REPAIR OF CONCRETE SURFACES

1. INTRODUCTION

Some decades ago, reinforced concrete was regarded as an extreme durable material and concrete strength was the most important concrete property. Damages on concrete surfaces, mainly due to rebar corrosion on structures more than 10 to 20 years old, or even younger ones, have been the reason to revise national concrete codes with emphasis on durability. Next to strength classes, classes of exposure have been defined with relevant allowable maximum water cement ratios on the one hand and increased minimum concrete covers on the other hand.
In the same period, where repairs were needed, several repair products came on the market and specialist repair firms showed a significant growth in a period of declining building activities.
In my lecture, which is restricted to concrete surface repairs only, I will pay attention to the following subjects:

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definition of concrete surface,
causes of damage,
desired properties of repair mortars,
types of repair mortar,
execution of repairs,
general conclusions.

2. THE CONCRETE SURFACE

As we all know the unit of surface is length to the square and as a surface has no volume, a concrete surface repair would require a volume of repair material equal to zero.

We know better than that, because repair generally means replacement of original concrete by a repair mortar. Hence, there is a need to define some thickness for the concrete surface.
Concrete is an inhomogeneous material consisting of fine cement grains, sand grains and coarse aggregates.
The next slide shows a piece of bulk concrete.

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If a saw cut was made following the dotted line A-B, the shaded coarse aggregates would be cut into two pieces. If on the contrary the line A-B would represent a mould surface, there would be no room for the shaded coarse aggregates. Consequently there must be a transitional zone near the surface with an increased mortar content. The depth under the surface, required to arrive at the real bulk concrete, is called the concrete skin. Following the same reasoning for sand grains, one can define a mortar skin, not only present near the moulded surface but also around coarse aggregates and rebars.
The same reasoning goes for the cement grains.
Investigations of the composition as a function of the depth under the surface results into the following classification:

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cement skin	0.1-0.3	mm
mortar skin	3-5	mm
concrete skin	25-40	mm

Thermal and hygric influences are decreasing with increasing depth under the surface. Daily changes in temperature may influence about 0.3 m concrete depth and only about 2 mm depth for hygric changes.
Seasonal changes (period of one year) might go as far as 6 m for thermal shrinkage and 40-60 mm for hygric shrinkage.

As mentioned earlier the concrete composition changes with the depth under the surface from practically pure hardened cement paste to finally the bulk concrete composition. Especially the shrinkage of the hardened cement paste is much higher than that of concrete.

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The next slide gives the most important properties as a percentage of the bulk concrete properties for different depths under the surface.

3. CAUSES OF DAMAGE TO CONCRETE SURFACES

Concrete can be exposed to a normal or non aggressive atmosphere, or to aggressive environments.
Rebars in concrete are protected from corrosion by the high alkalinity of the surrounding concrete, having a pH value of approximately 13. Under this condition a stable passivating layer is formed on the surface of rebars. For pH > 10 this layer is stable.
By intrusion of carbondioxyde gas (which is always present in the air) a reaction will take place with the free lime to form calciumcarbonate resulting into a pH value of approximately 8. In outdoor exposure a carbonated concrete cover generally results into rebar corrosion and as the corrosion products have a larger volume than the original steel, the concrete cover will crack and spall.

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The depth of carbonation (d) as a function of time (t) can be simply described as $d^2 = At$. The constant A depends on the type of cement, the concrete quality, in other words the w/c ratio and on the exposure condition. It goes without saying that for small covers the corrosion might start far earlier than with larger covers.

A good repair mortar must even for concrete covers of 5-10 mm prevent rebar corrosion by absolute tightness for oxygen in the case of polymer mortars and sufficient resistance against carbonation in the case of polymer cement and cement mortars.

Another cause of damage of rebar corrosion in a non aggressive atmosphere, is the presence of sufficient chlorides in concrete, e.g. mixed in as an accelerating agent. Chlorides disturb locally the passivation layer and as a result they promote corrosion even in non carbonated concrete. The speed of corrosion depends largely on the possibility for oxygen to reach the steel. Small covers can be dry over extended periods, providing access for oxygen to the steel. It is generally agreed that rebar corrosion damage, caused by chlorides, requires a polymer repair mortar.

