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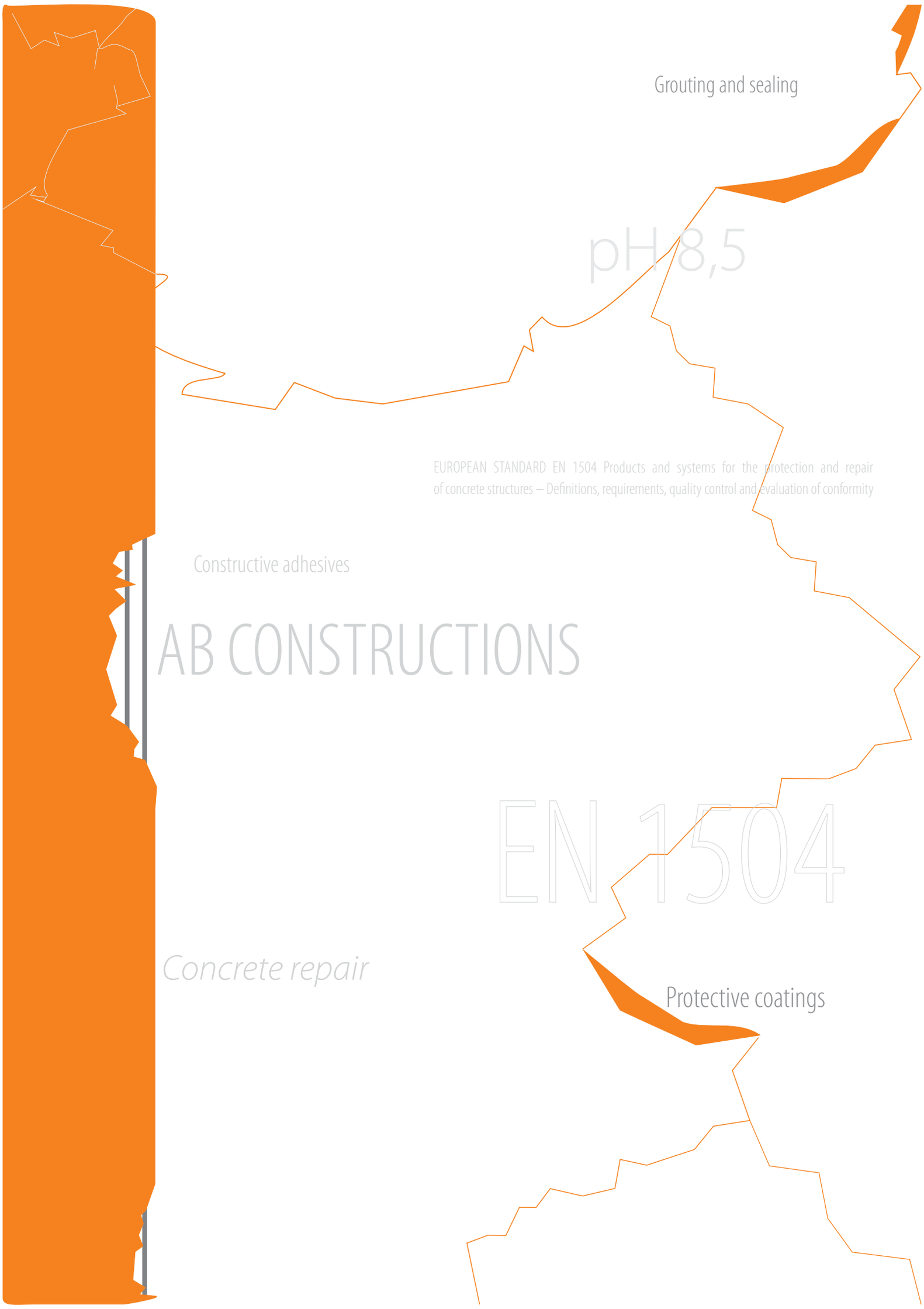
ADING SYSTEM AND TECHNOLOGY FOR REPARATION AND PROTECTION OF REINFORCED CONCRETE STRUCTURES, ACCORDING EUROPEAN STANDARD EN 1504


Grouting and sealing
pH 8,5
EUROPEAN STANDARD EN 1504 Products and systems for the protection and repair of concrete structures – Definitions, requirements, quality control and evaluation of conformity
Constructive adhesives
AB CONSTRUCTIONS
EN 1504
Concrete repair
Protective coatings

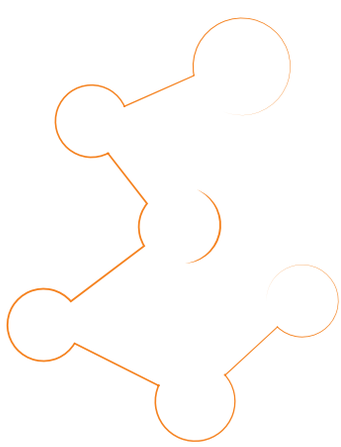
PREFACE

Worldwide expansion of the concrete as the most commonly used structural material in the world, makes need for reparation of concrete structures ewer more present. Concrete structures are regularly being damaged during exploitation, or due to errors in construction.

One of the principle challenges of ADING-s engineering team is finding solutions for problems connected with reconstruction of damaged steel-reinforced concrete structures. Modern day methodology for reconstruction of such structures rely on specialized materials designed according to the latest developments of the internationally recognized norms and standards, also used at the markets where ADING is present with its products.

Proper maintenance as well as frequent and timely reparation of concrete structures is a key factor for extending exploitation period of the objects. According to European standard EN 1504, ADING has adapted its products used for reparation and protection of concrete structures, thus fulfilling special challenges in this specialized field of civil engineering.

Reparation and protection of concrete and steel-reinforces concrete structures depends on relatively complex assessment of the structure condition and exposure, as well as complex reparation design. By introducing and defining key principles for reparation and protection of concrete structures, European standard EN 1504 ease tusk of contemplating the problems, thus finding the most reliable solutions during different phases of the reconstruction process. European Norms EN 1504 incorporates products, systems and practices for reparation and protection of concrete structures, and it is aimed to all parties that take part in the reconstruction process – investors, engineers, contractors, supervisors and producers of construction materials.



CONTENT

1. CONCRETE AS PRINCIPLE CONSTRUCTION MATERIAL

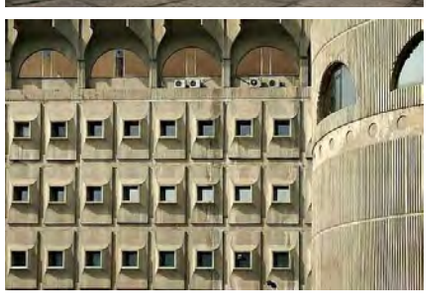
20-th Century will be remembered in history by many revolutionary inventions and their development, which practically brings new quality in the people's life. In construction field, concrete begin to dominate as principle construction material in most civil objects, hydro-technical systems and objects, and infrastructure objects. Intense development of the cement production industry, as well as technology for design and construction using steel-reinforced concrete, contributed that modern day civil engineering cannot be imagined without extended usage of these materials.

