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Industriefußböden
Industrial Floors

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Ladies and Gentlemen,

Because my co-worker Mr. Fára was not allowed to leave Czechoslovakia to take part in this colloquium and becaus our two paper are closely cohering, allow me - with the permission of the Chairman of the Session of course - to joint them and to give only one but lobger lecture.

In our lecture I wish to acquaint you with our experiences with research, design, production and performance of jointless synthetic floor covering if we consider it as a composite material forming a part of composite systeme of the whole floor. I wish to underline that our twenty years of experiences are founded by production of about 150 thousands aquare meters of jointless synthetic floor coverings per year, that is by sum area about 3 millions square meters of floors.

Have a look for properties which must be fulfilled by jointless synthetis floor covering: beside good long-term resistance to mechanical and chamical loads it is necessary to ensure high durability also in extreme environment conditions, viz. in higher or lower temperature and also during quick changes of them, good damping resistance, high limit strain, good relaxation or creep ability even in low temperature, faultless adhesion to the base, small coefficient of thermal elongation, small shrinkage, small inner stresses, a plenty of inner barriers against microfracture, etc.etc.

Only few of all these properties are given by producer of resin flooring materials /characterized often as a separate material/. The currently used method of ascertainment of performance of flooring with reference to their inner stress state is, mostly, their practical application. This "test" affords, after a certain period of time, information whether the floor in given conditions performs its function or fails but without any detailed knowledge of the relation of originating stresses to their ultimate values

/e.g. adhesion to base/. It can be stated that a majority of organizations concerned with the application of resion floordings has made, often unintentionally, such "tests". The costs and problems connected with the liquidation of an unsuccessful application need not be described here. Moreover, the conditions of these "tests" are not mostly specified precisely and, therefore, a transfer of the obtained results to other application case must not be successful.

The contemporary analysis methods of stress state ascertainment are based particularly on the date of shrinkage, temperature expansion, moduli of elasticity and other quantities, which aredifficult to determine. These analyses are considerably inaccurate because the properties of resin are time.dependent, changing themselves in the course of the hardening and with temperature changes,etc.

The shrinkage volume change of the material is generally determined as a free linear change of test specimens. In reality, the rigid base, which the floor covering is jointed with, hinders to free shrinkage of flooring material, It is obvious that the resulting behaviour of the applied floor covering need not correspond with the values ascertained on test experiment which can shrink freely. Further it is obvious that the magnitude of free shrinkage ω and the modulus of elasticity in given time t_1 it is impossible to determine even informatively the magnitude of the stress state arisen in the applied flooring material where the shrinkage has been hindered. The major part of the shrinkage takes place in the time when the modulus of elasticity in tension increases from zero to a certain value. More accurate, but still only informative magnitude of the stress state we obtain as a sum of the stresses due to the individual shrinkage increment $\dot{\omega}(t)$ in the selected time interval, considering the respective relaxation moduli of elasticity

E_r t_1

Further increase of accuracy could be achieved by the assessment of residual shrinkage ω_R at time t_1, that is the value of linear shrinkage of the floor covering hindered from the beginning to the time t_1 as in actual application. It is diminished against free shrinkage by creep and relaxation of present materials. Then, using E $/t_1/$, it would hold that

$$\sigma_w = \omega_R(t_1) \cdot E(t_1)$$

However, even this value does not characterize accurately the actual state.

Similarly, the estimate of the stress state brouglt about by mish-mush of thermal expansions of individual components of the floor covering material or of the floor covering and its base is difficult, for the dependance of many properties /modulus of elasticity, creep, etc./ on temperature and time.

When the temperature increases above "birth" value the modulud of elasticity of resin as well as the whole floor covering decreases, the stress relaxation increases because of the viscoelastic behaviour of the resin and , therefore, temperature increase usually, do not diminishe the performance of the floor. However, adverde effects could bring about accelerated ageing of the resin or the evaporation of volatile unbound components.

