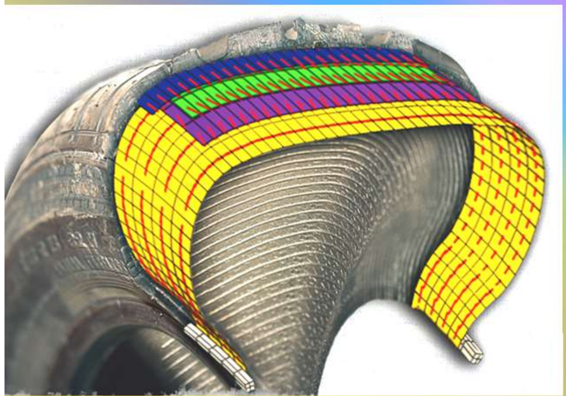
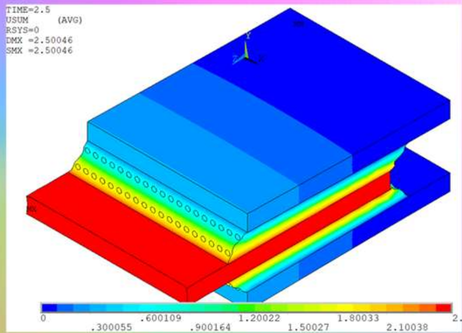
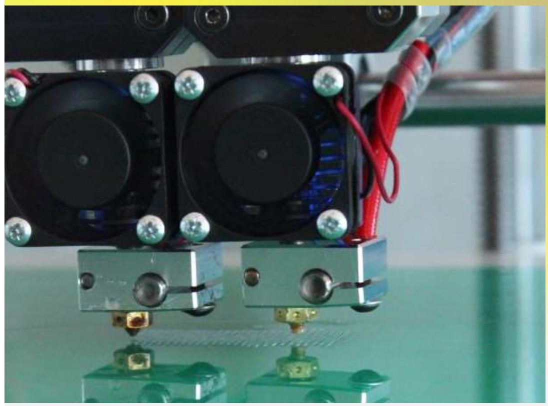
Faculty of Industrial Technologies
in Púchov, Slovak Republic

TIRANA, 17th October 2023







POSSIBILITIES OF COOPERATION IN THE FIELD OF MATERIALS RESEARCH AND ENGINEERING

Jan KRMELA

Head of Department of numerical methods and computational modelling

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84 slides

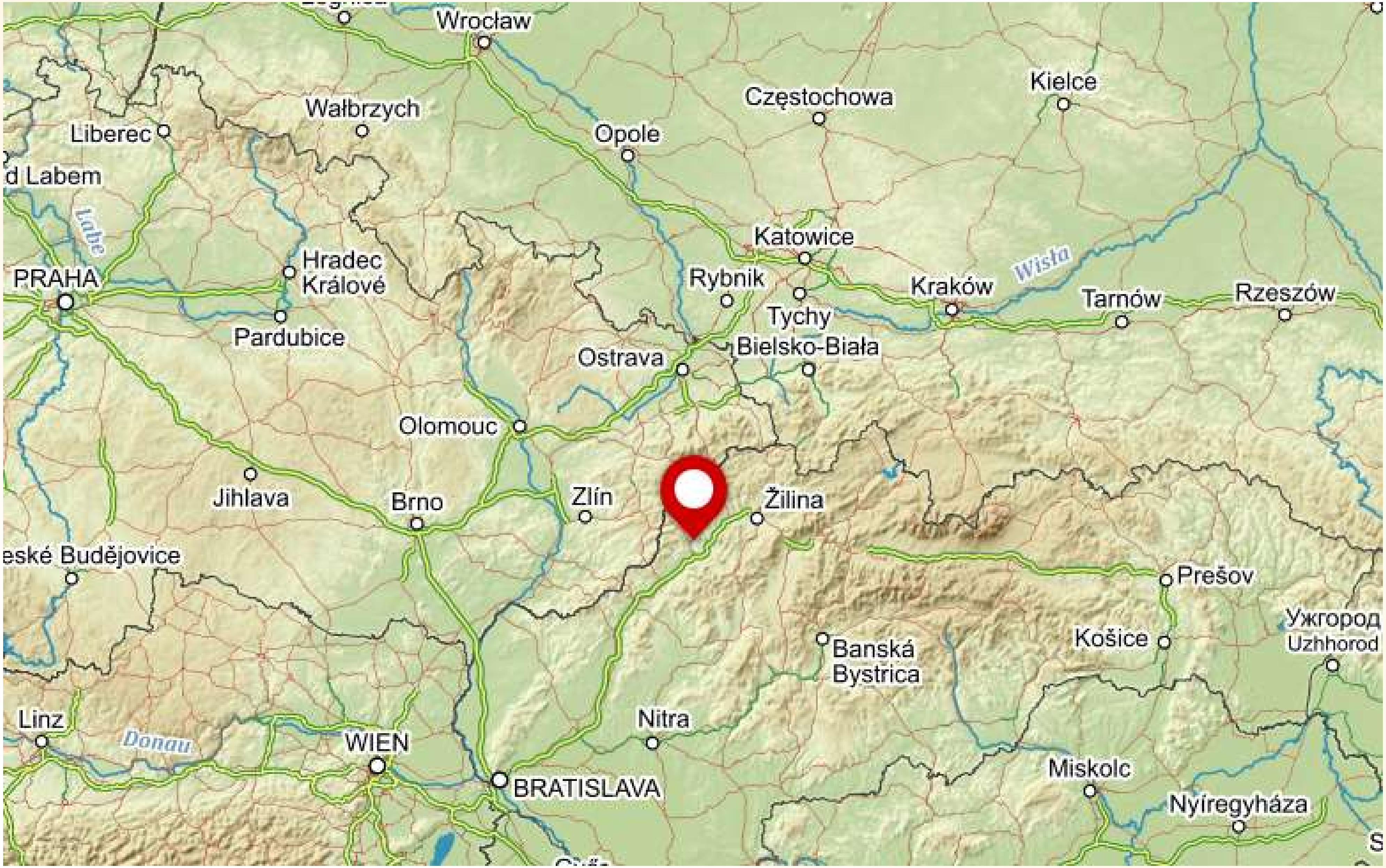
Content of the Presentation

- Introduction – about the University and the Faculty of Industrial Technologies in Púchov
- 3D print
- Research on tires and composites and polymers
- Computational simulations in ANSYS
- Conclusions, books

Trenčianska univerzita Alexandra Dubčeka v Trenčíne (Alexander Dubček University of Trenčín)
https://tnuni.sk/uchadzaci/foreign-student-s-guide/alexander-dubcek-university-of-trencin/

- **Faculty of Industrial Technologies**
- **Faculty of Social and Economic Relations**
- **Faculty of Special Technology**
- **Faculty of Healthcare**
- **Department of Political Science**
- **FunGlass - Centre for Functional and Surface Functionalized Glass**

www.fpt.tnuni.sk



Faculty of Industrial Technologies in Púchov


Olomouc
Frýdek-Místek
Přerov
Vsetín
Zlín
Žilina
Uherské Hradiště
Martin
Trenčín
Prievidza
Banská
Trnava
Nitra
BRATISLAVA
Levice
Nové Zámky
Komárno
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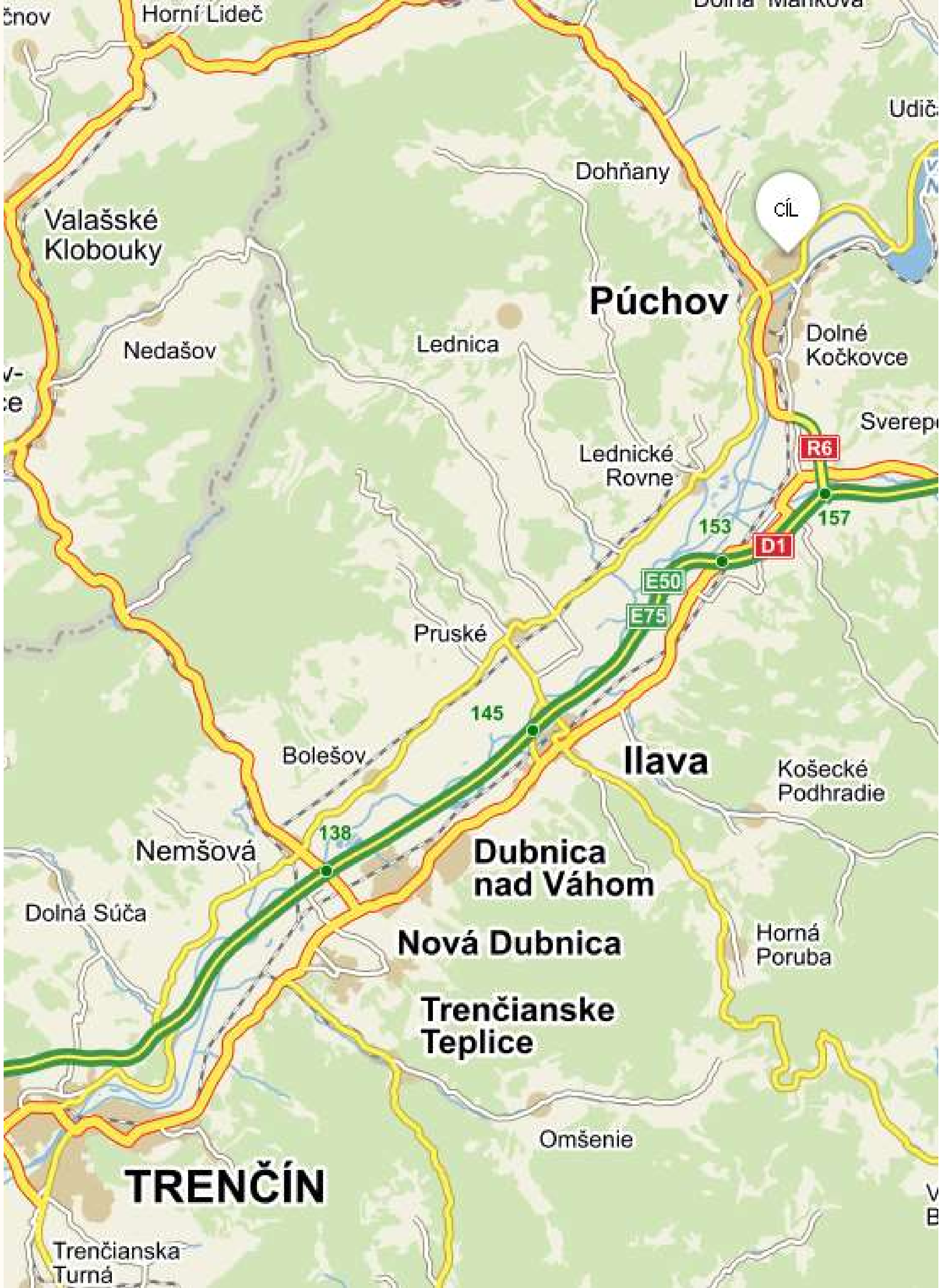
Horní Lideč
Dohňany
CÍL
Valašské
Klobouky
Púchov
Nedašov
Lednica
Dolné
Kočkovce
Lednické
Rovne
Sverep
R6
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D1
E50
E75
Pruské
145
Ilava
Bolešov
Košecké
Podhradie
138
Nemšová
Dubnica
nad Váhom
Dolná Súča
Nová Dubnica
Horná
Poruba
Trenčianske
Teplice
Omšenie
TRENČÍN
Trenčianska
Turná

Structure of Faculty of Industrial Technologies in Púchov

- ❖ **Department of Materials Technologies and Environment**
- ❖ **Department of Materials Engineering**
- ❖ **Department of Numerical Methods and Computational Modelling**

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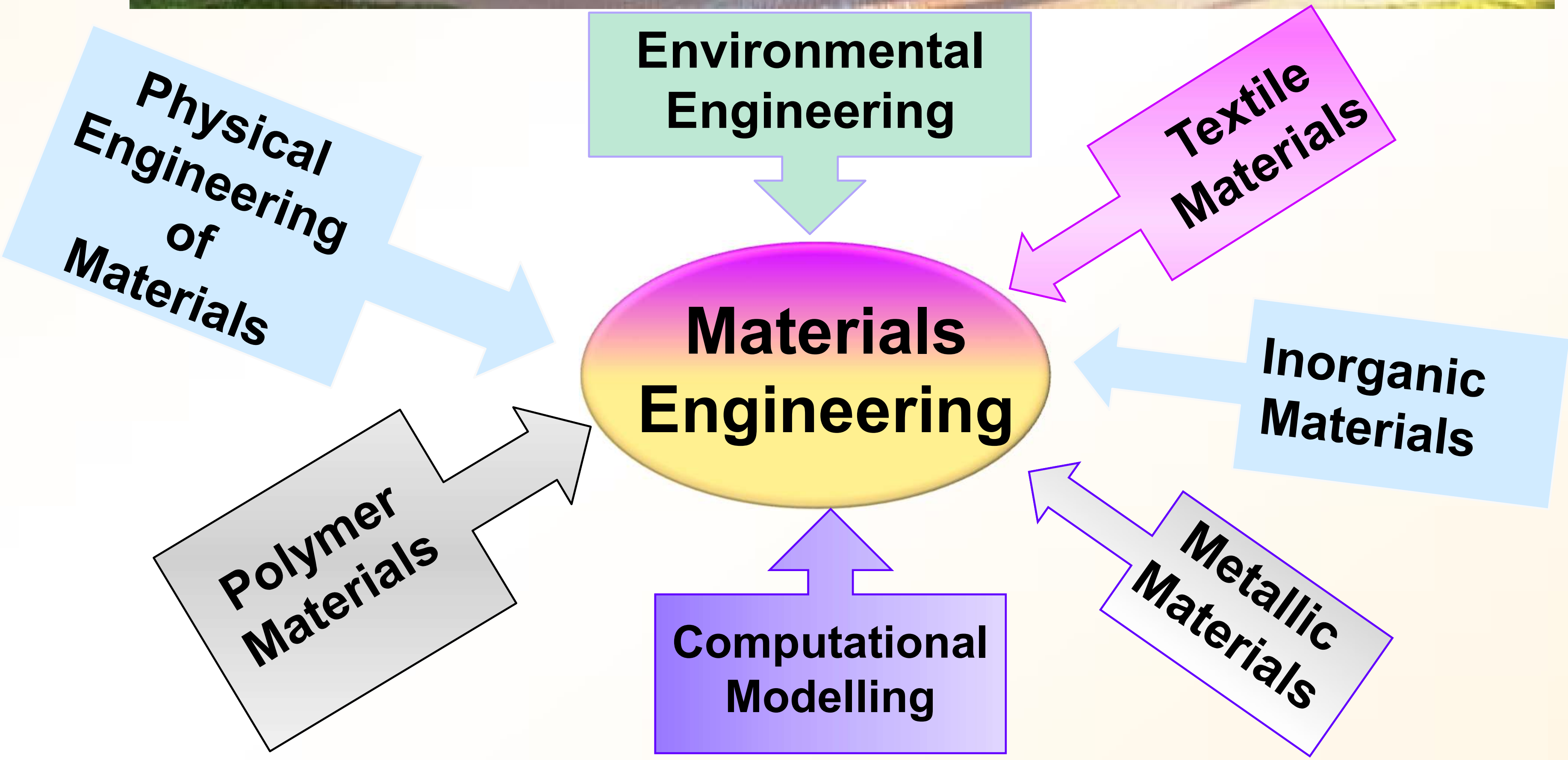


The actual accredited study programmes in the study field of Engineering - Materials

Accredited Study Programme / Acquired Rights	Title in Slovak
Materials Engineering*	Bc. (bachelor)
Computer-assisted Material Engineering	
Materials Engineering**	Ing. (master)
Materials	PhD.
Acquired right to carry out the habilitation procedures as well as procedures for promotion to be a professor	doc. prof.

*Specialization: Materials and Environmental Engineering / Materials and Technologies / Materials and Design

**Areas: Metallic materials / Inorganic materials / Polymer materials / Textile materials / Environmental engineering / Computer-assisted materials engineering /Materials a design

https://tnuni.sk/uchadzaci/foreign-student-s-guide/alexander-dubcek-university-of-trencin/faculty-of-industrial-technologies/

- The centre was established as a result of the project co-financed from the European Regional Development Fund resource within Operational Programme for Research & Development with goal: 1.1 Modernisation and building of technical infrastructure for research and development. ITMS: 26210120046

- Lab. Infrastructure in Faculty of Industrial Technologies in Púchov: Total sum: 2 800 000 €

- 23 new test machines

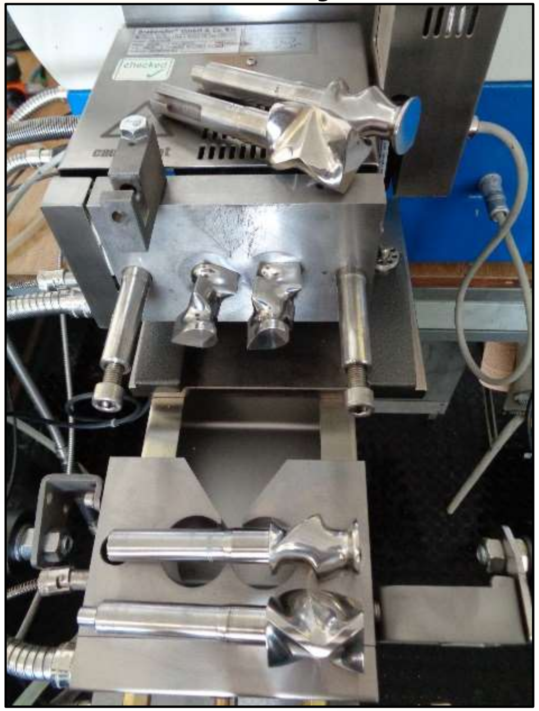
- Informations about some test machines for composite material namely

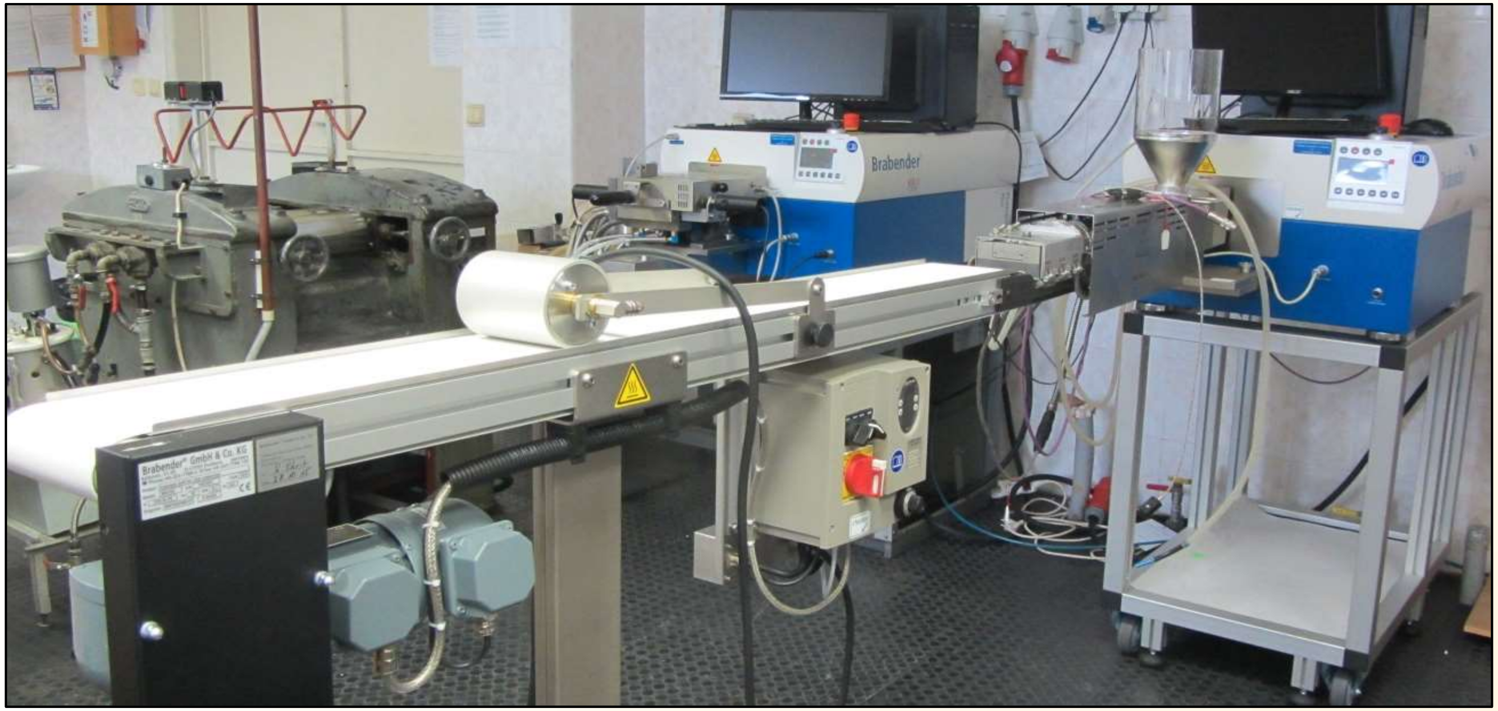
PREPARATION OF MATERIALS AND COMPOSITES

❖ TORQUE RHEOMETER – FOR MIXING AND EXTRUDING ELASTOMERS AND THERMOPLASTICS

Manufacturer: Brabender Model: Plastograph® EC plus

- Preparation and testing the processability of elastomers, thermoplastics, thermosets with various types of additives
- Simulation of polymer processing and manufacturing procedures under the laboratory conditions – heating, blending, mixing , reactive mixing, kneading





PREPARATION OF MATERIALS AND COMPOSITES

❖ VULCANISATION HYDRAULICS PRESS

Manufacturer: Fontijne Model: LabEcon 600

➢ Pressing of (sample) products from technical rubber, thermoplastics and thermosets using main design components of device, including press frame, press plates and hydraulic unit

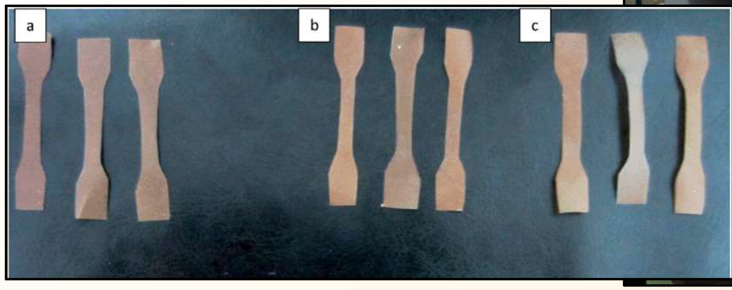
❖ PNEUMATIC HOLLOW DIE PUNCH

Manufacturer: CEAST

Model: HollowDiePunch –

pneumatic model code 6054.000

➢ Preparation of the samples from plastics , vulcanizates, composites in the shape of double-sided blades for tensile tests



EXPERIMENTAL EVALUATION OF MATERIALS AND COMPOSITES

❖ UNIVERSAL TENSILE TESTING MACHINE

Manufacturer: Shimadzu Model:

Autograph AG-X plus 5 kN

- Measurement of physical and mechanical properties of elastomers, thermoplastics and composites with a high accuracy
- Video-extensiometer

EXPERIMENTAL EVALUATION OF MATERIALS AND COMPOSITES

❖ AIR-COOLED DYNAMIC-MECHANICAL ANALYSER

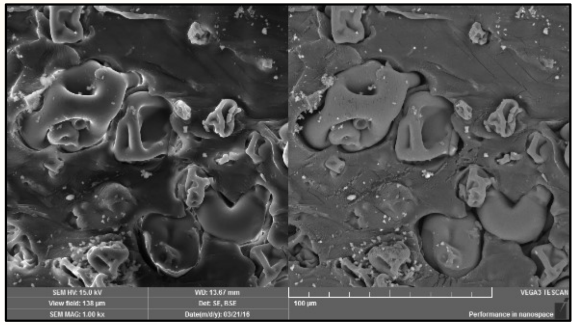
Manufacturer: TA Instruments Model: DMA Q 800

- **Measurement of materials viscoelastic properties**
- **Investigation of various effects and properties: composition of substances, effects of materials, effects of various fillers and additives on viscoelastic properties, softening, creep flow, glass transition, viscoelastic and stress relaxation behaviour, crystallisation and melting...**

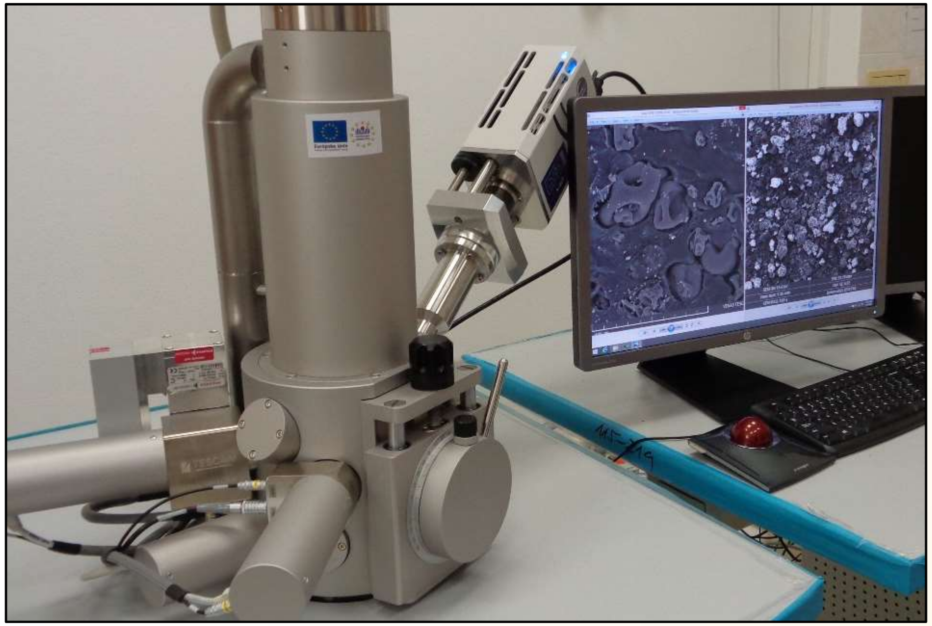
EVALUATION OF MATERIAL AND COMPOSITE STRUCTURES

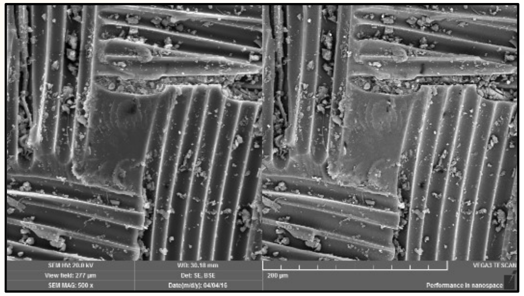
❖ THERMAL EMISSION SCANNING ELECTRON MICROSCOPE WITH EDX ANALYSER

Manufacturer: TESCAN Model: VEGA 3



Elastomer with Filler





Laminate – surface

EDX spectrum

- Investigation of microstructure relating to the wide range of materials and their composites
- Evaluation of topography and material contrast
- Analysis of the chemical composition by EDX detector

PREPARATION OF MATERIAL AND COMPOSITE SAMPLES

❖ **GRINDING, LAPPING AND POLISHING MACHINE**

Manufacturer: Struers Model: Labopol 25

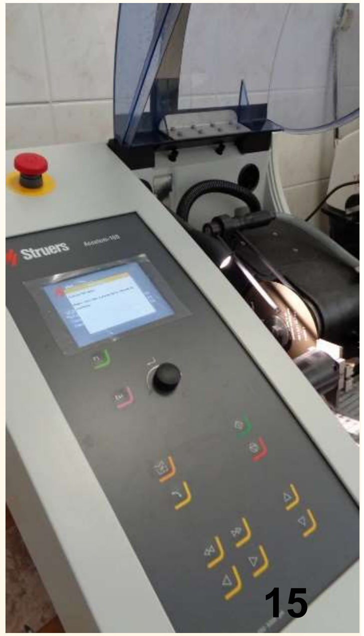
❖ **PRECISION TABLE TOP CUT-OFF AND GRINDING MACHINE**

Manufacturer: Struers Model: Accutom 100

❖ **ELECTRO-HYDRAULIC HOT MOUNTING PRESS WITH TWO CYLINDERS** Manufacturer: Struers Model: Citopress

PREPARATION OF SAMPLES FOR OPTICAL MICROSCOPY

- Cutting and grinding of the all types of steels, ferrous metals, non-ferrous metals, non-metallic materials before and after thermal and chemical treatment
- Grinding, lapping and polishing of metallic and non-metallic samples
- Pressing of metallographic samples of metallic, non-metallic materials and composites

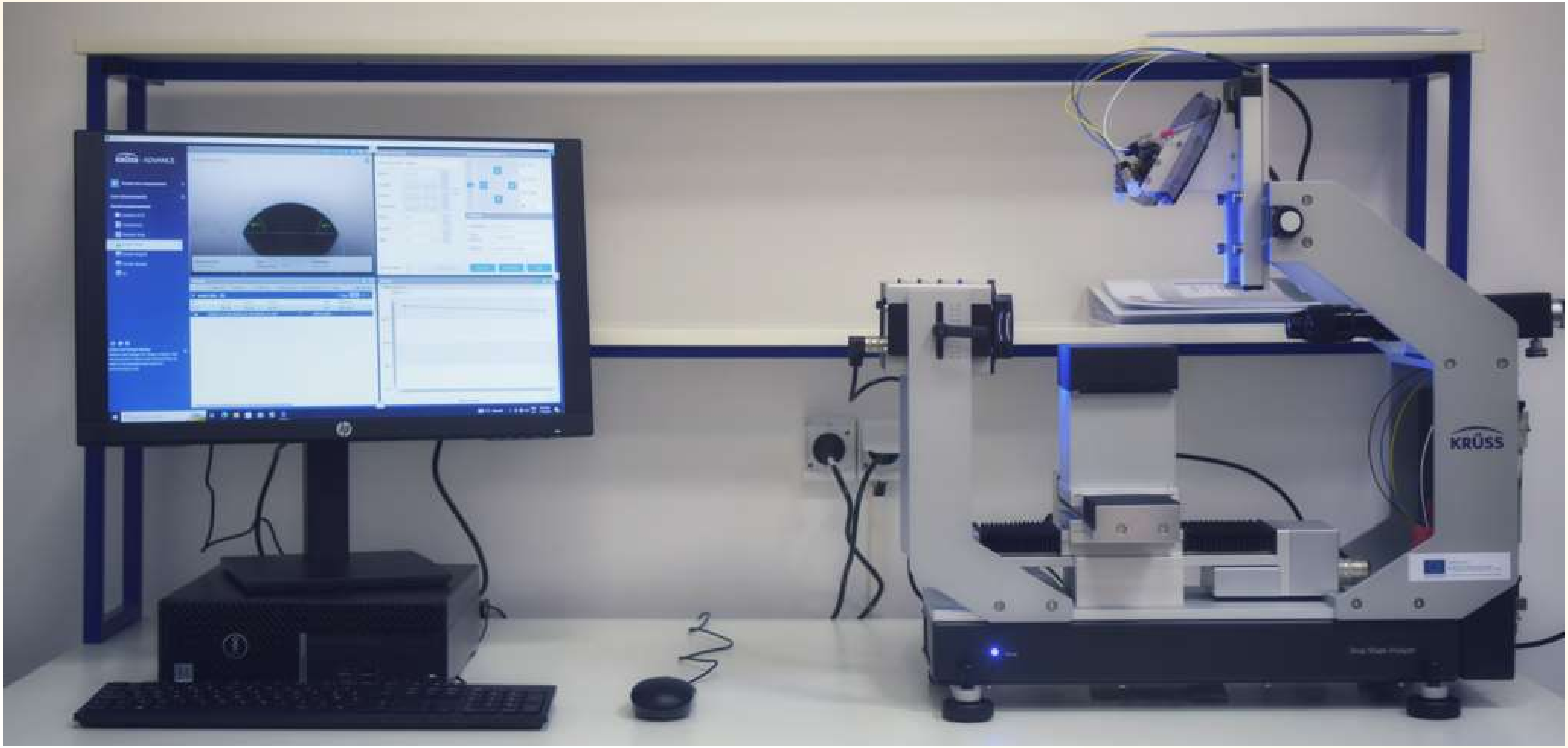


- **CEDITEK II „Advancement and support of R&D for "Centre for diagnostics and quality testing of materials" in the domains of the RIS3 SK specialization"**

- **Lab. Infrastructure TnUAD Total sum: 5 913 495.13 €**

- **Next new test machines**

DROPLET ANALYZER



MY RESEARCH AREA

- **composites, polymers, tires for transport vehicles**,
- **computational simulations** (FEM with ANSYS software),
- **specific mechanical tests** (cycle loading at temperature, design of methodologies),
- image analysis,
- **3D FDM printing, production of filaments for 3D printing**,
- determination and optimization of material parameters, Mooney-Rivlin material parameters, safety at work in experiments of polymers and composites, degradation processes, car construction designs, etc.

3D PRINTER

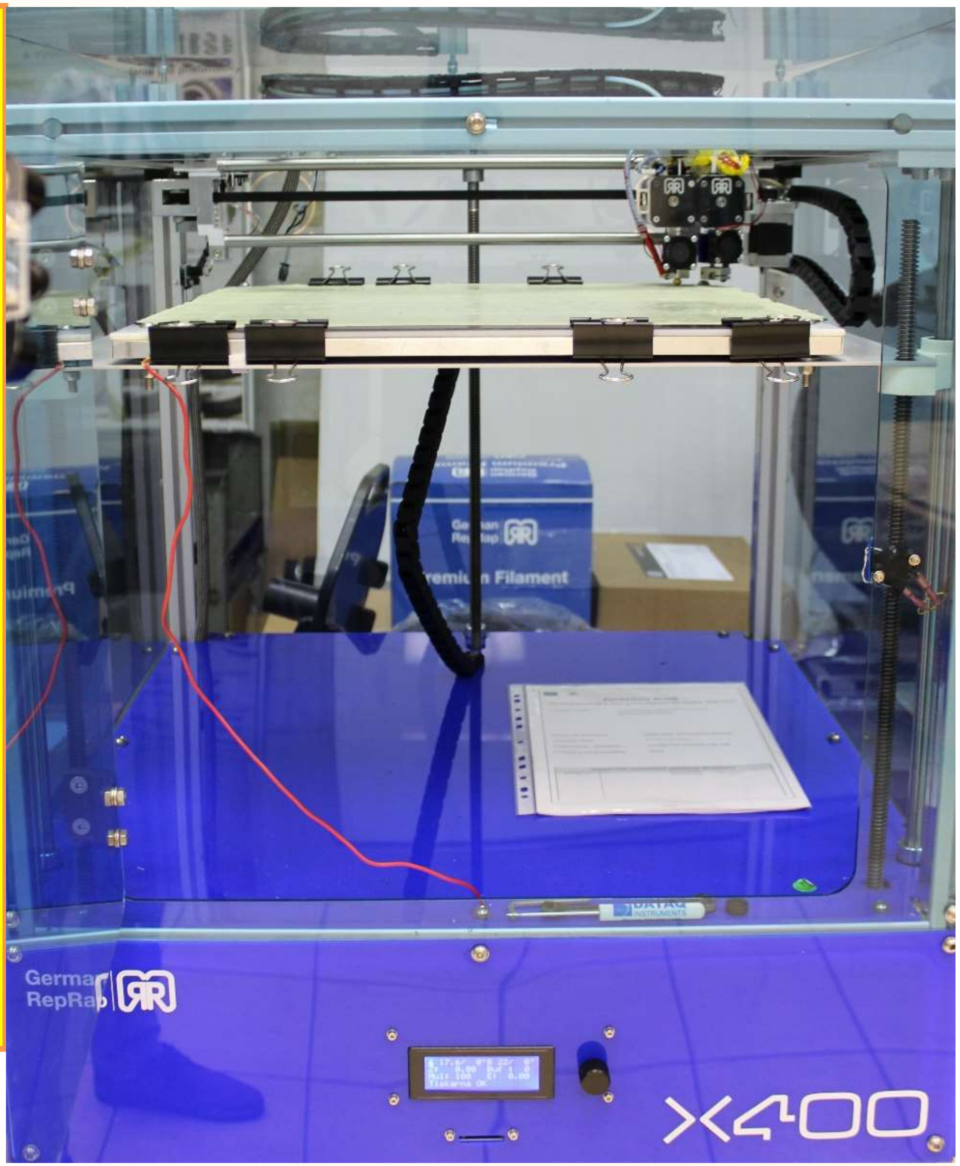
FOR CREATION OF SAMPLES AND PROTOTYPE OF TECHNICAL OBJECTS

3D PRINTER
Model: X400 PRO V3

German RepRap

Technology: <u>Fused Deposition Modeling (FDM) method</u>
(sometimes the abbreviation FFF is used)

This X400 printer was the first printer in Slovakia and Czech republic (at April 2016)!