Contemporary methods of design and realization of the structures enables construction of objects with more complex forms and bold spans. Design of these structures is relied to the basic principles of steel-reinforce concrete, where interaction between steel and concrete gives load-bearing capacity of the structure. Concrete bears compression stresses and the steel bears the strain in the construction element, whilst the design methods take in consideration their combined action.

In the Sixties, concrete technology was enriched by one more component – the concrete admixtures that contribute to gaining new qualities in characteristics of concrete and concrete structures. By using concrete admixtures, engineers can develop concrete with increased compression and flexural strength, self compacting concrete, waterproofed concrete, etc.

Due to its nature, reinforced concrete is highly stabile and durable material. In time, its strength characteristics increase. At the same time, steel is protected inside concrete and do not change its characteristics. Nevertheless, one must not forget that concrete structures are often exposed to outside aggression, as well as to mechanical damaging.



1.1 BASIC CAUSES FOR DEGRADATION OF CONCRETE STRUCTURES

Exposure of the structures to atmospheric and chemical influences

Concrete is inexpensive, durable, ecological material that offers infinite variety of opportunities for modeling and usage. These characteristics contribute in modern construction concrete and reinforced concrete to be the most widely used materials in the world. Further development of concrete technology is constantly expanding its use, in some cases transforming it to the new and seemingly unrecognizable building material.

Concrete is used in constructions on all continents, in every climate zone, for construction of hydro-technical and engineering objects, facilities for every type of industry, for underground structures, harbor facilities and structures, oil platforms and other objects inside and near the sea.

Such a wide range of usage makes different concrete structures to be exposed to aggressions caused by physical and mechanical influences, atmospheric influences, chemical aggression etc.

**Exposure of the structures to atmospheric and chemical influences*

Long term exposure of the structures build during the last century, as well as possible errors made in the process of the design or construction, inevitably causes damages and degradation of the constructions, thus loss of the functionality of the objects. Furthermore, lack of maintenance during the exploitation of the objects – especially systematic maintenance according to the prearranged project for surveillance and protection of the structure – causes additional degradation of the condition of the structure.

Mistakes in design of the structures

There are many possible causes for damages of the concrete structures. They can be caused by misjudgment in the design of the structure – usually dye to the wrong estimation of the structure behavior (ex. Not including proper expansion joints in the structure, or choosing inadequate construction system), that consequently causes formation of cracks on the object.

Cracks are often caused by uneven consolidation of the foundation of the structure (ex. In the case of building new massive object in the close proximity of existing smaller objects). Such cracks in the concrete enable penetration of aggressive media inside structure, thus causing corrosion of the concrete and steel reinforcement.

** Consequence of uneven consolidation of the foundations of the structure*

Often, damages of the structures are caused by wrong estimation of the mechanical loads on the structure, dynamic loads or vibrations, wind, earthquake, variable hydrostatic pressure or hydro-dynamical influences.

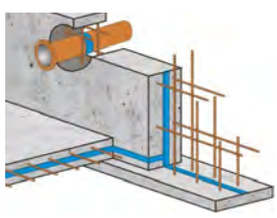
Insufficient determination and planning of the construction (usually caused by short execution period), as well as inadequate choice of materials and technology for building, can also cause mistakes and decreased quality of the structure.

**Consequences of the earthquake in 1995 in Kobe, Japan*

Most common errors in the construction of concrete structures

- Inadequate treatment of the construction joints (brake in concrete placing). Such places during exploitation remain to be "weak links" throe which water and aggressive materials can penetrate inside construction. Similar consequences can occur if the dilatation of the construction is improperly applied and prepared.

*Inadequate treatment of the construction joints

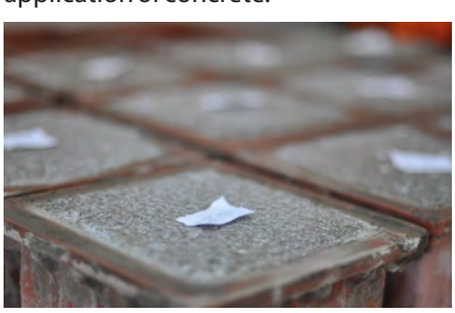


*Treatment of the construction joints

*Consequences of inadequate treatment of the expansion joints of bridge construction

Inadequate quality and performances of concrete.

Casting of concrete with insufficient strength or other performances often happens as a result of inadequate choice of constituencies in concrete (type and quantity of cement, aggregates, admixtures and other additives), incomplete laboratory and industrial testing of concrete, inadequate control of the materials and the process of production and application of concrete.



Segregations or other imperfections during concrete placing.

These problems usually happen as a result of inadequate choice of technology for application of concrete, or due to lack of adaptation of the concrete design to the ambient conditions. Depending on the technology of concrete application (pumping, extrusion, spraying, etc), and the type of the section to be concreted (densely reinforced, narrow or massive section), one need to choose adequate class of consistency of concrete (S1-S5 or SCC).

* Application of concrete with concrete bucket

* Application of concrete with concrete pump

Process of production of concrete also need to be adapted to the type of construction that is being concreted, thus not to let brakes in the concrete casting process (that will cause inadequate joint between concrete layers), as well as not to allow fresh concrete to "wait" in the mixer trucks. In case of prolonged transportation and concreting at high ambient temperatures, concrete design must be adapted using adequate admixtures for concrete (set-retarders and superplasticizers).



** Concrete segregation*

Inadequate curing of fresh concrete.
Inadequate curing can cause formation of cracks in the early phase of concrete setting. This phenomenon is especially common in cases of concreting structures with large surface exposed to sun and wind (high floor slab, bridges, concrete road pavement, etc.) Protection from this type of problem is prevention from rapid loss of water from fresh concrete dye to evaporation. For these purpose number of measures can be applied such as constant dampening with water, covering fresh concrete surface with material that prevents moisture loss (such as PVC foil, geo-textile, and alike), or by using special materials for curing fresh concrete.