If - on the contrary - the temperature drops the rheological properties of the floor covering deteriorate, the relaxation modulus increases, the toughness and the ultimate strain decrease and, moreoverm the sign of inner stresses due ti the drop of temperature and due to the hardening shrinkage are identical. Therefore, temprerature drop under "birth" temperature originates most unfavourable stress state and most often it leads to the less performance, less durability, defects or to the deteriorations of the floor. Thus for internal stresses in the floor system it holds that

$$\sigma_{in} = W\left(t, T, \varepsilon_w, E_r(t,T), \alpha(T), T_0\right)$$

It follows that a mathematical assessment of the stress state is extraordinarily complex and depends on the ascertainment of ~~the~~ suitable cummulation functions of the individual variables. The simple partial assessments often used, e.g. of the product $E_{/+20^{o}C/}$. , cannot yield sufficient information, particularly for low temperatures.

All mentioned problems lead to the endeavour to classify jointless synthetic floor coverings rather according to phenomenological and practical scales: according to theis thickness or to the method of their application /coatings, cast floorings, screeds, polymer mortars, polymer concretes/, according to their purpose or type of traffic /walked-on, driven-on by light-duty or heavy-duty vehicle/, according to the place of application /interior, exterior, wet environment, dry environment/, according to the base /concrete, anhydride/ or according to some specific properties /flexibilitym hardness,electric conductivity, skid-resistance, abrasion resistance/. All these classifications certainly serve their purpose when selecting and assessing the floor coverings according to the selected criterion. However, since they mostly have not physical basis, they cannot afford and explain an objective picture of the sum of short-term as well as long-term properties, performance and service life of the whole floor system, and optimization of the system for the given purpose lies more or less in the empiric plane, depending on experience and technical erudition of the designer or also, sorry to say, on purely commercial criteria.

Let us look at the matter from another, more principal, physico-mechanical viewpoint. The real objectivization of the performance - incorporating, apart from properties, also complex stress and strain states of the floor covering, considered as composite material, as well as of the whole floor system, considered as composite - have to be based on structural characteristics comprizing both geometrical and physical parameters. If we look at the jointless synthetic floor coverings from this viewpoint, we can we can classify them into three or four separate groups markedly differing in their physical behaviour and their response to outside actions.

Apart from the pure /unfilled/ polymer, applied only in the form of coatings either by brush or a spray-gun/ generally unsatisfactory for industrial flooersú the remaining floor coverings break up from the structural-geometrical point of view into two types: filled binders /cast floor coverings, screedsú and bonded fillers /polymer mortars, polymer concretes/. The former system, characterized by that its particular particles are segregated in the polymer, i.e. are not in the so-called force contact and, consequently, the stress transfer is carried out exclusively through shear flows in the matrix, is the composite of the 1st type. The latter system, characterized by that the stress transfer is effected mostly by normal forces among the particles af aggregated structure, can form - in accordance with the type of the ever present fluid phase, the composites of the 2nd and the 3rd types. As long as the fluid phase is enclosed in disjunct pores, it is the composite of the 2nd type /polymer mortar or polymer concrete with closed porosity/; if the fluid phase can communicate with external environment, its is the composite of the 3rd type /polymer mortar or polymer concrete with open porosity/.

There arises a justified question as to why the composites are structurally divided in this very manner, what are the reasons for this classification and what does it contribute? Let us look first at how the carious properties of the composite vary with the change of structural arrangement, expressed - for the sake of simplicity - by the ratio of the solid phases - the binder to the filler. Next figure shows quite indubitably that all properties vary continuously and monotonously in the first and the third parts of the diagrams, corresponding with the composites of the 1st and the 3rd types. A sudden change occurs always in the central part of the diagrams, in the area corresponding with the composite of the 2nd type.

The classification into these structurally different types makes it possible - without empiricism - to predict and control for every type the changed of properties, including their physical interaction with ambient environment, with a far greater assurance. There will remain only a single problem which requires a concentration of attention: what properties are we to require from the floor covering material in accordance with the composition of the whole floor system and the way of its use.

The performance of the floor system is influenced decisively by a major set of physical, chemical and physico-chemical properties of its components, the system and its environment including its base. In every group /cast floor coverings, screeds, polymer mortar with closed porosity/, however, other properties are of decisive weight, as simplifiedly shown in next pattern. As we can see, the highest number of required properties is imposed by cast floor coverings and screeds.

