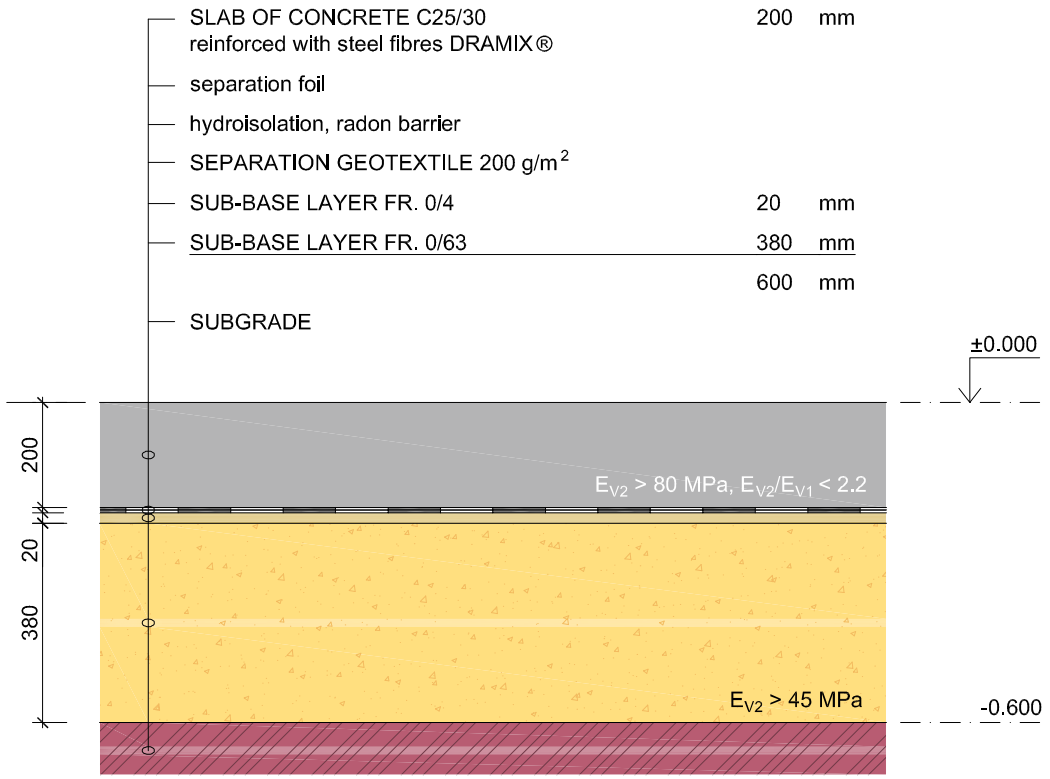
Example of a heavily loaded industrial floor:

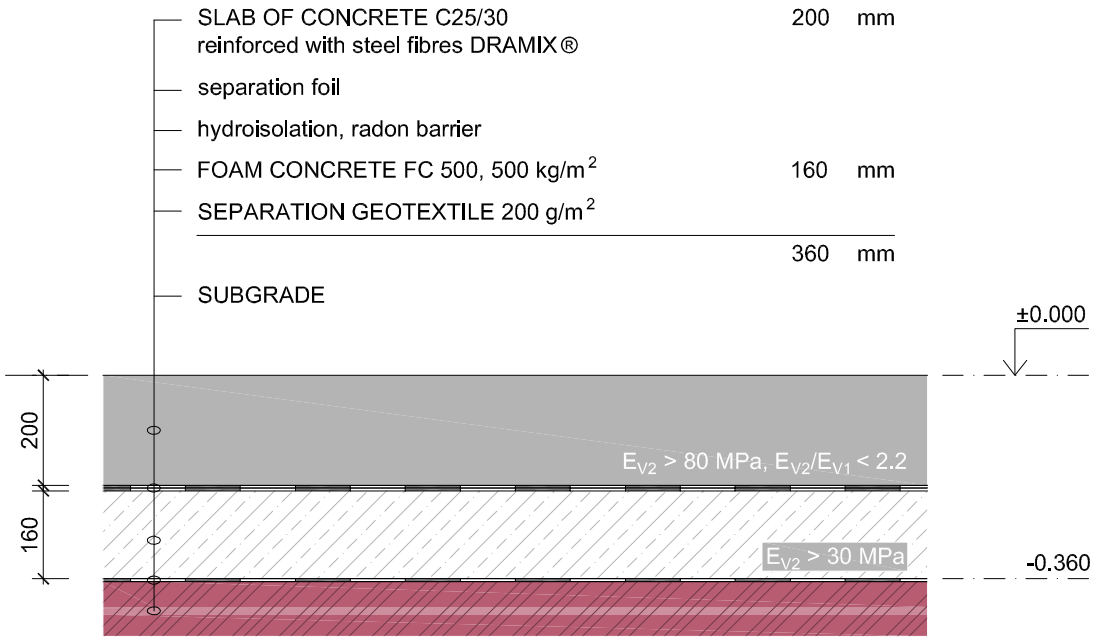
- concrete floor slab C25/30 200 mm thick reinforced with DRAMIX® steel fibers (L = 60mm, D = 0.9mm, R_m = 1160 MPa), the same for both cases
- the board is considered to be jointless with expansion joints at a distance of 30 x 30m, the same for both cases
- uniform surface load with characteristic intensity q_k = 100kN/m^2
- point load simulating a load from a forklift truck with an intensity of 56kN for 1 wheel
- point load of 75kN/1 stand from racks with floor plan layout of stands 1.1 x 2.8 m, with a distribution foot with dimensions of 150x150 mm at a mutual distance of the racks of 300 mm
- E_{V2} > 80MPa - applies to the surface of the underlying layer
- E_{V2} / E_{V1} <2.2 - applies to the surface of the subsoil