** Protection - curing of fresh concrete with Zastita B3*

** Protection of fresh concrete by covering*

1.2 CLASSIFICATION OF THE COMMON CAUSES OF CONCRETE DETERIORATION ACCORDING TO EUROPEAN STANDARD EN 1504 REPARATION AND PROTECTION OF CONCRETE STRUCTURES

As shown in the previous chapter, there are many common causes of concrete deterioration. According to European standard EN 1504 for reparation and protection of concrete structures, negative influences on the concrete structures are classified in two basic groups:

- Defects on concrete
- Defects of steel-reinforced concrete structures caused by corrosion of the steel reinforcement

Common causes of concrete deterioration

MECHANICAL

- Impact
- Overload
- Movement (eg. Settlement)
- Vibration
- Earthquake
- Explosion

CHEMICAL

- Alkali-aggregate reaction
- Aggressive agents (eg. Sulfates, salt, soft water)
- Biological action
- Efflorescence

PHYSICAL

- Freeze/thaw
- Thermal effects
- Salt crystallization
- Shrinkage
- Erosion
- Wear / Abrasion of concrete

*Chemical demage

*Mechanical damage

* Physical demage

Common causes of deterioration of reinforced concrete structure due to steel reinforcement corrosion

Corrosive contamination

- Exposure to chemically aggressive substances (eg. Chlorides from sea water or de-icing salt)

Chemical influences

- Passivisation of the protective layer of concrete dye to carbonation

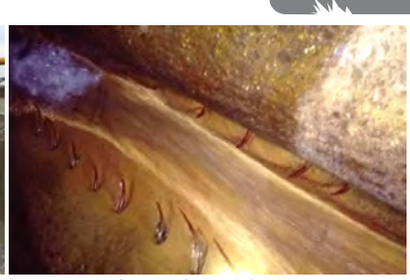
Electro-Chemical influences

Effects caused by electrical current in concrete
- Metals with different electrical potential form electrical circuit throe concrete
- Electrical circuit throe concrete is caused by electrical transmition systems

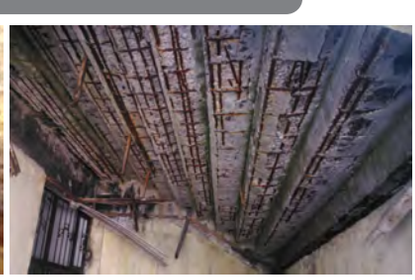
* Electric-chemical corrosion

* Influence of chlorides from sea water

* Combined influence of ice, salt for de-icing and carbonization



* Combined influence of ice, salt for de-icing and carbonization



* Carbonization

1.3 EXPOSURE CLASSES OF CONCRETE STRUCTURES TO ATMOSPHERIC INFLUENCES AND CHEMICAL AGGRESSION

Depending on the purpose of the objects, as well as their location, different steel-reinforced concrete structures can be exposed to different (mostly unfavorable) influences during their exploitation. In order to make a gradation of the intensity of destructive influences to which a structure is exposed, and thus to assess the risk of damage during the exploitation, European standard for concrete *EN 206-1 Concrete-Specification, technical characteristics, production and conformity* defines following exposure classes of the concrete structures to atmospheric influences and chemical aggression:

EXPOSURE CLASSES OF CONCRETE AND REINFORCED - CONCRETE CONSTRUCTIONS	
X0 – NO RISK OF CORROSION OR CHEMICAL ATTACK	
Concrete without reinforcement that is not exposed to ice, salts and chemical attack	
Reinforced-concrete with very dry and secured conditions	Ex. Concrete elements inside buildings with low humidity
XC1 – XC4 CORROSION INDUCED BY CARBONATION	
XC1 – Dry or permanently wet	Concrete permanently submerged in water, objects with low air humidity
XC2 –Wet, rarely dry	Foundation constructions
XC3 –Moderate humidity	External concrete sheltered from rain
XC4 –Cyclic wet and dry	
XD1 – XD3 CORROSION INDUCED BY CHLORIDES OTHER THAN SEA WATER	
XD1 – Moderate humidity	Concrete surfaces exposed to airborne chlorides
XD2 –Wet, rarely dry	Swimming pools ; Concrete exposed to industrial waters containing chlorides
XD3 –Cyclic wet and dry	Parts of bridges exposed to spray containing chlorides
XS1 – XS3 CORROSION INDUCED BY CHLORIDES FROM SEA WATER	
XS1 – Exposed to airborne salt but not in direct contact with sea water	Structures near to or on the coast
XS2 –Permanently submerged	
XS3 –Tidal, splash and spray zones	Parts of marine structures
XF1 – XF4 REEZE/THAW ATTACK WITH OR WITHOUT DE -ICING AGENTS	
XF1 – Moderate water saturation, without deicing agents	Vertical concrete surfaces exposed to rain and freezing
XF2 –Moderate water saturation, with de -icing agent	Vertical concrete surfaces of road structures exposed to freezing and airborne de -icing agents
XF3 – High water saturation, without de -icing agents	Horizontal concrete surfaces exposed to rain and freezing
XF4 – High water saturation, with de -icing agents or sea water	Road and bridge decks exposed to de -icing agents; Concrete surfaces exposed to direct spray containing re-icing agents and freezing Splash zones of marine structures exposed to freezing
XA1 – XA3 CHEMICAL ATTACK	
* Concrete exposed to chemical attack from natural soils and ground water or sea water, with limiting values of concentration of contaminants given in the standard EN 206 -1. For higher concentrations and other chemical aggression it is necessary to plan an additionally study.	

Within the same standard EN 206-1, recommendations are given for the preparation of concrete depending on which class of exposure is categorized. Such recommendations define the minimum requirements for concrete design according to its exposure class which include:

- Minimal strength of the concrete
- Minimal quantity of cement
- Maximum W/C – ratio
- Type of cement
- Contain of entrained air

RECCOMMENDED LIMITING VALUES FOR COMPOSITION AND PROPERTIES OF CONCRETE DEPENDING OF THE EXPOSURE CLASSES

						Chloride-induced corrosion					
	No risk of corrosion or attack	Carbonation-induced corrosion				Sea water			Chloride other than from sea		
Exposure class of concrete	X0	XC1	XC2	XC3	XC4	XS1	XS2	XS3	XD1	XD2	XD3
Max W/C	-	0,65	0,6	0,55	0,5	0,5	0,45	0,45	0,55	0,55	0,45
Min. strength class	C12/15	C20/25	C25/30	C30/37	C30/37	C30/37	C35/45	C35/45	C30/37	C30/37	C35/45
Min. cement content (kg/m^3)	-	260	280	280	300	300	320	340	300	300	320
Min. air content (%)	-	-	-	-	-	-	-	-	-	-	-