The selection of components influences, apart from the required initial properties of the composite, also the primary state of stress /due to the factors connected with the birth of the material, its polymerization shrinkagem influence of exothermy and of the solidification cooling/ as well as the secondary state of stress due to the action of external factors after solidification. Primary stress state should be as low as possible at the "birth" temperature mostly near the temperature of application, and the secondary stress state should be as homogeneous as possible. Apart from that the system must contain a sufficient number of energy barriers preventing or retarding defect propagation. The relations among the phases of the system, the system, external environment and properties, primary and secondary stress state and the performance of the composite are shown on the example of a polymer mortar /polymer concrete/ in the next figure.

In accordance to a closer look at some aspects of the stress state of the system basing our considerations on the assessment of the floor as a structural system /composite system consisting of the floor covering and its partly impregnated base course, an insulating layer and the load bearing structure/ and on the assessment of every layer as a further substructural system, as in abstract introduced in our papers, we can do these conclusions:

- the tensile stresses in the structure of a very well designed bonded filler /polymer concrete/ due to shrinkage of the matrix are at least 2,5 - 3,0 MPa, the shear stresses 0,5 - 0,9 MPa
- the slower the progress of polymerization, the more advantageous /lower, more homogeneous/ the stress state due to the polymerization volume changes /including temperature changes due to the exothermy/
- the stress state due to shrinkage in a structural system consisting of polymerizing binder and a filler is the lower, the lower the volume of binder among the filler particles, which is the consequence of adaptability of the weaker partner under the action of interphase stresses. For this reason also a certain volume of closed voids is advantageous diminishing inner stresses due to shrinkage by 12 - 15 %. A lower mean thickness of binder layer can be achieved also by a denser arrangement of filler particles
- a significant reduction of primary stresses in a structural system /and simultaneously reduction of costs/ can be achieved by the use of a "binder" instead of pure resin prepared previously by mixing the resin with a certain amount /50 - 100 % by weight/ of microfiller with particles several times smaller than the average thickness of the envelope of major particles

- the shrinkage stresses in the structure of every well designed bonded filler due to temperature change 10°C and of the order of 5,0 MPa, the shear stresses 0,7 - 1,3 MPa
- the shrinkage stresses in the contact joint with the base are the higher, the higher the thickness of the hardening layer
- the higher the thermal capacity, the less vulnerable the flooring is by temperature changes
- the thinner the floor covering layer and lower its thermal capacity, the higher the speed with which it will react to temperature changed and the less advantageous it becomes in the composite system as a whole /the opposite conclusion against the influence of shrinkage/
- the nearer the moduli of the flor covering and the base, the lower the shear stresses in their contact and the lower the stress state of the system as a whole
- the speedier the temperature changes, the higher the stress state of the floor covering and of the contact zone
- the average tensile stresses of floor covering prepared of good binders /without or with very small filler content/ and perfectly connected to the base are /after the thermal curing/:
  - . due to the shrinkage under 0,3 MPa
  - . due both to shrinkage and temperature drop of 40°C under 3,5 MPa
- the course of the shear stress along the thickness of the floor covering and of the base is non-linear, attaining hte maximum in the environs of the contact zone. Normal stresses in the floor covering vary along its thickness only very little. At each end of the floor covering as well as at the edges of an area crack in the contact zone high concentrations of horizontal shear stresses originate, the peak of which is even three times as high as the mean shear value

- the less filled the layer, the thinner it should be to limit its composite action /as bimetallic element/. leading to cambering or lifting of the edges. For this reason, the floor covering should be arranged so that it be symmetrical to its middle plane /for example surfacing cast layer - polymer concrete - bonding layer/
- dynamic loads produce the higher stress state of the contact zonem the greater the difference of the moduli of elasticity of the base and covering
- static concentrated loads produce the higher stress state of the contact zone, the greater the differences of Poisson's coefficients of the base and covering and the smaller the thickness of floor covering. Therefore, the thinner the floor covering, the higher base strength and mutual adhesion of the layers are desirable: for milimetre layers 20 - 25 MPa in compression and at least 1,5 - 2 MPa in tension /pull-out test/, for centimetre layers 15 - 20 MPa in compression and 1,3 - 1,5 MPa in tension

All afore mentioned conclusions and experiences prove that ~~the~~ decisive for the good performance of synthetic jointless floor covering is the strength of the contact joint /base-covering/. The importance of base preparation cannot be, therefore, overaccentuated. Always it is necessary to remove the surface layer from the surface of the concrete in order to enable the priming coat to penetrate to sufficient depth of sound concrete and thus enable the distribution of shear stresses from a single plane to a whole zone. At least to the supposed depth of penetration the base must be - in the moment of penetration - dry, i.e. its pores must be empty. The priming solvent must be carefully selected to enable the penetration to the asked depth before it evaporates. The golden rule covering the harmony of requirements imposed on the mechanical properties of the base and the mechanical properties of the contact joint is that the shear /tensile/ strength of the contact joint has to be higher than /or at least equal to/ its own strength.