Although carbonation and the presence of chlorides do not harm directly the concrete material itself, the damage to concrete is caused by the volume increase of rust products.

The concrete material itself can be attacked by chemicals such as acids or certain salts.

Very often chemical attack is visible as an exposed aggregate surface. It goes without saying that cement based concrete, which proved not to be resistant, needs a polymer repair mortar or a polymer cement mortar or a cement mortar protected by a coating.

Deicing salts may destroy a concrete surface in most cases limited to loss of the mortar skin.

Mechanical influences will bring about wear and also loss of the cement and mortar skin.

Damages due to physical and mechanical action require repair mortars that resist the prevailing physical and mechanical influences.

4. DESIRED PROPERTIES OF REPAIR MORTAR

Without any proof some people claim that the best repair mortar is the one that produces the same properties as that of the surface part of concrete that is going to be replaced. This is of course impossible.

Removed concrete has from outside to inside a cement skin, a mortar skin and some bulk concrete. The applied repair mortar will consist of a cement skin, a mortar skin, bulk repair mortar and again a mortar skin and a cement skin. This last one is very important as a bonding layer to the prepared concrete substrate. Of course, instead of a cement skin, one can also speak of a polymer cement skin or just a pure polymer skin, depending on the type of mortar used. To obtain the maximum bond there should be sufficient cement skin or polymer skin in full contact with the substrate. Maximum contact can be obtained by the use of mortars rich in binding agent and of high consistency in relation to the application method. Separate bonding layers can also be used.

A good bond is essential for the success of a repair. The strength of a connection can never be higher than that of the weakest part of the chain, the repair mortar, the bonding layer or the substrate.
Repair mortars and bonding layers can be made very strong and in such a case the limiting factor is the strength of the substrate. For this reason a well prepared concrete surface should have a tensile strength, when tested in a pull off test, of at least about 1.5 N/mm^2 and the tensile bond strength should also have at least this value. This level is deemed necessary to provide sufficient shear strength of the bonding zone as the repair mortar wants to undergo substantial length changes due to thermal or hygric gradients.

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When a layer of repair mortar wants to shrink, the length of that layer has to stay the same as that of the substrate to which it is bonded and a tensile force T is introduced being equal to the product of cross-sections A times the modulus of elasticity E times the shrinkage value ϵ.
The tensile force is introduced by shear stresses in the bond area near the ends and it takes only a distance of a couple of times the layer thickness to introduce practically the full tensile force.

For cement based mortars, the tensile stresses generally become so high, that cracks will be the result. Such cracks reduce the maximum tensile stresses in the non cracked parts and also the shear stresses are reduced. Although cracking is beneficial to reduce the shear stresses cracking itself is an undesired aspect and cement based mortars should be designed to have the least possible drying shrinkage.

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The drying shrinkage of hardeneD cement paste is approximately 0.2% that of mortar 0.1% and for concrete 0.04%. Reduction of shrinkage can obviously be obtained by increasing the maximum aggregate size compatible with the thickness of the repair layer. By addition of polymers to cement based mortars drying shrinkage can also be reduced.
The coefficient of thermal dilatation for cement based mortars does not differ toomuch from that for concrete.
Resins however have an α value about three times as high as the α value for concrete. By adding aggregates to resins the α value can be reduced. This is of importance in cases where repair mortars are exposed to temperatures above their glass transition temperatures. In such a case compressive stresses built up during temperature rise disappear by relaxation. Subsequently cooling down will than introduce high tensile stresses and shear stresses.
To reduce adversary affects of drying shrinkage and thermal shrinkage, the amount of binding agent cement paste or pure resin should be restricted. This measure however interferes with other disired properties such as strength and durability. Higher cement ratios allow mortars to be made with lower water cement ratios producing higher strengths and lower constants of carbonation. The strength of the mortar should be at least that of the concrete structures to be repaired or higher when resistance against deicing salts or a high wear resistance is required.
It goes without saying that for rebar protection in the case of polymer mortars the space between the aggregate grains must be completely filled with resin, even when not required for strength reason only.