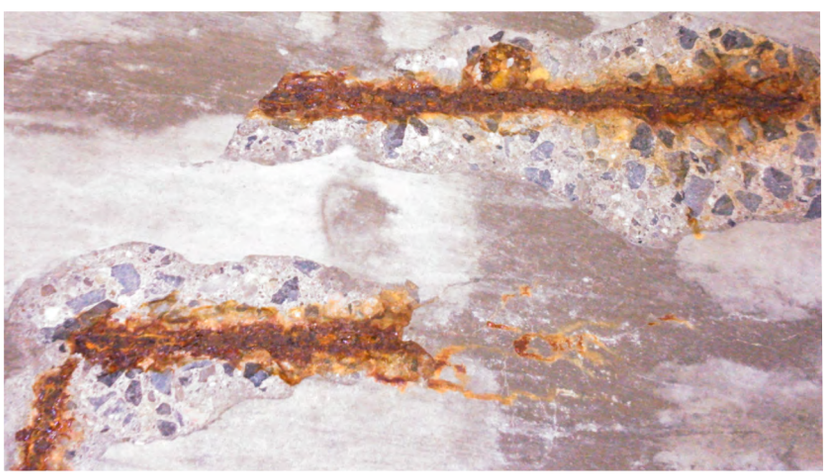
RECCOMMENDED LIMITING VALUES FOR COMPOSITION AND PROPERTIES OF CONCRETE DEPENDING OF THE EXPOSURE CLASSES

	Freeze/thaw attack				Aggressive chemical environments		
Exposure class of concrete	XF1	XF2	XF3	XF4	XA1	XA2	XA3
Max W/C	0,55	0,55	0,50	0,45	0,55	0,50	0,45
Min. strength class	C30/37	C30/37	C30/37	C30/37	C30/37	C30/37	C35/45
Min. cement content (kg/m^3)	300	300	320	340	300	320	360
Min. air content (%)	-	4,0[a]	4,0[a]	4,0[a]	-	-	-
Other requirements	Aggregate in accordance with EN 12620 with sufficient freeze/thaw resistance					Sulfate – resisting cement	

Poor assessment of the degree of chemical aggression to which a structure is exposed inevitably leads to degradation of structures. In such a case, the materials used for repair and protection should also be suitable for use in an environment with the same exposure class as the construction

1.4 CARBONIZATION

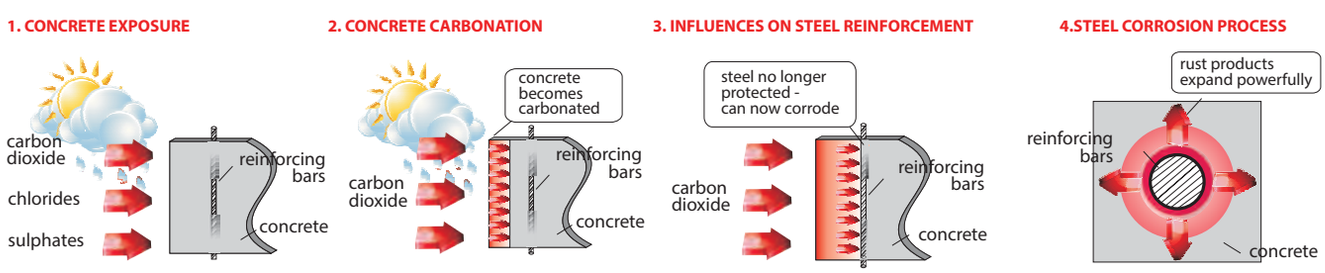
Global climate changes, industrial development, and especially the spread of urban environments are also contributing to changes in environmental aggressiveness- atmospheric pollution with CO_2, sulfates, chlorides, etc. As with humans, this effect is particularly harmful to older buildings that do not provide adequate concrete resistance (impermeability to aggression), which means they do not have sufficient protective layer of the reinforcement. Huge efforts and resources are made in many cities around the world to protect buildings that are of cultural and historical value, and are seriously endangered due to excessive air pollution. Exposure to high concentrations of CO_2, especially in urban areas and road infrastructure (tunnels, bridges) leads to reduction in the alkalinity of the concrete, i.e. the loss of the protective role of the concrete and the occurrence of corrosion of the steel reinforcement. This occurrence is called carbonization.



* Steel reinforcement corrosion, caused by concrete carbonation

Newly formed carbon acid react with alkali calcium hydroxide present in concrete matrix forming insoluble calcium carbonate, in the same time decreasing pH ratio from 12,5 to 8,5.

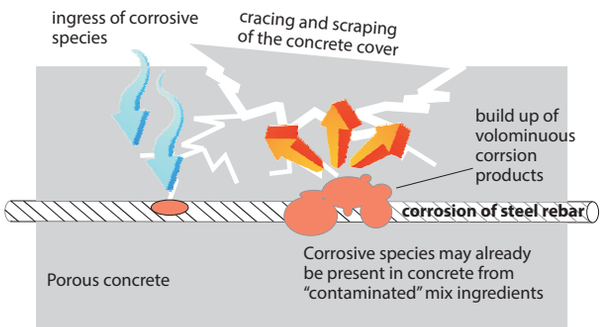
$H_2CO_3+Ca(OH)_2 \rightarrow CaCO_3+2H_2O$

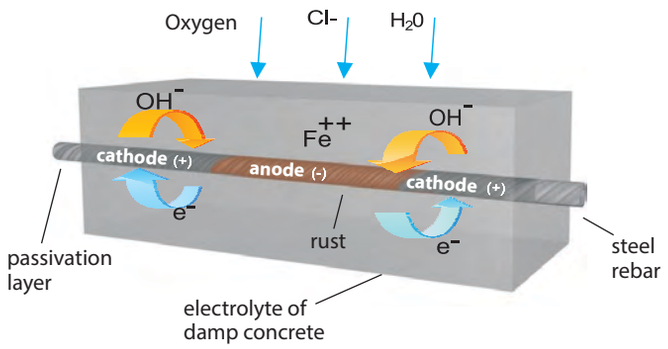


Real treat from carbonation in steel-reinforced structures comes from decreasing of pH ratio of concrete. In environment where pH ratio is lower than 11, steel is exposed to corrosion. Thus, as soon as the carbonation of concrete reaches reinforcement, protective layer around the steel rebar can no longer fulfill its roll and prevent corrosion.
Furthermore, steel rust formed by corrosion process expands - causing stresses to the surrounding concrete, forming cracks in concrete, thus increasing ingress of water even further and subsequently accelerating degradation process.
In protected dry environment, concrete often completely carbonizes without any visible sign of deterioration, exposing steel to air but not to water ingress. Problems occur in cases when concrete is exposed to atmospheric influences, or in moist environment inside objects such as kitchens, bathrooms, production facilities or other environment subjected to condensation, moisture or water.