The static assessment of floor construction variants was performed in accordance with the Concrete Society TR34 regulation

Sections of a heavily loaded industrial floor with gravel and FC 500IF is on the next page

FC 500IF design for industrial flooring – sections





Usual design with compacted embankment 0/63 mm

Design with FC 500IF

FC 500IF design for industrial flooring – sections

Usual design with compacted embankment 0/63 mm

- CONCRETE BOARD C25 / 30 200 mm reinforced with DRAMIX® steel fibres
- separating foil
- waterproofing, radon insulation
- SEPARATION GEOTEXTILE 200 g / m^2
- COMPENSATION SUBSYPE, FR. 0/4 20 mm
- GRAVEL SUBBASE, FR, 0/63 380 mm
- PREPARED SUBGRADE SOIL

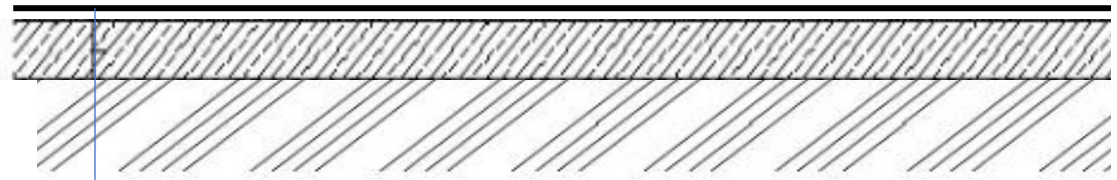
Design with FC 500IF

- CONCRETE BOARD C25 / 30 200 mm
- reinforced with DRAMIX® steel fibres
- separating foilwaterproofing, radon insulation
- CONCRETE FC 500, 500 kg / m3 130 mm reinforced with ORLITECH MESH basalt mesh
- SEPARATION GEOTEXTILE 200 g / m^2
- PREPARED SUBGRADE SOIL

FC 500IF: roadway of sidewalk and cycle path

The roadway of the Cycle route with completely excluded freight traffic (economically minimized variant)

The innovative construction of a semi-rigid asphalt road pavement with a subbase layer of foam concrete FC 500V + OM + GTX designed with minimized layer thicknesses



AC 8 abrasive layer	30 mm
infiltration spray	
FC 500V+OM+GTX	100 mm
total thickness	***H_{v6} = 130 mm***

Boundary conditions of use:

Ep, n = min.$E_{p,n}$ = min. 25 MPa, E_{def2} / E_{def1} ≤ 2,5, assuming the sustainability of the parameters listed here

If the road is to be on a compacted embankment, ie. above the surrounding terrain, it is necessary to place curbs in a concrete bed along the edges of the road

Local shrinkage cracks in the FC 500V layer do not affect its functionality

foam concrete as concrete

Useful links:

https://www.iwtech.sk/vysledky

https://betononline.sk/2019/05/31/penobeton-a-jeho-kvalita/

http://www.geomatejournal.com/sites/default/files/articles/115-120-8293-Drusa-July-2019-59g.pdf