When taking into account the desired properties discussed the different types of mortar will produce a modulus of elasticity of the following levels:
polymer mortar 10,000 N/mm^2
cement and polymer mortar 20,000 N/mm^2
very high quality shotcrete 30,000 N/mm^2, which is about the same level as for structural concrete.
In the case of structural repairs where substantial parts of a cross-section have to be replaced by a repair mortar shotcrete or ordinary concrete is to be preferred.

Up till now required properties in the hardened state have been discussed. Ideal hardened mortars must also be applied and therefore must have certain properties in the fresh or plastic state during and shortly after their application.
High consistency mortars can only be applied in a shuttering or on horizontal surfaces.
Mortars of lower consistency can be applied by trowelling and skill is required to applications on vertical surfaces or horizontal surfaces above the head, particularly when the substrate is a cyclic loaded structure.
The stiffest mortars can be applied as so called shotcrete.
Consistency measured as slump or flow value is insufficient to describe the easyness of application. During application by trowelling the mortar must be deformed by pressure to follow the roughness of the substrate. For equal consistencies the workability or defomability for various mortars can be totally different. The same goes for the risk of sagging after applications and in this respect there is a difference between polymer mortars and cement based mortars (with and without polymers).

5. MORTAR TYPES

As mentioned earlier, the repair mortars can have a binding agent consisting of cement, polymer cement or pure polymer.

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According to Mr. Faury's theories on gradings, the hollow space between aggregate and cement particles is proportional to a constant K over the fifth root of the maximum aggregate size. For cement based mortars the hollow space is filled with water and to arrive at a maximum water cement ratio either for strength or durability reasons the minimum cement content can be computed as the water content over the water cement ratio.
For polymer mortars the hollow space has to be filled with resin. The cement content and the polymer content can be reduced by increasing the maximum aggregate size. The maximum aggregate size is however limited to 1/3 of the thickness of the repair layer to be applied.
It is too much asked to have on a building site good quality aggregates, fillers, additives and binding agents to produce continuously mortars of a constant and high quality. This is however not a problem, because in many countries nowadays several repair mortars are available on the market covering the ealier mentioned types of binding agents. Very often the repair mortar is part of a system that comprises also:

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- a bonding agent to improve bond between repair mortar and concrete
- a coating to be brushed on derusted steel, sometimes an anti-corrosive is added to such a coating
- a very fine mortar to smoothen a rough surface obtained by the application of coarser mortars.
- a coating to improve the visual aspect but also to reduce the permeability for aggressive liquids and gasses.

It goes without saying that these extras in the several repair systems add extra value to repair work.

A couple of years ago I had the honour to test about thirty repair mortars or systems available on the Dutch market. The systems were developed in The Netherlands, the federal republic of Germany, France, Switzerland and the

United Kingdom. About half of the systems had a pure resinous mortar, in all cases epoxy mortar. The other repair mortars mainly consisted of polymer cement mortars in which mainly styrene burtadiene or acrylic dispersions had to be incorporated.
In the fresh state the pure polymer mortars showed less flow on the shock table than the polymer cement based mortar (105 mm versus 130 mm). Nevertheless some of these stiffer polymer mortars showed sagging when applied on a rough vertical surface in a layer thickness of 20 mm.

The applied repair mortar layers were subjected to an accelarated carbonation test with 5% carbondioxyde in an atmosphere of 20°C and 50% relative humidity. Even without a surface coating the cement based mortars showed zero to 3 mm depth of carbonation during an exposure time of three months. Ordinary concrete of the quality B 22.5 showed a depth of carbonation of 20 mm in the same test.
Concrete provided with a 20 mm resinous repair mortar showed no carbonation underneath this mortar layer.

When tested for bond strength by a pull off test on square areas of 100 x 100 mm rupture in the underlaying concrete was found in all cases of resin mortars. It must however be said that in all cases according to the producers specifications a seperate bonding layer of pure epoxy resin being part of the system had to be applied.
With the cement based mortars including the polymer modified ones the plaine of rupture was mainly in the bond area, sometimes in the underlaying concrete near the bond area and if this was the case the tensile force to produce rupture was substantial lower than in the case of polymer mortars. This discrepancy can be explained by the fact that the mortars were cured at 65% relative humidity and due to drying shrinkage, stresses in the bonding area had already been introduced in the case of cement based mortars.