Exposed concrete facade surfaces are also exposed to carbonation, especially if the protective layer does not have sufficient thickness.
Second negative effect of carbonation is that decreasing alkalinity of concrete increase exposure of reinforcement to corrosion caused by chlorides. Most common cause for these type of corrosion is sodium-chloride (see salt), present in the see water, soil, or used on road pavement and parking places for defrosting in winter period.

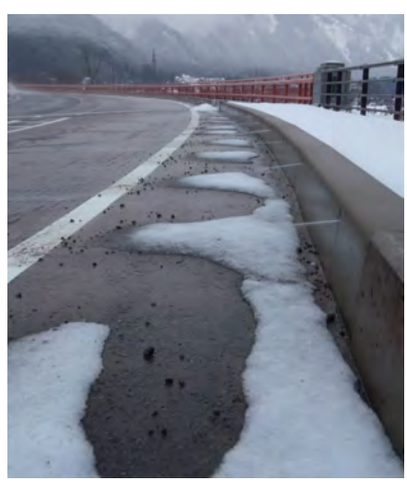
EFFECTS OF THE CONCRETE CARBONATION





1.5 RESISTANCE OF THE CONCRETE TO INGRESS OF WATER AND AGGRESSIVE SUBSTANCES

As can be seen from the classification of concrete exposure classes, the basic medium through which harmful chemicals can enter in the concrete is water. Water often contains dissolved chlorides (e.g. seawater, groundwater or water from roads treated with defrosting salt). Chlorides are extremely unfavorable for concrete and reinforcement steel, causing chemical corrosion. In addition to chlorides, through the water in to the concrete structure can enter sulfates, organic materials, carbonic acid (during carbonization), etc. Additionally, the water itself that enters in to the concrete and freezes can physically disrupt its structure. Pure spring water (so-called "soft water") can chemically dissolve calcium from limestone (aggregate) and degrade concrete.



** Physical-mechanical influence of water on concrete*

By itself, concrete is a hydrophilic material, i.e. it can never be 100% resistant to water penetration. There are two basic mechanisms by which water can penetrate the concrete structure

· Water ingress as a result of hydrostatic pressure
· Water ingress as a consequence of capillary absorption

Water ingress under pressure. Resistance of the concrete to water ingress as a result of hydrostatic pressure depends of the strength of the concrete and its performance. European standard EN 12390-8 Depth of water penetration under pressure, defines the method of testing the impermeability of concrete to water ingress under pressure. This standard determines exposure of the concrete at constant water pressure of 5.0 Bar, lasting 72 hours. It is up to the designers to determine for themselves which water resistance to water ingress meets the requirements for a particular project, of course taking into account the degree of exposure of the concrete in the given construction.



** Testing the resistance of concrete to water penetration under pressure*

In order to illustrate how the different performances of concrete and admixtures affect the resistance of concrete to water penetration under pressure, the results of four different comparative tests are made with different strength classes and four different combinations of concrete admixtures from the production program of ADING. All of the tested samples of concrete are produced with the same type of cement CEM II/A-V 42.5 R. The aggregate is crushed, of limestone origin with a maximum granulation of up to 32mm. Consistence of the concrete is high class S3 and S4 (pumped concrete).

Sample No.	Quantity of cement [kg/m ^{3}]	Plasticizer/Superplasticizer	Water resisting admixture	Consistency Slump	Concrete weight [kg/m ^{3}]	Compressive strength [MPa]	Max. water ingress [mm]
1	360	Fluiding M	/	S3	2364	43,6	35
2	360	Fluiding M	Hidrofob T	S3	2353	46,8	21
3	390	Superfluid 21M EKO	/	S4	2413	58,2	19
4	390	Superfluid 21M EKO	Hidrofob 21	S4	2413	57,3	11

Conclusion: Results from testing show that the resistance of the concrete to water ingress under pressure is influenced by the class of the concrete, quality of application, compactness and homogeneity of the concrete. All this facts contribute for closed structure of the concrete which will reduce the percentage of micro cracks, through which water can penetrate. This effect can be achieved using the admixtures from the group of plasticizers and superplasticizers, which enable reduction of water in the concrete mix, higher strength characteristics and better installation of the concrete. Additionally, using the specialized admixtures for water resisting concrete can achieve higher level of water resistance and closing of the pores.

Capillary absorption of water in concrete. Another way water can penetrate into the concrete is by capillary absorption -transfer of water through a system of capillary cracks present in the concrete. To achieve capillary absorption, it is sufficient for the concrete to be in contact with water or moisture, i.e. it does not have to be influenced by active hydrostatic pressure. Capillary moisture often "climbs" and penetrates in to the parts of the structure that are not in direct contact with water.


**Effect of capillary water absorption in concrete*

**Water-repellent concrete surface*

Similar to the resistance to water penetration under pressure, reduction of the possibility for capillary water absorption in concrete is achieved by producing concrete with high strength characteristics and performances. In addition, use of specialized water resisting admixtures to concrete (Hidrofob T or Hidrofob Fluid), achieves the formation of water-insoluble crystals in the pores of concrete that further enclose its structure.
The most effective way to prevent capillary water absorption in concrete is to use silan-siloxan-based admixtures (Hidrofob 21), which affect the surface tension of concrete elements, acting in such a way that the concrete surface repels water molecules and they cannot penetrate the concrete capillaries. In this way, the concrete surface becomes hydrophobic (water-repellent).
Capillary absorption in concrete is determined according to the standard EN 480-5 Determination of capillary absorption. The amount of water absorbed after 7 days is examined (the test is performed on standard mortar, tested and compared with reference concrete).The specimens are kept in a closed chamber, placed on bars, constantly sunken in water with a height of 2-4 mm. After 7 days, the weight of the samples is measured and the amount of water absorbed is determined.

** Testing of concrete resistance to capillary absorption*

Using the water resisting admixtures for concrete (Hidrofob T, Hidrofob 21, Hidrofob Fluid) reduces the capillary absorption of concrete by at least 50% (up to 70%) compared to reference concrete.

FLUIDING M	**Plasticizer/Set retarder for concrete**
SUPERFLUID 21 M EKO	**Superplasticizer for concrete**
HIDROFOB T	**Water resisting admixture (it closes the pores in the concrete structure)**
HIDROFOB FLUID	**Plasticizer, water resisting admixture (it closes the pores in the concrete structure)**
HIDROFOB 21	**Water resisting admixture (it makes the concrete structure water-repellent)**

A similar effect on forming of water-repellent concrete surfaces (usually during repairs) is achieved by using materials for surface treatment of concrete in accordance with EN1504-2, method 1-hydrophobic impregnation. European standards provide more methods for determining the degree of resistance of capillary water absorption to concrete and other building materials that have an open structure.
Another method used to determine capillary absorption is the Karsten tubes method. According to this method, the volume of water absorbed in a medium over a period of time is examined. The water application is done through a tube (Karsten tube), which is fixed on the surface of the porous material.This method examines various materials which surfaces are treated with hydrophobic impregnation agent (concrete, mortar, natural stone, brick). Depending on the type of substrate, using Fasil B as protective coating for hydrophobic impregnation reduces water penetration from 70 to 100%.

