

Supplementary materials

Table S1. List of abbreviations and symbols in this work (except physical units).

Properties	
Z, Z_c, Z_{mn}, Z_m	– property without specification—generally, for composite materials, porous and non-porous matrix
E, E_m, E_{mn}, E_c	– elastic modulus—generally, for non-porous matrix, porous matrix, composite
$\sigma_{Fmax}, \sigma_{m,Fmax}, \sigma_{c,Fmax}$	– ultimate strength—generally, for non-porous matrix, composite
$\varepsilon_{Fmax}, \varepsilon_{m,Fmax}, \varepsilon_{c,Fmax}$	– ultimate strain—generally, for non-porous matrix, composite
$A_{Fmax}, A_{m,Fmax}, A_{c,Fmax}$	– energy need for ultimate strength achievement—generally, for non-porous matrix, composite
$S_{m,rel}$	– relative area lying below tensile curve up to ultimate strength achievement in the case of non-porous matrix (obtained by calculation, measured is not available)
Structural parameters	
n, n_m	– porosity (generally), matrix porosity
n_{max}, n_{min}	– maximal and minimal porosity
$\rho, \rho_{it}, \rho_{it}$	– density (generally), theoretical density of sample (porosity neglecting) resp. of its component
v_{it}	– volume fraction of <i>it</i> th component in material
$v_m, v_{m(it)}$	– matrix volume fraction—real and with porosity neglecting
n_p	– interspace filling
$v_f, v_{f(it)}$	– volume fractions of filler—real and with porosity neglecting
$1-v_f$	– interspace volume
$1-n$	– solid rate of material
n_{pf}	– matrix rate in solid rate of material = matrix volume fraction if the porosity is neglected
$m, wt. \%, V, vol. \%$	– mass, weight percent, volume, volume percent
Remaining parameters	
b, c	– exponents ensuring the best fitting of spatial exponential function serving for filled porous composites mechanical behavior description (different properties = different <i>b, c</i> values)
d, e, f, g	– parameters arising through <i>b</i> and <i>c</i> fitting by matrix properties
δ	– OH/NCO rate in polyurethane matrix before curing, substituting the matrix polarity and adhesion of matrix for other material components
Chemical components designations	
<i>P</i>	– pre-polymer Unixin PU4223 based on MDI
<i>MDI</i>	– methylene-di-phenyl-di-isocyanate
<i>W, G, CO</i>	– curing agents—water, glycerol, castor oil
<i>LO, Si, Ca, Fe</i>	– matrix modifiers—linseed oil, quartz, calcite, iron
<i>R₀, R₁, R₂</i>	– rubbery filler fractions
<i>DBTL</i>	– di-butyl-tin-di-laureate

Table S2. Member meaning and mean of their obtaining for totally all equations contributing to elastic modulus calculation from the general beginning (getting structural parameters) to the end (porous matrix including). The other properties are not mentioned because of the same calculation method.

Parameter	Significance in Equations (1), (5), (6), (8-9)	Derived from...
n_p	interspace filling	calculated by Equation (5)
n	sample porosity	calculated by Equation (1)
$v_{m(t)}$	matrix volume fraction in hypothetical nonporous material	known (adjusted)
$1-v_f$	interspace volume	calculated by Equation (6)
$1-n$	solid rate of material	calculated from porosity (by Equation (1))
v_m	volume fraction of matrix	calculated by Equation (8)
n_{pf}	matrix rate in solid rate of material	calculated by Equation (9)
Parameter	Significance in Equations (10), (12)	Derived from...
E_c	E value of composite	measured (10,12)
E_m	E value for nonporous matrix	obtained by fitting in (10) and then used in (12)
v_m	volume fraction of matrix	calculated from porosity (by Equation (1)) and composition (known)
$1-v_f$	interspace volume	calculated by Equation (6)
b, c (10)	exponents	values ensuring the highest R^2
d, e (12)	b exponent parameters	fitting of b according to E_m in (12)
f, g (12)	c exponent parameters	fitting of c according to δ (12)
δ (12)	OH/NCO ratio in uncured matrix	known (adjusted)
Parameter	Significance in Equations (11), (15)	Derived from...
n_p^*	interspace filling	calculated by Equation (5)
d, e (15)	b exponent parameters	b fitting according to E_m and δ (16)
the other members	same meaning as in Equations (10,12)	corresponding to Equations (10,12)
Parameter	Significance in Equations (21), (22)	Derived from...
E_{mn}	E value for porous matrix	measured
E_m	E value for nonporous matrix	from Equations (10) or (11)
n_m	porosity of porous matrix	measured
b	exponent	calculated by Equation (21)
d, e (22)	b exponent parameters	b fitting according to E_m in (22)