Compressive strength levels varied between 30 and 100 N/mm^2 for polymer mortars as well as for cement and polymer cement based mortars.

It is obvious that a broad scala of adequate repair mortars is available. A final remark on epoxy based repair mortars must be made. A number of mortars had a glass transition temperature substantially lower than 40°C and in one case even less than 20°C.
It can be doubted whether resinous mortars with low transition temperatures are applicable in outdoor conditions when exposed to irradiation by the sun.

6. EXECUTION OF REPAIRS

Every surface repair will start with the preparation of the substrate to remove a depth of concrete where this material is carbonated or contains too much chlorides in the case of rebar corrosion damage. To obtain sufficient bond strength, concrete having a tensile strength of less than 1.5 N/mm^2, when tested in a pull off test has also to be removed. Contaminations in the concrete, such as oil or grease which adversaly affect the bond have also to be removed. To remove concrete a number of techniques are available such as chiselling, jackhammering, sand blasting and also water jetting and flame jetting. Corroding steel bars have to be derusted preferably all around in the case of corrosion caused by chlorides. Good results are obtained by sand or gritblasting. Very often the prepared concrete substrate is only surface dry but this is generally sufficient dry for epoxy based repair systems.
In the case of cement based repair systems it is generally recommended by producers to prewet the prepaired concrete substrate.

There is no general need for the application of separate primers on rebars and separate adhesive layers on the prepared concrete substrate. Such measures however, can add more safety with respect to rebar protection and a high level of bond. Inspections of repaired structures have revealed that under practical conditions in a number of cases the obtained qualities are far less than can be obtained under laboratory conditions. This has obviously to do with practical site-circumstances but also with the skill of the people making the application.

To obtain good bond the most difficult application is the application by trowelling. In a shuttering or in horizontal surfaces where high consistency mortars can be applied it is much easier to make full contact with the substrate and to fill the space behind rebars.

Special requirements for the repair mortar surfaces can be brought forward. The surface must be rough to provide anti slip properties, but in some cases the mortar surface has just to be very smooth to ease cleaning or to produce a substrate on which a paint can be applied.

During and after application of the repair mortar the ambient curing temperatures should preferably be above 5 to 10°C depending on the type of mortar used. In the case of cement based mortars producers do not stipulate wet curing. This has obviously to do with the good water retention of polymer based mortars. For cement mortars it is however advised to prevent loss of water from the mortar.

What finally counts is the practical result and it is obvious that the best results are obtained.
- with good repair mortars or systems, designed for specific cases of damage and
- executed by skilled labour
- under good supervision where the result
- of the repair work is checked by adequate tests where the assessment of the in situ bond strength is by far the most important.

7. GENERAL CONCLUSIONS

In a thirty minutes lecture it is of course impossible to present more than a general idea of the state of the art of concrete surface repairs. Detailed information on subtopics is given in the literature to which belongs the latest publications presented during this symposium under this topic.

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I want to end my lecture with some wishful thinking towards an ideal situation which is in my opinion realized when there are national codes for repair work just as we have national concrete codes. Such codes should specify minimum repair mortar or repair system qualities for different cases of damage in terms of properties to be established in specific tests.

The execution of repair work has also to be laid down in certain rules to arrive at a minimum level of realisation and finally codes should deal with the acceptance of repair work.

In several countries a start for a concrete repair code has been made. Should it not however be better to make an international concrete repair code when we know that repair systems developed in one country are used in several other countries.

Accepted test methods for concrete repair systems should be developed; this must be a challange for an organization such as RILEM. RILEM TC 52 proposes anyway a set of test methods to establish the bond strenth. I know that many nice autumns in Aix en Provence will have gone by before an international code will be ready.

In the meantime producers of repair systems could further improve their systems and special courses and training on concrete repair work could upgrade the workmanship of all those involved in repairs.

Universities and institutes may execute special basic research programmes related to concrete repair.