The problem which is often discussed is the permissible moisture content of the base. The regulations usually require the moisture content - as a static property - near the equilibrium value /about 3 % by weight/ but rarely afford attention to the kinetics of the moisture in the system.

It has been found that if the hardened resin is not susceptible to hydrolysis /as some types of unsaturated polyesters are/ and if the surface layer of the base is dried to at least the depth of the presumed priming penetration, a hirgher moisture content of the base need not be necessarily harmful.By the way, actually in 90 % of all cases the moisture content of the base exceeds the required limit, which everybody knows, but keeps tactfully quiet.

The actuak acceptable moisture content depends primarily on prevailing temperature gradient in the whole floor system. If it is endured, for instance, that the temperature gradient will be permanently or mostly negative, i.e. the floor temperature drops from floor covering downwards, the moisture present in the system will be transported away from the floor covering and be not harmful. Only if the moisture in the floor system is permanently transported towards the floor covering, i.e. in case of a positive temperature gradient produced for example by a radiant-heating system built in the ceiling, so high vapour overpressure below the floor covering or even moisture condensation can arise, which will exceed the bond strength in the contact joint or the tensile strength of one of the partners and a local or overall failure of the floor covering will occur.

For this reason, when assessing the moisture content of the base, it is advisable to take into account also its temperature gradient and to be interested more in konetic moisture conditions.

The problem of synthetic floor coverings is the low resistance of all used polymers to atmosphere factors, particularly to the UV radiation. However, there are two realstic ways to a successful solution of this problem.

On the other hand, the resistance of all composite materials /that is also flooring materials/ against UV radiation increases by jump at the transition from the first to the second type, i.e. after the aggregation of the filler and the minimization of the binder in the system. The tests of polymer concretes carried out in the course of 10 years have shown that the degradation of resins in such systems is so retarded that it becomes insignificant. Another waym particularly in cast and screed floorings - which, however, are less suitable for exterior applications particularly because of their higher sensitivity to temperature changes - is the dense sprinkling of the unhardened surface with fine-grained gravel.

From the point of view of chemical resistance it can be concluded that flooring systems with furane binder have best proved in the hardest chemical loading. An example of its application is the cladding of all surfaces in an acrylic acid and resins plant, where no other polymer flooring had by far satisfied the preliminary tests.

The importance of the stress state problem and impossibility to analyze it by any in practice appliable theoretical method confirms the need of some simple methodology for the integral assessment of the stress state in the floor covering due to hardening shrinkage and temperature changes. Therefore, the new testing apparatus - Rheometer - and method of measurement was developed. The apparatus measures the stress state of a flat sample of flooring material through a magnitude of the reaction required for the equalization of the longitudinal deformations of the test specimen with the specimen is cast directly in the testing apparatus in the depth 5 mm for cast floors or 100 mm for polymer concrete floors, the measured length is 240 mm and the width is 150 mm.

After the coating of the test specimen the flooring material changes during hardening its state as well as modulus of elasticity /from the liquid to the solid/ without any inner stresses. As further shrinkage takes plac after a certain modulus of elasticity is acquired the deformations will generate the potential stress energy and tensile stresses will originate. In mutual applications these stresses are conditioned by the adhesion of the flooring material to the base, which prevents the flooring material from chrinkage. In the apparatus this state is modeled by that the mobile jaw is held in the initial zero position by the reaction of the dynamometric ring. By this way is determined a value of linear stress state σ_{ω} /t, Torr $^{\circ}$C/ originated in the flooring material, when it was prevented from shrinkage during hardening. Releasing the reaction of the dynamometric equipment could be determined the value of residual shrinkage ω_R as a function of time.