* instead of $1-v_f$ in (10,12)

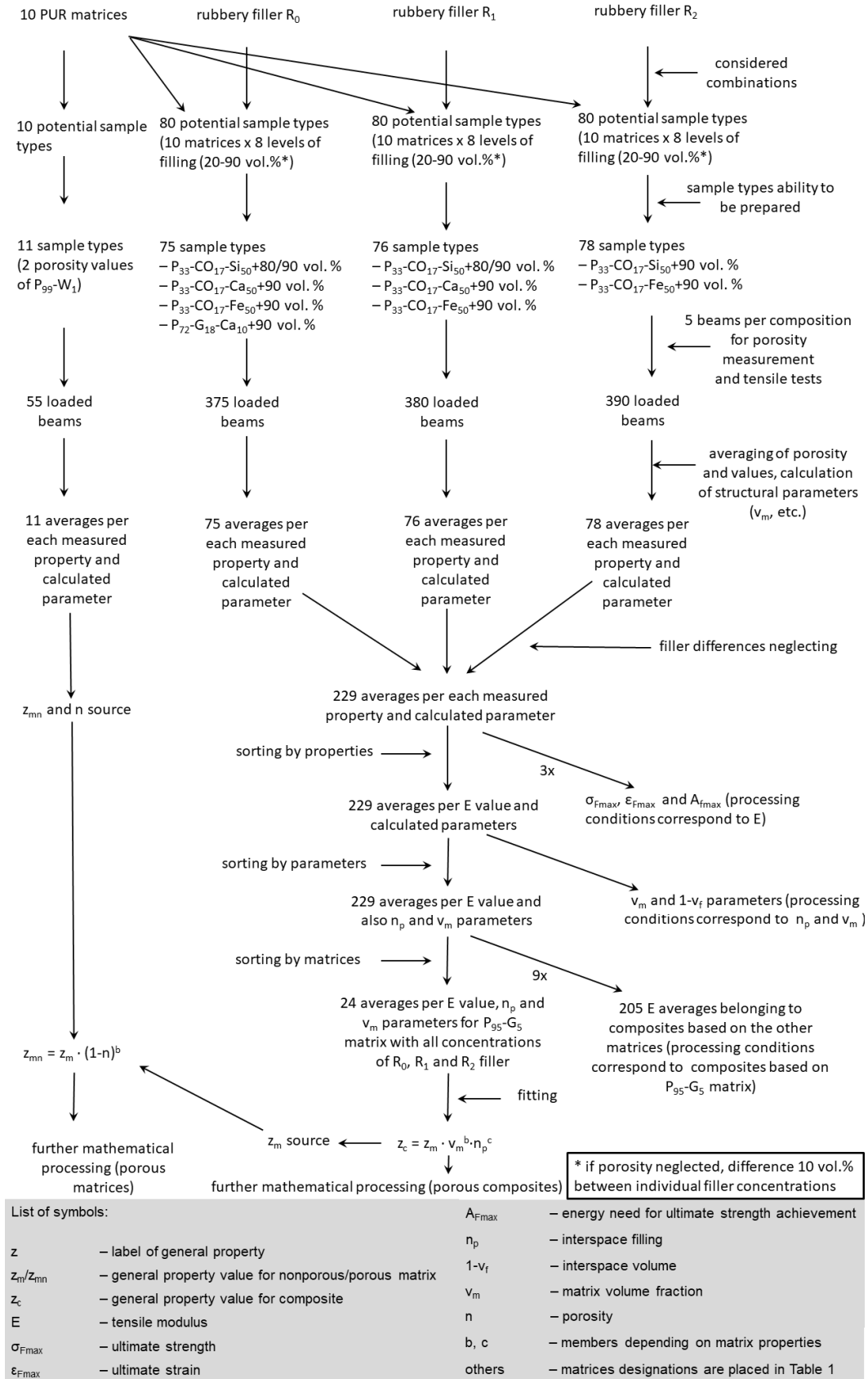


Figure S2. The schematic overview of preparation and testing of samples and following data and style of their utilization in further mathematical processing.