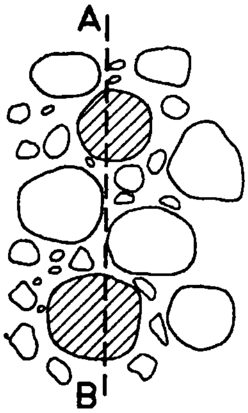
The ambitious horizon I just pictured with still a lot of work ahead does not mean that it nowadays is not possible to make good repair work. On the contrary in my state of the art I have pointed out that good repair systems and application techniques are available to produce quality repair work and with this important conclusion ladies and gentlemen I thank you for your attention.

IBBC TNO
Ir. P.D. Steijaert

SUBJECTS

- CONCRETE SURFACE
- CAUSES OF DAMAGE
- DESIRED PROPERTIES OF REPAIR MORTARS
- TYPES OF REPAIR MORTARS
- EXECUTION
- GENERAL CONCLUSIONS

SLIDE 1

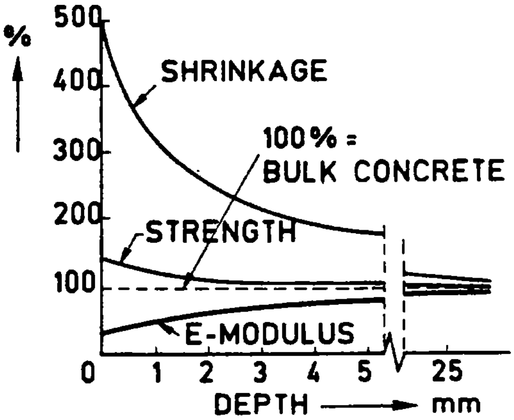


SLIDE 2

DEPTH UNDER SURFACE

CEMENT SKIN	0,1 - 0,3 mm
MORTAR SKIN	3 - 5 mm
CONCRETE SKIN	25 - 40 mm

SLIDE 3



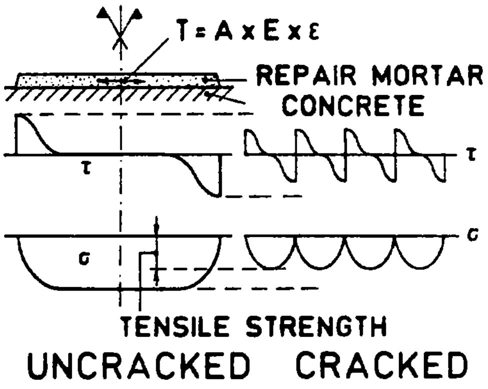
SLIDE 4

$$d^2 = A \times t$$

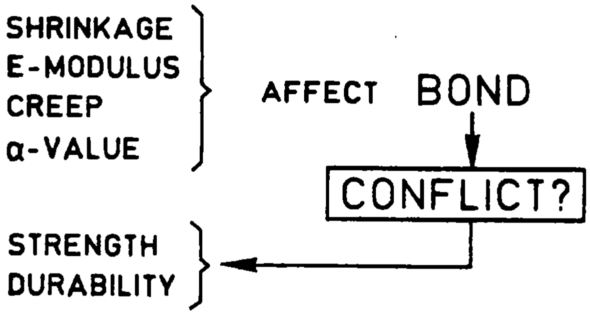
(mm) (years)

	HIGHER	LOWER
CEMENT TYPE	SLAG	PORTLAND
W/C RATIO	HIGH	LOW
EXPOSITION	DRY	WET

SLIDE 5



SLIDE 6



SHRINKAGE
E-MODULUS
CREEP
α-VALUE

AFFECT BOND

CONFLICT?

STRENGTH
DURABILITY

SLIDE 7

HOLLOW SPACE =

WATER CONTENT $= \dfrac{k}{\sqrt[5]{D_{max}}}$

CEMENT CONTENT =

$$\frac{k}{\sqrt[5]{D_{max}}} \times \frac{1}{W/C}$$

SLIDE 8

PREPARATION OF CONCRETE
DE RUSTING OF STEEL

PREWETTING OF CONCRETE
BONDING LAYER ON CONCRETE
PRIMER ON STEEL

APPLICATION OF MORTAR

FINE MORTAR FINISH
PAINT

SLIDE 9

FUTURE

CONCRETE REPAIR CODE

DESIGN
MATERIALS || Q.C.
EXECUTION || TESTS

IMPROVEMENT OF SYSTEMS
BASIC RESEARCH
TRAINING

SLIDE 10

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[illegible] jsou [illegible] - [illegible]

Some Notes on the General Report " **REPAIR OF CONCRETE SURFACES**"
ISAP '86

R.A. Bareš

The greater the number of concrete structures, the longer their age and the more detrimental the environment in which they are situated, the larger number of defects of their surfaces appear and the more it is necessary to make their repairs.