If the selected elongation is introduced and maintained constant the relaxation modulus of elasticity could be determined.

The stress state ascertained at a temperature drop /for example 40°C/ as well as residual deformation and the relaxation modulus of elasticity in these conditions will be obtained by repeating the previous measurement at the temperature -20°C. The comparison of both residual deformations yields the mean coefficient of linear thermal expansion.

After the basic tests /+20 and .20 $^{\circ}$C/ the whole experiment is repeated after thermal curing of the material modeling long term ageing at a normal temperature.

The experiment on Rheometer has to be, of course, followed also by the determination of free shrinkage values, tensile characteristics /tensile strength, modulus of elasticity, ultimate deformation, stress-strain diagram, relaxation and creep moduli of elasticity, impact strength/.

So far were 55 different flooring systems investigated. As a concrete example of test results this table gives the ascertained values of four types of flooring materials:

- ChS Sadurit 1330 /low-molecular epoxy resin modified by a mixture of dicarbon acids, polyamide hardener, 20 % microfiller/
- ChS Sadurit 1330 with 63 % by weight special corrundum filler
- ChS 104 polyester resin / on the basis of phthalic acid and ethyleneglycol/ softened by 12,5 % by weight of ChS 200 polyester resin/ on the basis of adipic acid and diethyleneglycol/
- softened epoxy binder Concretin GMH.

Beside the numerical values given in the table the stress-strain diagrams of these four types present this figure.

From the number of 55 testes systems none is optimally satisfactory from the deformation and rheological viewpoint for cast flooring layers in the case of major temperature drop, although some of them are - according to the producer`s statements - directly intended for the application of cast floors. From four types given in the table, the best results were ascertained in the case of the Concretin GMH binder in which, inspite of stress state increase after thermal curing, the stress state value at a temperature drop lies at the lower boundary of values ascertained in all testes epoxy binders usable for flooring purpose. However, the ratio of discovered stresses to tensile strength - namely after thermal curing - is much higher than for other systems, bringing smaller safety factor. After thermal curing also a substantial reduction of ultimate deformation was ascertained and the impact toughness is only average.

It is only natural that the properties of composite flooring materials formulated with the use of testes binders, particularly in the composites of the 2nd and 3rd types /bonded fillers/ will differ considerably and some unfavourable binder properties could /but must not/ be eliminated.

The set of ascertained properties represent already a sufficient basis for objective information on the performance safety of flooring materials with regard to their stress state. However, the values obtained cannot be unified and it is impossible to prepare a "resipe" for a relative comparison of types. Apart from the ascertained stress state values also other ascertained values are significant. Therefore, it is necessary to define a narrower set of decisive properties in accordance with the purpose of the material. As a rule, however, a flooring material with a markedly lower stress state value and satisfactory service resistance is most suitable. The need of attaining a higher stress safety in the contact joint between the floor covering and its base is accentuated by the possibility of absence if one of the assumed prerequisited for the application of the flooring material and the possibility of origin of unforeseen changes in the floor loading.

The results of the rests of various types of flooring materials carried out so far are unsatisfactory. It is obvious that little attention has been paid so far ba the research of resin and flooring materials producers to the set of properties determining the long-term performance safety of their applications with regard to their stress state. It is necessary to achieve better parameters to increase durability and scope of applications of highly effective cast and screeded flooring materials.

Laboratory methods cannot naturally evaluate exhaustively the durability of new materials in the conditions of their actual application. Comparative tests, however, can enable a comparison of the fundamental properties of new materials with the properties of materials well proven in technical practice, assess the degree of their suitability and determine with a high probability, whether they will or will not prove satisfactory in service conditions.

The results of tests made by the RGM apparatus have proved the justificaion of the methodology of ascertainment of relative values of linear stress state of flooring materials as well as their ability to afford further important information required for their assessment.

(1)

R. A. Bareš - F. Fára

Some notes to design, production and performance
of jointless synthetic floor covering

(2)

Properties to be fulfilled:

Good long-term resistance to mechanical and chemical loads
High durability also in extreme environment conditions /higher or lower
temperature, quick changes of temperatures/
Good damping resistance
High limit strain
Good relaxation or creep ability /even in low temperature/
Faultless adhesion to the base
Small coefficient of thermal elongation
Small shrinkage
Small inner stresses
sefisnsy
Sufficiency of inner barriers against microfracture
etc.,etc.