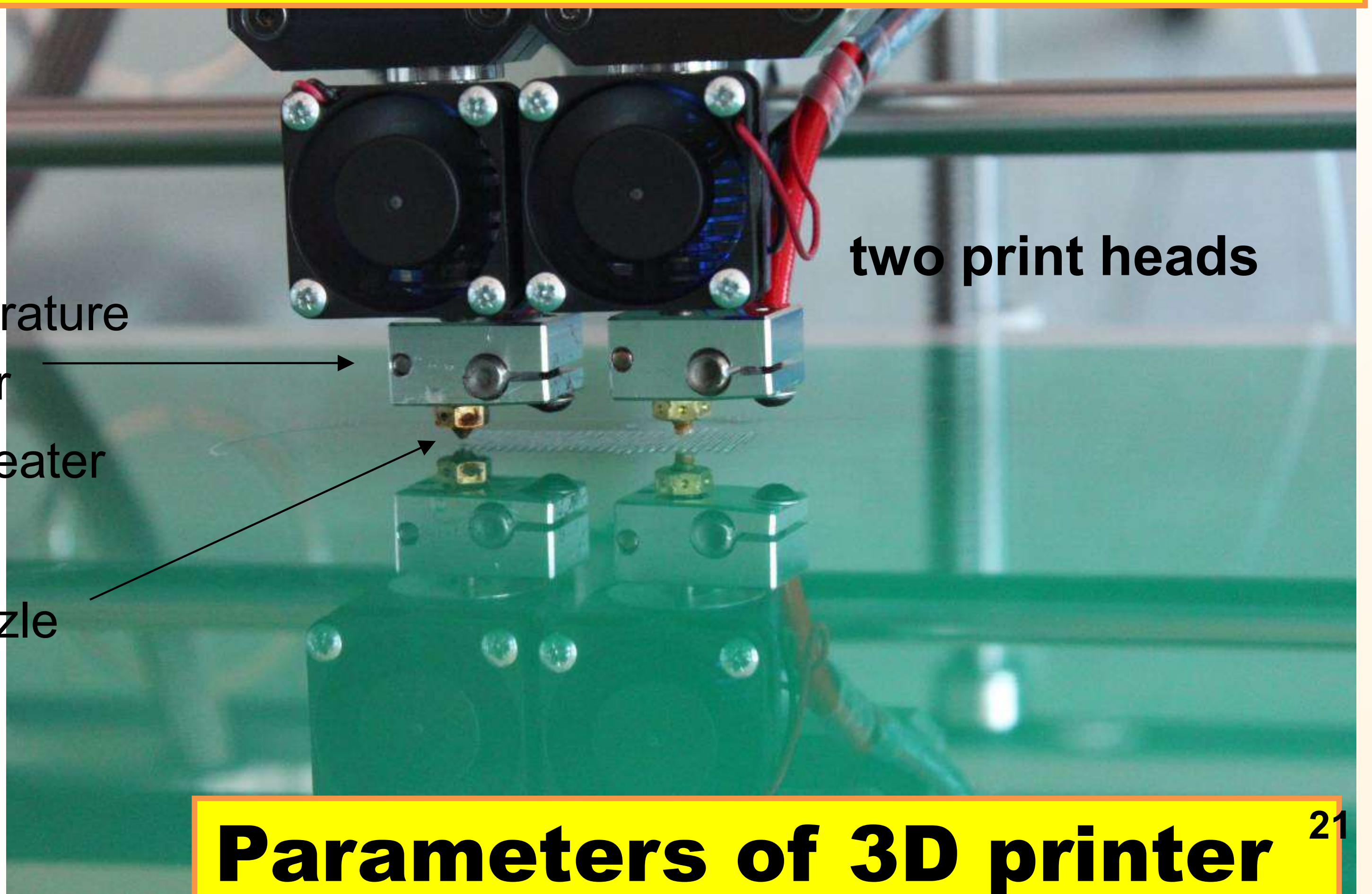
German RepRap GmbH

Big space of build platform **390 x 400 x 326 mm !**

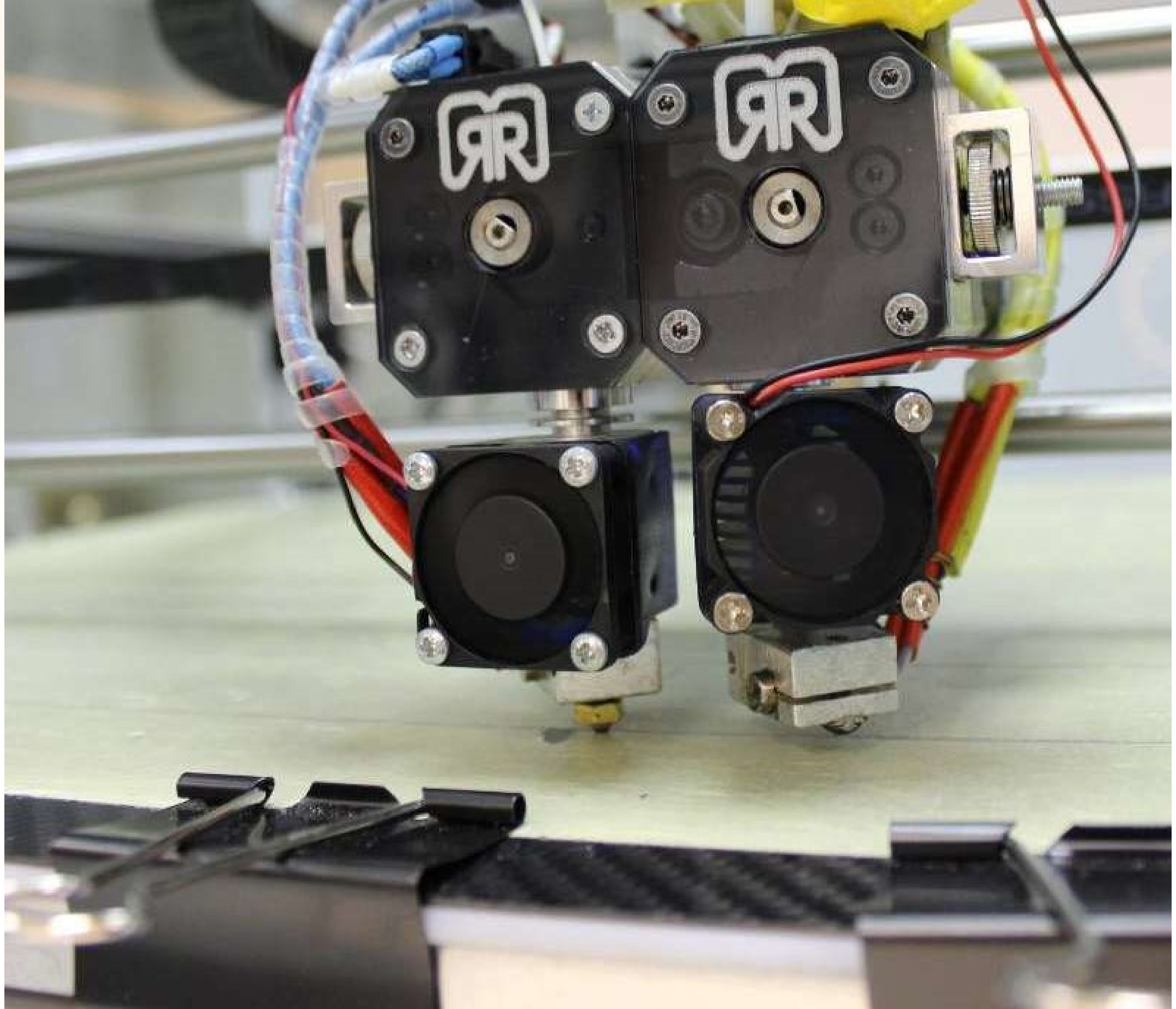
Materials: ABS, PLA, Nylon, TPU93, Carbon20, Laywood, Laybrick, Soft-PLA, aj. (**<u>max. temperature 290 °C</u>**) – **different materials !**

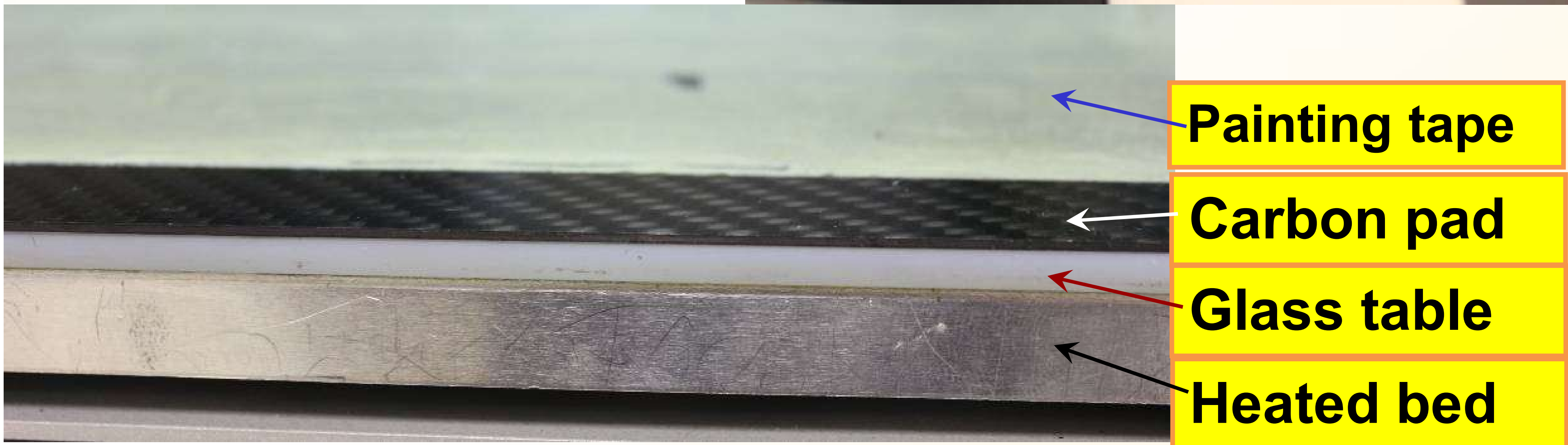
DD3 Dual extruders (2 nozzles) **Heated bed** max. **120 °C.**
Filament with a diameter of 1.75 mm.

Nozzles:
0.80 mm
0.60 mm
0.45 mm
<u>0.40 mm</u>
0.25 mm



Parameters of 3D printer




Painting tape
Carbon pad
Glass table
Heated bed

Final 3D printed technical objects

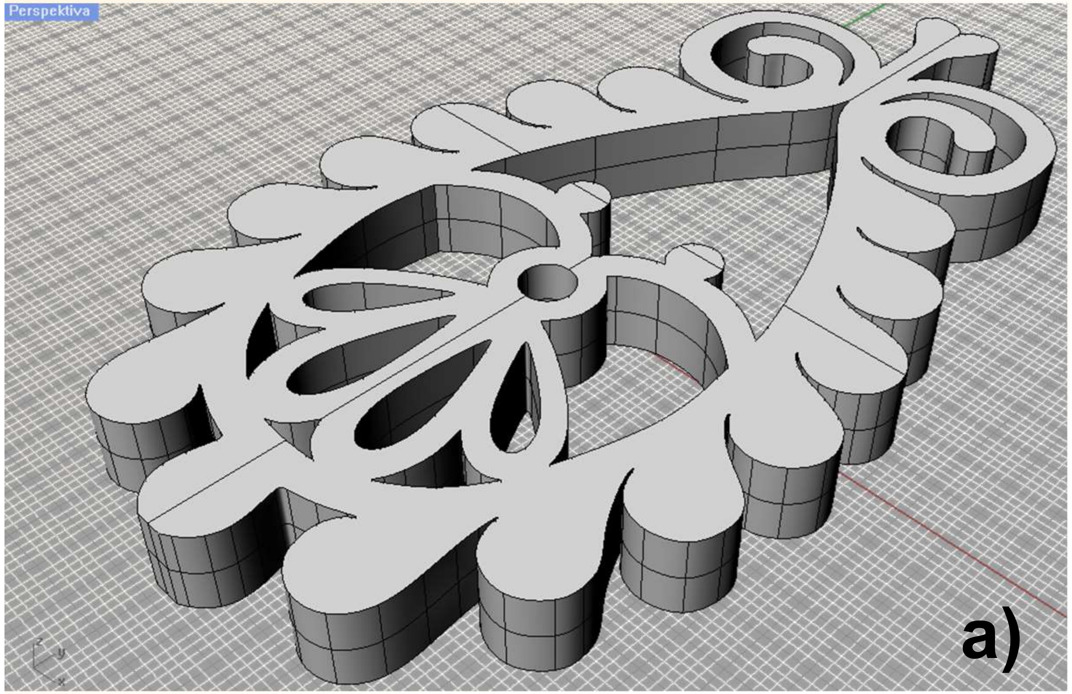
As samples of final 3D printed technical objects are

the earrings and ring from

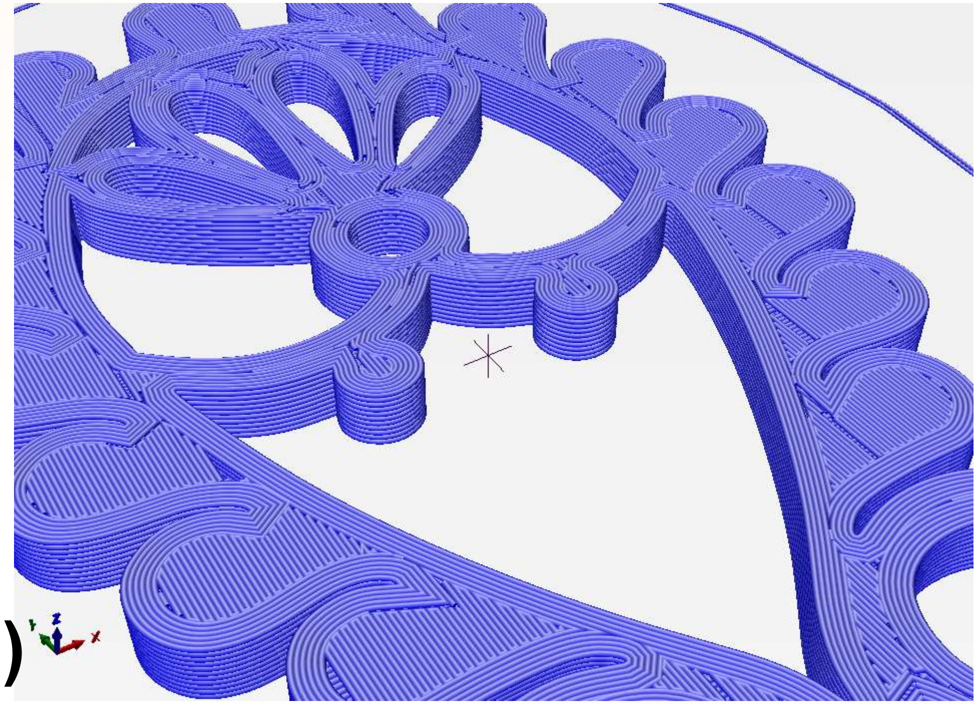
“wood“

for student model collection

Material **Timberfill** Print time of selected one earring was 4 hours



a)



b)

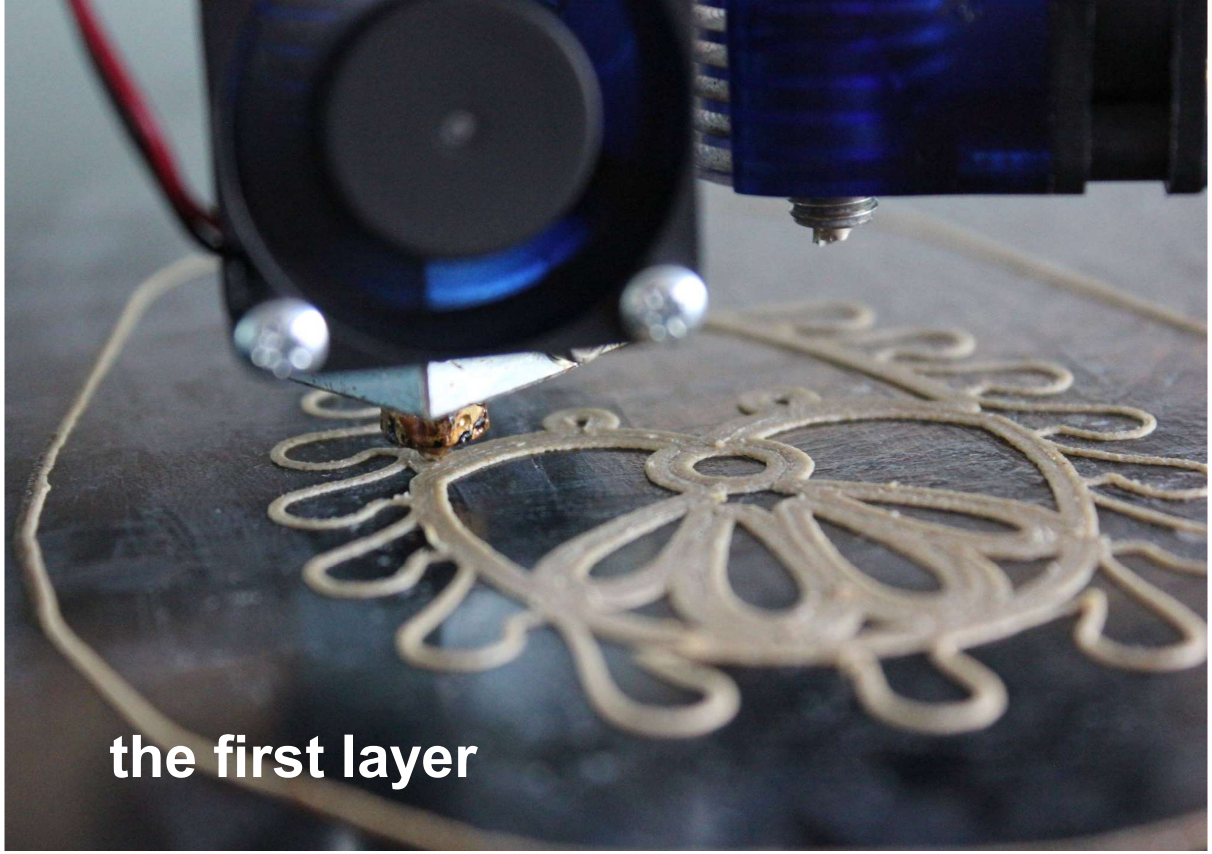
c)

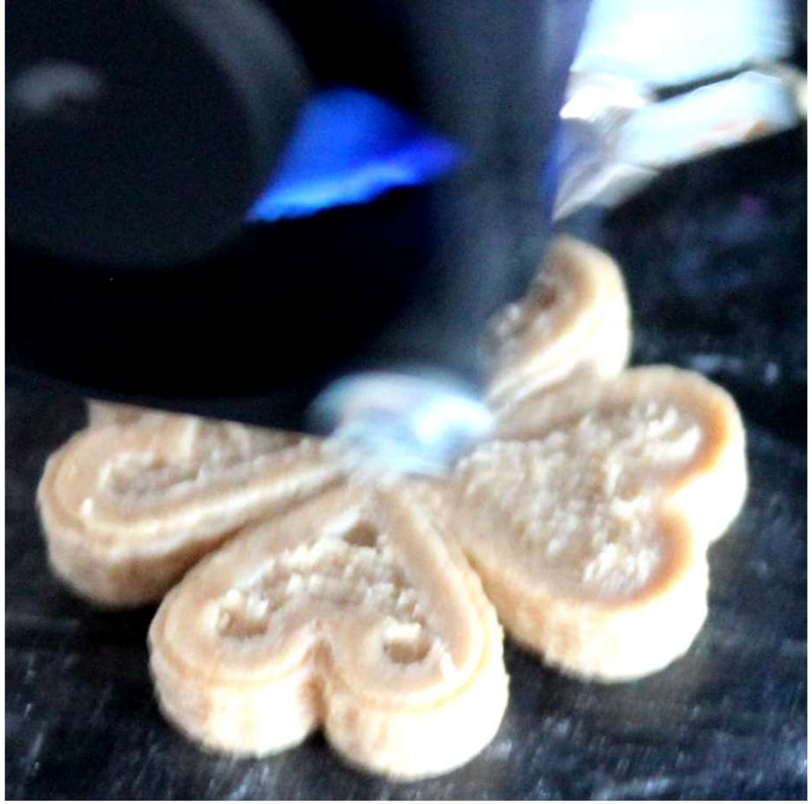
From design to printing:

a) design in Rhinoceros

b) slicing

c) printing of final layer


the first layer



Final model collection

earrings and ring

Final 3D printed technical objects

High profiles from PLA

By control programs the printing of some parts altogether but sequentially is possible.

As sample the two same profiles:

the first step = the entire one profile was printed,

the second step = after whole first profile printed the second profile was printed.

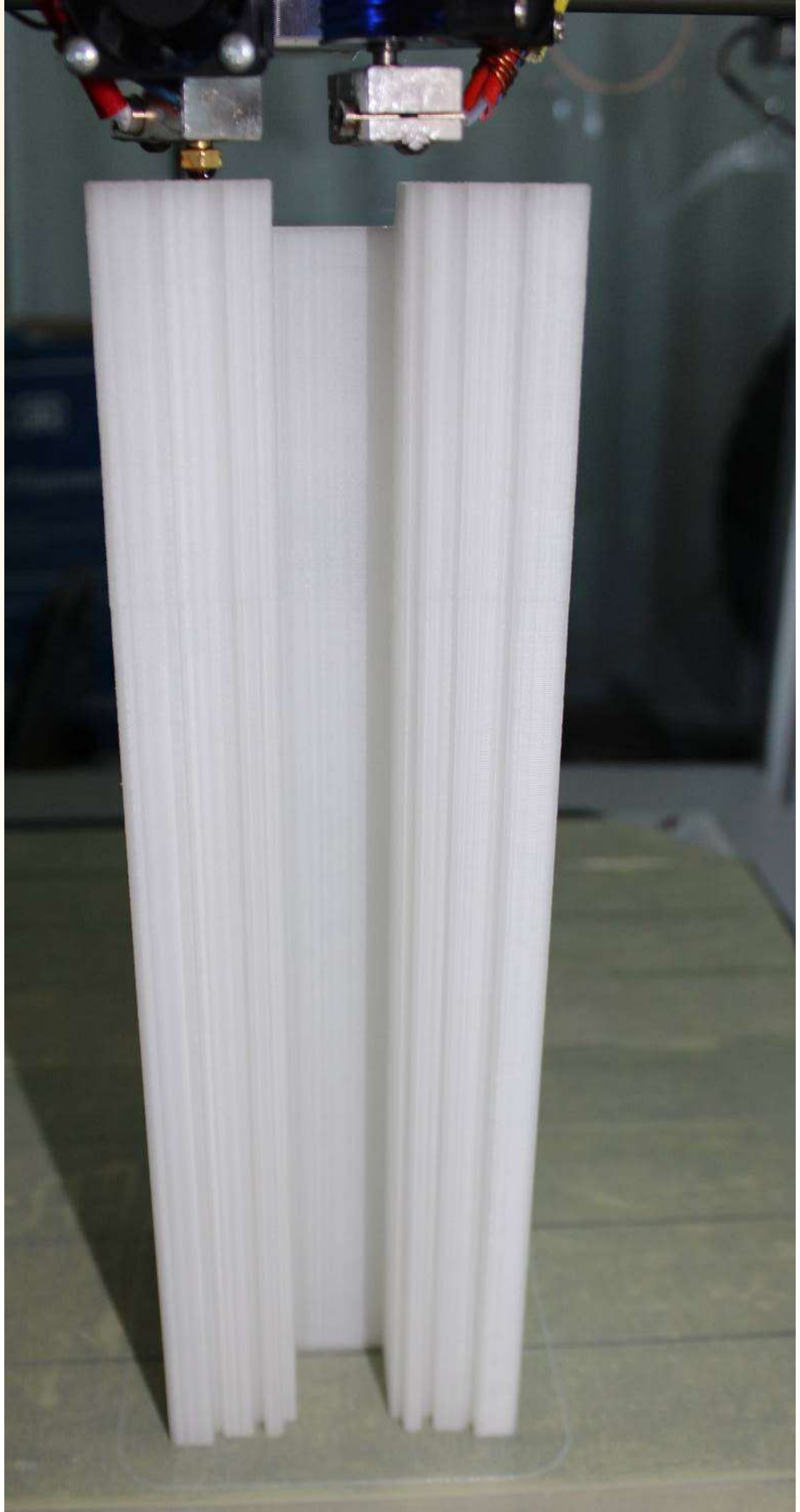
Printing takes place as a single G-code file, but printing of the profiles takes place sequentially!

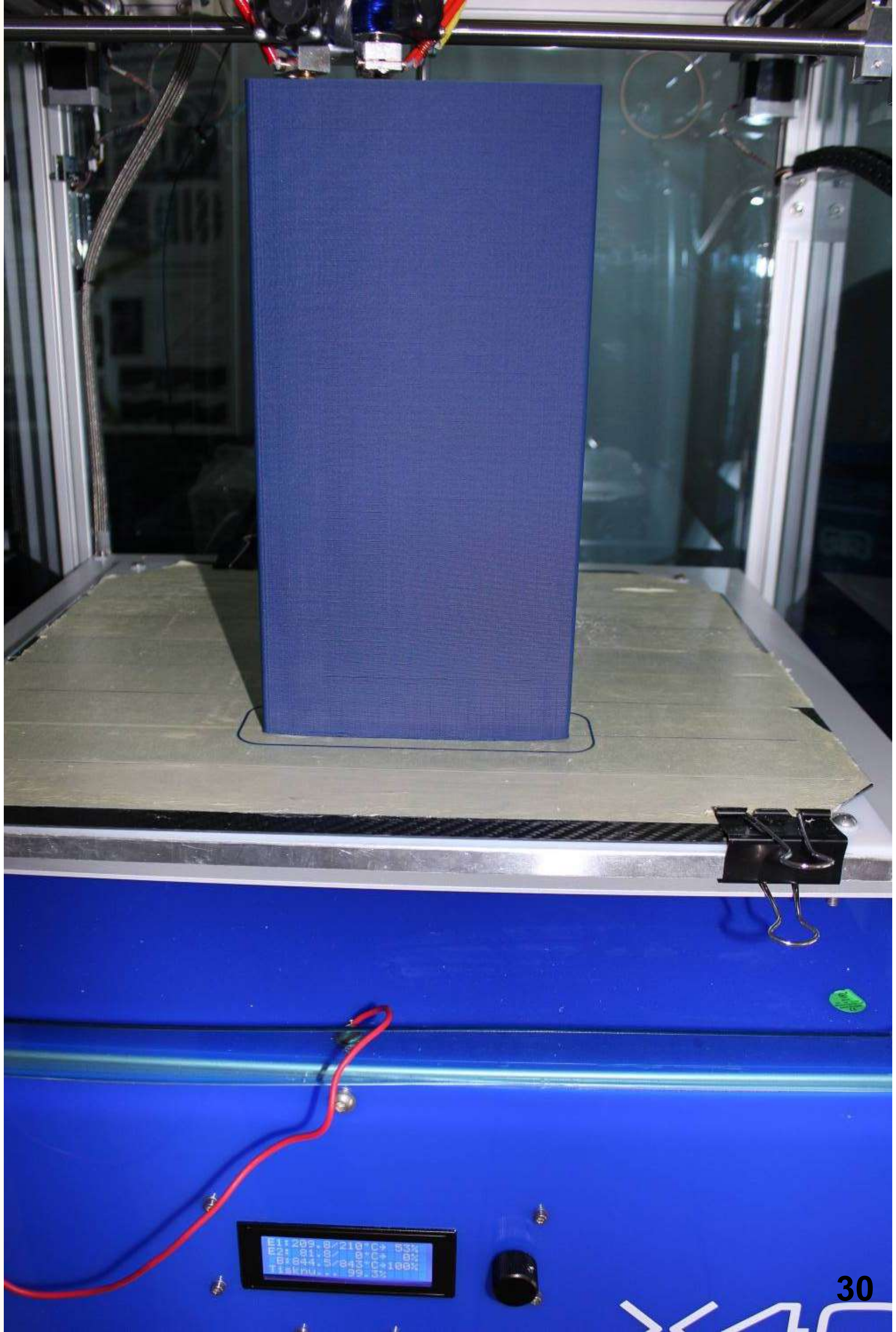
The profiles have high of 200 mm. The G-code was optimized for obtaining of short print time and good quality!

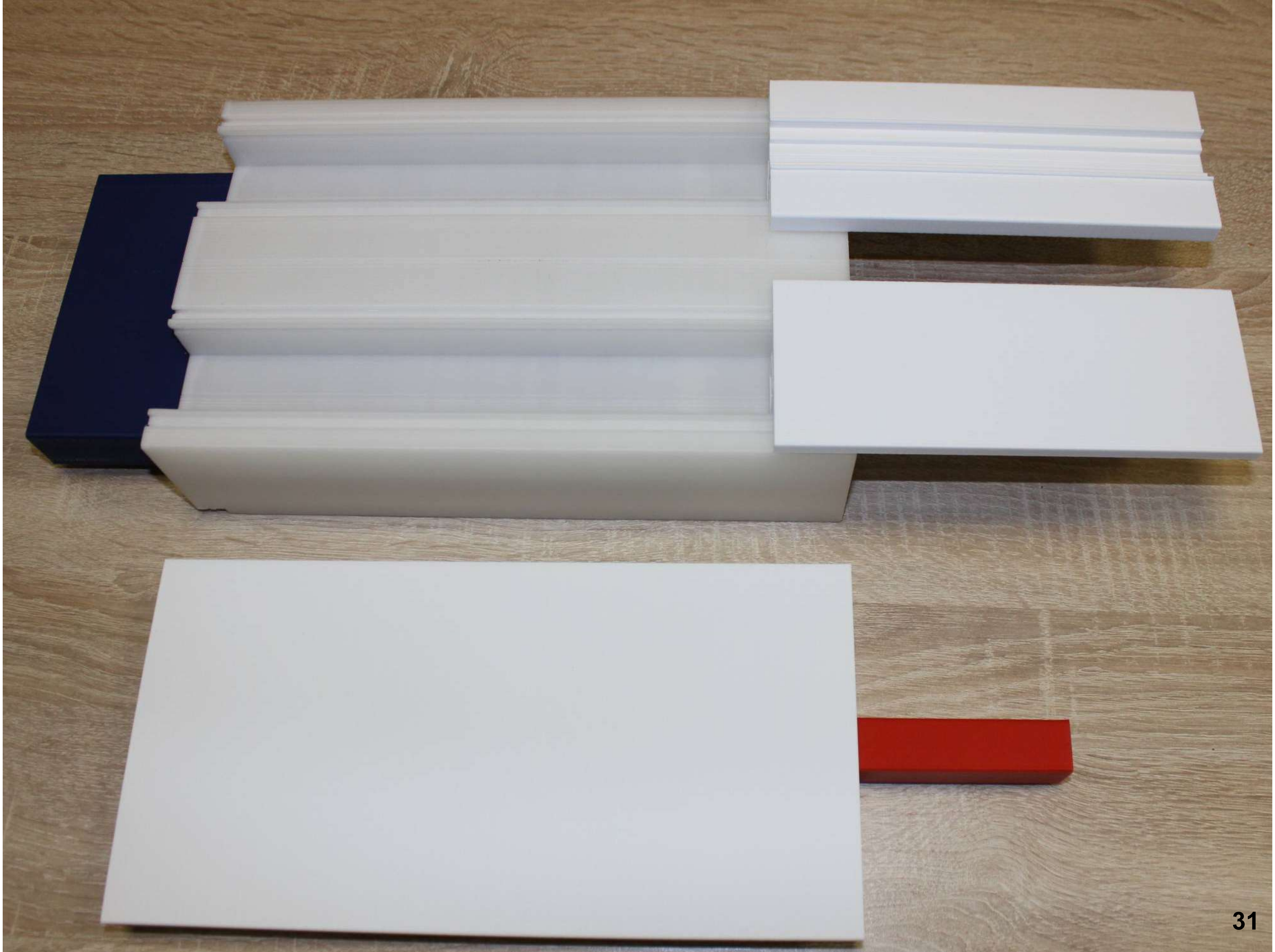
The dimensional accuracy is ± 0.1 mm !