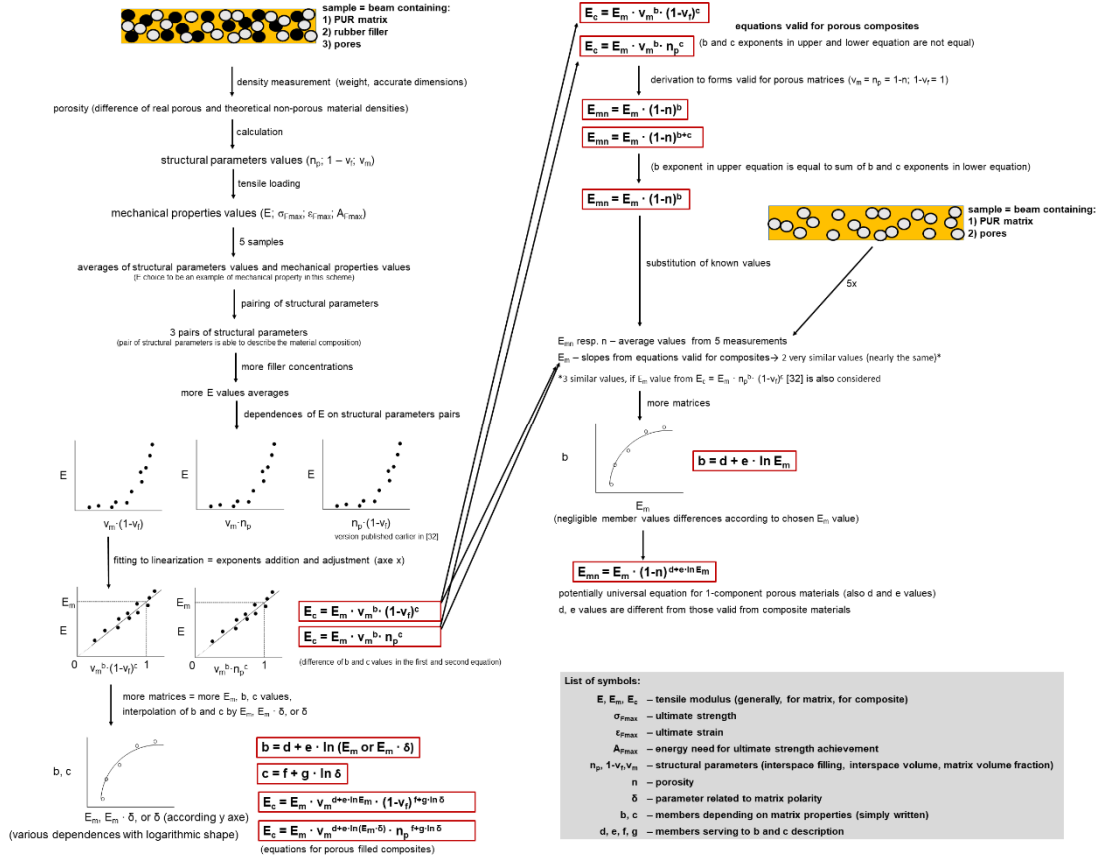


Figure S3. Data obtaining and processing—from beams to final equations.

Notice: In the previous article [32] (related to this work), there is no flow chart. This flow chart includes the creation of relationships typical for both articles.

Porous composites with complicated microstructure including randomly shaped particles and voids in various volume fractions.

Are the physical models suitable for the connection of properties and composition?

No, it is hard to imagine, how to reduce the system to reach precise theoretical description of microstructure without the ability decrease to describe the material.

Decision to try finding a something new. But what?

Looking for the parameters obvious from macroscopic point of view.

Reasoning based on idea, that porous composite behavior should be dependent on connection of particles by matrix (besides many forgotten reasonings).

How can this be expressed on macroscopic level?

Volume fraction of matrix in the space lying among particles (= interspace)?

How can it be called and calculated?

The interspace filling (n_p) can be calculated from the knowledge of porosity (n) and matrix volume fraction in composite, if the porosity is neglected $v_{m(t)}$.

$$n_p = 1 - \frac{n}{n + \frac{v_{m(t)}}{1 + \frac{n}{1 - n}}}$$

Do the observed properties depend on n_p ?
(generally labelled property = z , z_c for composite)

Yes, they do. Various exponential, linear or logarithmic functions $z = f(n_p)$ can be observed in various cases of property/matrix (only 1 type of filler).

Can the dependences be transformed into one type of equations?