2. EUROPEAN NORMS FOR REPARATION AND PROTECTION OF REINFORCED-CONCRETE STUCTURES EN 1504

In order to systematize and simplify the process of reparation of a particular reinforced concrete construction, in particular to simplify the proper selection of methodology and materials for reparation, the European standard for protection and reparation of concrete structures EN 1504 has been introduced.

Nowadays, European standard EN 1504 is implemented by all 33 members of the European Committee for Standardization (CEN), including Macedonia. In these countries EN 1504 has the status of a national standard, while in over 20 countries in Europe and beyond, these standards are in the process of implementation.

Reparations in general are relatively complex mater that involves large number of professionals from different fields of expertise such as investors, engineers, designers, contractors, highly specialized contractors for specific aspects of constructions, producers of specialized repair and protection materials and supervisors. In all cases of exposure or damage to concrete structures, if it is not reacted in time, there may be a loss of functionality and even a threat to the stability of buildings. Depending on the character of the structure and the degree of its damage, the process of reparation and protection of the structure from further degradation may vary in terms of the degree of complexity and cost. In certain cases, the cost of repairs may exceed the cost of the structure.
Therefore, an essential part of any reparation is to make a proper estimate of the cost price versus the effects of the work performed. Successful reparation can be considered that reparation in which the functionality of the construction is fully restored and further degradation of the construction is prevented. In many cases, achieving this goal is not possible without further strengthening the structure - in order to make up for some of the lost load capacity due to damage. As always, in the case of concrete constructions, it is much better to take measures which will reduce the damage to the constructions, than to repair them.
The development of concrete technology as well as new building materials make it easy and relatively inexpensive to protect structures from the negative impacts they are exposed to during exploitation. In addition, the intensive development of polymer-based building materials also provides great opportunities for application during repairs of damaged concrete structures.

2.1. REPARATION PHASES

European Norm EN 1504 completely defines process of reparation of concrete or reinforce-concrete structure – starting from proper estimation of the condition of the structure (diagnostics), preparing reparation project and design, proper choice of materials and technology for application, quality control of materials and application, determining measures for protection and control of the object in further exploitation.
Schematically presented, Standard EN 1504 includes fallowing phases of reparation:

EN 1504 Phases of concrete reparation and protection process

Information about the structure	Process of assessment of structure condition	Management strategy	Design of repair work	Repair work	Acceptance of repair work
Condition and history of structure - Documentation - Previous repair and maintenance	-Determination of existing defects -Determination of the reasons for an eventually existing defects -Estimation of the condition of the construction	- Options - Principles - Methods - Safety/ structural appraisal during protection and repair	Planed application of materials and technologies. Definition of the conditions: - The substrate - The products - The construction Specification Technical Documentation and drawings	- Choice and use of products and system and method and equipment to be used - Tests of quality control - Health and safety	Testing of the fulfilled work -Reception of documentation -Determination of measures for maintenance

EN 1504

2.2. STRUCTURE OF THE STANDARD EN 1504

European Standard for repair and protection of concrete structures *EUROPEAN STANDARD EN 1504 Products and systems for the protection and repair of concrete structures – Definitions, requirements, quality control and evaluation of conformity,* consist of 10 sections:

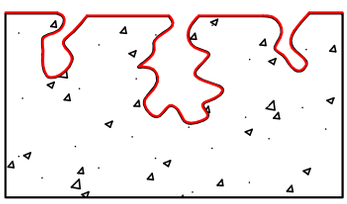
DOCUMENT NO.	DESCRIPTION
EN 1504 - 1	Definitions – Defining the specific terminology used in the standard
EN 1504 - 2	Surface protection systems for concrete
EN 1504 - 3	Structural and non-structural repair
EN 1504 - 4	Structural bonding
EN 1504 - 5	Concrete injection
EN 1504 - 6	Anchoring of reinforcing steel bar
EN 1504 - 7	Reinforcement Corrosion Protection
EN 1504 - 8	Quality control and evaluation of conformity
EN 1504 - 9	General principles for the use of products and systems
EN 1504 - 10	Site application of products and systems, and quality control of the works

2.2.1 **EN 1504-1** Definitions – Defining the specific terminology used in the standard

First chapter of the standard EN 1504-1 defines the specific terminology associated to products and technology for reparation, structural strengthening, protection and maintenance of concrete structures.

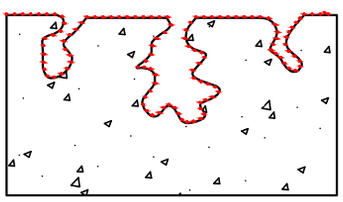
2.2.2 **EN 1504-2** Surface protection systems for concrete

EN 1504-2 is a part of the standard EN 1504 that defines methods for surface protection of concrete - Hydrophobic impregnation, Impregnation, Coating.



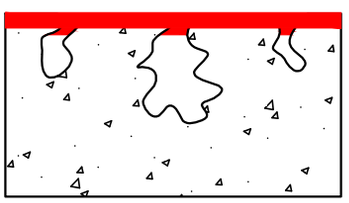
Impregnation

Treatment for reducing permeability and improving the physical and mechanical characteristics of the substrate through partial or complete sealing of pores and forming an intermittent thin film on the surface.



Hydrophobic Impregnation

Treatment applied in order to obtain water-repellent and vapour-permeable surface, whereby the appearance of the surface is not changed at all.



Coating

Forming a continuous uninterrupted layer on the concrete surface with thickness of to 5mm which protects concrete against moisture and aggressive agents, increases the physical and mechanical resistance of the substrate and the resistance against chemical aggression.