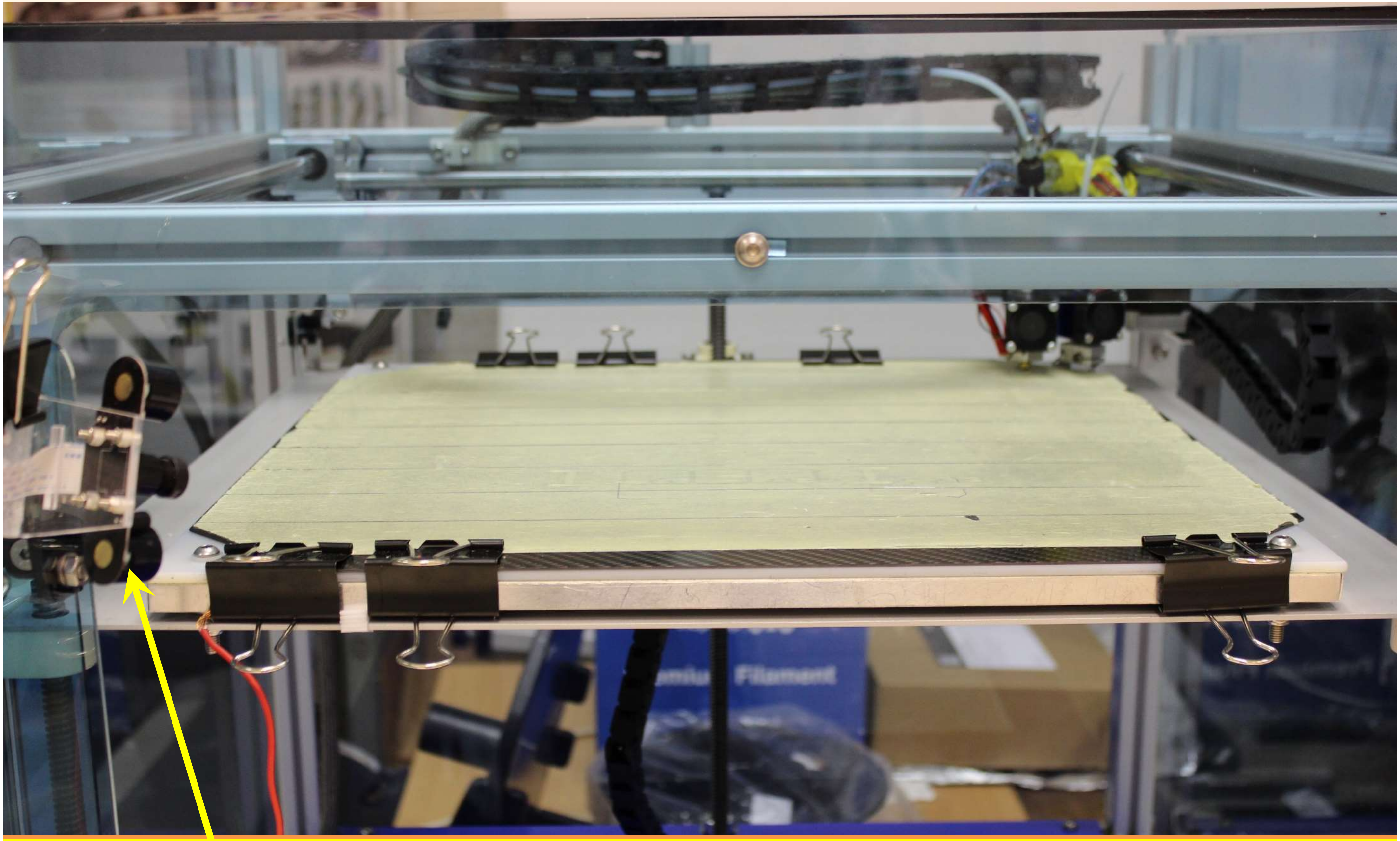
The other big profiles had **high of 300 mm**, almost the whole height of build platform is used. Sometimes the print time was **over 50 hours** per one profile only.

3D printing can sometimes be labeled as **not quickly** production but production requiring longer production times.



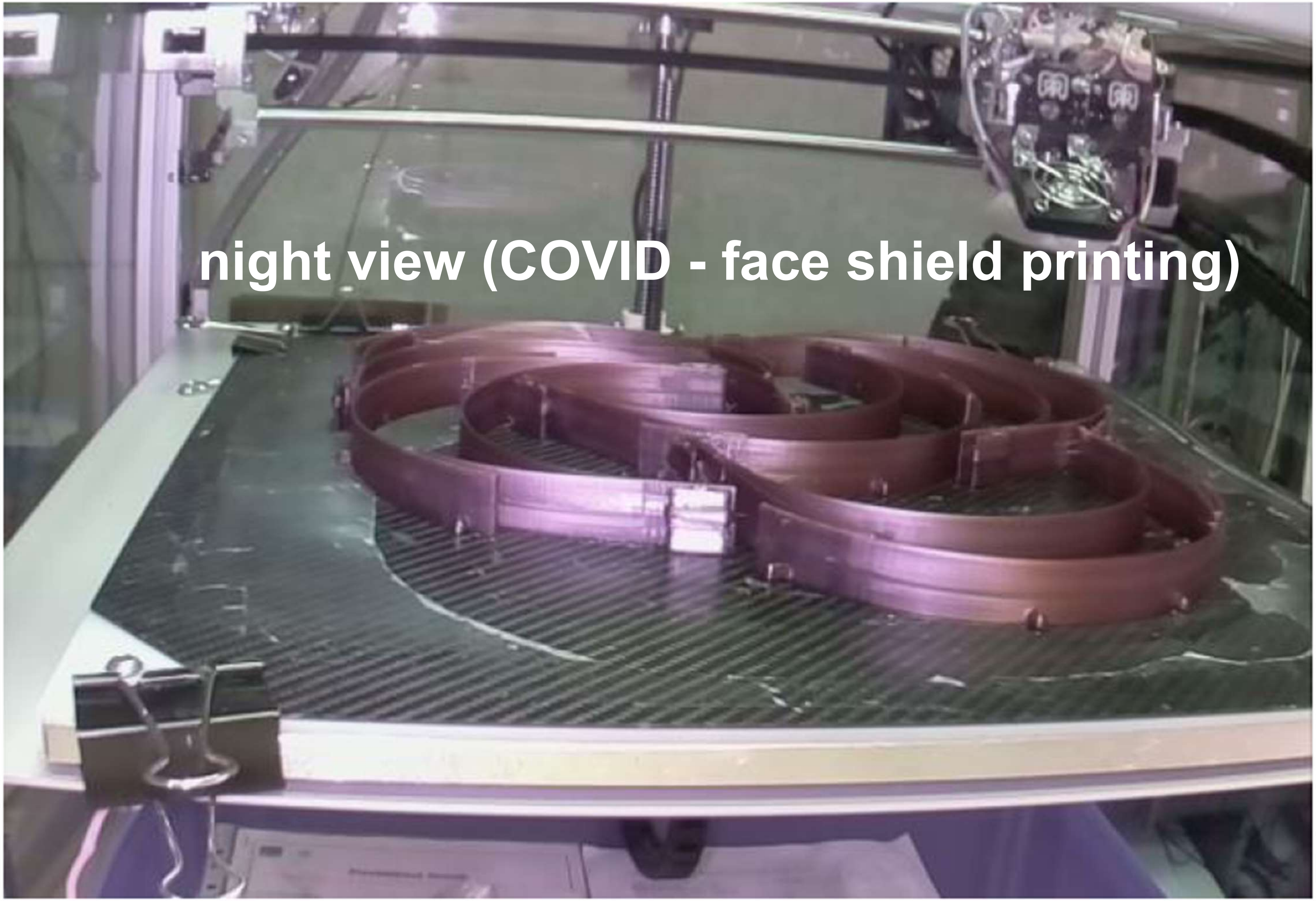




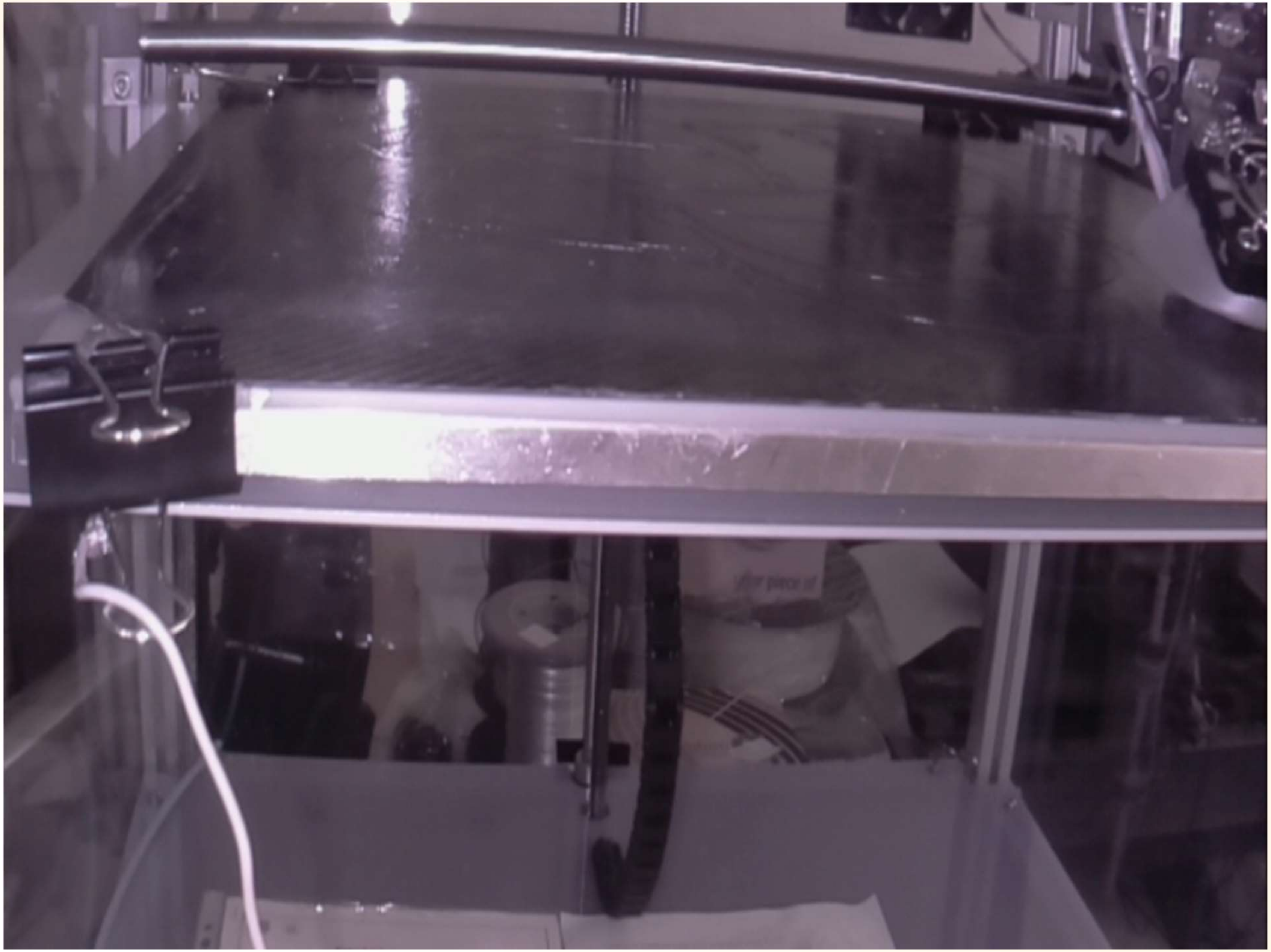


Online printing and Online monitoring by infra camera


night view (infrared camera)


night view (COVID - face shield printing)

night view (COVID - face shields)



VIDEOS:

- **Ear-ring**
- **Dress accessories**
- **Profiles**

- **<u>print with two materials elastic and hard</u>**

  <u>= composite</u>

FEA software at faculty

ANSYS

Adina

MSC Marc

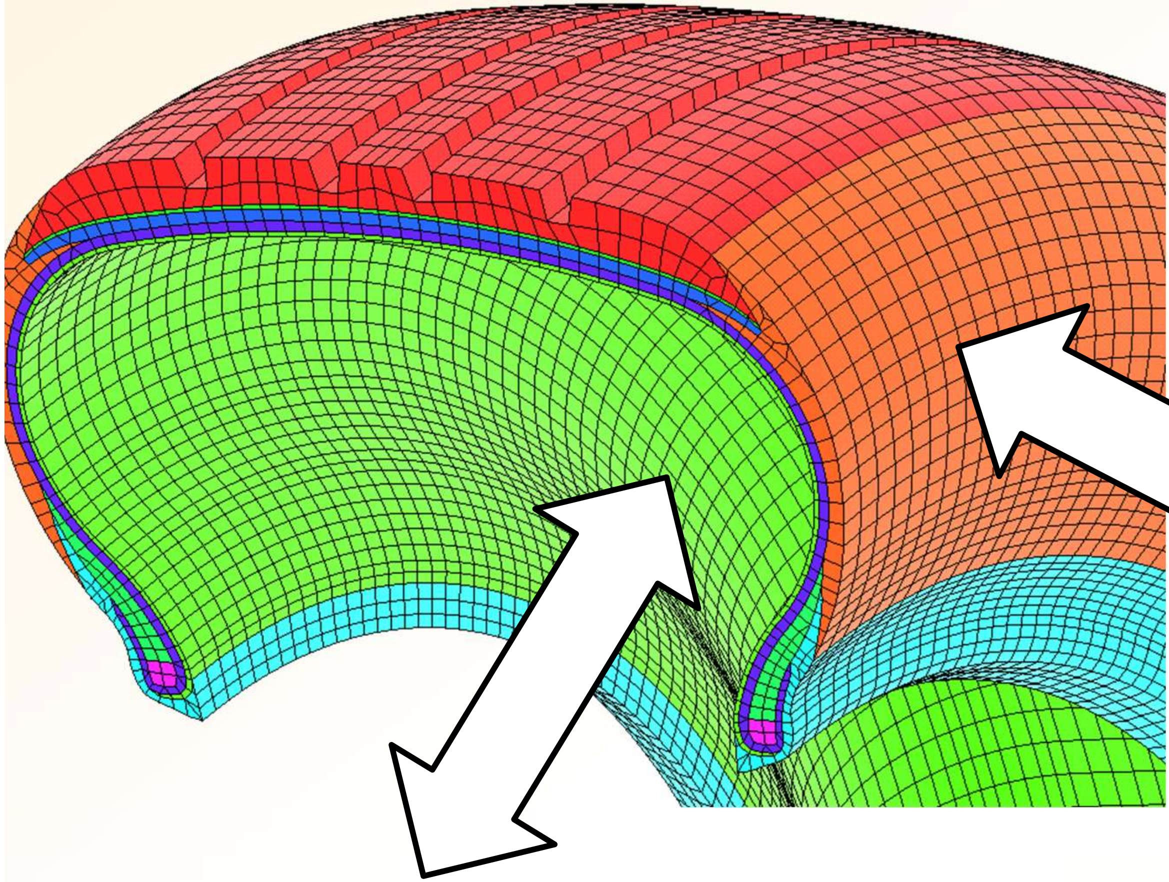
SolidWorks

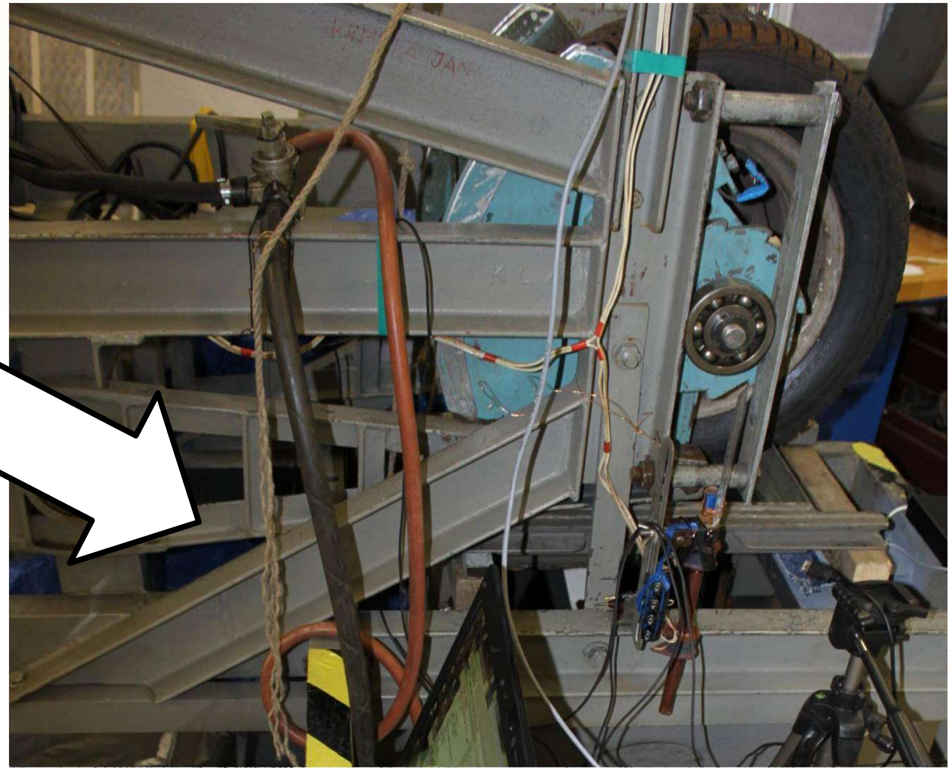
MSC Patran

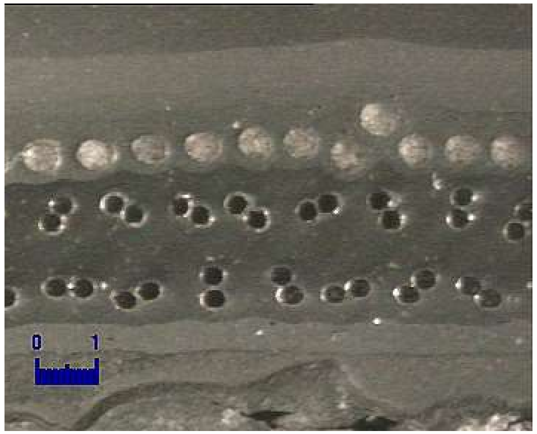
Experiments of

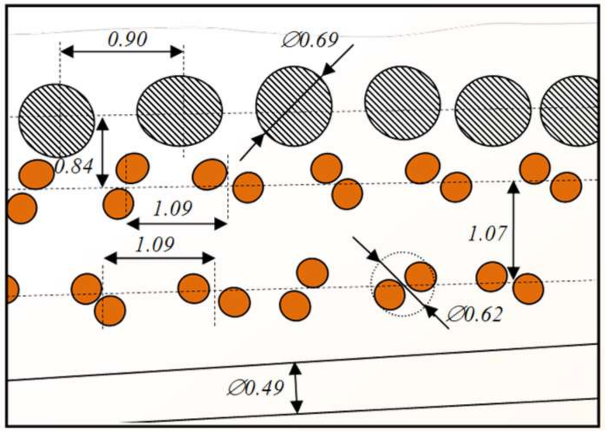
COMPOSITE - TIRE

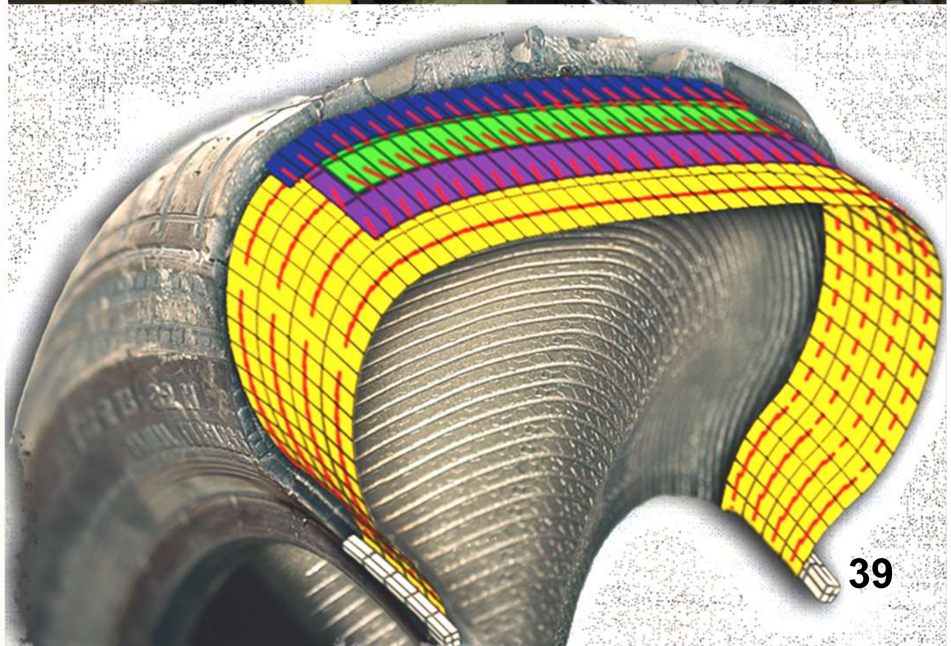
INTRODUCTION











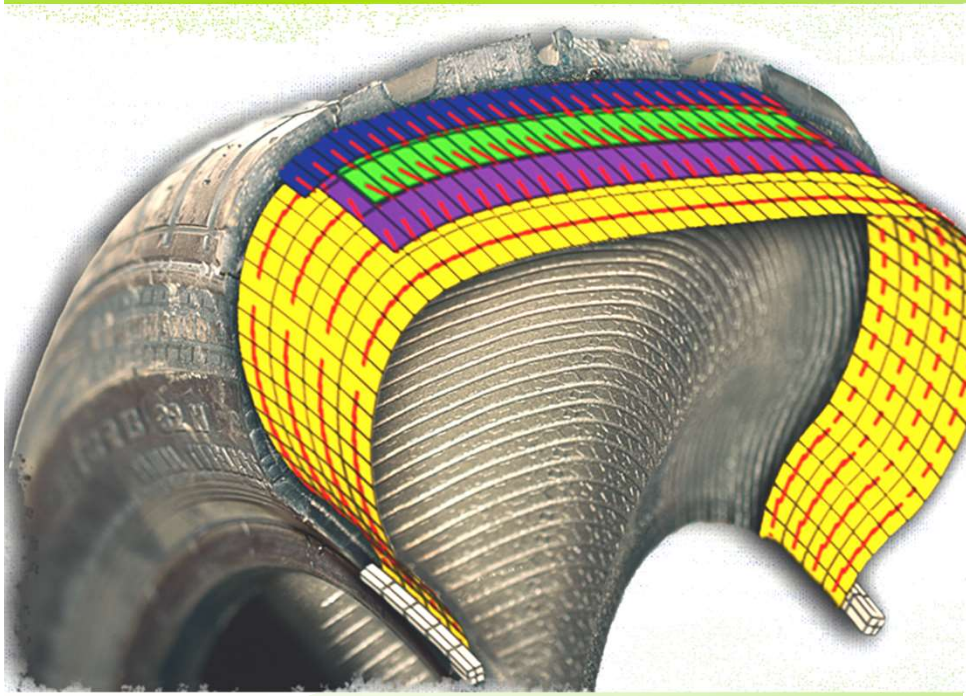
The research work deals with **computational simulation of basic and specific tests** of polymer composites with textile and steel cords, which are used as reinforcement for the composites.

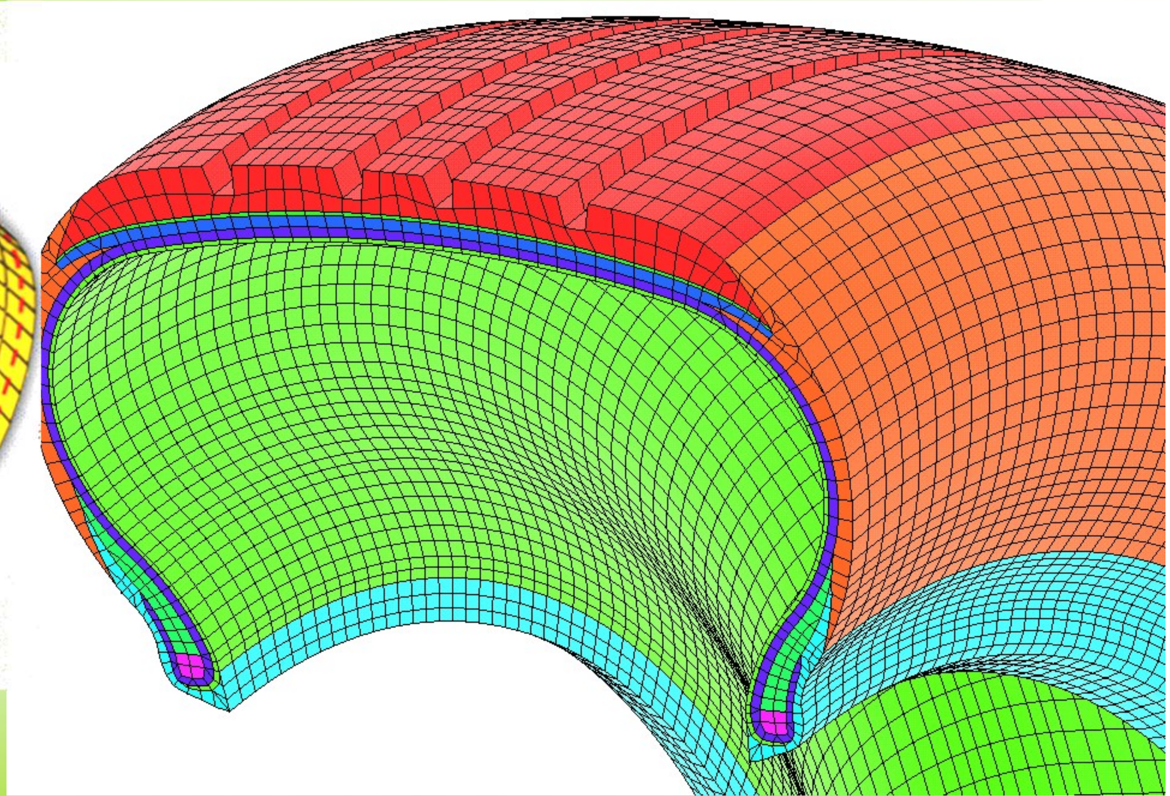
RESEARCH AIM

1). The aim of this research work is **design of computational models which can be used for simulation of tests of composites based on experimental data which were obtained by test machine with video-extensometer and temperature chamber**.

RESEARCH AIM

2). Design computational models of tires.





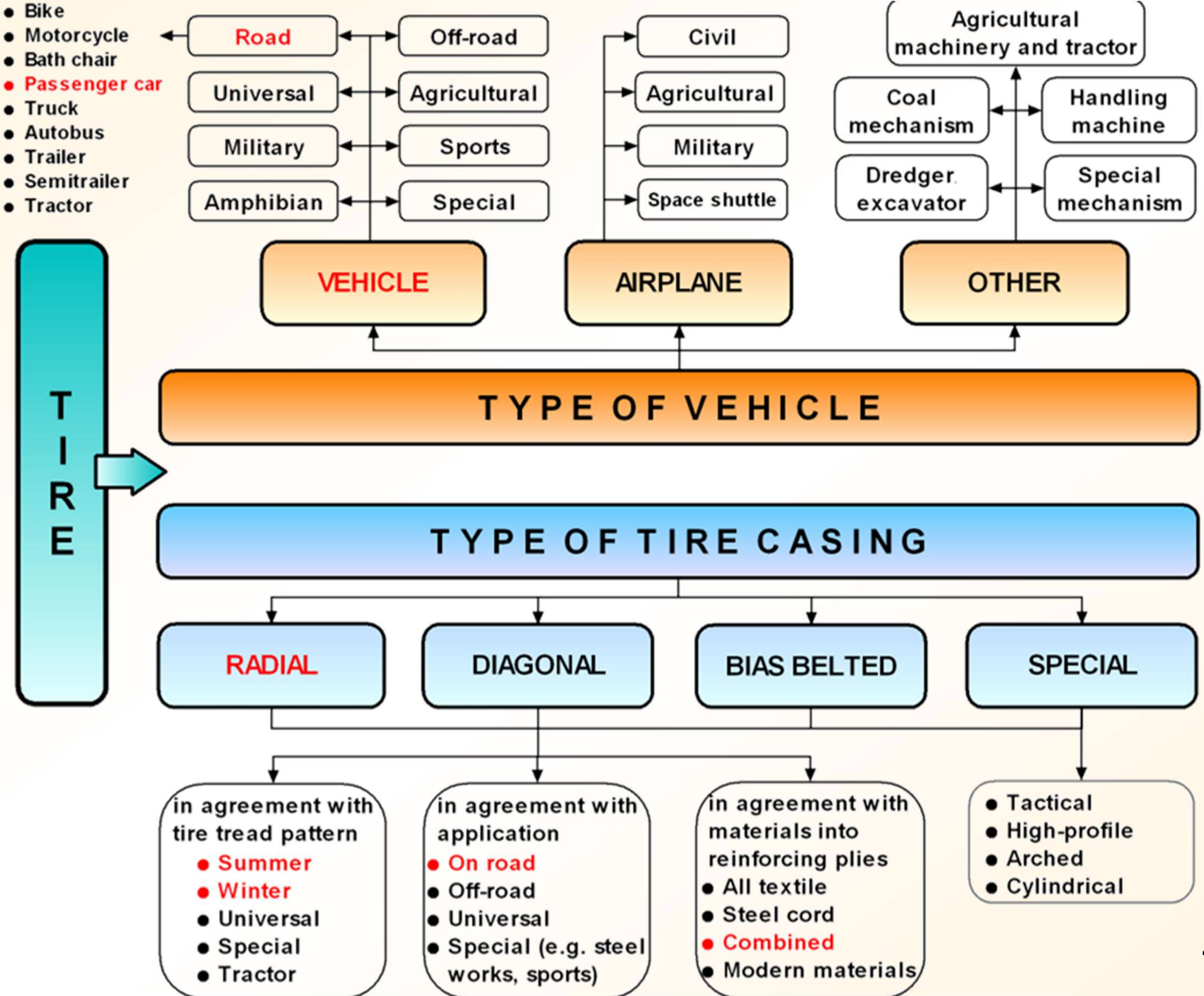
3). Design of methods for specific cyclic testing of composites.

APPROACH

<u>COMPUTATIONAL MODELING</u> (analyses: stress-strain, modal, temperature field, combine, dynamic) via FEA program ANSYS

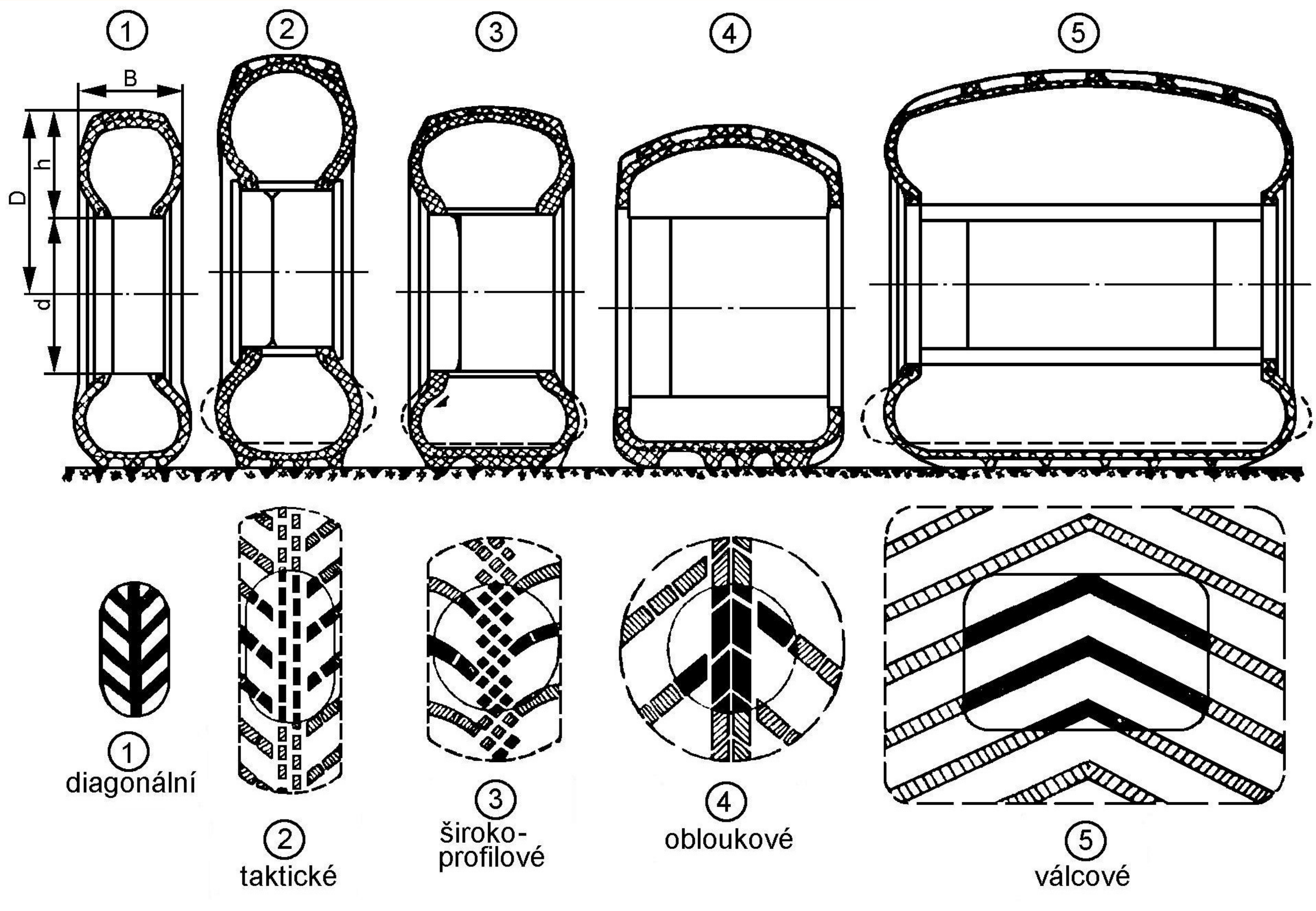
- ✓ <u>EXPERIMENTS</u> OF MATERIAL PARAMETERS
- ✓ EXPERIMENTS OF TIRES ON „ADHESOR“
- ✓ PRESSURE FOOTPRINT <u>ANALYSES</u>