Yes. The n_p on axe x is powered by b to get linear dependence. Number b is chosen to reach the best linear fitting.

$$z_c = a_1 + a_2 \cdot n_p^b$$

Do the slope and displacement have any real mean?

No, they do not.

Could be useful the change fitting to get only dependence going through beginning of diagram?

Yes, the slope gets the property value typical for hypothetical nonporous matrix (because $n_p = 1$ for nonporous matrix).

$$z_c = a \cdot n_p^b = z_m \cdot n_p^b$$

Does the exponent b have any real mean?

Yes, its value is higher, when the property of nonporous matrix z_m is higher (not for all used matrices, therefore the dependence is unclear).

Figure S4. Flow chart including the thinking process through the whole research—1st part.

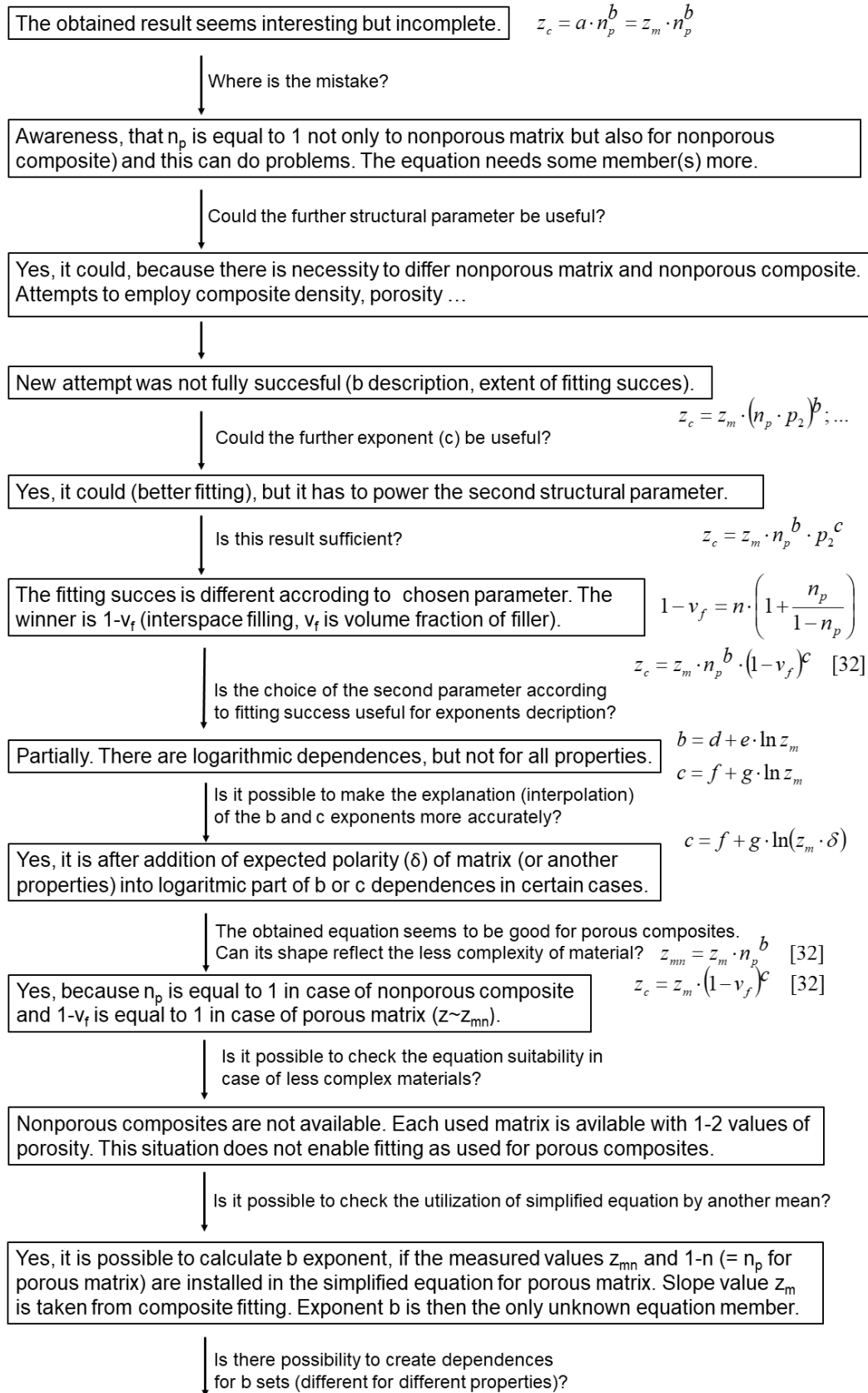


Figure S5. Flow chart including the thinking process through the whole research—2nd part.