The defects of surfaces are of different types. The most frequent defects of concrete surfaces originate as a consequence of the carbonation of concrete, the extent of which increases with the increasing acidity of atmosphere. The carbonation results in the loss of natural passivation of reinforcement in concrete due to its alkaline medium, its corrosion followed by the origin of cracks and the scaling of the concrete cover. These defects appear on unprotected concrete surfaces of all types in exterior conditions, both vertical and horizontal surfaces.

Carbonation is accelerated by heavily aggressive environment in factories produced indirectly by the production process, similarly as the artificially created aggressive environment produced on horizontal surfaces in winter by de-icing salts. The penetration of acid ions to the reinforcement through the capillaries of concrete causes reinforcement corrosion with all subsequent phenomena even without carbonation. Corrosion is produced also by the origin of electrical fields in concrete components due to the influence of a number of external and internal factors.

All defects of this type are very difficult to identify before the origin of cracks and the scaling of concrete cover, although they can be predicted on the basis of known facts with relatively high reliability.

In spite of different primary causes in all of these cases the subjective appearance of the defect is generally the same. On the other hand, the method of repair depends on the cause of the defect which must be known before the repair is carried out and respected, when the technology of the repair is chosen.

Apart from the above causes the most frequent cause of of concrete are excessive mechanical effects / which are particularly unfavourable when combined with chemical effects due, for example, to de-icing salts/, resulting in the crushing of surface layers, loss of cohesion, origin of pot-holes, breaking of edges, corners, etc.

The repair of such surface defects is a complex and difficult problem / like all surface repairs in general / both from the technical and from the aesthetic point of view. From the technical point of view it is necessary to take into account a number of factors. At the same time the compliance with various requirements often requires sometimes even contradictory properties and technologies.

From the physical point of view is it only natural to require that the material used for the repair should have similar physical parameters as the original concrete, that is the same coefficient of thermal and moisture expansion, modulus of elasticity, strength, abrasion resistance, permeability, etc.

From the chemical point of view the new material must be compatible with the old in the long run. Apart from that it is necessary to ensure the removal of all concrete contaminated with aggressive chemical agents, or to neutralize all these agents in concrete before the repair or remove them from the concrete.

The aesthetic point of view requires not only the same colour, but also the same texture of the repair and the original concrete.

One of the necessary prerequisites of a successful repair is a sufficiently strong adhesion ~~connection~~ of the new material to old. The strength in the joint should be at least equal the cohesion strength of the original material, permanently, even under the effect of various external factors, particularly m moisture. The provision of ~~compliance with~~ this requirement usually is the most difficult point of the whole operation. It~~s~~ ~~success~~ depends to a considerable extent on the preparation of the repaired surface, which thus becomes the decisive parameter of the repair.

The provision of adhesion of the new material to old by a jointing layer is one of the most successful methods. However, it results almost always in the creation of an watertight ~~xxxxxxxxxandxofthxxxxxx~~ membrane, which is simultaneously also often a vapour barrier, i.e. the creation of a new composite system, for which the structure as a whole has not been originally designed. This circumstance can ~~cause~~ become the origin of new defects at a later date, mostly due to physical causes /vapour overpressure, moisture condensation, ~~fxxxxing~~ frost heave / and the return to the originally defective state . With a few exceptions the layer permitting vapour diffusion is not water resistant permanently and, consequently, inacceptable in moist conditions. If the physical properties of the old and the new materials are considerably different, it is possible in some special cases / determined by structural design / to ensure the jointing of both parts by means of the so-called (transparent). transposition layer enabling a smooth transition of properties over the contact and a reduction of internal stresses in the