<u>VERIFICATION APPROACH</u> TO COMPUTATIONAL MODEL OF RADIAL TIRE

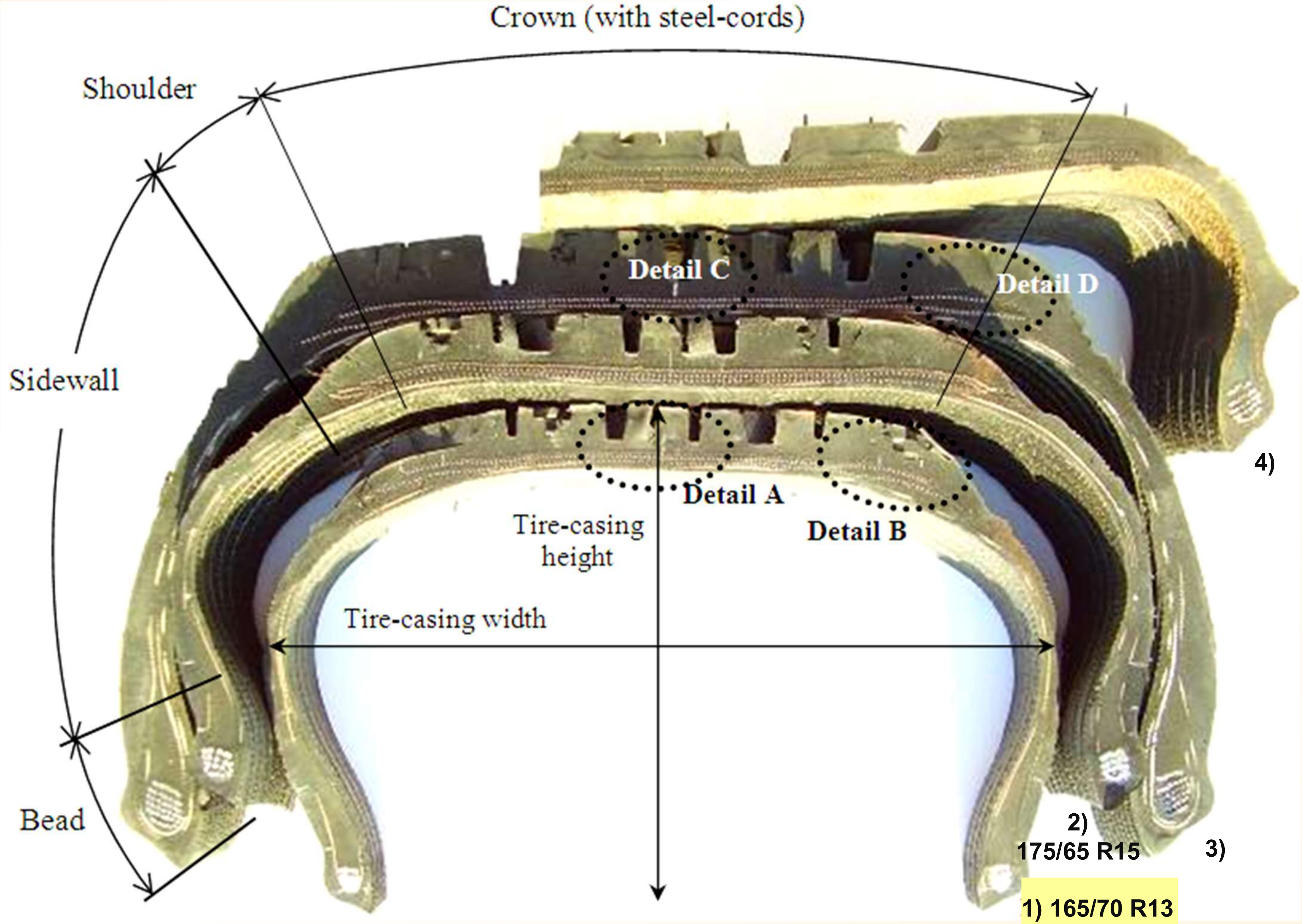


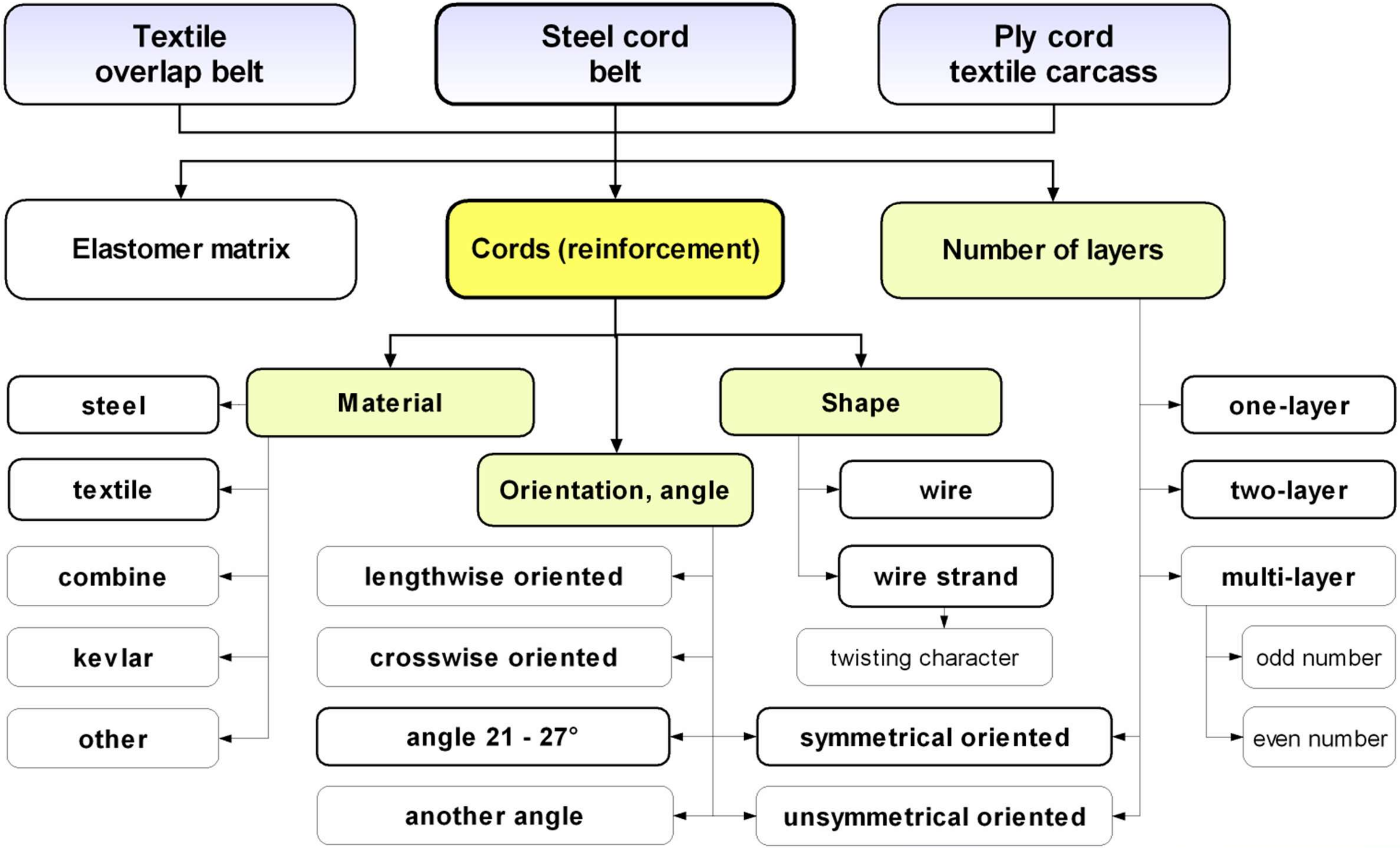
Bike
Motorcycle
Bath chair
Passenger car
Truck
Autobus
Trailer
Semitrailer
Tractor
Road
Off-road
Universal
Agricultural
Military
Sports
Amphibian
Special
Civil
Agricultural
Military
Space shuttle
Agricultural machinery and tractor
Coal mechanism
Handling machine
Dredger excavator
Special mechanism
VEHICLE
AIRPLANE
OTHER
TIRE
TYPE OF VEHICLE
TYPE OF TIRE CASING
RADIAL
DIAGONAL
BIAS BELTED
SPECIAL
in agreement with tire tread pattern
Summer
Winter
Universal
Special
Tractor
in agreement with application
On road
Off-road
Universal
Special (e.g. steel works, sports)
in agreement with materials into reinforcing plies
All textile
Steel cord
Combined
Modern materials
Tactical
High-profile
Arched
Cylindrical

Special constructions



TIRE STRUCTURE

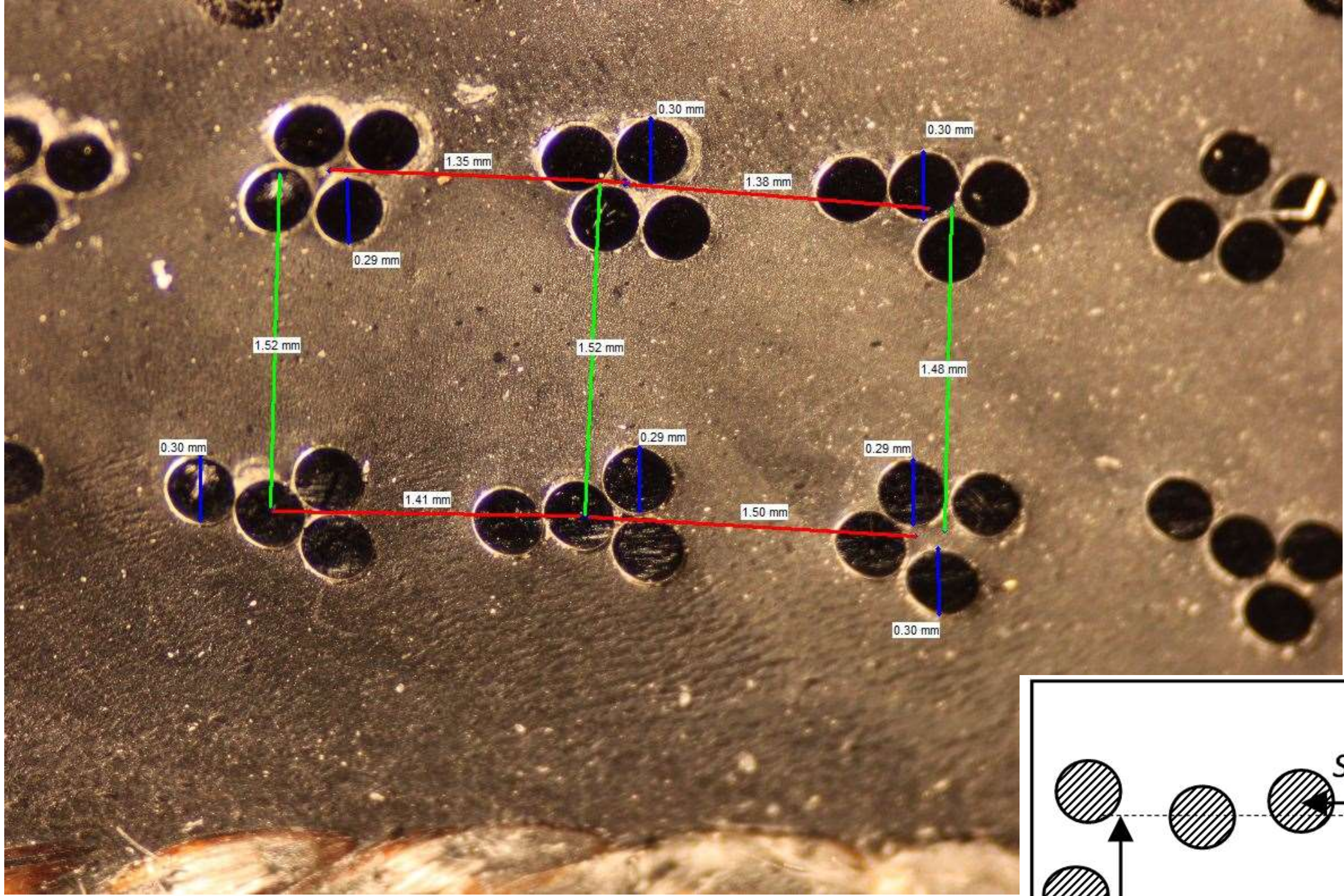



Textile overlap belt
Steel cord belt
Ply cord textile carcass
Elastomer matrix
Cords (reinforcement)
Number of layers
steel
Material
Shape
one-layer
textile
Orientation, angle
wire
two-layer
combine
lengthwise oriented
wire strand
multi-layer
kevlar
crosswise oriented
twisting character
odd number
other
angle 21 - 27°
symmetrical oriented
even number
another angle
unsymmetrical oriented

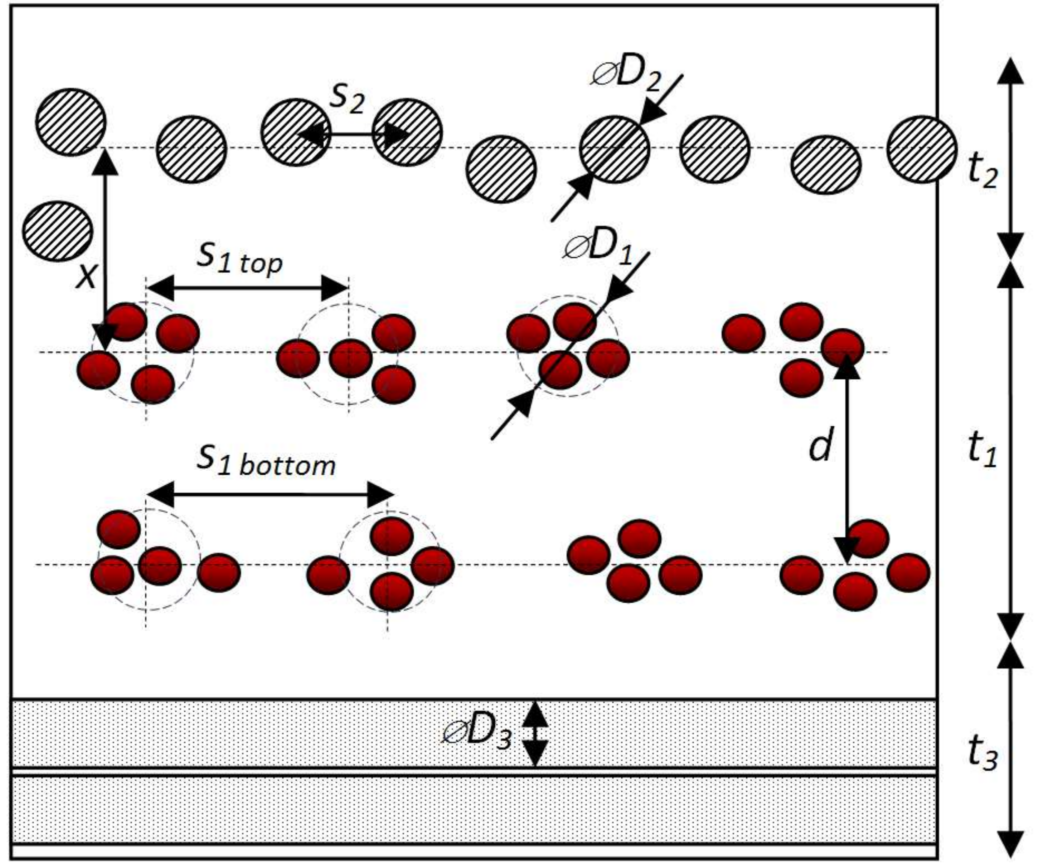
Data about cross-sections, construction-reinforcing plies, etc. are a necessary input for the creation of computational models of tires.

The image analysis is applied for obtaining the information about geometric parameters of cords such as distances between cords, ply thickness, cord diameters, etc.

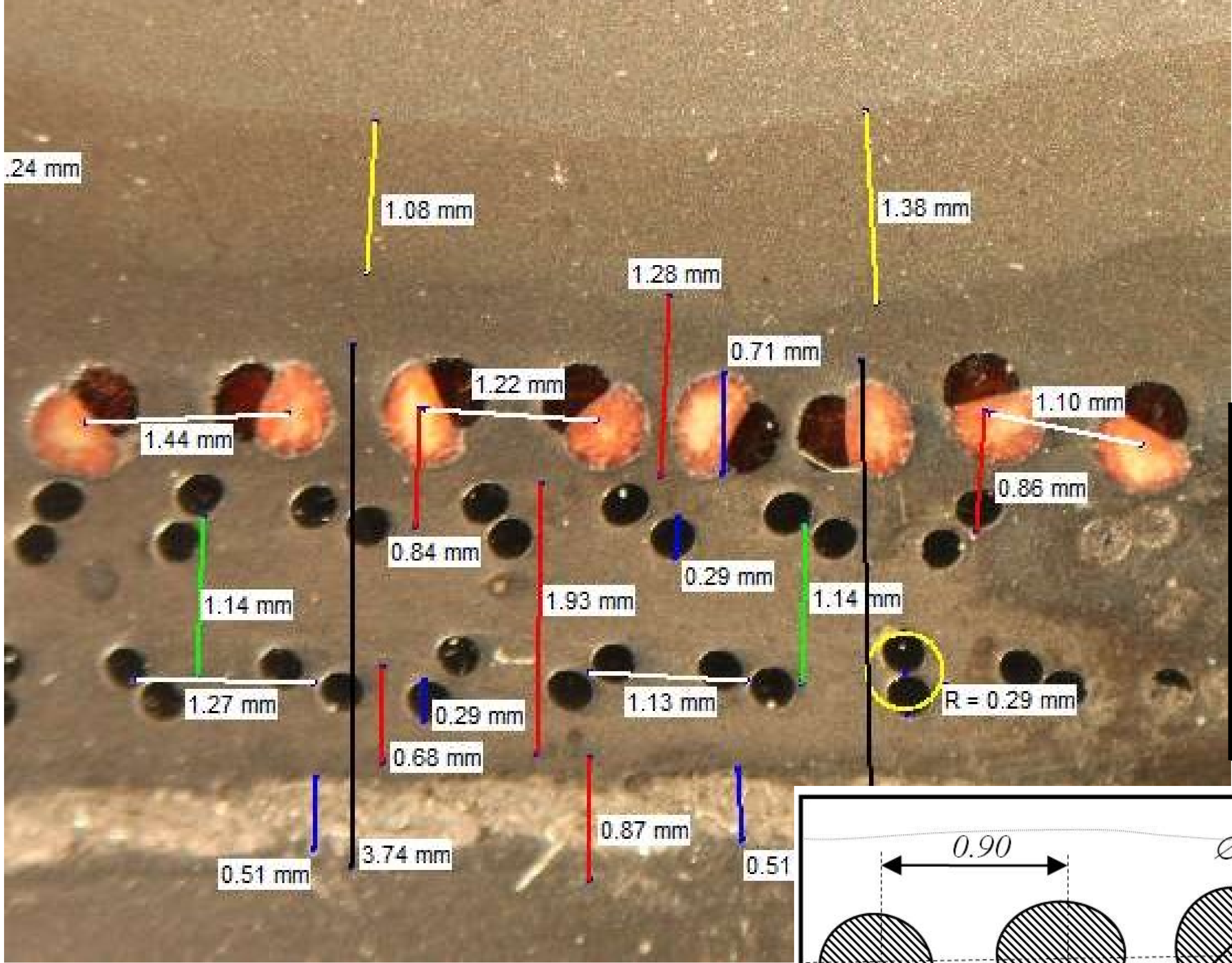
MICROSCOPY OBSERVATION



PHOTOGRAPHS ANALYSES



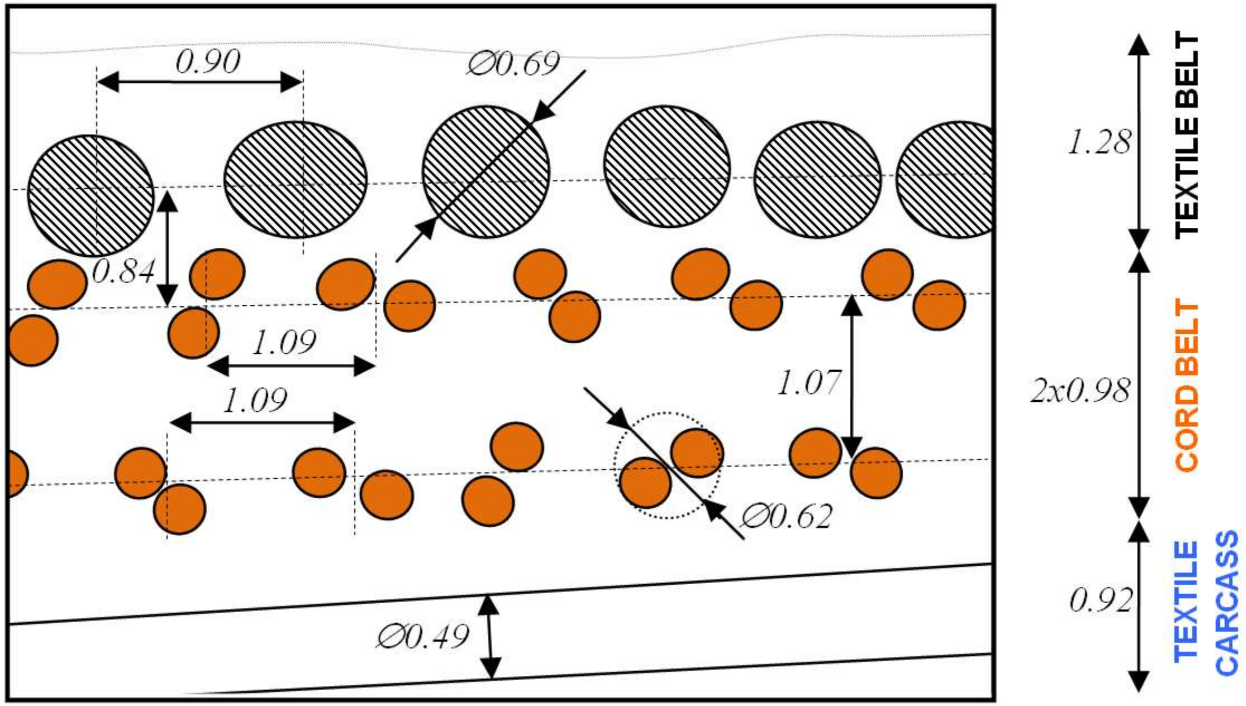
Thickness of layers *t* [mm]
Diameter of cords *D* [mm]
Construction of steel-cords
Number of steel-cords per decimeter width of one steel-cord belt layer (plumb on cords) [$10cm^{-1}$] (EPDM) ......

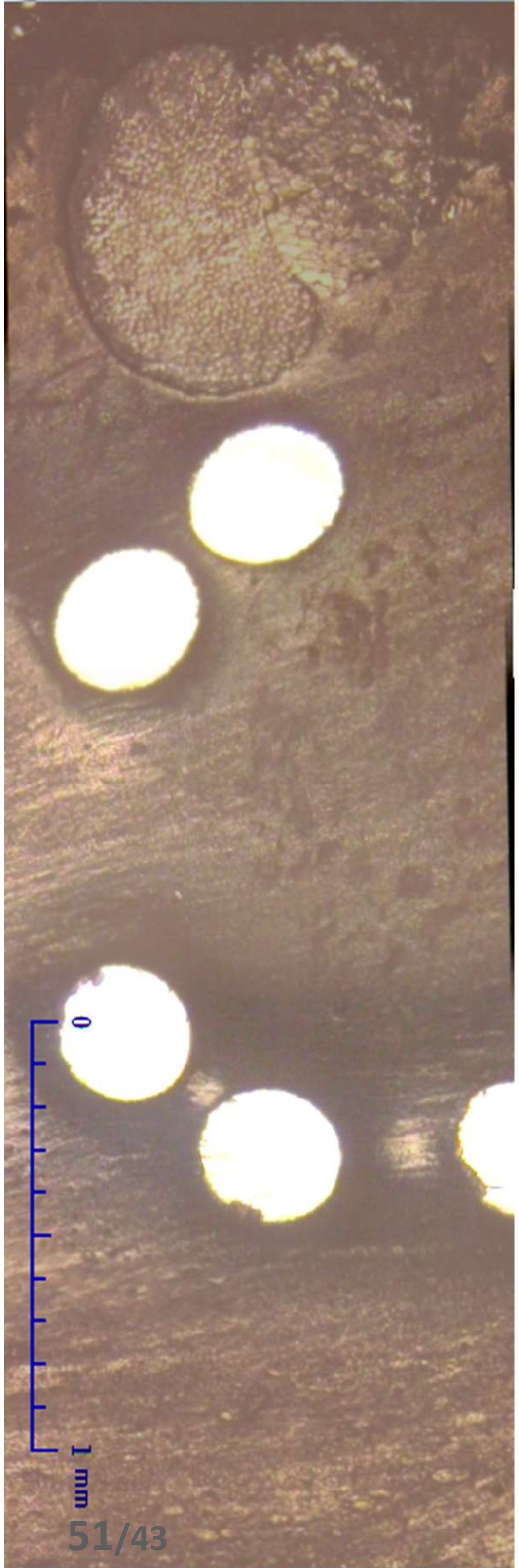


PHOTOGRAPHS ANALYSES

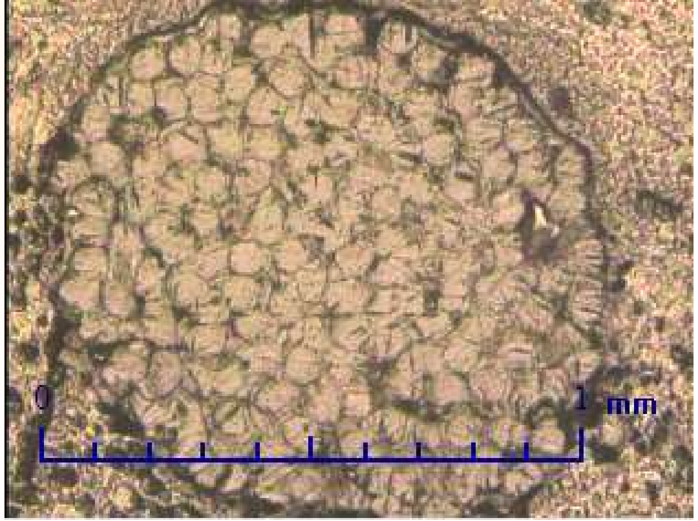
Thickness of layers *t* [mm]
Diameter of cords *D* [mm]
Construction of steel-cords
Number of steel-cords per decimeter width of one steel-cord belt layer (plumb on cords) [$10cm^{-1}$] (EPDM) ……