(3)

Analysis methods of stress state ~~should be~~ are based on: the data of shrinkage, temperature expansion, moduli of elasticity,other quantities hardly to determine /time-dependant, temperature-dependent, hardening-dependent/

e

(4)

4) The product of residual shrinkage ω_R in time t_1 and ~~[illegible]~~ $E(t_1)$, that is
$\sigma_\omega = \omega_R/t_1/.E/t_1/$ ⟶ best but not accurate results for the stress state

1.) Free linear changes ω → not usable

2.) Products of ω and modulus elasticity E in time t_1 → not usable for the stress state

3.) Sum of increment of product $\omega(t) . Er/t/$ that is
$\sigma_\omega = \int_0^{t_1} \omega(t) E_r(t)\, dt$ → informative magnitude of stress state

Stress state by mish-mash of thermal expansions coefficient:

- dependance on temperature and time
- dependance on „birth" temperature

Thus

$$\sigma_{in} = W(t, T, \varepsilon_\omega, E_r(t,T), \alpha(T), T_0)$$

What are suitable cumulation functions of the individual variables?

Simple pattern $E_{(T20°C)} \cdot \alpha$ cannot yield sufficient informations

Used classifications /phenomenological and practical scales/ according to

- thickness
- method of application
- purpose /type of traffic/
- application place
- kind of the base
- specific properties
- etc.

⑥

Principal viewpoint:

based on structural characteristics /comprizing both geometrical and physical parameters/

⑦

Conclusions:

- stresses in the structure of aggregated filler due to shrinkage
  - tensile 2,5 - 3 MPa
  - shear 0,5 - 0,9 MPa
  - the slower the progress of polymerization, the more advantageous the stress state
  - the lower the stress state, the lower the volume of binder among the filler
  - a certain volume of closed voids diminishes inner stress by 12 - 15 %
  - the use of a "binder" as the homogeneous mixture of resin and microfiller is advantageous
- the higher stresses in the system /contact joint/ due to the shrinkage, the higher the thickness of the flooring
- stresses in the structure of aggregated filler due to temperature change
  - tensile ~ 5 MPa for change 10°C
  - shear 0,7 - 1,3 MPa for change 10°C
  - the higher the thermal capacity, the less vulnerable the flooring

⑧

⑧ - the less advantageous is the system, the thinner the floor covering layer from the viewpoint of temperature changes

- the nearer the moduli of the flooring and the base, the lower the shear stresses in their contact
- the speedier the temperature changes, the higher the stress state of the system
- the average tensile stresses of good cast or screed flooring perfectly connected to the base
  - . under 0,3 MPa due to the shrinkage
  - . under 3,5 MPa due to both shrinkage and temperature drop of 40°C
- the course of the shear stress perpendicularly to the plane of covering is non-linear

⑨ - the concentrations of horizontal shear stresses at each end of the floor covering reach three times higher value of themean

- the less filled the layer, the thinner it should be to limit composite action
- dynamic loads produce the higher stress state of the contact zone, the greater the difference of moduli elasticity
- static concentrated laods produce the higher stress state of the contact zone, the greater the differences of Pisson`s coefficients and the smaller the thickness of floor covering

⑩ - the thinner the floor covering the higher base strength and mutual adhesion are desirable: for mm layers - 20 - 25 MPa compr.

1,5 - 2 MPa tension

for cm layers - 15 - 20 MPa compr.

1,3 - 1,5 MPa tension

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Conclusion from conclusions

the decisive for good performance is the strength of the contact joint

/very important - the base preparation/

12

Permissible moisture content:

as a static property / 3% by weight/ —— not sufficient

to afford attention to the kinetics of the moisture in the system

/temperature gradient !/

Resistance to atmosphere factors /UV radiation/

Ways to a solution:

- minimization of the binder above aggregation boundary of filler /composite of 2nd type - polymer concrete/
- 13 sprinkling of cast and screed flooring surfaces - with fine-grained gravel