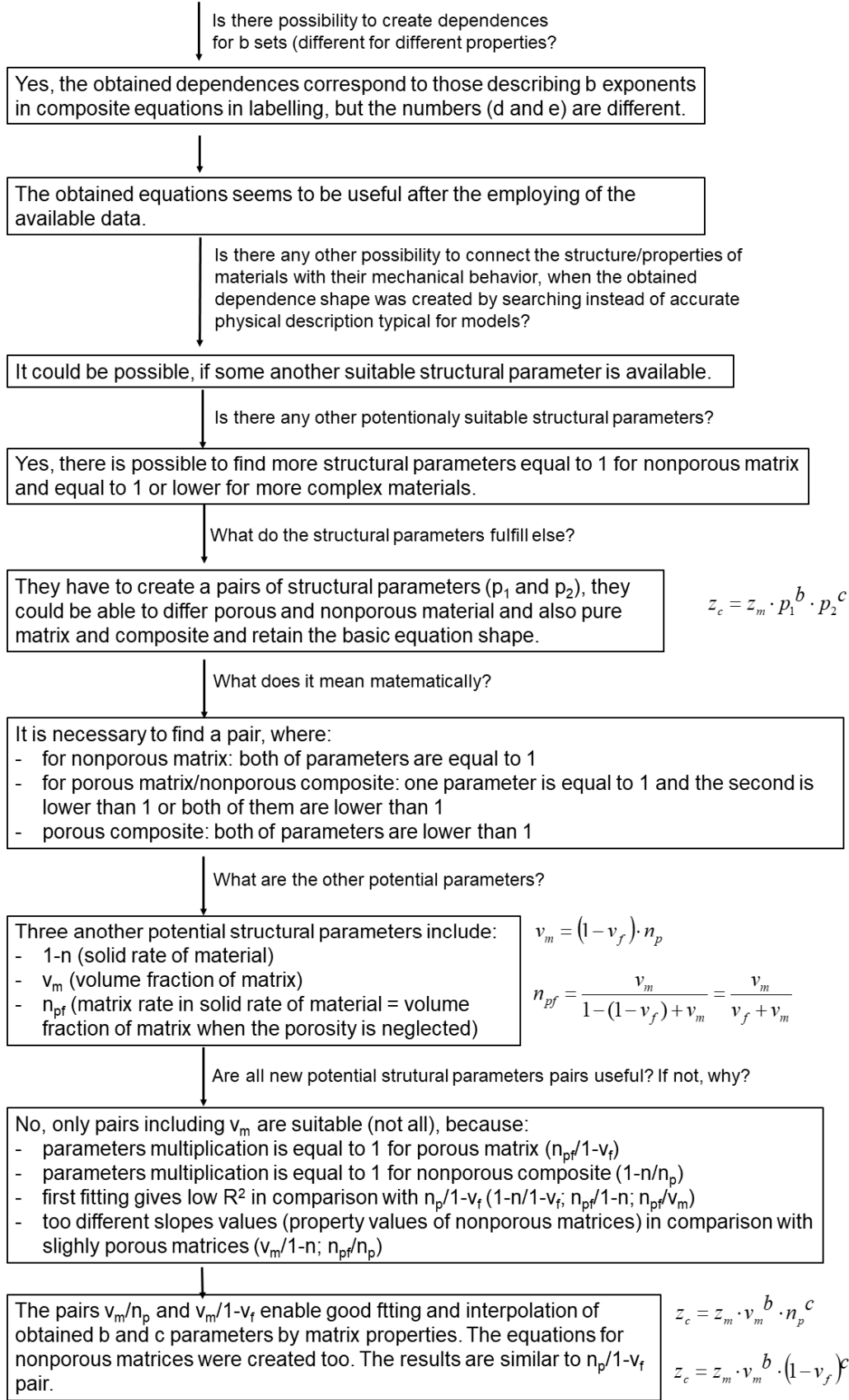


Figure S6. Flow chart including the thinking process through the whole research—3rd part. It is necessary to add that Equation (3) (valid for 1-component materials in the form telling that exponents are number, not function) is mathematically at the beginning, but mentally is in the end. The results occurring in the literature belonging to 1-component materials were found after the research to add a suitable background. The results

not including models/simulations for porous composites were looked for at the beginning of the research without success.