Structure of GEOMETRY in the tire-crown



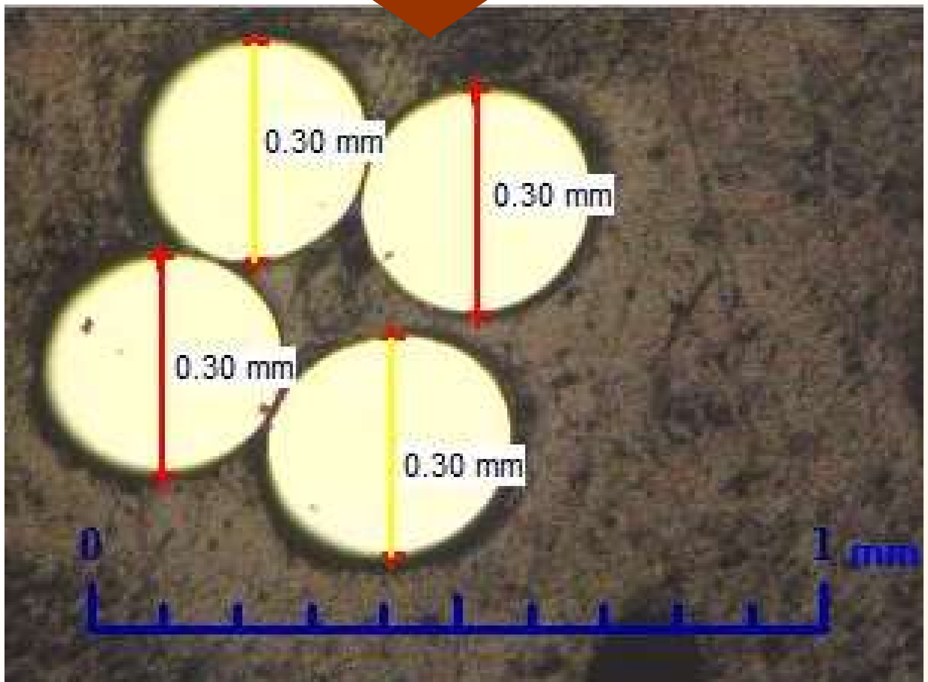


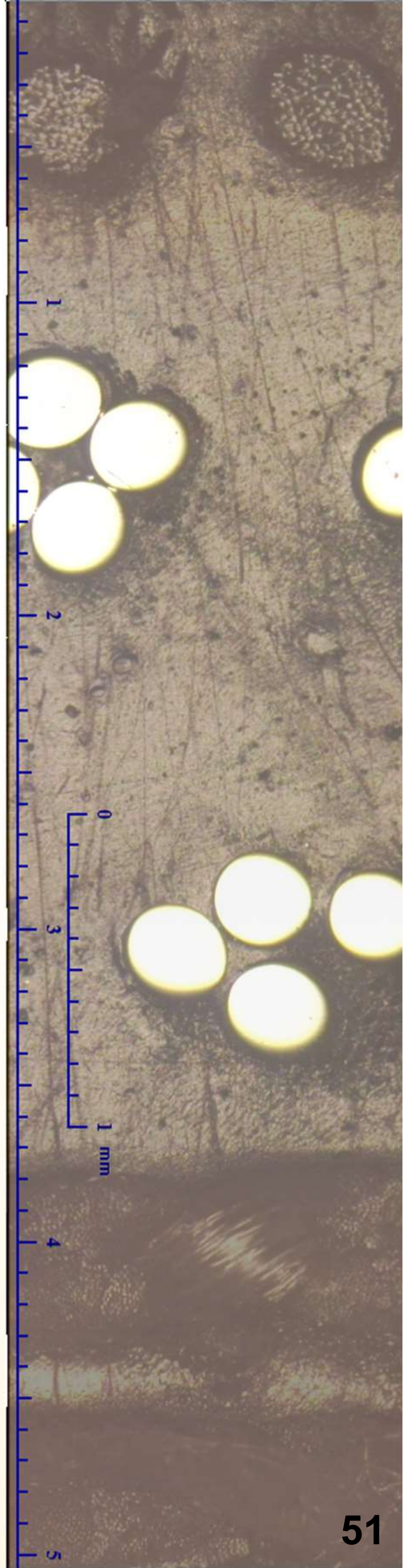
textile cord

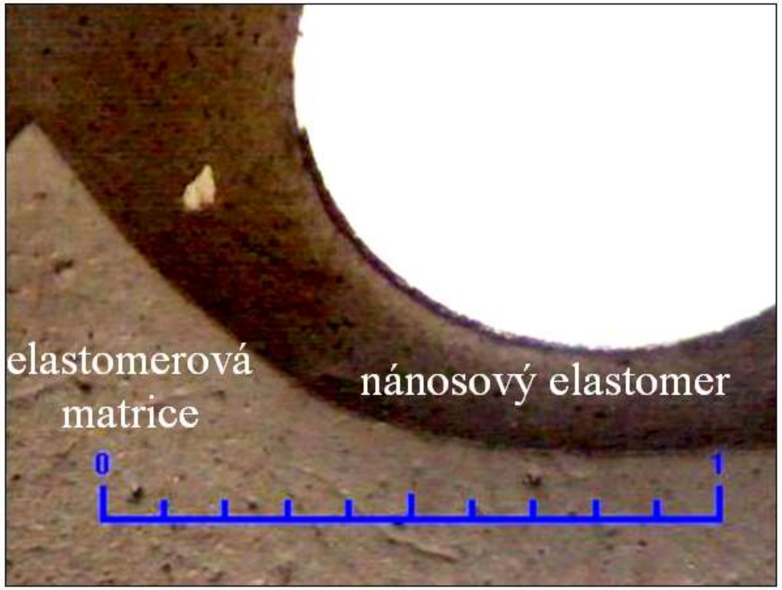


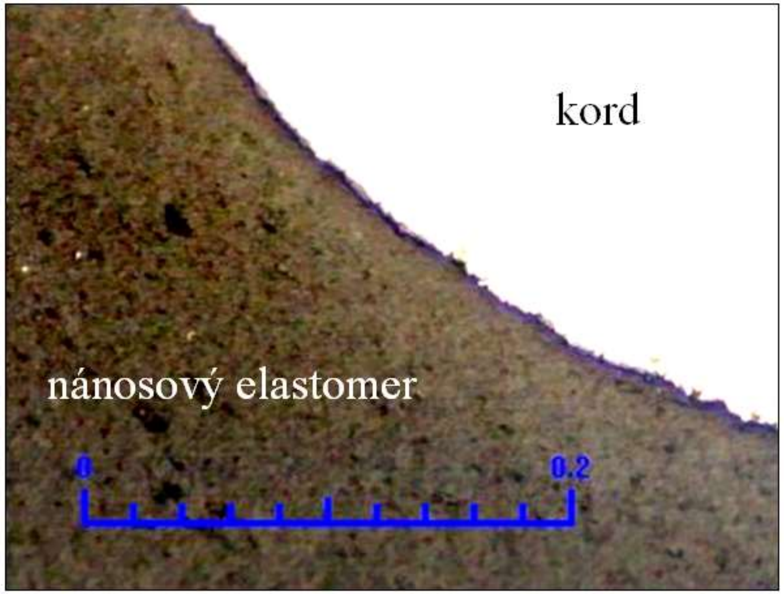
MICROSCOPY OBSERVATION

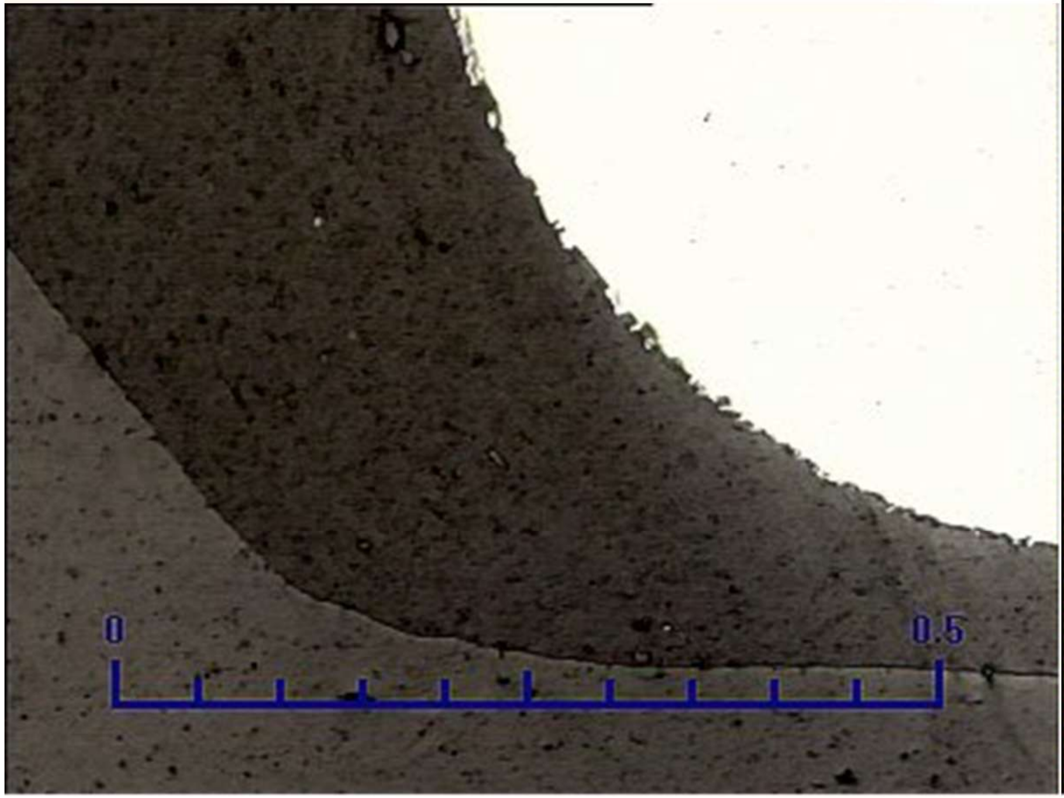
steel cord

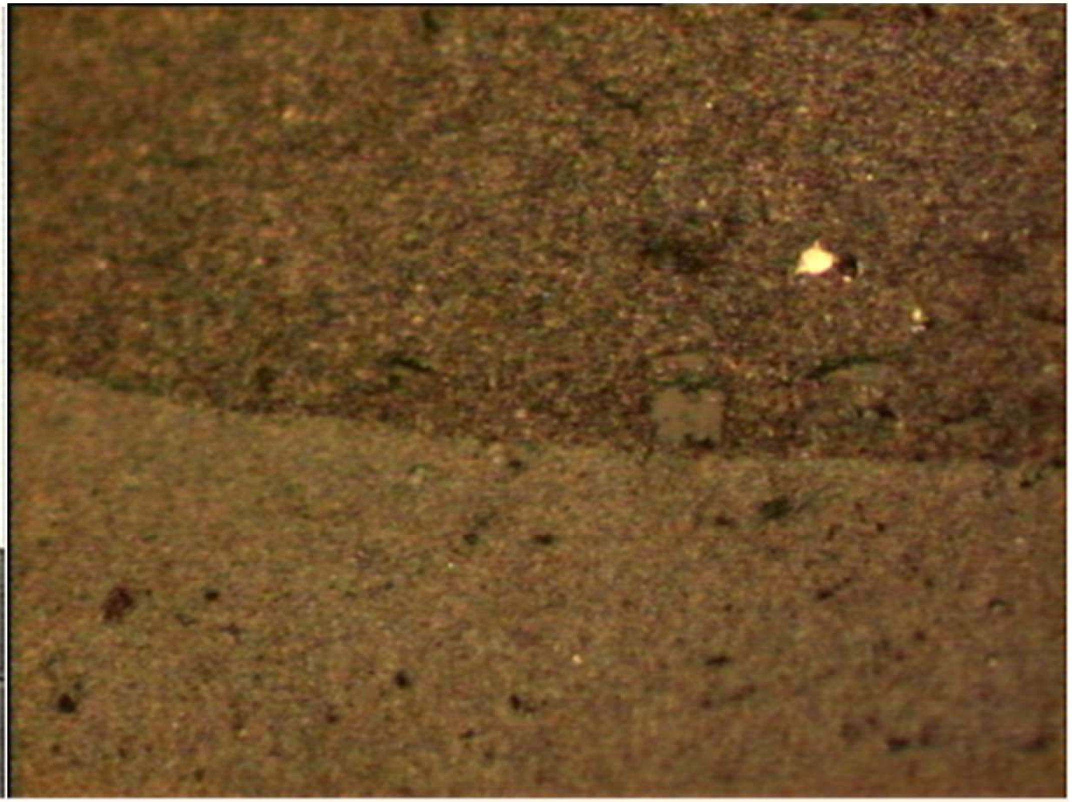





elastomerová matrice
nánosový elastomer
0
1


kord
nánosový elastomer
0
0.2

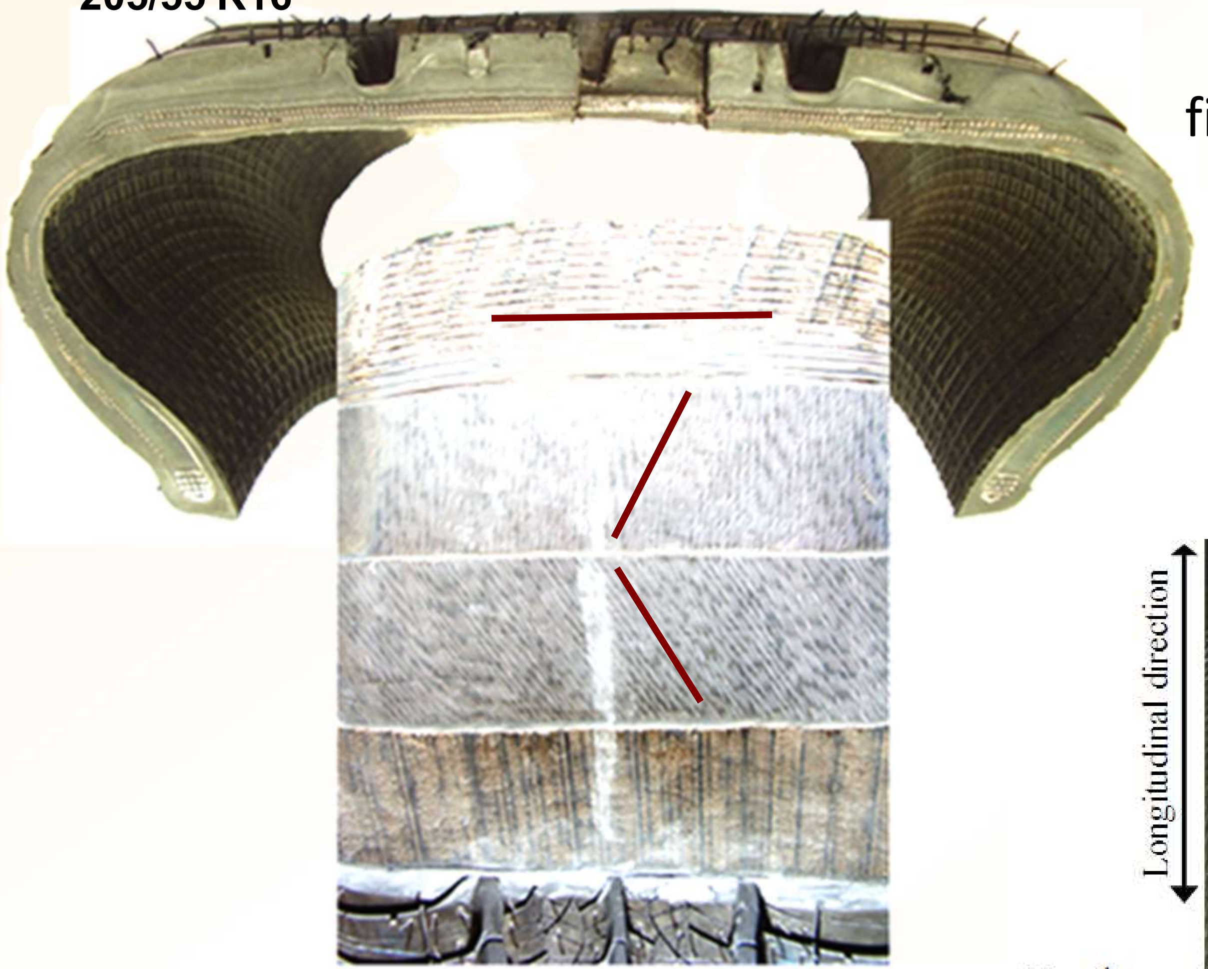

0
0.5



Truck tire casings or agricultural tire casings have different structures

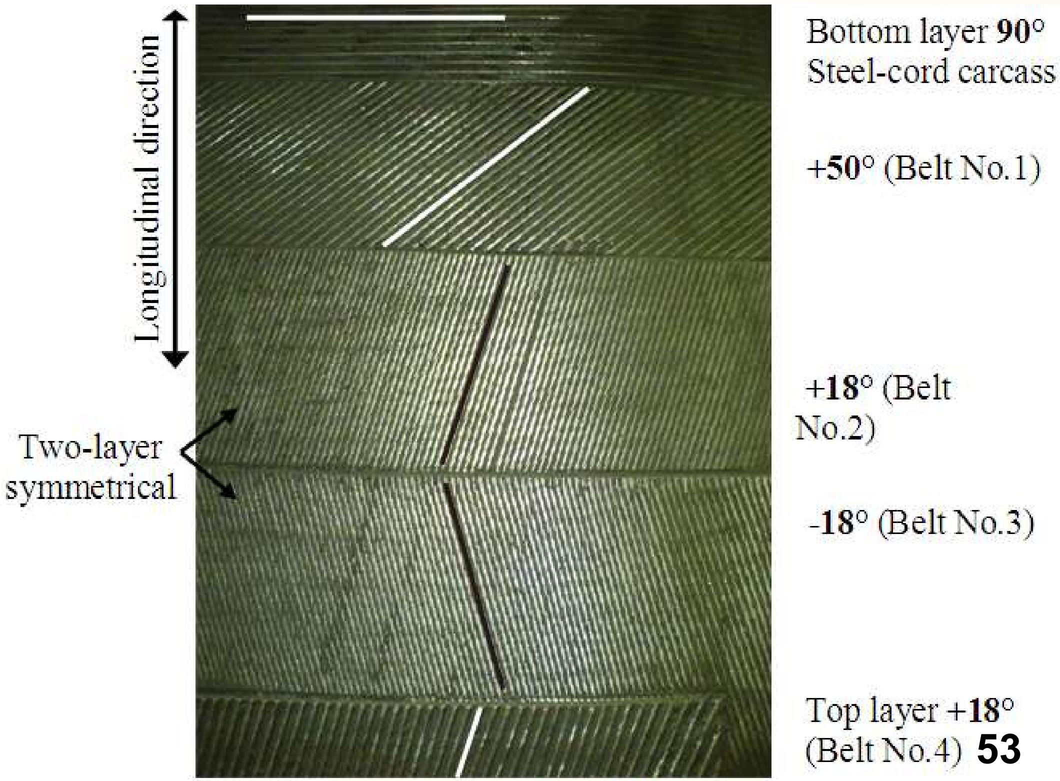
five layers in the middle of tire crown

205/55 R16



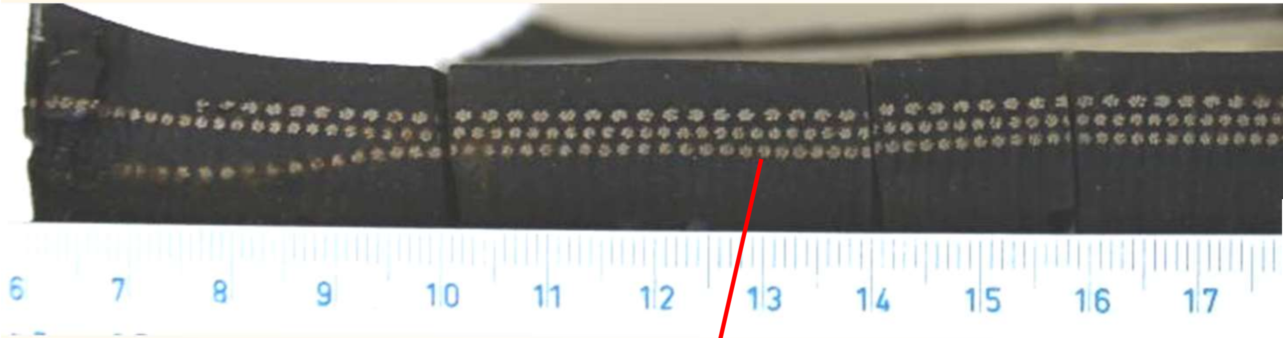
TRUCK radial tire – structure of belts of tire crown

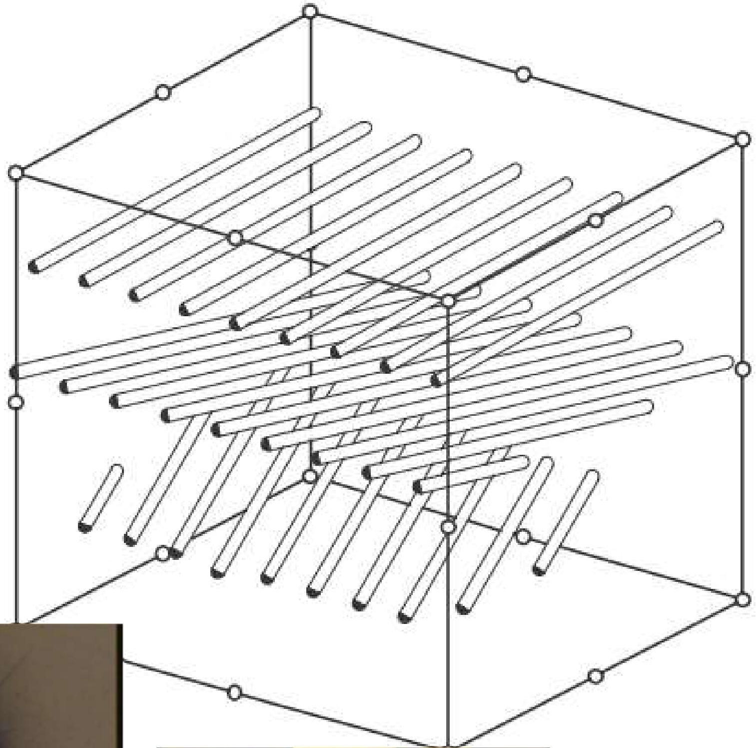
Matador 22.5”

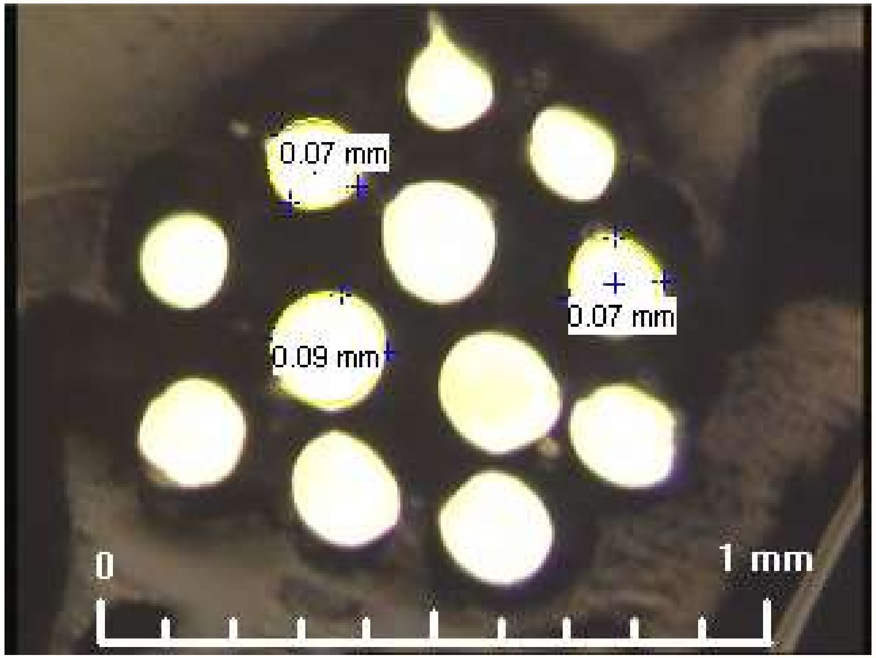


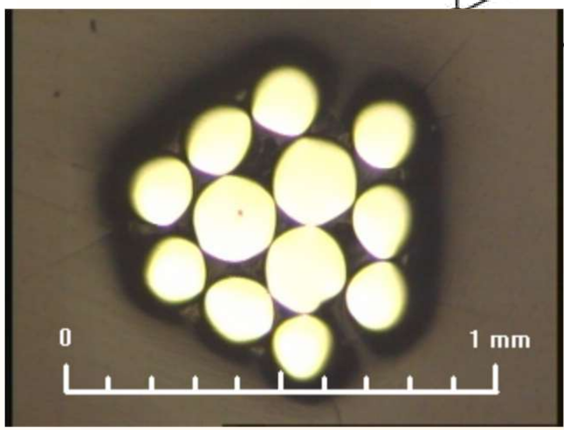
Structure of truck tire in the middle of tire crown

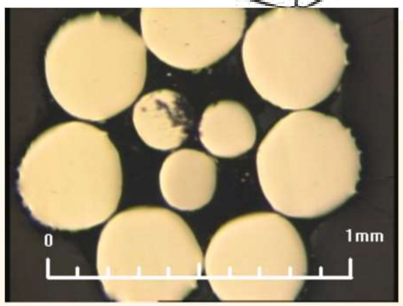
The cords have complicated constructions,
cord details from the microscopic observation







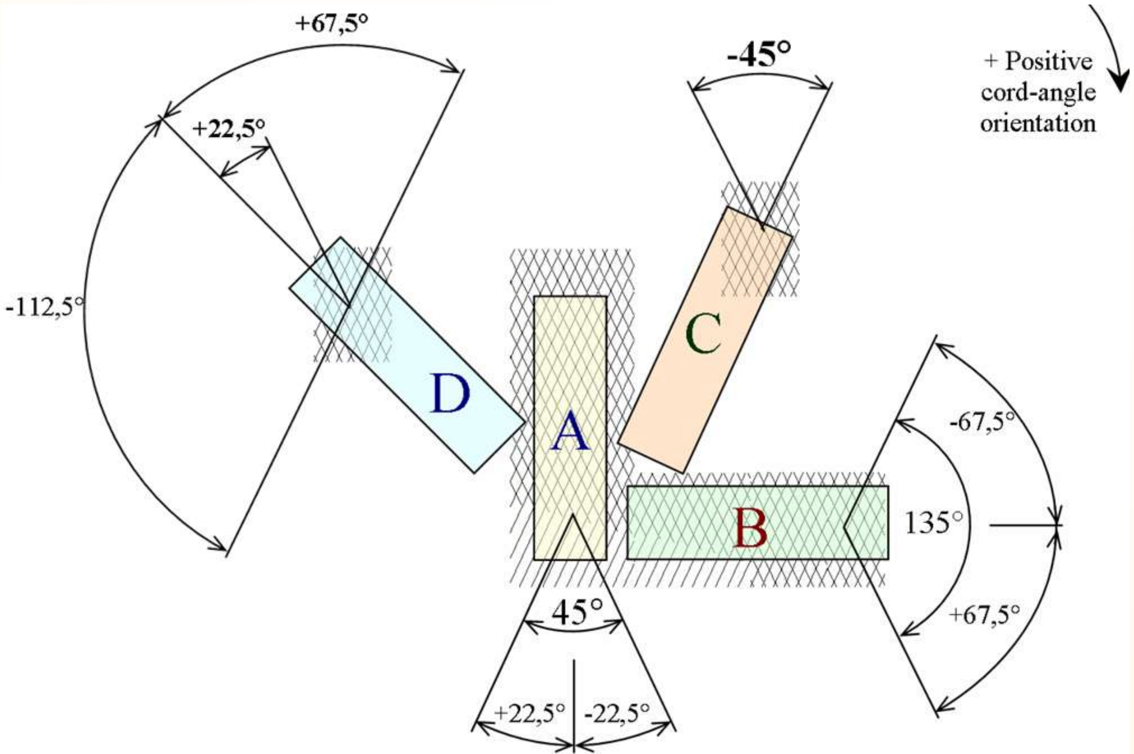


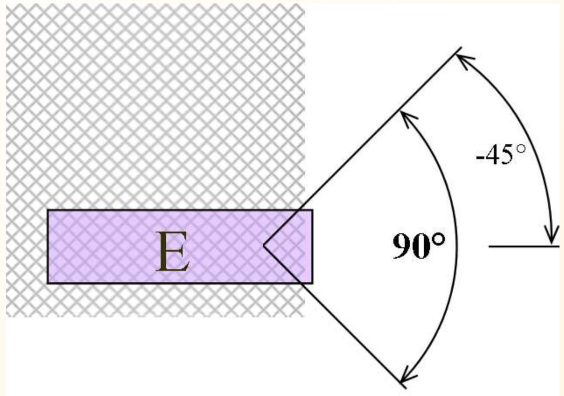


EXPERIMENTS OF PART OF TIRE CASING

The tire casing was cut by water jet cutter in longitudinal and transverse direction in order to obtain the specimens from the whole under-tread reinforcing area of the casing. The specimens were prepared with different width and it was 10, 15 and 20 mm.

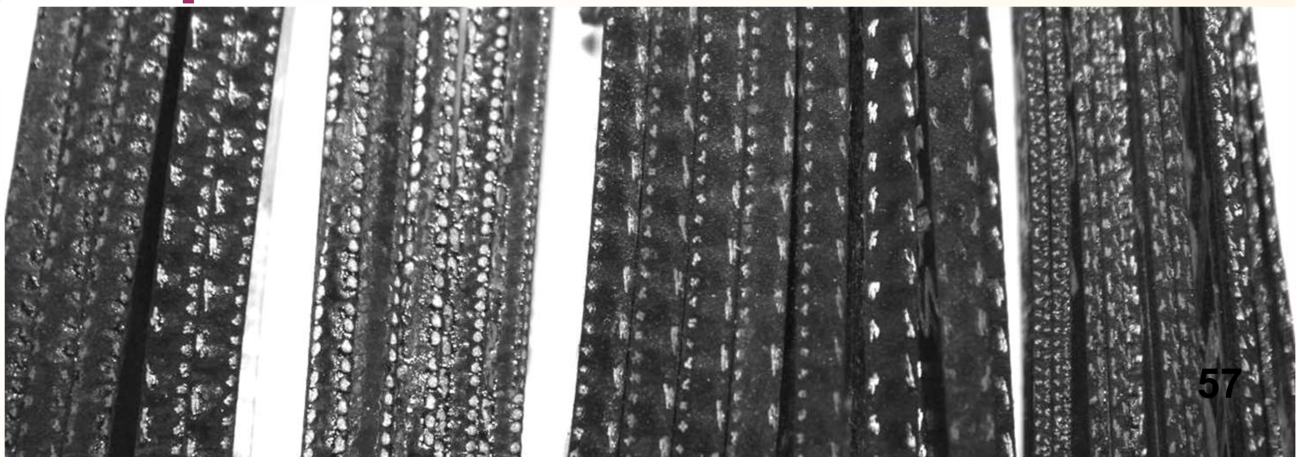
steel cord belt ply of tire

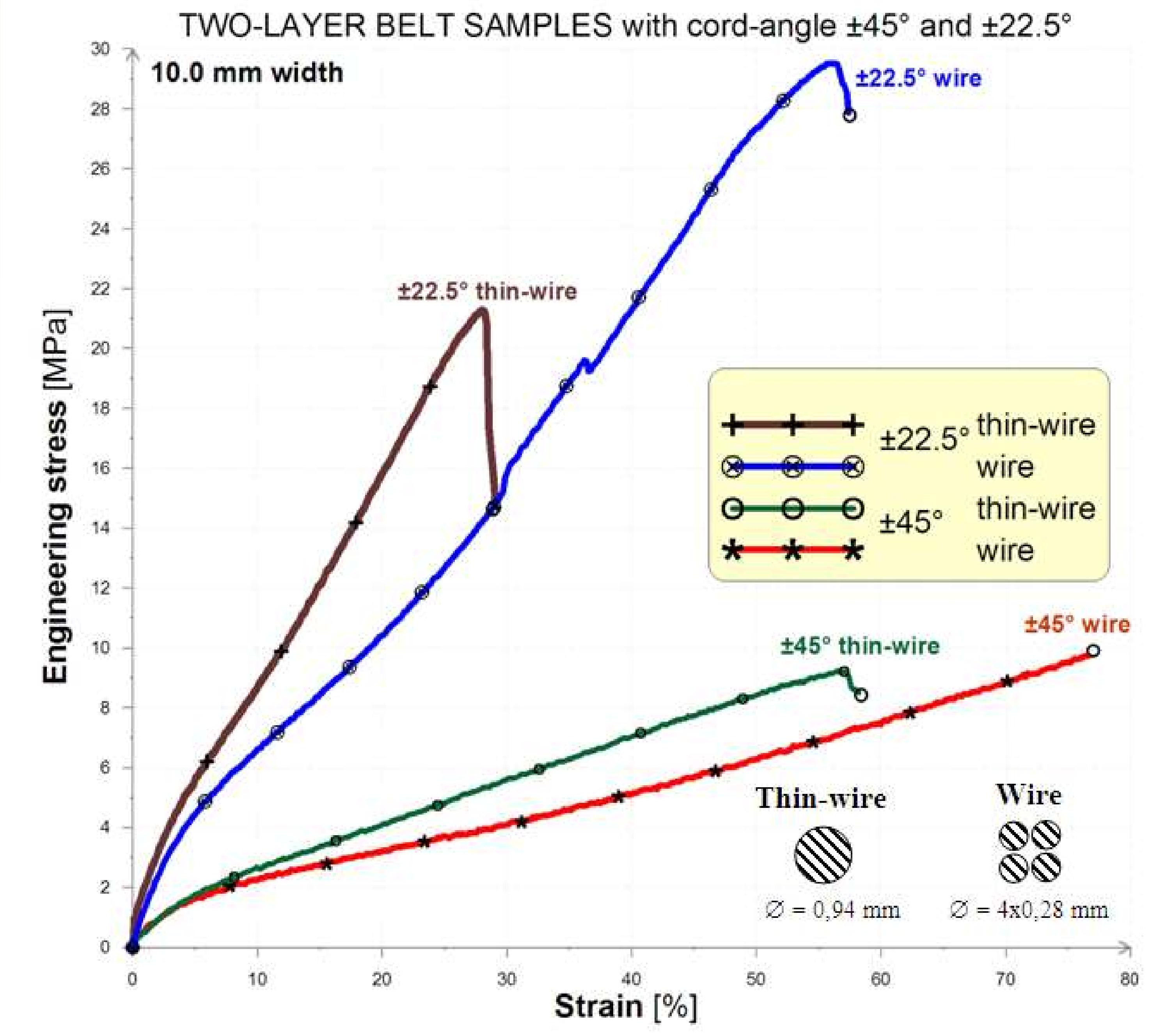




The samples must have different:

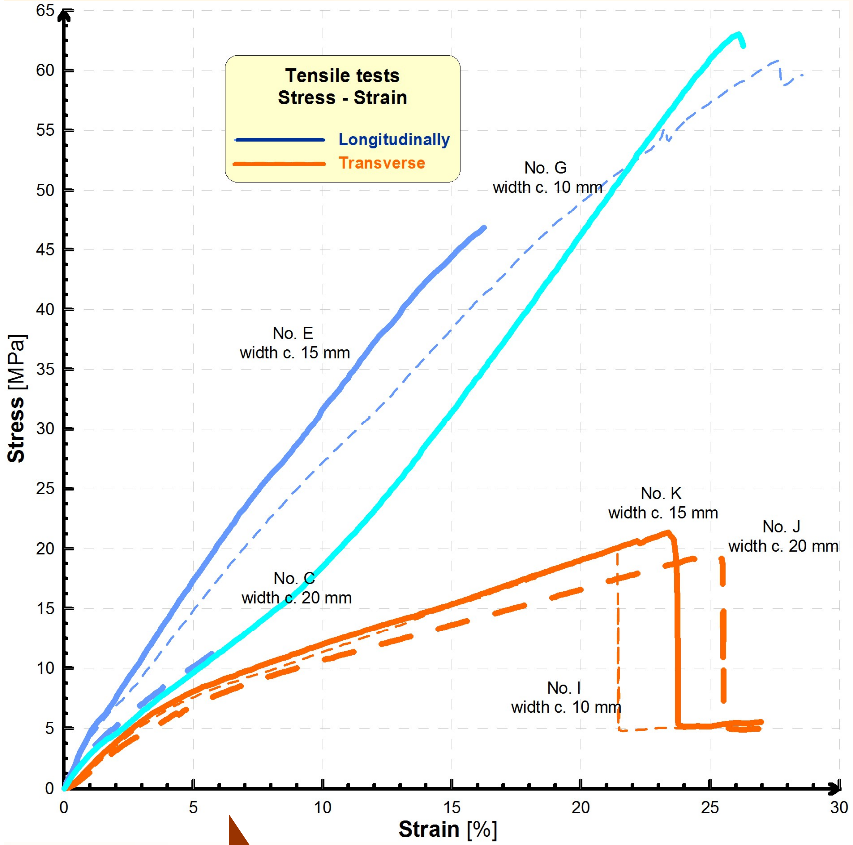
- **Angle** of cord (with respect of the direction of loading – not only longitudinal and transverse orientated samples);
- **Material** of cord (surface treatment);
- **Form** of cord (wire, thin wire);
- **Number of layers** (single-layer, two-layer, multi-layer);
- Specimen **width, shape** etc.

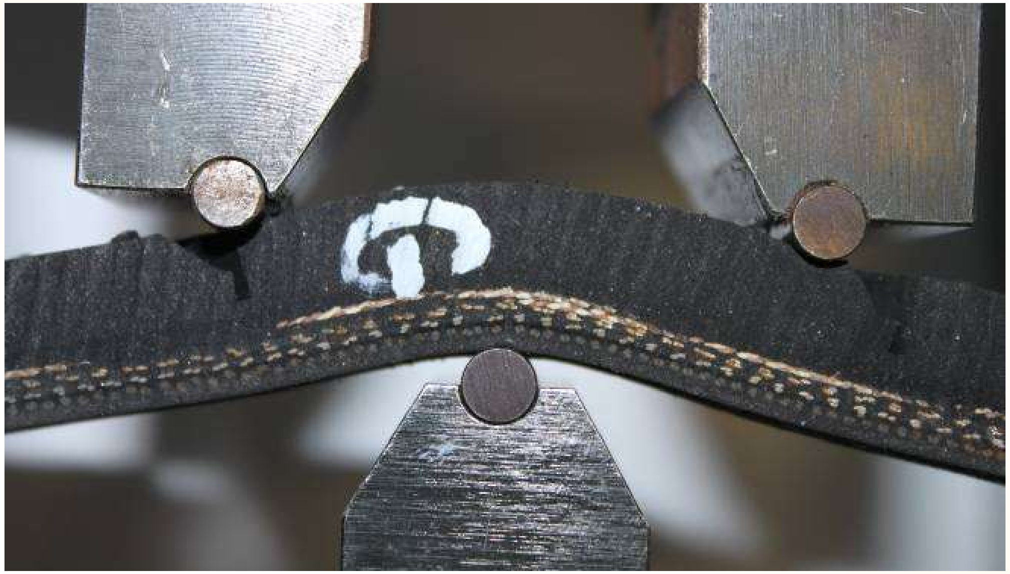


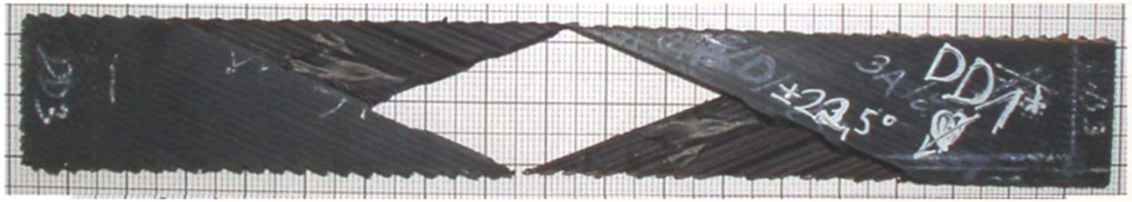


Outputs from tensile test of steel-cord belt samples – stress-strain dependences

TENSILE TESTS: The specific initial conditions of uniaxial static tensile tests are the speed of loading 10 mm/min and the initial length of specimen 80 mm between the clamps of the test machine.
BEND TESTS: The distance between outside points = 50 mm. The loading speed = 5 mm/min.







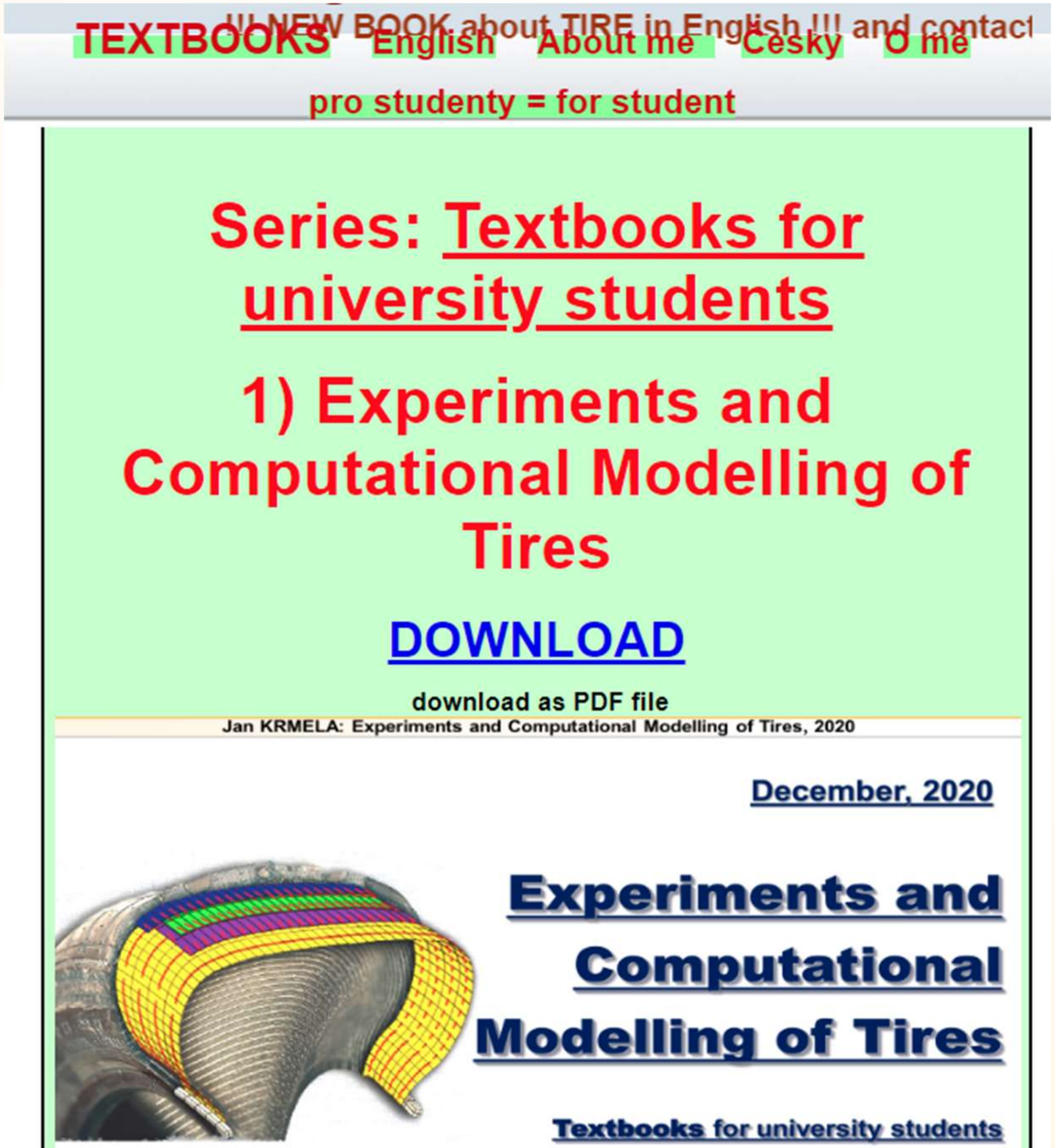
MODULES OF ELASTICITY

245/40 R18

Modulus of elasticity [MPa]		Specimen width 10 mm	15 mm	20 mm
Loading in direction	Longitudinally [1]	380	400	285
	Transverse [1]	200	205	185
	Radial [2]	90-110 for longitudinally specimens		

krmela.wz.cz

http://krmela.wz.cz/krmela_textbook_tire.pdf



MATERIAL PARAMETERS MATRIX

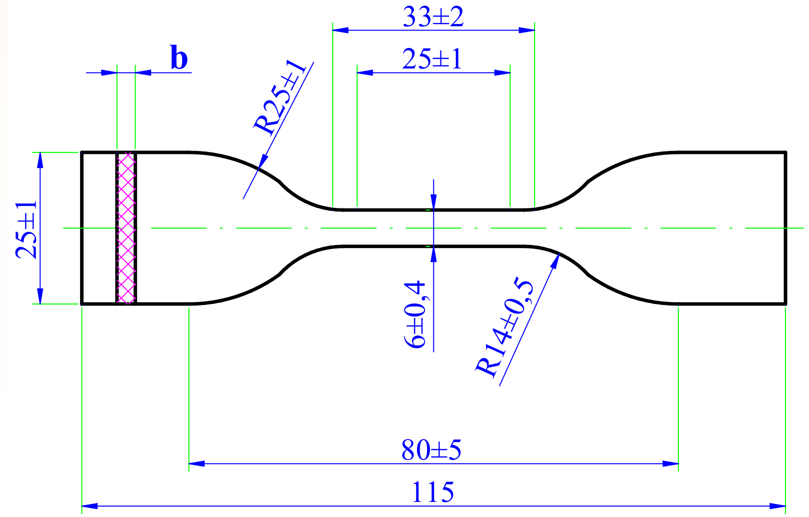


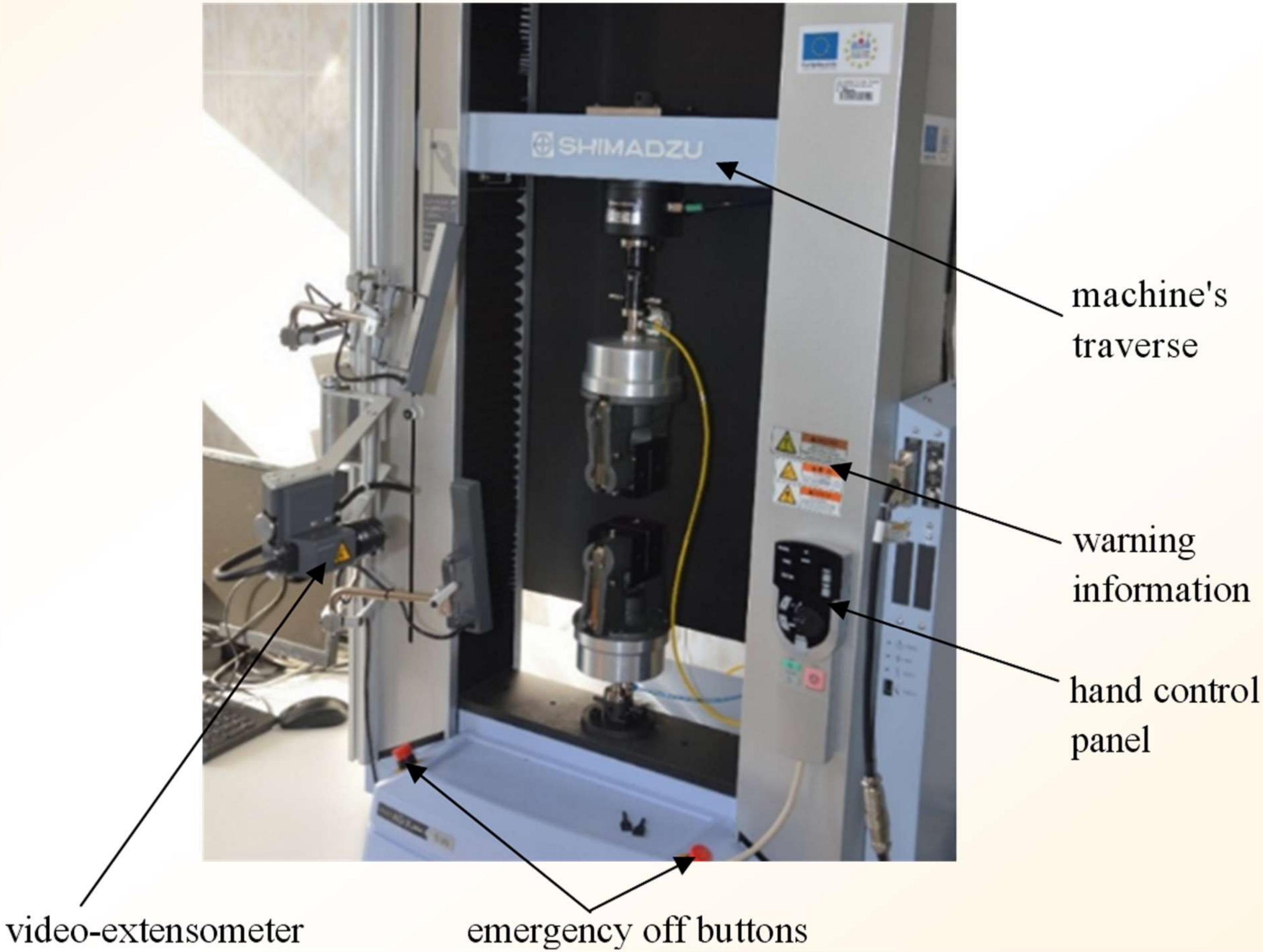
Table: Mooney-Rivlin parameters for elastomer parts