In the prevailing majority of cases, however, it is the perfect bond between both materials along the whole repaire surface that represents the necessary prerequisite for a successful repair. So far it has not been entirely cleared which treatment / particularly in actual practice / can best ensure this bond, although the majority of experience points to ~~sand~~ blasting as far as sound and uncontaminated concrete is uncovered. The suitability of base preparation can be best assessed in practic by the pull-out test, although the ideas about the critical value of strength differ considerably according to authors as well as rules and vary from 0.8 to 2.0 MPa. Naturally also the intensity of possible stresses plays a role of importance which depends, once again, on the thickness of the applied layer, type of material, shrinkage of the repair material, environmental conditions and external loads. It seeems, however, that 1.2 MPa is a safe strength regardless of the mode of failure / in the connecting layer, in concrete or partly in concrete and partly in the connecting layer /. Also further procedure, if this value has not been attained, is problematic. In some cases the removal of another layer of concrete, in other cases deep impregnation of concrete with a suitable monomer or pressure grouting can be applied. It is difficult to give some explicit instructions in this respect and the individual cases will have to be solved individually. It can also happen thet the pull-out test will show that the repair is useless, unable to ensure a reconstruction of sufficient service life, and will form the basis for the design of a complete or partial replacement of the structure by a new one.

Another important parameter, which can significantly influence the success of reconstruction, is the moisture content of the base. Some repair materials require high moisture content, for others any moisture is harmful. This aspect must be considered particularly carefully in every individual case.

A number of tests has shown that the application of a primer or a connecting layer is usually advantageous in any repair type. Other procedures and other materials are suitable for reinforcement, if present in the repaired spot, others for concrete. Similarly it is necessary to use different materials, if the repair material is identical with the repaired material or different from it. In this respect, as we have already mentioned, it is not only the provision of good and permanenent adhesion that must be ensured, but also the creation of such diffusion conditions as are suitable or required in the given case. Apart from that it is also necessary to consider also the influence of the repair on the whole system in other respect, such as the incompatibility of primers used for reinforcement and concrete, the origin of electric cells of the treatments in repaired place and the influence on surrounding material and structure, etc. ~~environment, etc~~.

For the repairs of concrete three groups of materials can be generally considered :

- cement mortars,
- polymercement mortars,
- polymer mortars.

Each of them has its indubitable advantages and disadvantages and each of them will have its specific field of application.

The principal advantages of cement mortar are its properti which harmonize with those of concrete; the disadvantage is usually a weaker bond than the cohesion strength of both parts of the repair. Improvement can be attained by the selection of suitable special cement types / e.g. cement with hig specific surface / or by the addition of some monomers or oligomers and an addition of surface-active admixtures or tensides / plasticizers, superplasticizers/ ensuring better wetting.

Polymercement mortars have been the high hopes for many years. Polymercement mortar has similar properties as the repaired concrete, and the admixture of the polymer should ensure higher adhesion in the contact joint. Unfortunately, with the exception of some acrylate dispersions, the results - particularly in respect of adhesion and volume changes of the mortar - have not been by far so explicit and are heavily influenced by moisture in the majority of cases. Moreover, they vary considerably in time. It seems that in spite of the enormous amount of work / probably the greatest amount in the field of polymer concretes / expended in this field no explicit and definite conclusions have been reached.

Polymer mortars have considerably different properties from the repaired concrete which causes the ~~most~~ varied difficulties. Their number includes not only the problems of different thermal and moisture changes, moduli of elasticity or strengths, which can be overcome by suitable modifications of the system, but also - and particularly - the problem due to the different diffusion coefficients. An increase of the diffusion resistance above that of concrete / even if no connecting, usually impermeable layer is considered / brings about in many cases the accumulation of moisture under the repaired place and a potential danger of further defects. A reduction of the diffusion resistance results in the loss of water-tightness and the potential danger of further reinforcement corrosion, not passivated by alkaline environment like in concrete.

An objective assessment shows that under certain conditions and in certain cases it is possible to achieve a perfect and durable repair of concrete by any of the above mentioned material groups. Even the colour and the texture of the material present no problem. What is important, however, is the fact that every group has its suitable and unsuitable fields of application, and it is impossible to generalize and monopolize any material as ideal for the repairs of concrete. It is always the matter of considering <u>all</u> aspects, conditions and possibilities.