Choice of proper material or system for surface protection of concrete is made based on assumption of existing or potential negative influences to the construction. In short, choice is made according to fallowing:

- Estimation of stresses, evaluation of the structural condition and detecting existing damages to the construction, their classification and determination of the causes for the existing problems.
- Based on the conducted evaluation o the structure condition, basic principles for reparation and protection of the structure are determined.
- After the determination of the Reparation and protection principles, proper methods for surface protection are chosen (Hydrophobic impregnation, Impregnation, Coating or combination).
- Depending on the condition of the object and its environment (possible exposure of the structure), adequate protection material or system is chosen, taking in consideration fallowing characteristics of the material/system: liner shrinkage, compression strength, ratio of thermal expansion, resistance to abrasion, adhesion strength, adhesion to moist surfaces, permeability to CO2, water vapor permeability, capillary absorption and water-tightness, resistance to freezing and salt, long term durability, chemical resistance, extreme chemical resistance, crack-bridging ability, resistance to impact, reaction in contact with fire, surface friction (skid-free surfaces), depth of penetration inside concrete, antistatic properties, resistance to chlorides diffusion and other specific properties. In any case, after setting, used systems must not release harmful substances in the environment.

For illustration of the standard EN1504-2, in addition are presented some protection materials produced by company ADING AD Skopje.

MATERIALS FOR SURFACE PROTECTION OF CONCRETE – HYDROPHOBIC IMPREGNATION **EN 1504-2**

FASIL V **Silicon-based material for impregnation of surfaces made of porous materials**

DEKOSIL V **Material for impregnation, care and protection of new and old concrete surfaces**

MATERIALS FOR SURFACE PROTECTION OF CONCRETE – COATING	EN 1504-2
HIDROMAL FLEKS	Two-component, polymer modified, cement-based elastic waterproofing
HIDROMAL FLEKS 1K	One component, elastic waterproofing with fibers based on cement and polymer
ADINGFLEKS	Highly elastic, acrylic based waterproofing
REPARATUR PENETRAT	Pre-coating (primer) used for improving the bond between old and new concrete or cement mortar
ANTIKOROZIN BB	Acrylic -based anti-corrosive colored coating for protection of concrete surfaces
ANTIKOROZIN BR	Protective colored coating for concrete surfaces based on synthetic resin and solvent based
ADINGPOKS 1B	Epoxy colored coating for protection and decoration of concrete walls
ADINGPOKS 1BP	Epoxy colored coating for protection and decoration of concrete floor surfaces
ADINGPOKS 1	Low viscosity, two component, solvent free epoxy resin used as transparent final coating or for preparation of epoxy mortar
ADINGPOKS 2	Two component self-leveling epoxy floor system
ADINGKOLOR RF	Final coating for concrete and asphalt substrates, based on synthetic resins and solvents
ADINGPOKS AKVA	Epoxy-cement based coating/mortar for reparation and surface protection

MATERIALS FOR SURFACE PROTECTION OF CONCRETE – IMPREGNATION	EN 1504-2
DEKOSIL	Transparent final coating (lacquer) and methacrylate based primer

2.2.3 **EN 1504-3** Materials and systems for structural and non-structural reparation

EN 1504-3 is a part of the standard EN 1504 that specifies requirements for performances of repair mortars and concrete used for reparation and/or replacement of damaged/degraded concrete and reinforcement protection.
Reparation materials are used in order to restore functionality and to extend exploitation period of damaged concrete structure. Basic methods for reparation and protection of concrete structures are:
- Recasting with concrete
- Hand-applied mortar
- Spraying concrete or mortar

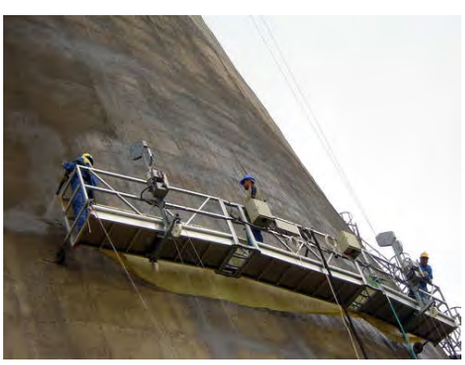
**Repair of reinforced concrete column by recasted with self-leveling ready concrete Eksmal 4*





**Hand repaired concrete with Reparatur Malter F*

When choosing a material for reparation, it is necessary to take into account following characteristics in order for the material to correspond to the existing construction and operating conditions: compressive strength, substrate adhesion, volume stability, carbonization resistance, thermal compatibility, module of elasticity, waterproofing. At the same time, it is necessary to choose the right type of bonding material that will allow achieving a durable structural bonding with the existing structure. Depending on the application method, material (reparation mortar) needs to have adequate open workability time in order to be properly applied by required application method.
Furthermore, methodology for application must be appropriate for specific position-horizontal surface, vertical surface, sealing or irregular - spherical surface. In its production program, the company ADING offers several products and systems for structural and non-structural reparation of concrete constructions, certified according to the European standard EN 1504-3.


** Recasting of concrete by spraying with Reparatur Malter FS*

MATERIALS FOR STRUCTURAL AND NON-STRUCTURAL REPARATION	EN 1504-3
EKSMAL 1	Ready-mix, self leveling grout, with compensated shrinkage. Used for grouting of sections with thickness 5 to 20 mm
EKSMAL 4	Ready-mix self leveling grout, with compensated shrinkage. Used for grouting of section with thickness above 20 mm
REPARATUR MALTER F1	Cement-polymers based mortar, used for reparations of concrete in layers 0,3-0,7 cm thick, with compensated shrinkage and reinforced with polypropylene fibers
REPARATUR MALTER F2	Cement-polymers based mortar, used for reparations of concrete in layers 0,7-1,5 cm thick, with compensated shrinkage and reinforced with polypropylene fibers
REPARATUR MALTER F4	Cement-polymers based mortar, used for reparations of concrete in layers 1,0-2,0 cm thick, with compensated shrinkage and reinforced with polypropylene fibers
REPARATUR GLET	Cement-polymers based leveling compound for concrete surfaces and repaired concrete surfaces
REPARATUR MALTER FS	One-component, cement-based, microfiber reinforced system for repair of concrete and reinforced-concrete structures, intended for mechanical application by spraying (shotcrete application)

2.2.4 **EN 1504-4** Materials and systems for structural bonding

EN 1504-4 is part of the standard EN 1504 that specifies requirements for identification, performances and safety of products and systems to be used for structural bonding of strengthening materials to existing concrete structure. Concrete reparation – strengthening according to EN1504-4 includes:
- The bonding of external plates of steel or other suitable materials (e.g. fibre-reinforced composites) to the surface of a concrete structure, including laminating of plates in such applications.
- The bonding of hardened concrete to hardened concrete typically associated with use of precast units in repair end strengthening.
- Casting of fresh concrete on hardened concrete using an adhesive bonded joint where it forms a part of the structure and is require to act compositely.