Mooney-Rivlin parameters	C_{10} [MPa]	C_{01} [MPa]	d [MPa^{-1}]
Tread	0.417	0.519	0.103
Inner liner	0.109	0.259	0.206
Bead elastomer	0.692	0.371	0.267
Sidewall with a tread side edge	0.532	0.065	0.138
Bead bundle	-0.111	1.945	0.088
Elastomer drift for a steel-cord belt	0.638	0.284	0.151
Elastomer drift for a textile carcass	0.328	0.119	0.101
Elastomer drift for a textile cap	0.548	0.112	0.056

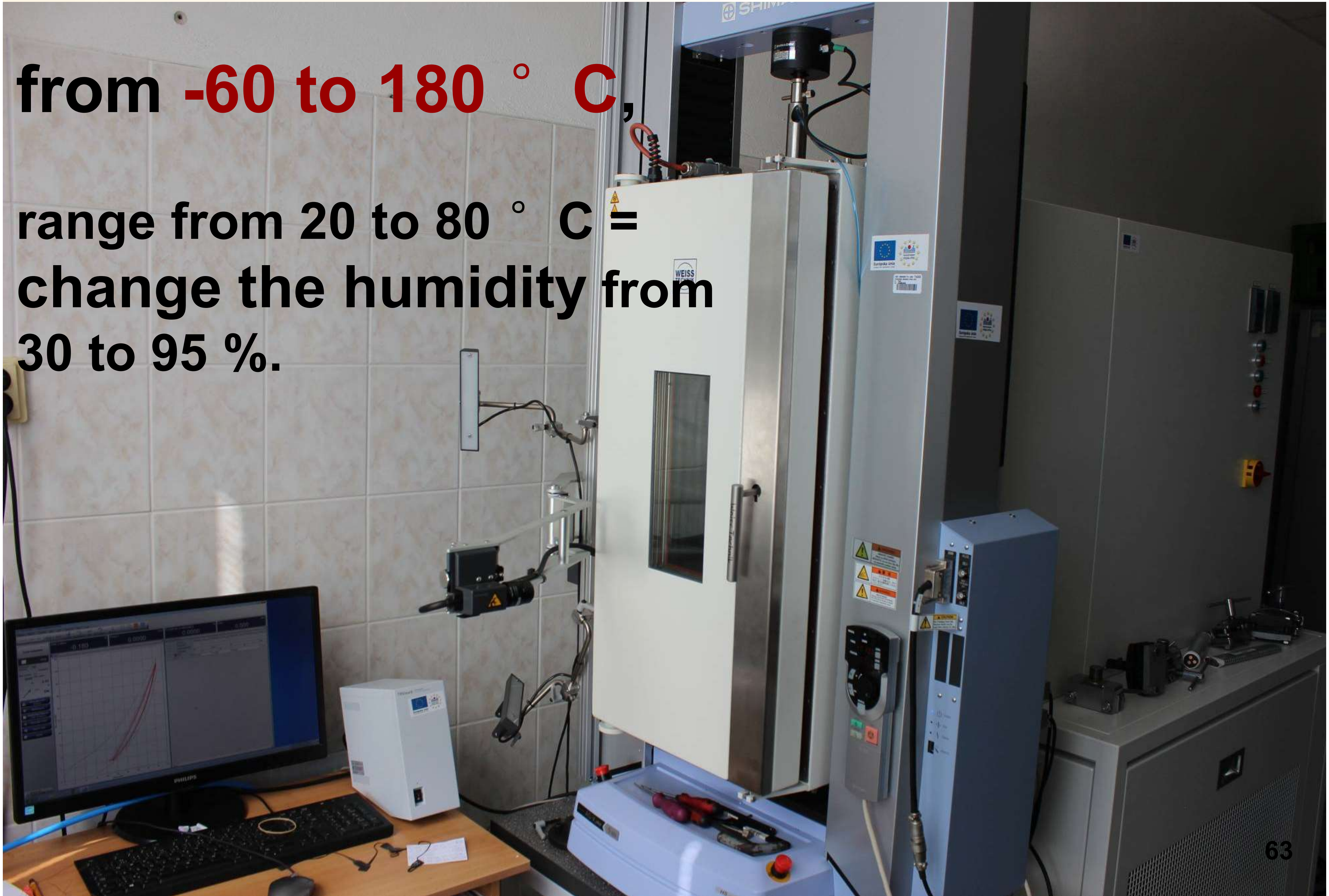
or Mooney-Rivlin from hardness - excel tables and word

Testing machine: Autograph AG-X plus 5 kN – Shimadzu <u>with a video-extensometer</u>

Control mode of TrapenziumX software.

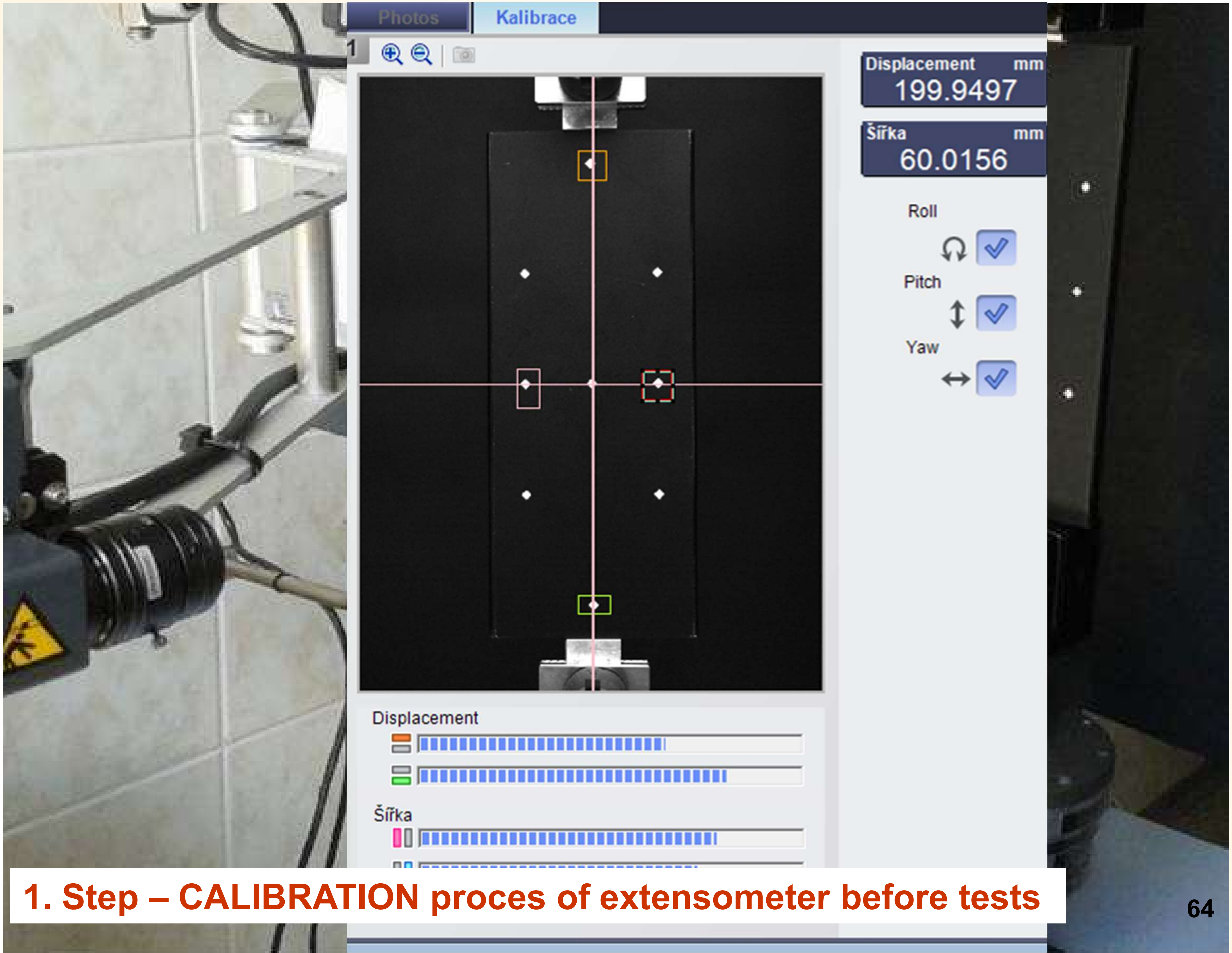


with a hybrid temperature-humidity chamber !

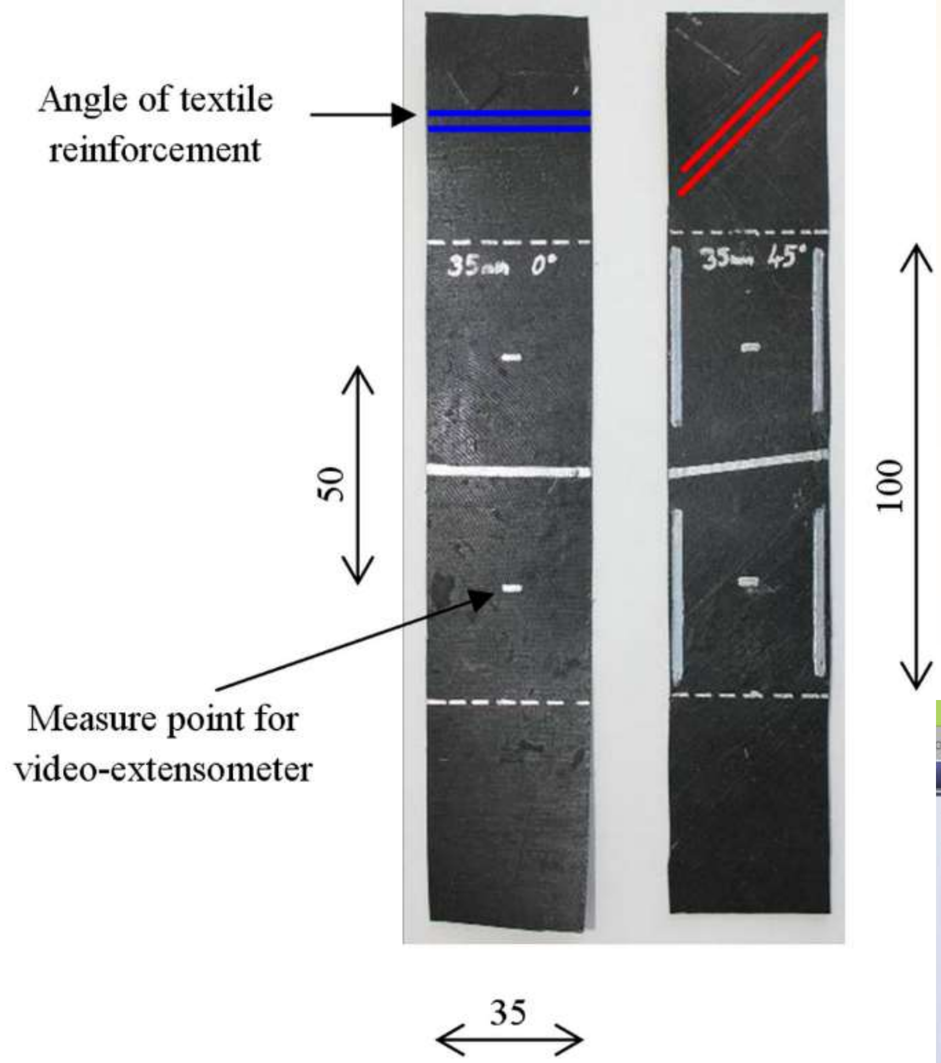


from -60 to 180 ° C,

range from 20 to 80 ° C =
change the humidity from
30 to 95 %.

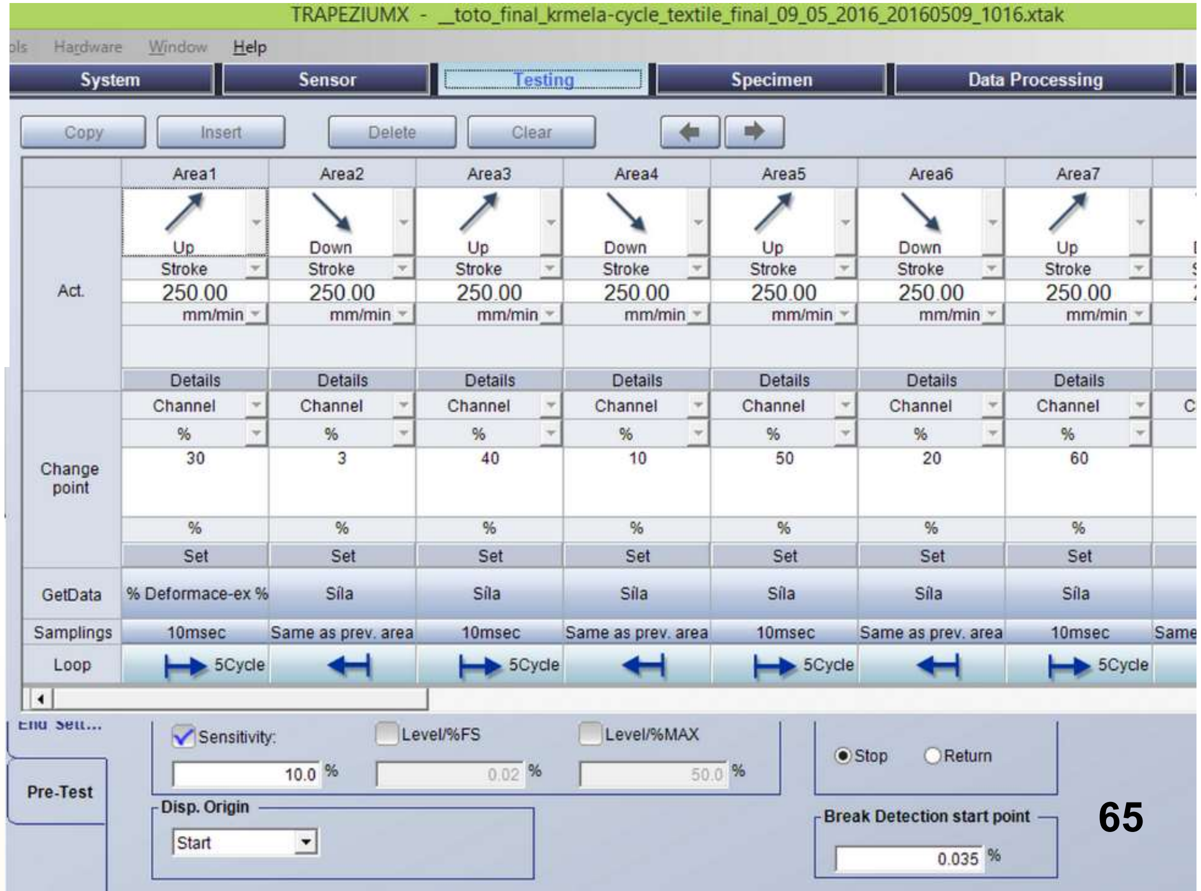


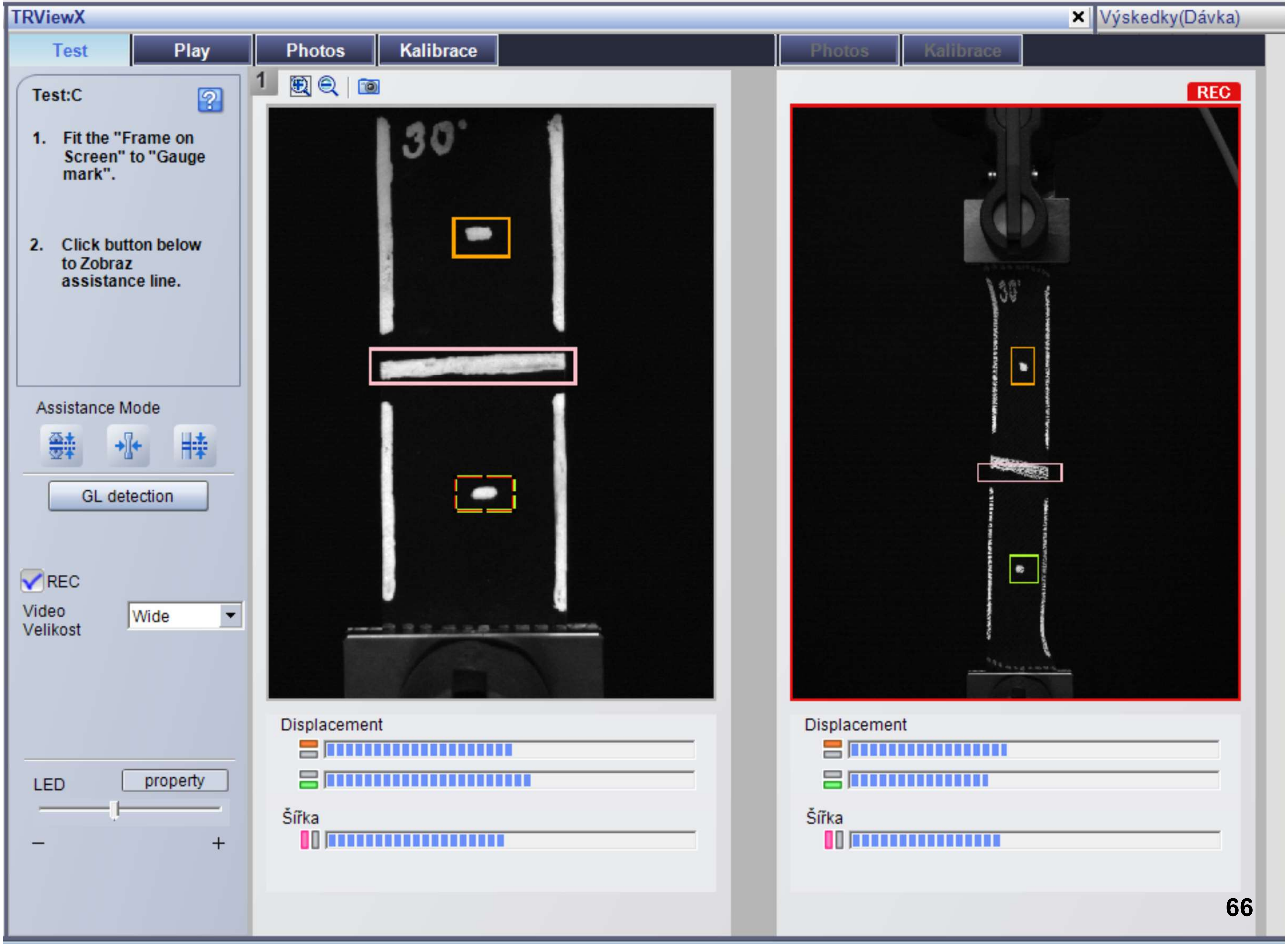
1. Step – CALIBRATION proces of extensometer before tests

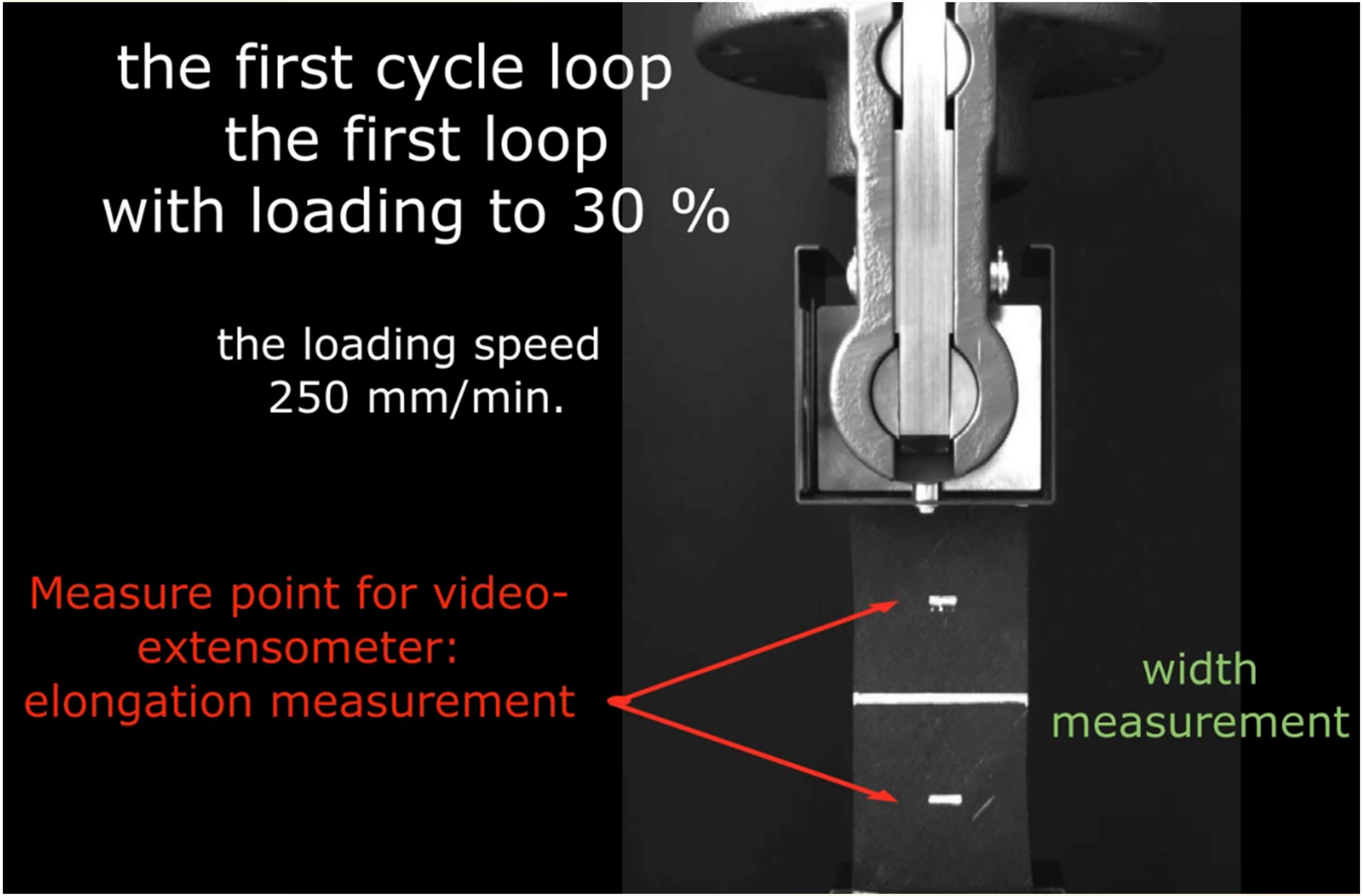


2. Step - Design of SPECIMENS of composite

3. Step - Design of METHOD for cyclic loading test




TRViewX
Výskedky(Dávka)
Test
Play
Photos
Kalibrace
Photos
Kalibrace
Test:C
1. Fit the "Frame on Screen" to "Gauge mark".
2. Click button below to Zobraz assistance line.
Assistance Mode
GL detection
REC
Video Velikost
Wide
LED
property
–
+
1
30°
REC
Displacement
Šířka
Displacement
Šířka

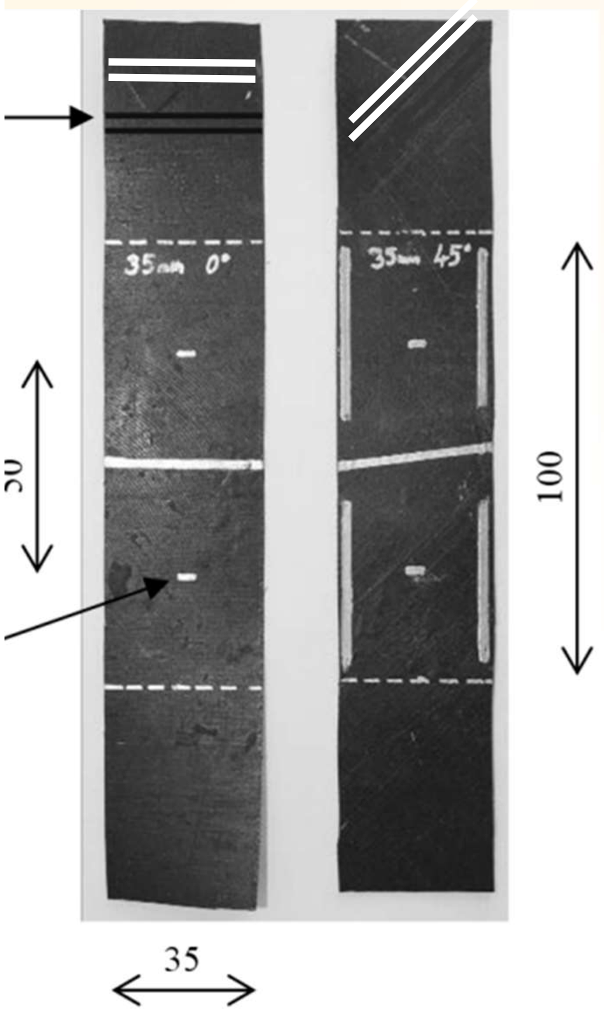

the first cycle loop
the first loop
with loading to 30 %
the loading speed
250 mm/min.
Measure point for video-
extensometer:
elongation measurement
width
measurement

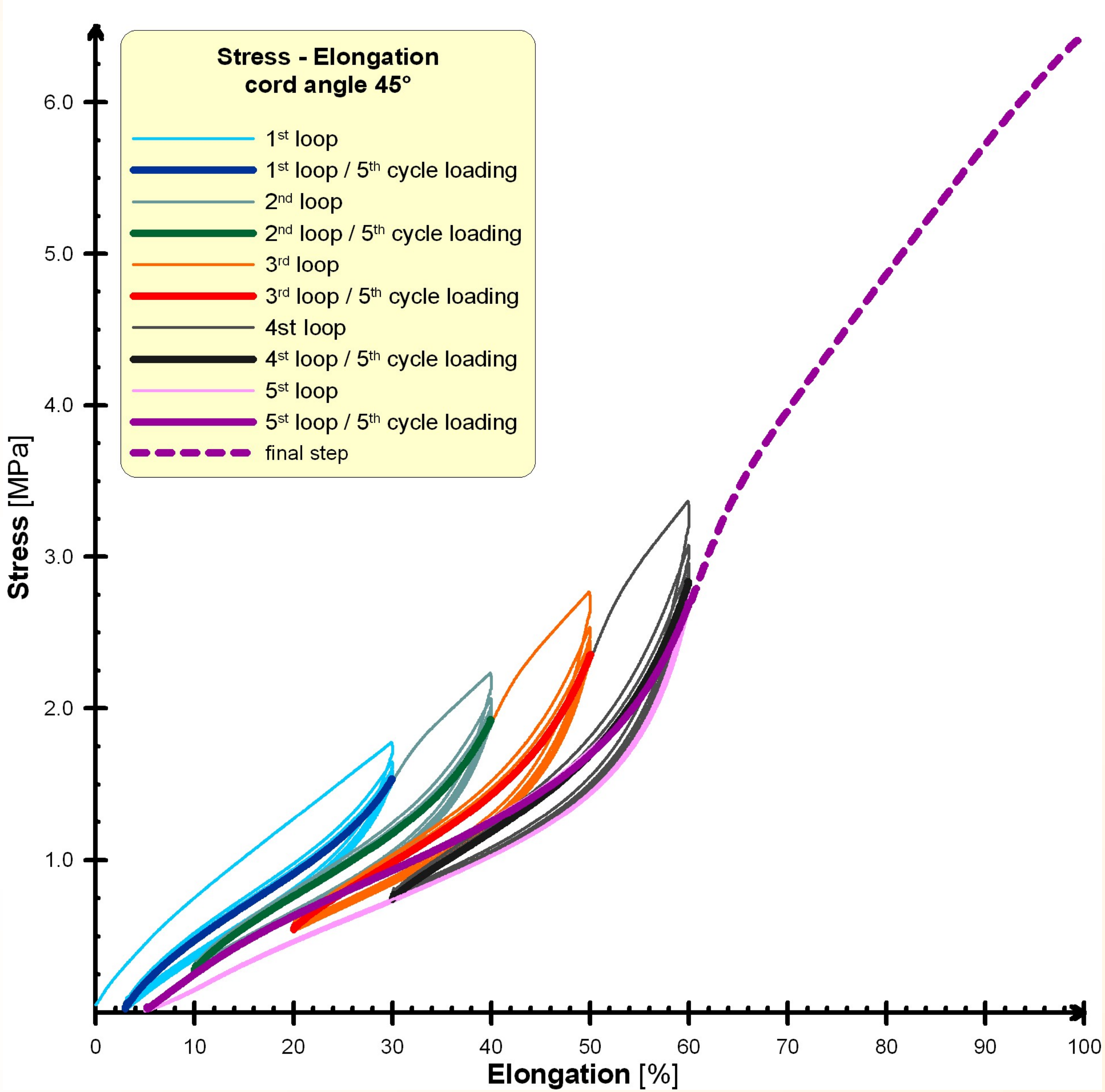
composite test

THE TESTS OF LOW CYCLIC LOADING

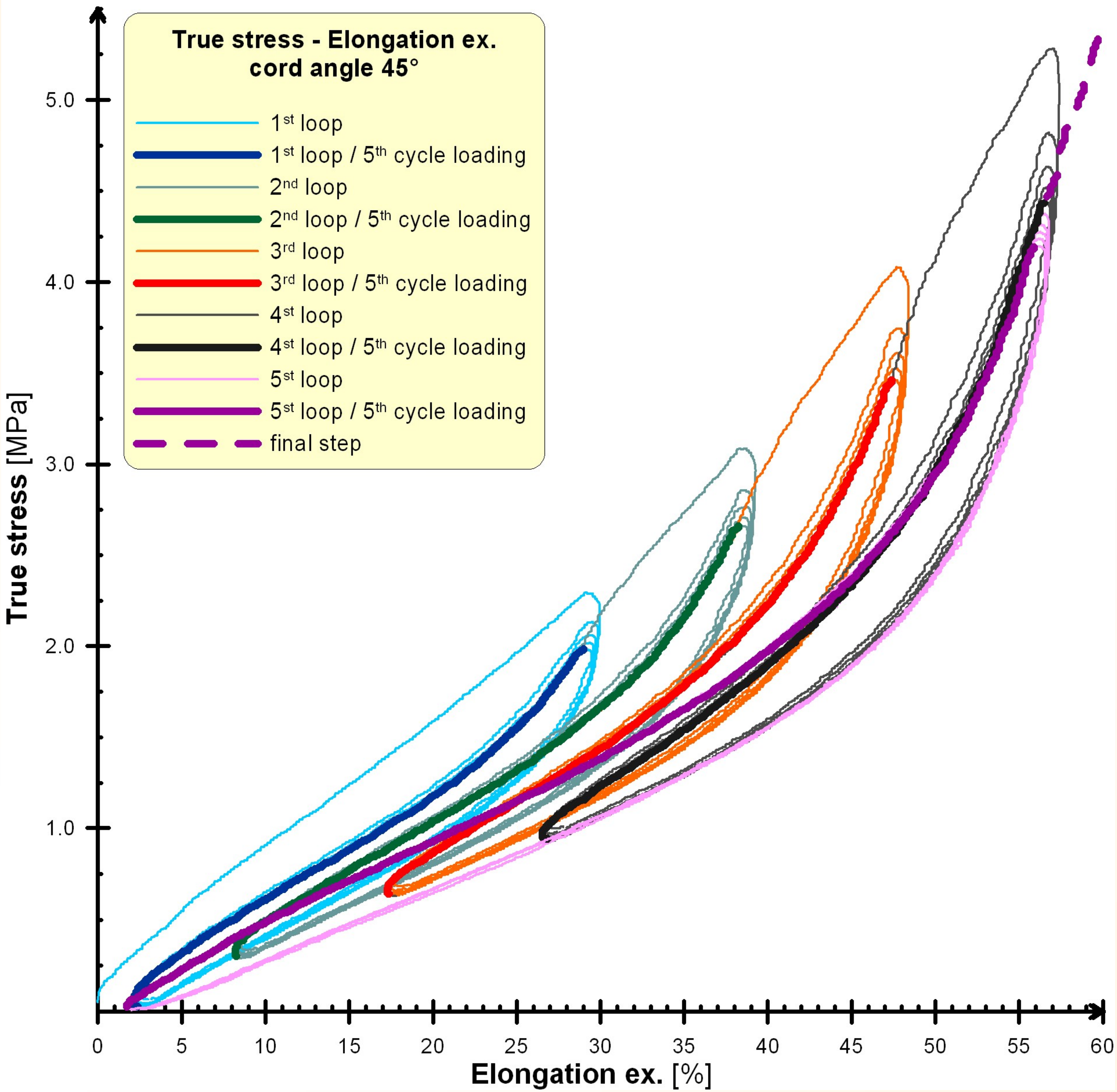
a cord angle of 45°

Five cycle loops are applied. Every cycle loop consists of five cycles. Every cycle is defined as loading to a certain percentage of elongation between clamps of a test machine and unloading to a certain percentage of elongation between clamps of a test machine.





true stress on elongation between points for a video-extensometer



DYNAMIC TESTS OF TIRES
„DYNAMIC ADHESOR“

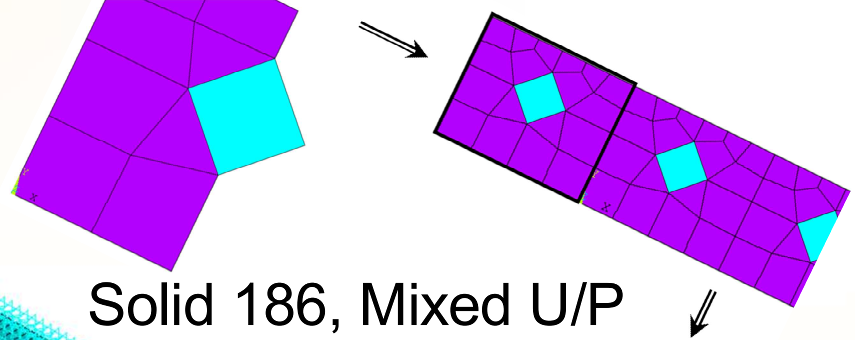
Radial loading max **0.5 t**
Max. **velocity 180 km/h**

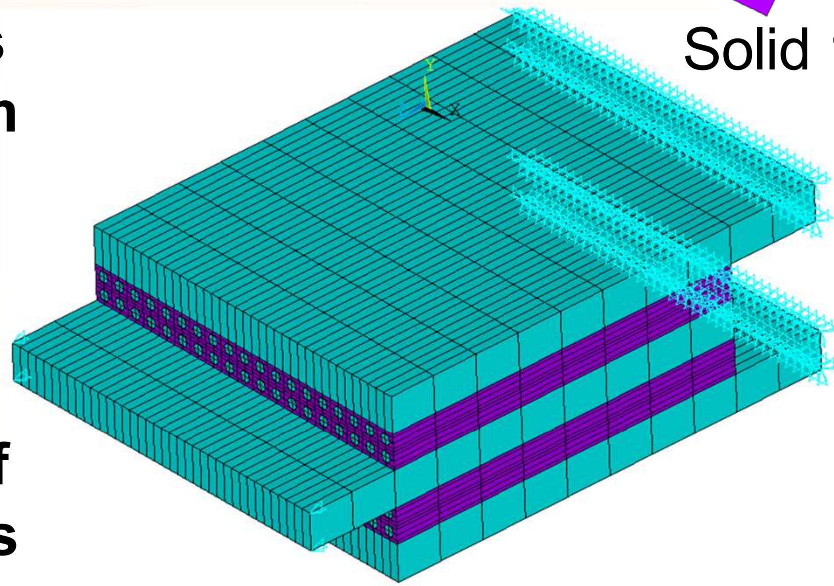
The tire test data results from the static and dynamic test machines such as contact footprints and radial stiffness are evaluated.