Resistance to chemical loading:

furane binder or furane-.other resins compolymers have best proved

Experimental integral assessment of the stress state: with the aid of Rheometer model~~ed~~ing the true conditions of flooring /together with residual shrinkage, temperature changes, modulus of elasticity, relaxation modulus, coefficient of thermal expansion/

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Further needed experimental data:

- free shrinkage
- tensile characteristics /strength, dynamic modulus of elasticity, ultimate deformation~~s~~, stress-strain diagram, relaxation and creep moduli/
- impact strength

Results of so far investigated 55 different flooring systems:

- 15 none cast flooring is optimally satisfactory from the deformations and rheological viewpoint, namely in the case of major temperature drop
- in polymer concrete floorings the unfavourable binder properties are mostly eliminated

R. A. Bareš - F. Fára

Some notes to design, production and performace of jointless synthetic floor covering.

Properties to be fulfilled:

Good long-term resistance to mechanical and chemical loads.

High durability also in extreme environment conditions (higher or lower temperature, quick changes of temperatures)

Good damping resistance.

High limit strain

Good relaxation or creep ability (even in low temperature)

Faultless adhesion to the base

Small coefficient of thermal elongation

Small shrinkage

Small inner stresses

Sufficiency of inner barriers against microfracture

etc., etc.

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2) ~~Product of~~ ω and modulus elasticity
~~E in time~~ → not usable for the stress state

3) Sum of increment of product $\omega(t) \cdot E_{r(t)}$ that is

$$\sigma_\omega = \int_0^{t_1} \omega_{(t)} E_{r(t)} \, dt \rightarrow$$ informative magnitude of stress state

4) The product of residual shrinkage ω_R in time t_1 end $E_{(t_1)}$, that is

$$\sigma_\omega = \omega_{R(t_1)} \cdot E_{(t_1)} \rightarrow$$ best but not accurate results for the stress state

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  - a certain volume of closed voids diminishes inner stress by 12 - 15 %
  - the use of a „binder" as the homogeneous" mixture of resin and microfiller is advantageous

- the higher stresses in the system (contact joint) due to the shrinkage, the higher the thickness of the flooring

- stresses in the structure of aggregated filler due to temperature change

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the higher the thermal capacity, the less vulnerable the flooring

- the less advantageous is the system, the thinner the floor covering layer from the viewpoint of temperature changes
- the nearer the moduli of the flooring and the base, the lower the shear stresses in their contact
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- the average tensile stresses of good cast or screed fllooring perfectly connected to the base

- under 0,3 MPa due to the shrinkage
- under 3,5 MPa due to both shrinkage and temperature drop of 40°C

- the course of the shear stress perpendicularly to the plane of covering is non-linear

- the concentrations of horizontal shear stresses at each end of the floor covering reach three times higher value of the mean

- the less filled the layer, the thinner it should be to limit composite action

- dynamic loads produce the higher stress state of the contact zone, the greater the difference of moduli elasticity

- static concentrated laods produce the higher stress of the contact zone, the greater the differences of Poisson's coefficients and the smaller the thickness of floor covering

- the thinner the flloor covering the higher base strength and mutual adhesion are desirable:

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1,5-2 MPa tension

for cm layers 15-20 MPa compr.

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- none cast flooring is optimally
- ● satisfactory from the deformations and rheological viewpoint, namely in the case of major temperature drop
- in polymer concrete flooring:
- ● the unfavourable binder properties are mostly eliminated

Permissible moisture content:
as a ~~static property~~
(~3% by weight)

→ not sufficient

to afford attention to the
kinetics of the moisture
in the system
(temperature gradient!)

Resistance to atmosphere factors (UV radiation)

Ways to a solution:

- minimization of the binder above aggregation boundary of filler (composite of 2nd type - polymer concrete)
- sprinkling of cast and screed
- flooring surfaces - with fine-grained gravel

Resistance to chemical loading:

furane binder or furane - other resins co-polymers have best proved

Experimental integral assessment of the stress state:

with the aid of Rheometer modeling the true conditions of flooring (together with residual shrinkage, temperature changes, modulus of elasticity, relaxation modulus coefficient of thermal expansion)

Further needed experimental data:

- free shrinkage
- tensile characteristics (strength, dynamic modulus of elasticity, ultimate deformation, stress-strain diagram, relaxation and creep moduli)
- impact strength