Another field ~~is~~ are the repairs of jointless synthetic floorings / screeds, resin concretes/. It often happens that the use of unsuitable technology, the non-observation of prescribed conditions / of base preparation, environment, loading / or the use of unsuitable raw materials results in the origin of defects / either local or general / of such floorings. In such cases the most difficult problem is to diagnose the cause of the defect. Their number can include chemical, physical of physico-chemical , sometimes even microbiological ~~causes~~ factors. When the cause has been identified, it is necessary to select the method of repair. The principal role will be played by chemical criteria, as a rule. In a number of cases the repair will be impossible / e.g. in the case of chemical destruction of polyester resin concrete by oxidation of styrene ~~and~~ giving rise to the origin of products of decomposition /, and the only solution will be the placing of a new flooring. It is necessary to adhere to the principle that it is impossible, as it is sometimes the case, to superimpose further and further layers of synthetic materials to obtain an aesthetically efficient surface / e.g. in the case of local abrasion/, Such method of repair leads to a distaster in the end and results in high - and totally unnecessary - costs. In some cases adequate impregnation can strengthen the layer of resin concrete, in other cases a partial exchange of deteriorated patches may be most suitable. ~~However~~, A new surfac~~ing~~ layer can be applied only after the old, deteriorated one has been removed.

In spite of the publication of a great many data on modified cement mortar none but phenomoenological results have been obtained for various reasons . Every work which can elucidate the actual deformation and strength mechanism of modified cement mortars and their cooperation with old concrete, particularly their bonding mechanism, therefore, is welcome. One of the fundamental contributions is the work by Dr Chorinsky, who assesses the suitability of the systems which are on the market and discusses the possibilities of further development. From this particular viewpoint, in accordance to ~~this contribution,~~ ~~similarly as in~~ the contribution~~s~~ by Naderi, Cheland, Long , the importance of adequate preparation of the repaired surface is accentuated, whose neglect represents probably the cause of ~~the~~ failure of the majority of repairs in service.

Of great importance in concrete repairs is the selection of the methods of prevention of further corrosion in damaged reinforced concrete. This does not concern only the repair ~~itself~~ alone, but also the influence of the repair on the further behaviour of concrete and reinforcement not only in the repaired place, but also in the whole concrete member. The problems connected with this field of concrete repairs are dealt with in the papers by McCurrich, Cheriton, Little, similarly as Paillere, Cochet and Serrano.

All considerations and conclusions following out of such papers must be substantiated with experimental research. In this respect it is important to identify those properties and, consequently, those tests which are decisive for the assessed mechanism. A survey of such important experimental characteristics is contained in the paper by Naniwa.

Apart from the analyses of principal character and experimental studies also properly evaluated experience with executed applications represents an inexhaustible source ~~well~~ of new data and knowledge. One such analysis is presented by Lorin and Chamut in their paper discussing the application of epoxy resins.

What we would like to accentuate is that we should not lose the perspective of the highway because of observing ~~regarding~~ one grain of send on its surface under the microscope. It is always necessary to assess all properties and aspects simultaneously, jointly. For instance, we often overestimate the momentary value of the bond of the repair mortar with repaired concrete, without considering the change of diffusion conditions caused by the repair in the whole system and the changes of other characteristics of the system in time. Or we overstress the importance of chemical compatibility or chemical reaction and disregard the other, e.g. physical aspects. In other cases we forget, when seeking some sophisticated ways of efficient repairs, the possibility of proper application of well known and time-proven physical and particularly physico-chemical laws of surface phenomena which can ofteh ~~explain the~~ easily the contradictory results and save considerable costs of experiments which are doomed to failure in advance. One of such quantities is, for instance, the surface tension and the wettability, connected with it.

To conclude briefly ~~I~~ it should ~~like to~~ be accentuate the fact that the principal and indispensable rule governing the way to the final purpose of a durable repair of concrete surfaces, in our opinion, is the necessity of assessing all characteristics and aspects jointly and that the approach to the problem~~s~~ of concrete repairs should be synthetic rather than ~~xx~~ specialized and analytical in character.