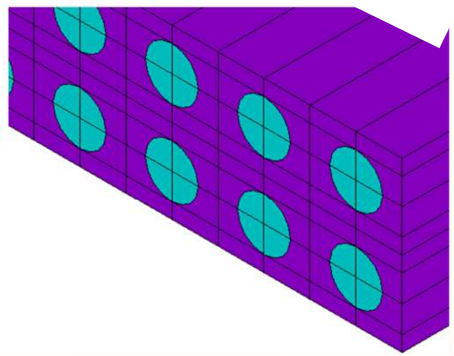
COMPUTATIONAL MODELING

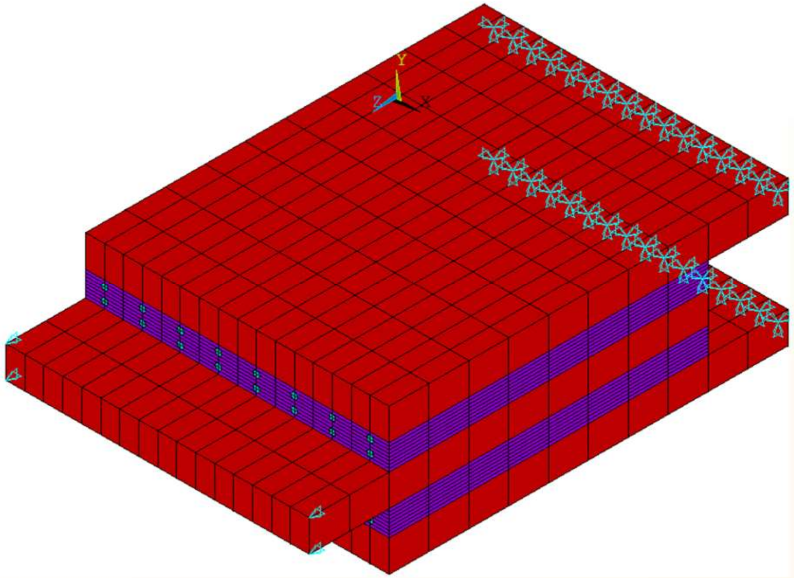
It is necessary to **quickly create computational models** with the required cord geometry parameters, the computational models **for strain-stress analyses were created using APDL (ANSYS** Graphical User Interface) procedures **for the automatic creation of models from geometric parameters** such as a cord diameter, cord distance and one-layer thickness, width and length of the layer and **material parameters**.

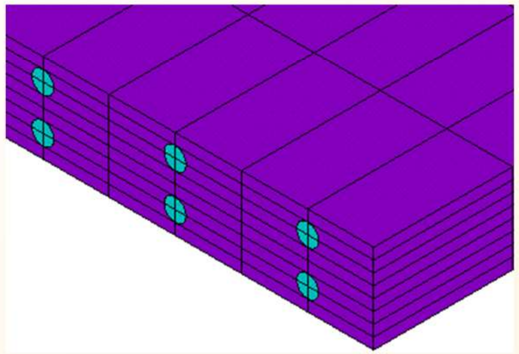
The models are reverse loaded, the displacement in *z*-axis is defined and the sum reaction forces at the area of steel edges (using these edges, the specimen will be clamped in the jaws of the testing machine) is searched.





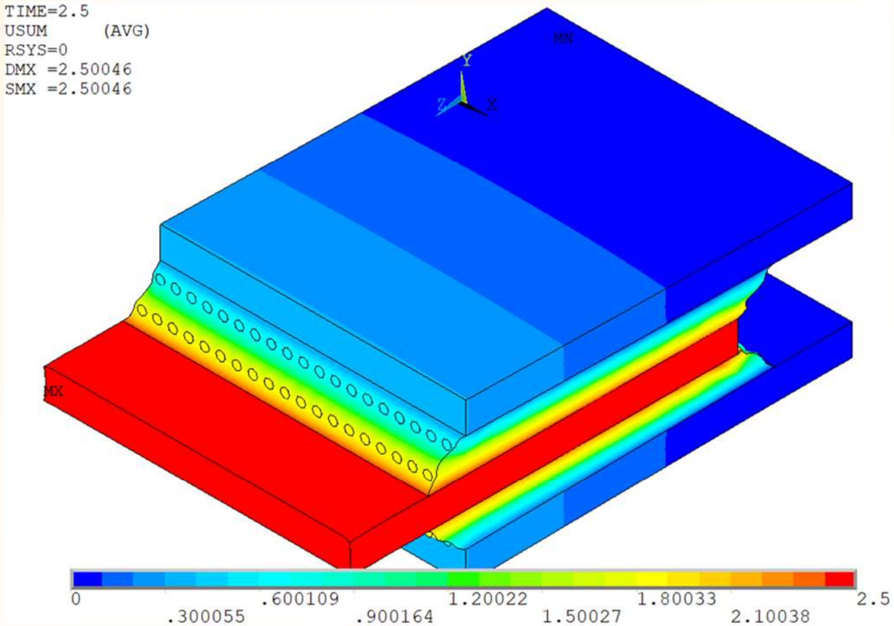




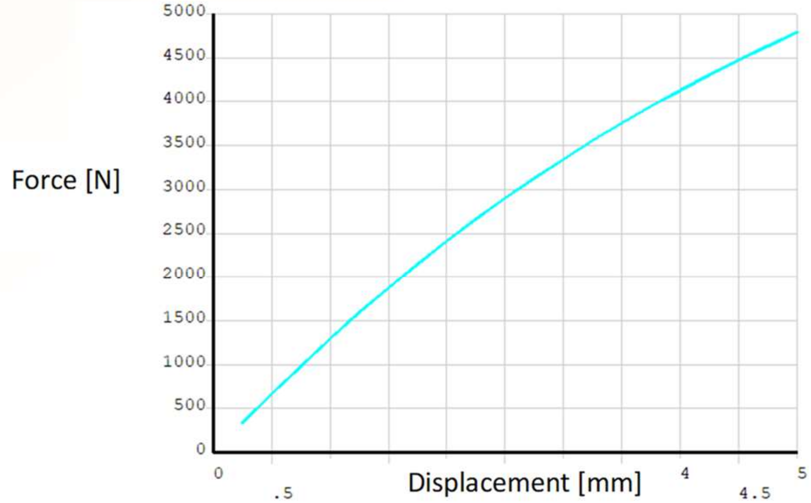


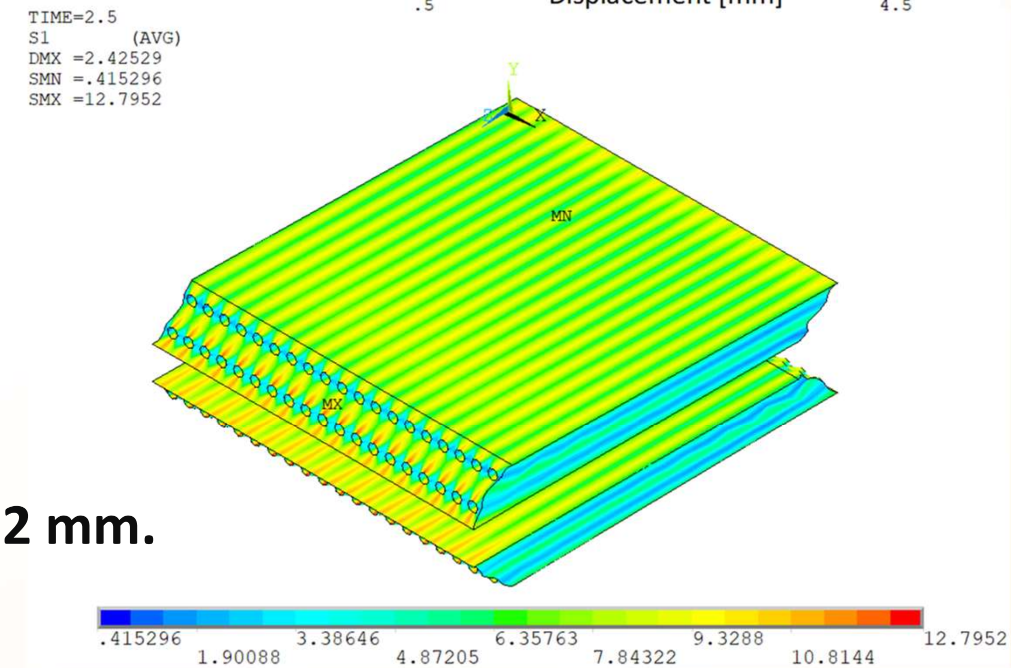
The computational model with a steel-cord diameter of 0.60 mm and a textile-cord diameter of 0.40 mm (down) with details of meshing.

steel-cord with diameter 0.6 mm



Sum displacement – computational model with steel-cord “2+2”.



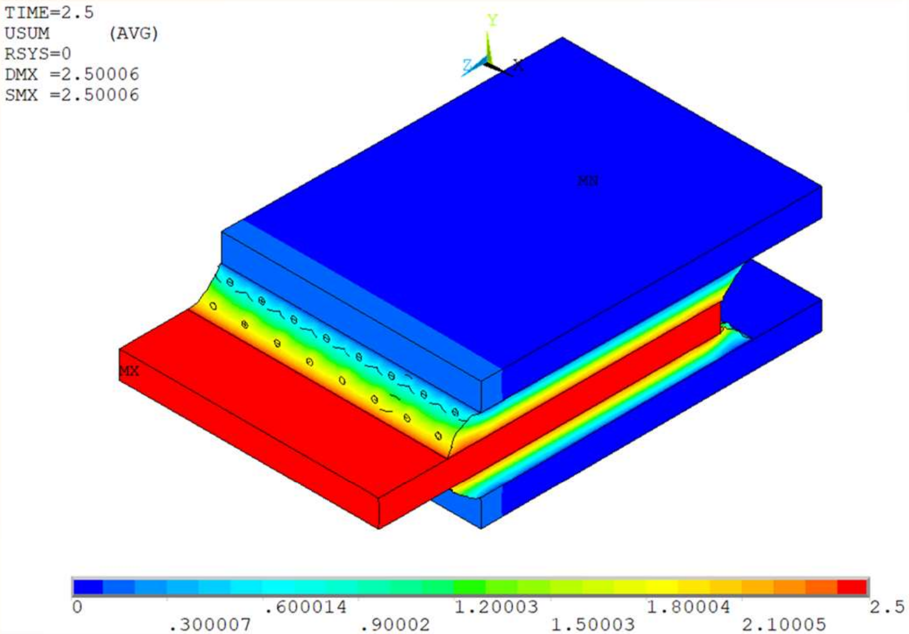


Sigma1 – computational model with steel-cord “2+2”.

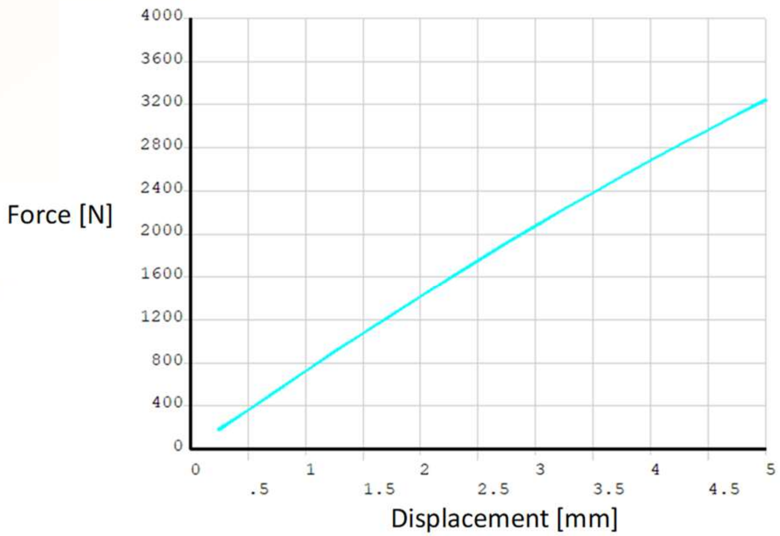
F = 2866 N for deformation of 2.5 mm.

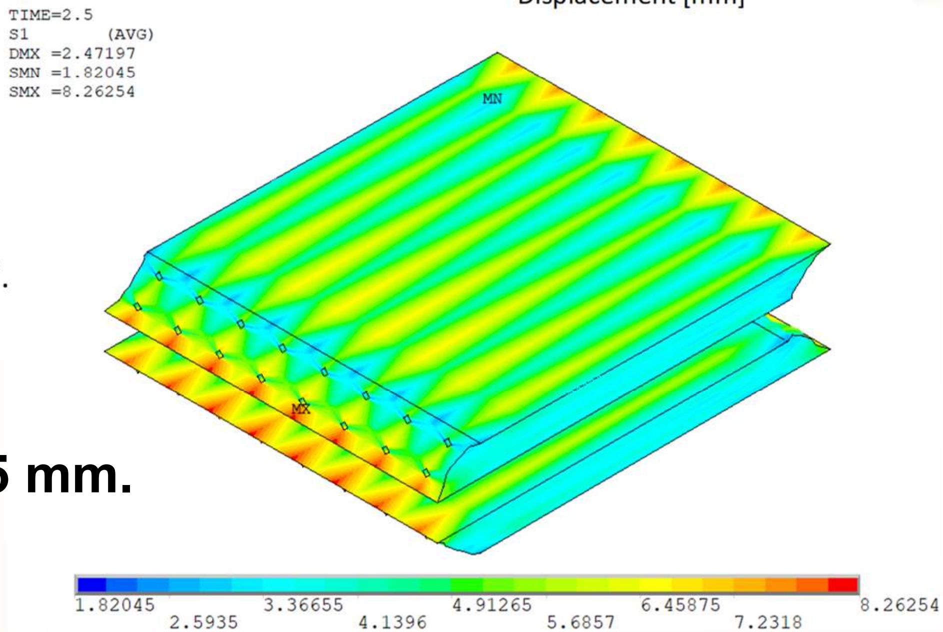
Sigma1 = 12.8 MPa for deformation of 4.2 mm.

PA66 cord with a diameter 0.4 mm



Sum displacement – computational model with PA66 cord “2+2”.

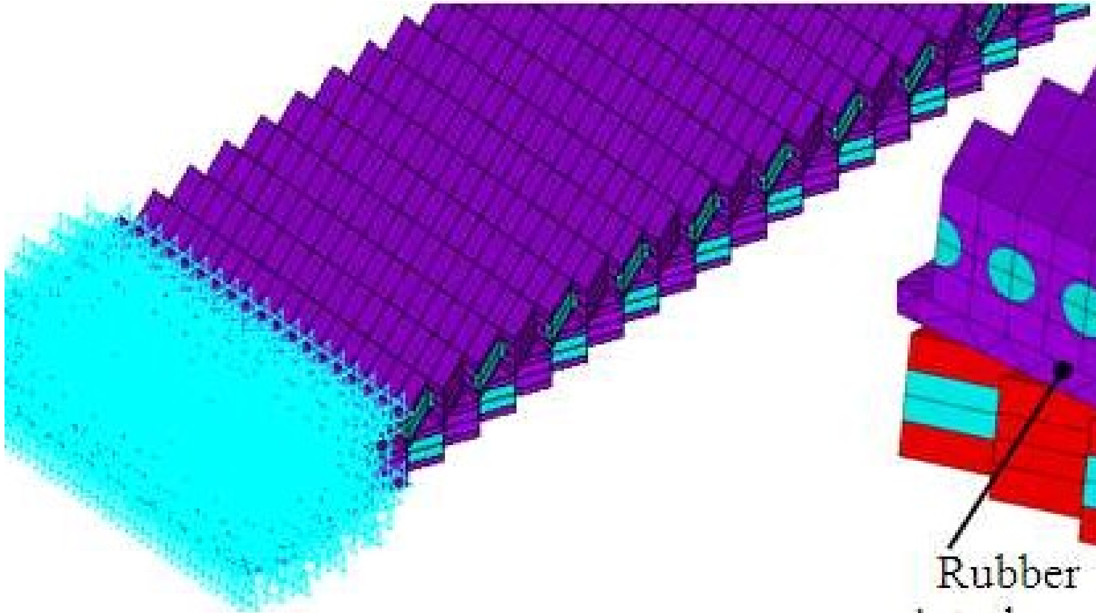


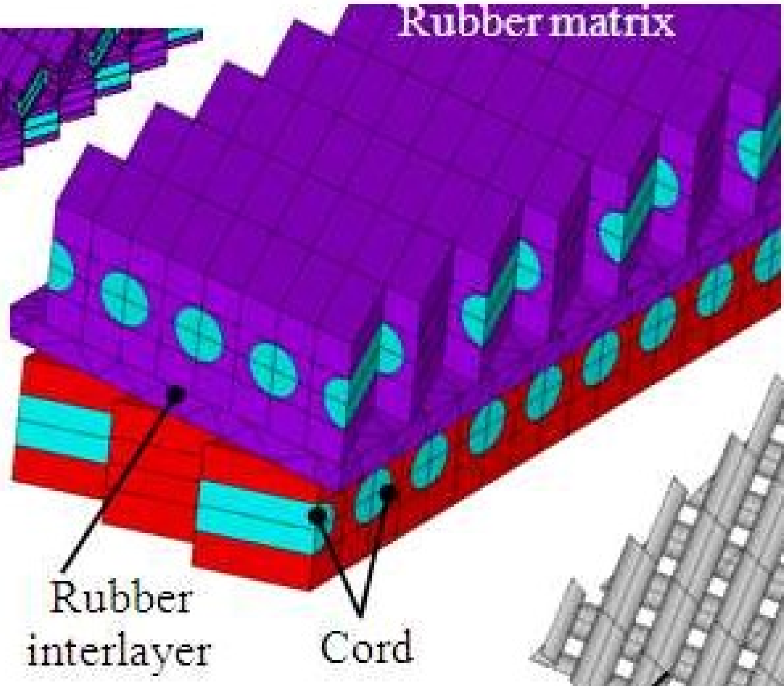


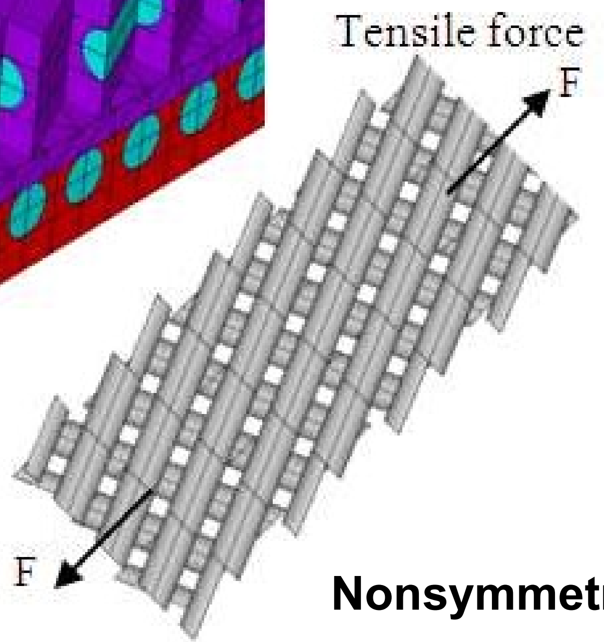
Sigma1 – computational model with PA66 cord “2+2”.

F = 1753 N for deformation of 2.5 mm.
Sigma1 = 8.3 MPa for deformation of 2.5 mm.

The difference in forces between the steel cord and textile PA66 cord is about 61 %.





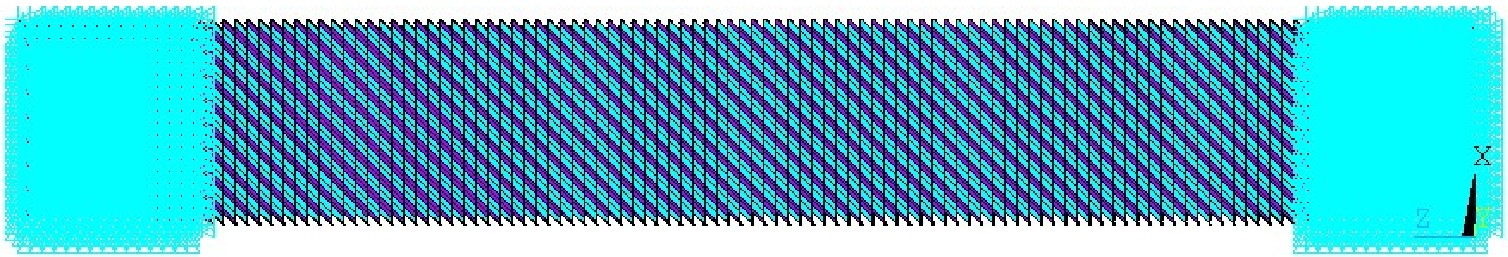


Symmetrical

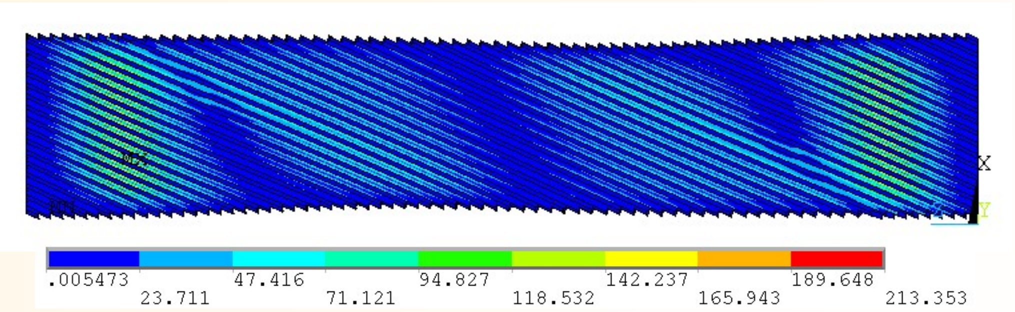
Nonsymmetrical

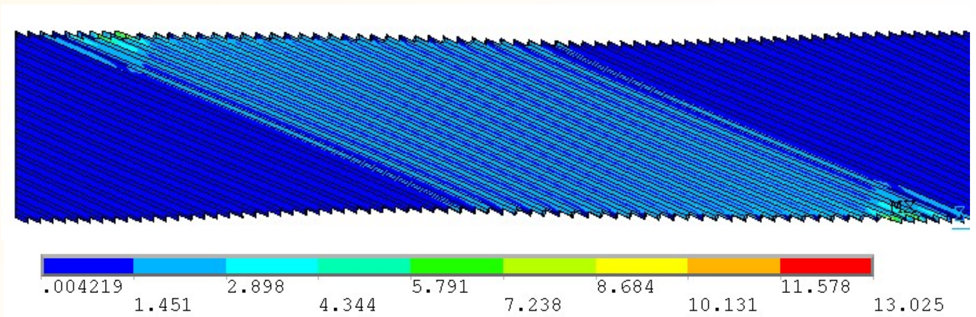
Tensile
Bend

One-layer / Two-layer

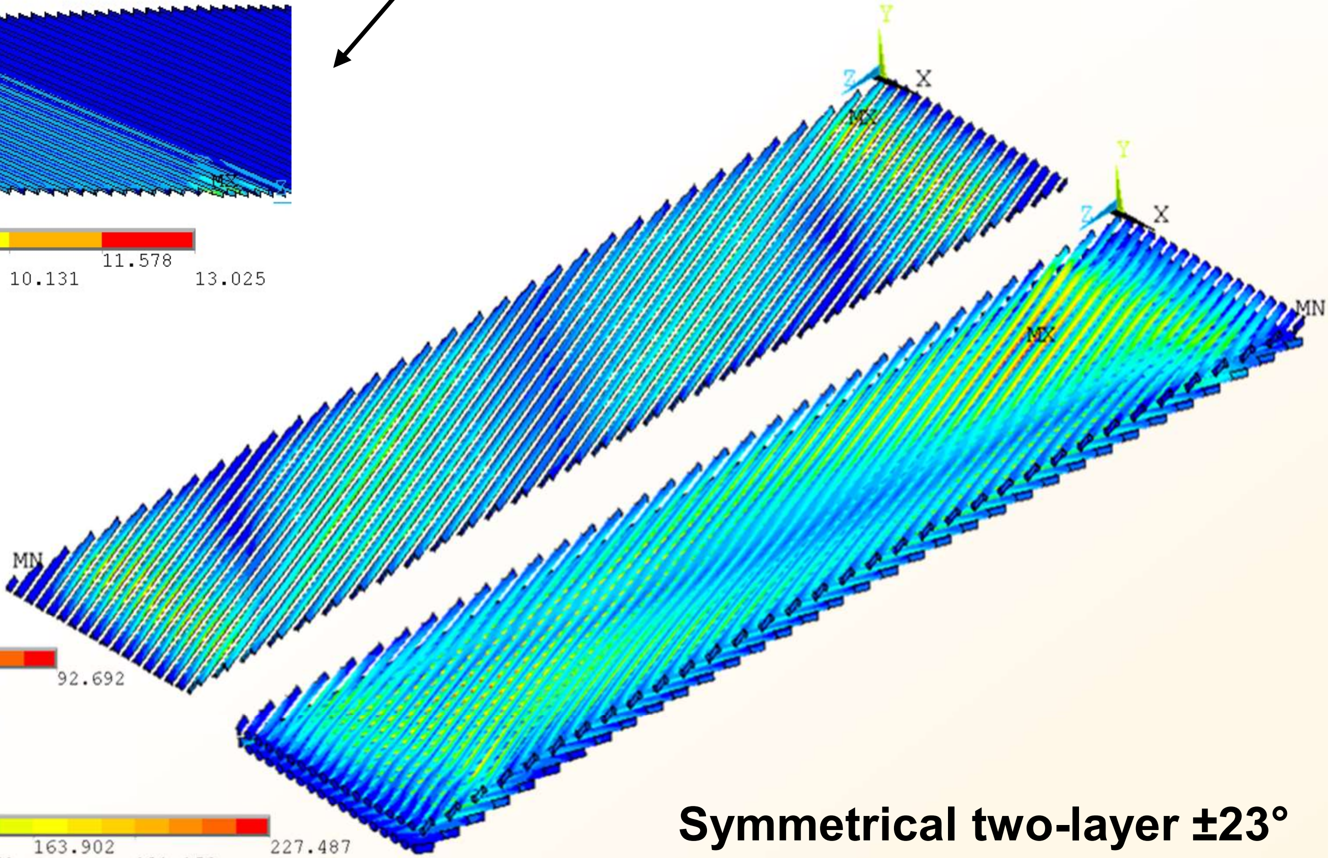


One-layer 23°
stress [MPa]
- **cord stress**
- **matrix stress**



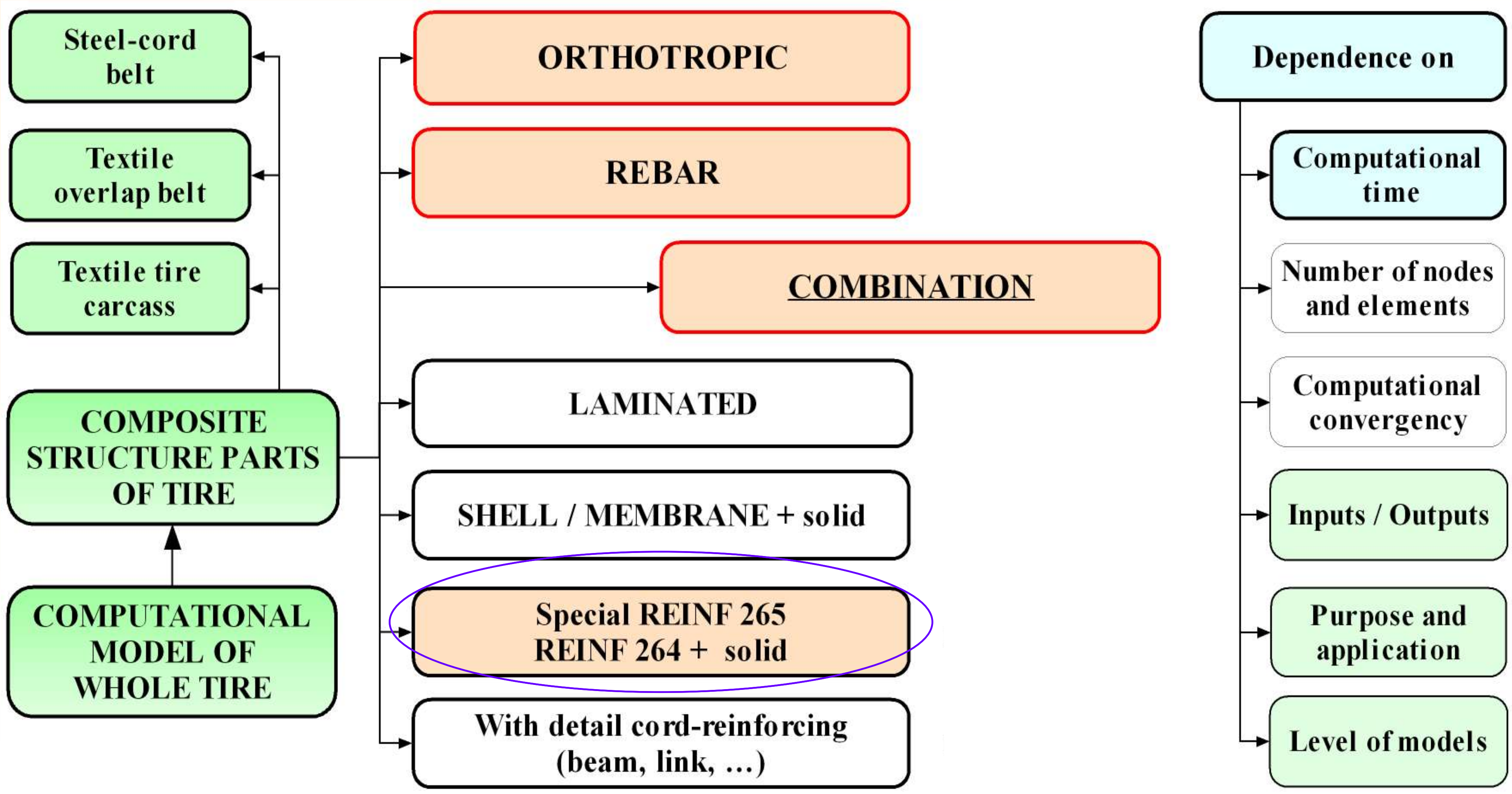


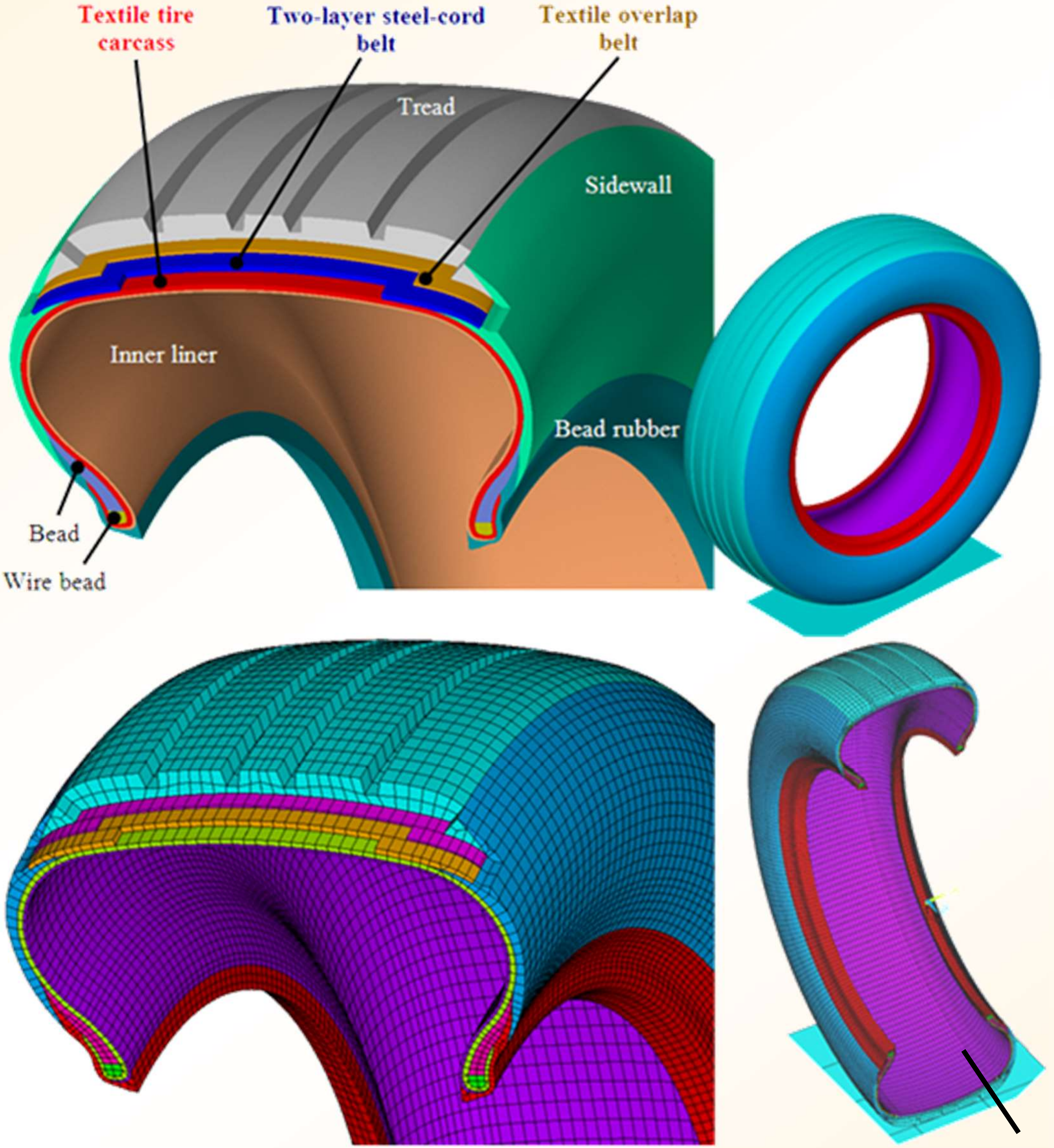
TENSILE



Symmetrical two-layer ±23°
cord stress [MPa]

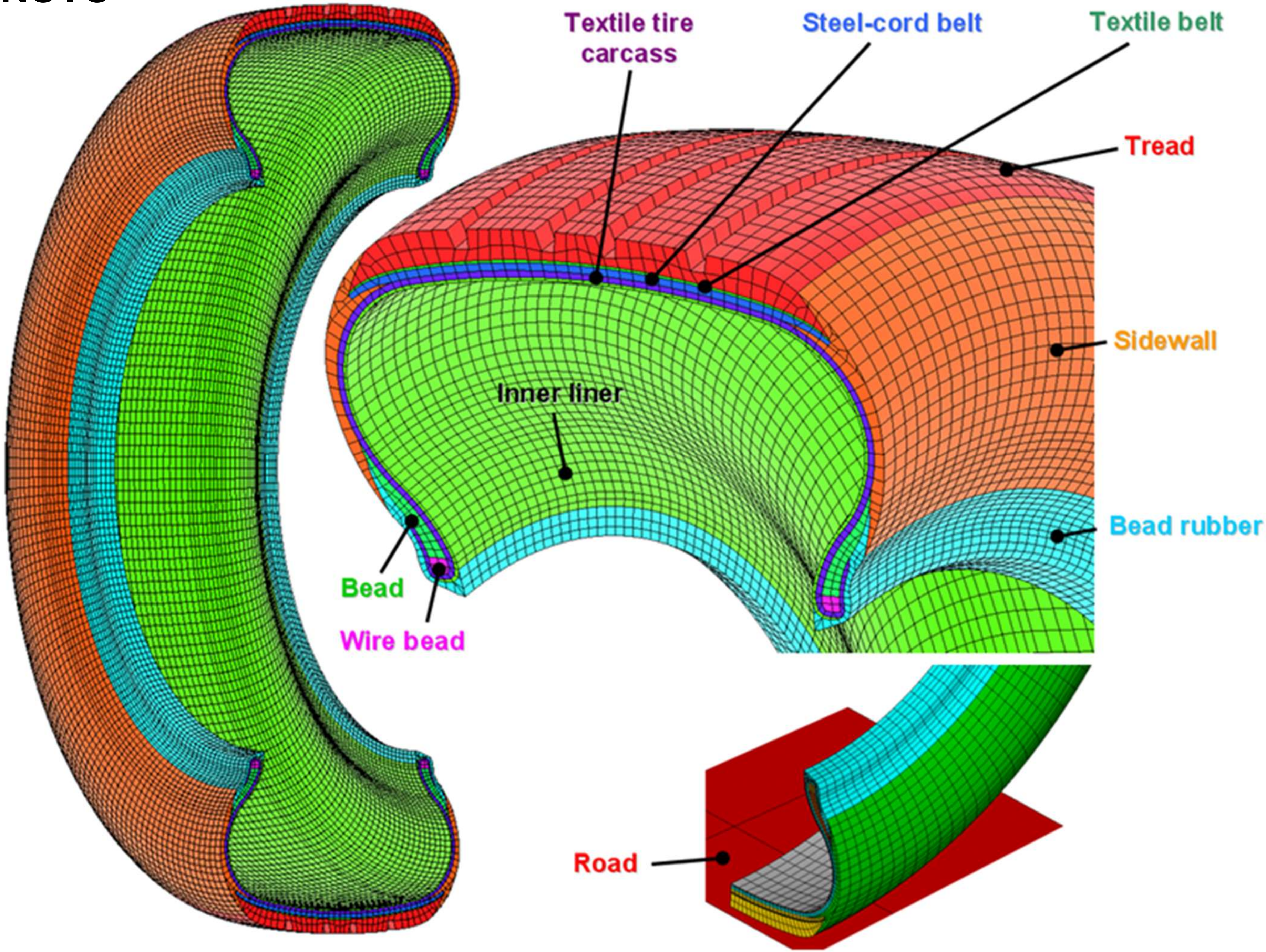
Different descriptions of composite structure parts into tire computational models

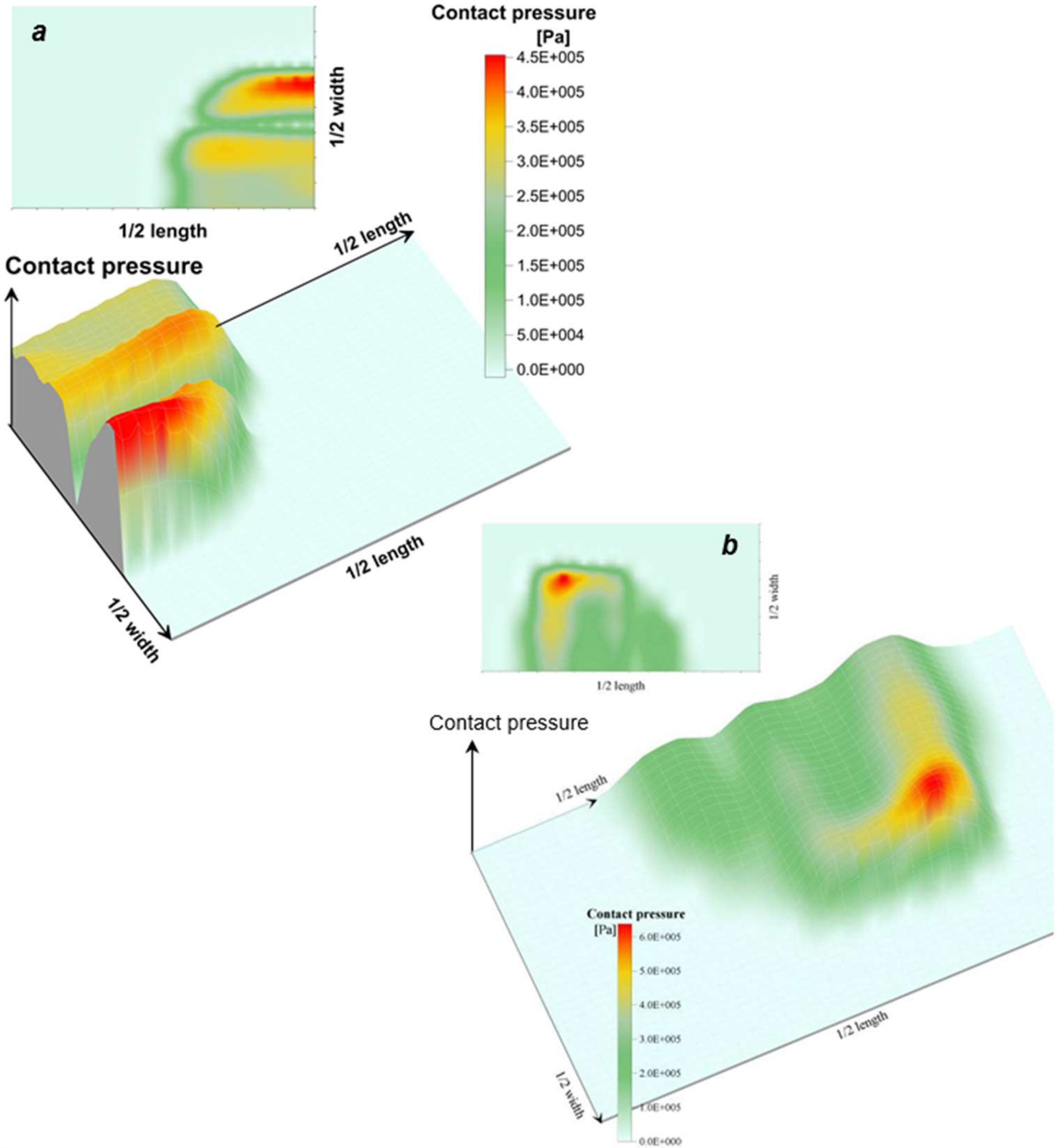




Fourth part of model:
36 000 elements
155 000 nodes

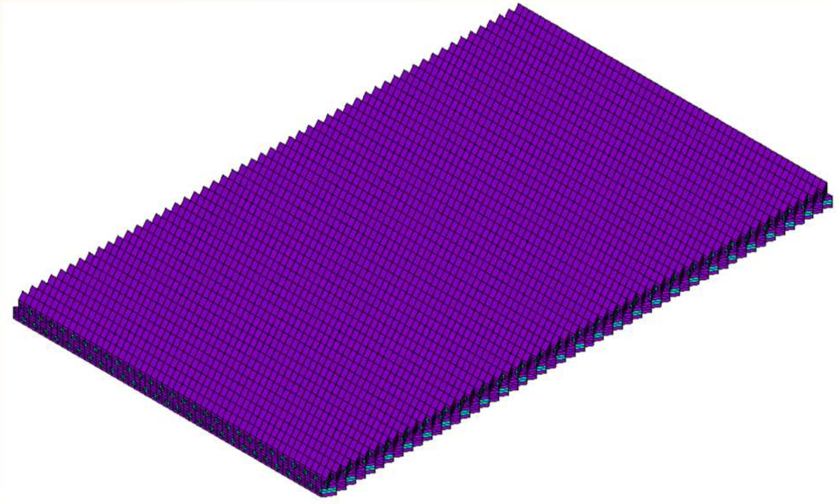
ANSYS

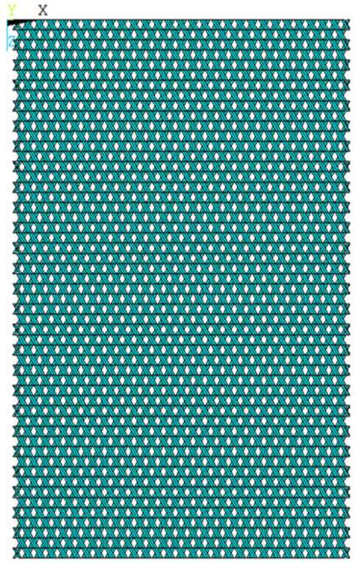

Textile tire carcass
Steel-cord belt
Textile belt
Tread
Sidewall
Inner liner
Bead rubber
Bead
Wire bead
Road

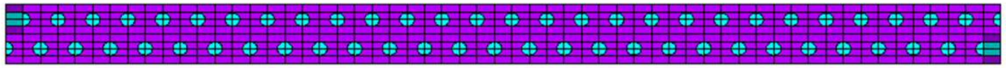


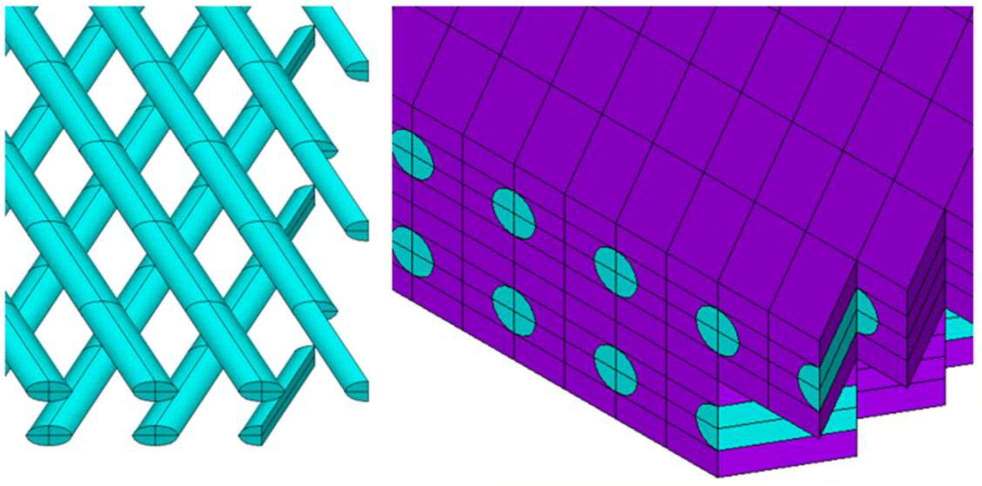
Distribution of contact pressure in a three-dimensional image: *a* – a plane road for radial deformation 15 mm; *b* – a concave obstacle for radial deformation c. 20 mm (inflation pressure 180 kPa)

two-layer rectangular shape model with cord angles of [±30°]



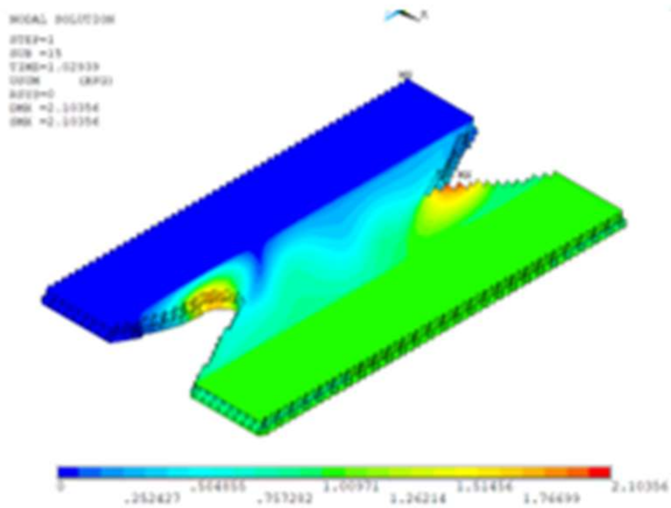




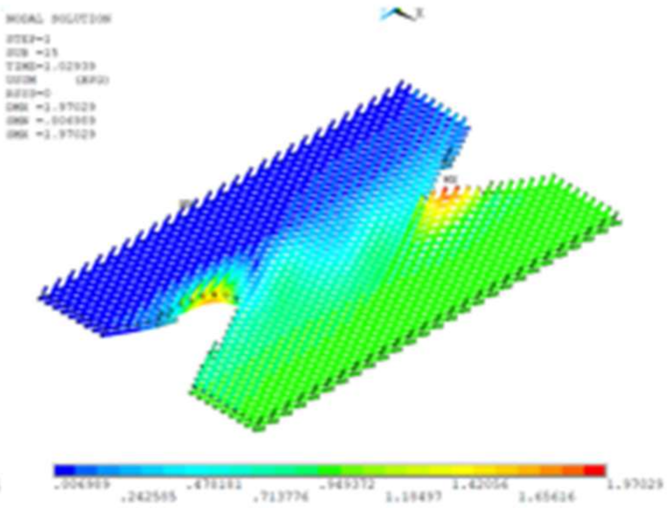


The second variant (others by placing cords in the second layer)

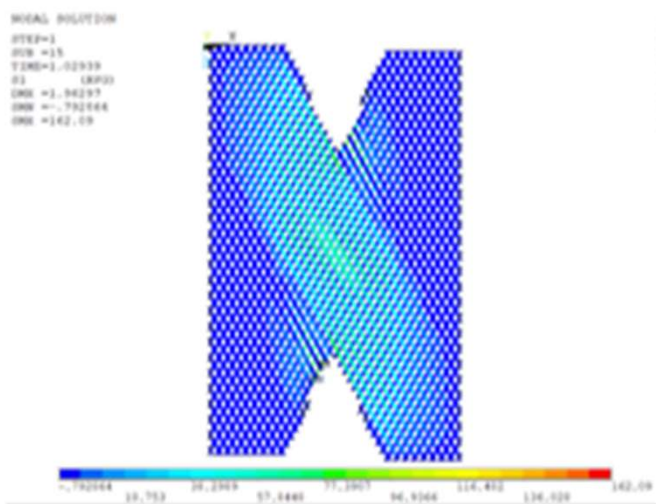
Simulation results of the two-layer ARCAN shape model [±30°] for the load of 1 mm and 2 mm



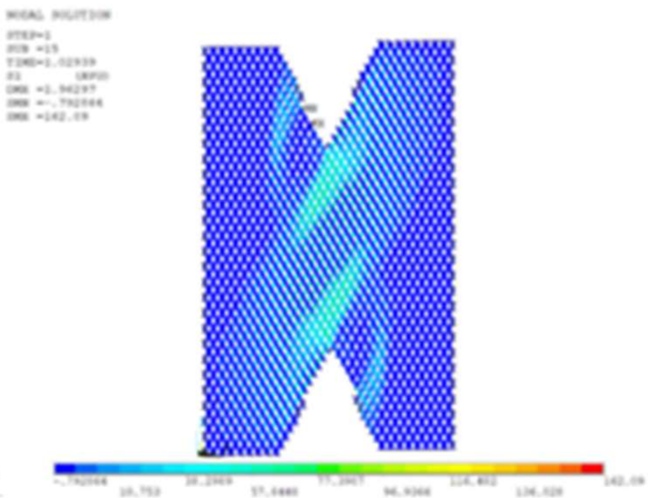
Summary displacement for the load of 1 mm



Displacement of cords for the load of 2 mm



Stress sigma1 in cords in the upper layer for the load of 1 mm



Stress sigma1 in cords in the bottom layer for the load of 1 mm

CONCLUSIONS

The results from tests and computational modeling of POLYMER COMPOSITES provide better understanding of the mechanical properties under static and specific loading.

Next computational models will be created for combination load states and for simulation of multi-axis load.

Acknowledgments:

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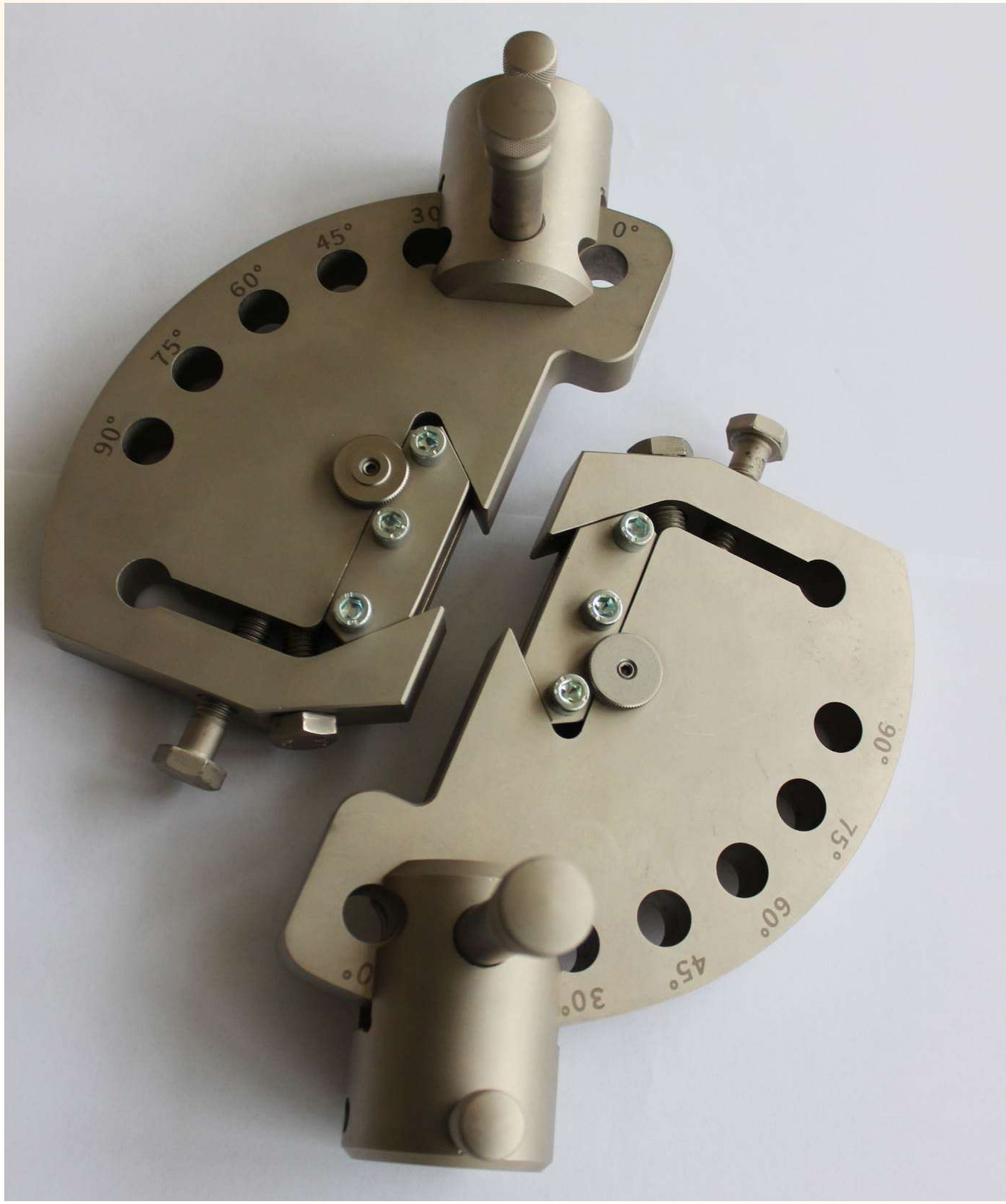

NEXT RESEARCH:

Composites
Arcan + cycles +
temperature
EXPERIMENT

↓

COMPUTATIONAL
SIMULATIONS

↓

...

The Influence of Temperature and Other Parameters on the Tensile Properties of Polymer Composites and Polymers under Cyclic Loading

Jan Krmela

The present scientific monograph is focused on specific testing of polymer composites and textiles cords, which are used as reinforcement for the composites. The basic mechanical tensile test at standard temperature does not provide all the information for obtaining the material parameters. It is also necessary to perform the tests at elevated or reduced temperatures, depending on where the polymer composites and polymer reinforcement will be used. It is necessary to consider stress relaxation in specific tests for practical use. This work experimentally investigates the effect of temperatures of 20 °C and 120 °C and relaxation times 60 and 120 seconds on the mechanical properties of selected textile yarns from PA66 under uniaxial tensile tests. Furthermore, the angle of the cords to the resulting material parameters of the composites is also evaluated based on low cycle load. A testing machine with a video-extensometer is used for testing, so that outputs are true stress values. The monograph also deals with computational modeling in the program ANSYS (by APDL procedures) – shear test simulations with determination of material parameters for calculations.

Videos of specific low cyclic loading tests of composites and polymers, and video-presentation are included on the enclosed DVD.

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Częstochowa, POLAND

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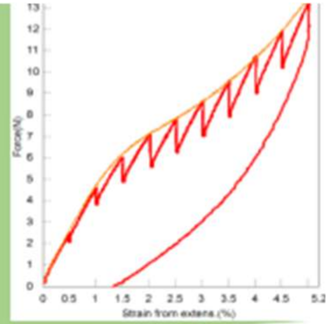
Jan Krmela: The influence of temperature and other parameters on the tensile properties of polymer composites and polymers under cyclic loading

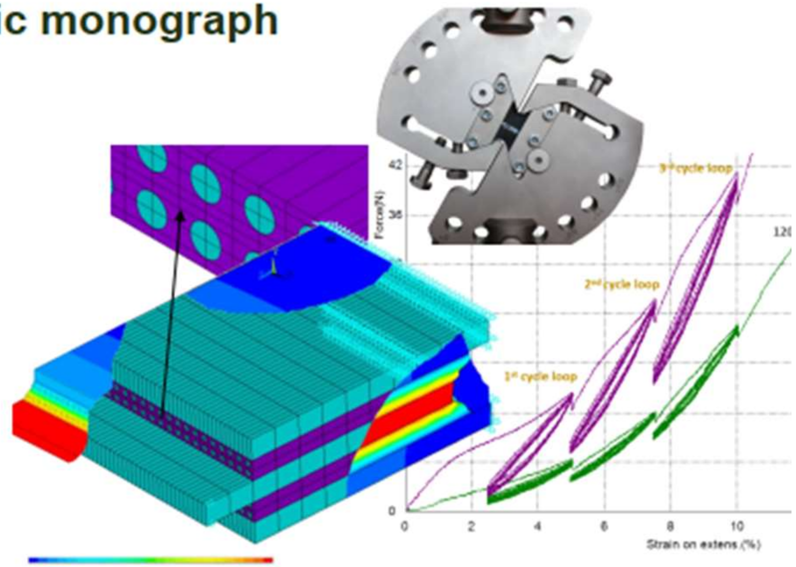


Jan KRMELA

The Influence of Temperature and Other Parameters on the Tensile Properties of Polymer Composites and Polymers under Cyclic Loading

Scientific monograph

2021



Tire Casings and Their Material Characteristics for Computational Modeling

Jan Krmela

The scientific monograph is focused on computational modeling of car tires in combination with experiments with an emphasis on input material parameters into computational models. Monograph divided into three parts.

The first part is focused on the determination of geometric and material parameters of tire casings, planning of experiments and tire experiments with pressure footprint analyses as well as the prediction of radial stiffness with the introduction of special test charts from the dynamic tests of tires.

The second part is devoted to experiments of parts of tire casings, tests of low cycle loading with use of modern instrumentation, tests of samples after corrosion and methods for determination of modules of elasticity.

The third part focuses on creating of computational models with the inclusion of hyper elastic and orthotropic material models for replacing of composite elements of a tire casing with parameters obtained from experiments. An emphasis is placed on the comparison of results from calculations with experimental data from both stress-strain analyses of tire and specific parts of tire casings and modal analyses of tires.

Videos from dynamic tests of tires and low cyclic loading tests of composites are included on the enclosed DVD.

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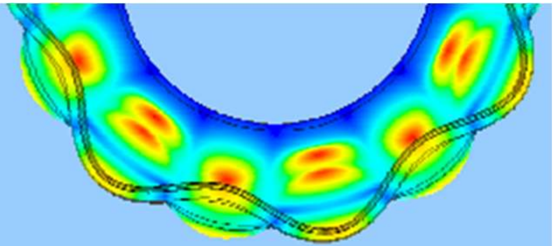
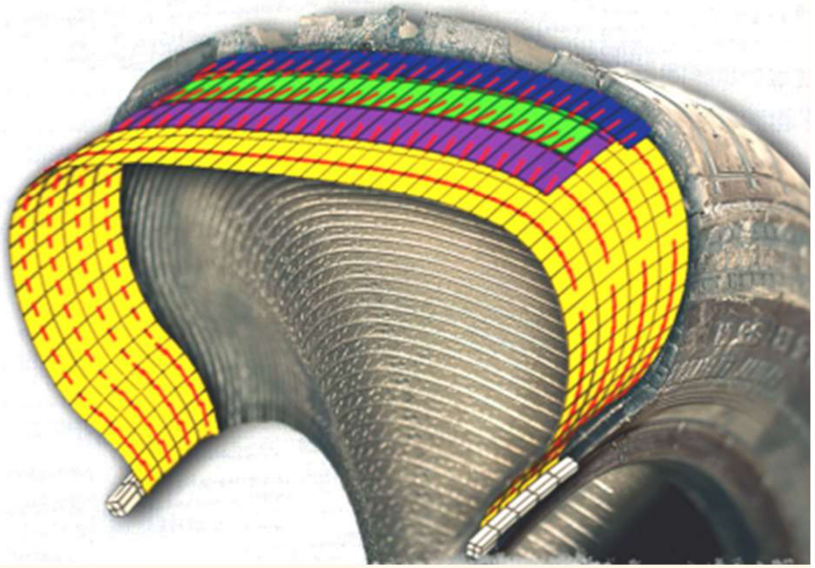


Jan Krmela

Tire Casings and Their Material Characteristics for Computational Modeling

Scientific monograph



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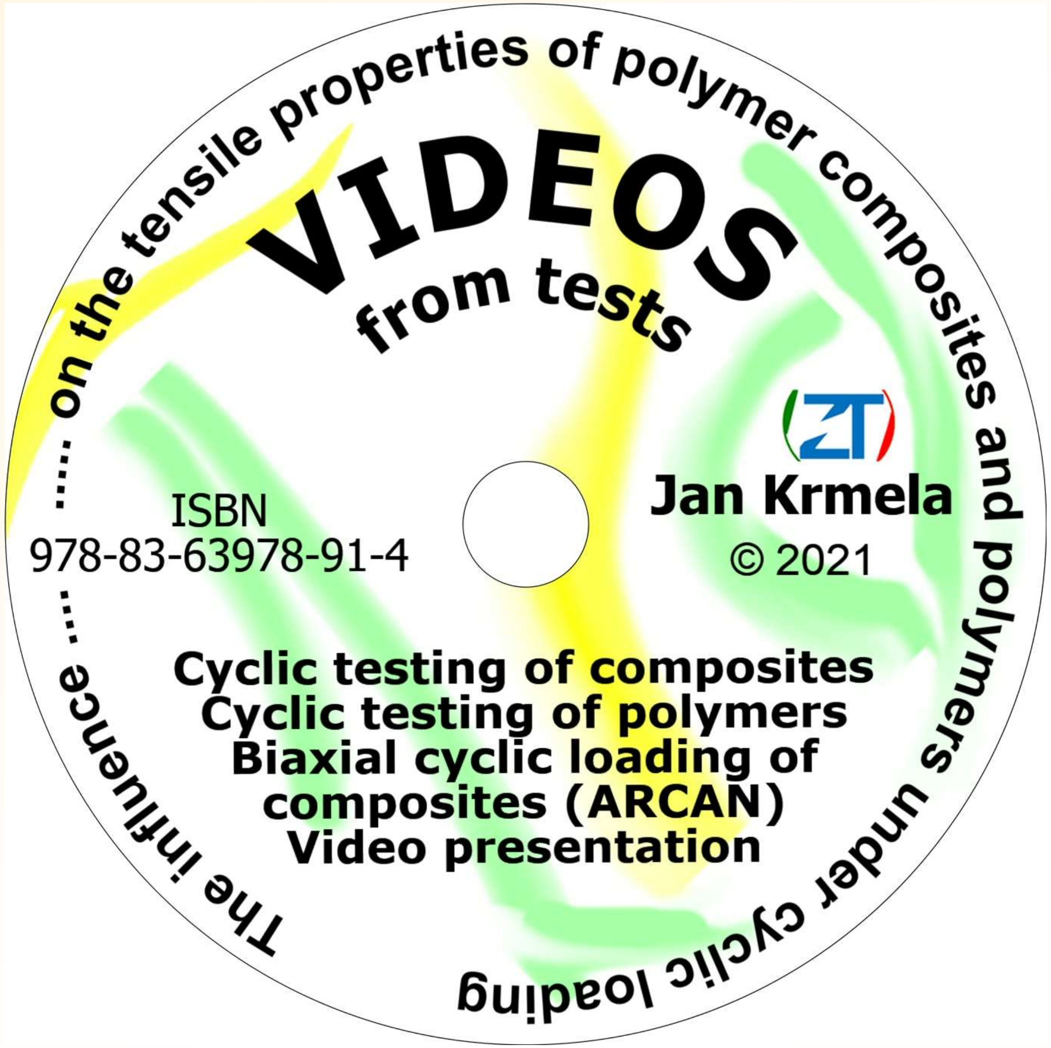

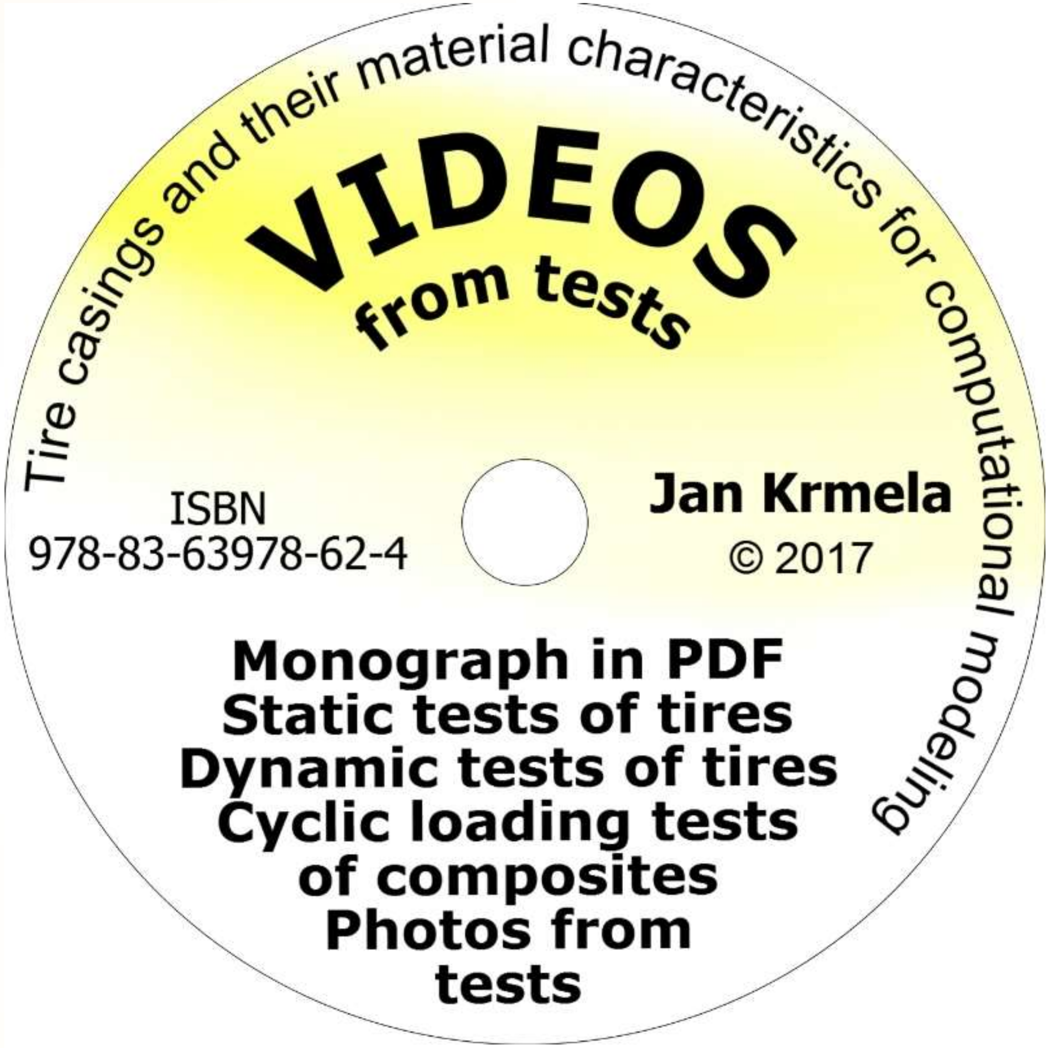

☼ Thank you for your attention ☺