Choice of proper material or system for structural bonding is carried out based on fallowing performances:
- Possibility for application on horizontal surfaces, vertical surfaces or by injection under pressure (these performances depend on viscosity and tixotrophy of the material).
- Possibility for application on moist surfaces
- Possibility for application on extreme ambient temperatures (positive or negative).
- Possibility for application on different substrates (steel plates, stainless steel plates, hardened concrete, fresh concrete).
- Durability to exposure to thermal cycling or worm-moist environment
- Open workability time, compression strength, share strength, glass-transition temperature (temperature on which solid material (glass) change in to semi-molten state (like rubber) – this temperature is always lower than melting temperature), thermal expansion ratio, shrinkage.

* For illustration of the standard EN1504-4, in addition are presented some protection materials produced by company ADING AD Skopje. More information about concrete protection materials are presented in the chapter No3.

ADINGPOKS N

Three-component material based on epoxy-resin (reactive binder) suitable for use on moist concrete surfaces. Achieves excellent strength characteristics and adhesion to the substrate from concrete, or to fresh concrete. Adhesion strength is so high that it regularly exceeds tensile strength of concrete and failure in pull-off testing occurs in concrete (not the bonding agent).

2.2.5 **EN 1504-5 Materials and systems for injection**

EN 1504-5 is part of the standard EN 1504 that specifies performances of materials used for reparation and protection of concrete structures that are applied by injection. Injection is a procedure for the application of reparation material in a certain medium (concrete, rock mass, incoherent soil) by applying increased pressure and with the help of application packers. Contrary to injection, grouting is application of reparation materials without applying pressure (only by gravity).
By applying injection/grouting, the pores and cracks in the concrete structure are closed, or the space between the concrete and the soil or the rocks in the excavated structures, tunnels, foundations, etc. In this way, water-tightness of the structure is increased, prevents ingress of aggressive media that can cause corrosion of steel reinforcement, consolidates structure and strengthens the structure. By injecting into incoherent soil, consolidation can be achieved.
For different purposes in the construction, different types of repair materials are injected:

- Protection of the structure from further degradation by filling the crack and preventing the ingress of water and aggressive substances. For this purpose, elastic and ductile materials are usually used, which have the ability to deform and accept the dilatations of the structure. Materials which are used are based on reactive resins (mostly acrylic and polyurethane).

PUR-O-CRACK

Elastic polyurethane-based material used for water-tight filing of cracks and waterproofing of concrete structures. Material is highly ductile and it can adapt to the structure dilatations. PUR-O-CRACK has low viscosity and it is applied by injection under pressure.

-Preventing active water ingress in the structure. In cases where water penetrates under pressure through the cracks in the construction, the "usual" repair materials cannot be used because the water that enters the construction "washes" the repair material and does not allow it to set. For this purpose, materials that have extremely short setting time (a few seconds) are applied, as well as materials that expand in contact with water closing the crack and preventing water penetration. Materials based on polyurethane reactive resins are commonly used for this purpose.

PUR-O-STOP	Elastic polyurethane-based material used for instant prevention of active water penetration throe concrete structures. In contact with water PUR-O-STOP expands, thus it prevents water ingress. it is applied by injection under pressure directly in the water-bearing crack

- Structural repair by filling cracks with rigid material that can withstand stresses. In this way, part of load-bearing capacity of the structure is restored, which was lost with the occurrence of cracks. Materials with high strength characteristics and elastic modulus are used for this purpose. They can be based on cement emulsion, as well as on reactive resins (usually epoxy and polyurethane). These types of injection materials - especially cement-based materials and admixtures - are commonly used to improve soil and rock mass, injecting anchors into tunnel construction and other geotechnical projects, and injecting for protection of pre-stressed tendons.

PRODUCTS-MATERIALS AND SYSTEMS FOR INJECTION	EN 1504-5
ADINGPOKS I	Low viscosity, solvent free, two-component epoxy resin - based compound for injection and grouting
INJEKTING K	Admixture for cement injection grouts, grouts for prestressing tendons and mixtures for grouting and repair
INJEKTING K2	Admixture for cement injection grouts, grouts for prestressing tendons and mixtures for grouting and repair

When choosing a suitable product for injection, and depending on the purpose of the injection, following material characteristics should be taken into account: strength characteristics and modulus of elasticity, ductility, adhesion, elasticity, volume stability, viscosity, time of reaction, etc.

**Repair of crack in reinforced concrete slab, by injecting with Adingpoks I*

2.2.6 EN 1504-6 Anchoring reinforcing steel bars

EN 1504-6 is a part of the standard EN 1504 that specifies requirements for performance of the materials used for anchoring reinforcing steel bars in existing concrete structure, which will provide its structural strengthening and continuity of the steel reinforcement. Additionally, specialized materials are used for anchoring in tunnel constructions.

EN 1504-6 Anchoring reinforcing steel bars

EKSMAL 1	*Ready-mix self leveling grout, with compensated shrinkage. Used for structural reparation and steel anchor grouting.*
ADINGPOKS 1	*Low viscosity, solvent free, two-component epoxy resin-based compound for injection and grouting*
KOMPLEKSING AM	*One-component rapid setting powdery mixture for grouting anchors*

** Grouting anchors with Eksmal 1*

2.2.7 EN 1504-7 Reinforcement corrosion protection

EN 1504-7 is part of the standard EN 1504 that specifies requirements for identification and performance of the materials used for active and barrier coatings for protection from corrosion of existing uncoated steel reinforcement in concrete structure repair.

REPARATUR PENETRAT	*Ready-mix material based on cement and polymers used for active protection of steel reinforcement from corrosion*

**Applying Reparatur Penetrat*

2.2.8 **EN 1504-8** Quality control and evaluation of conformity

This part of the standard is especially dedicated to producers of reparation and protection materials, as well as to the institutions that test and approved such products. EN 1504-8 defines procedures for quality control, evaluation of conformity, "CE" labeling of the products. According to the standard, "CE" label must contain following information about product:

CE
2032

ADING AD Skopje
Novoselski pat (ul.1409) br.11,
1060 Skopje, R.North Macedonia
11
2032-CPR-11.5

EN 1504-3
EKSMAL - 4
Concrete repair product for structural repair CC mortar (based on hydraulic cement)

Compressive strength:	**class R 4**
Chloride ion content:	**≤ 0,05 %**
Adhesive bond:	**≥ 2,0 MPa**
Carbonation resistance:	**Passes**
Elastic modulus:	**≥ 20 GPa**
Thermal compatibility, part 1:	**≥ 2,0 MPa**
Capillary absorption:	**≤ 0,5 kg·m^{-2}·h$^{-0.5}$**
Reaction to fire:	**Euroclass A1**

- "CE"- label Identification number of notification body
- Name and identification number of the producer
- Year of certification
- Number of the certificate
- Number of the specific part of the standard
- Product description
- Product performances

2.2.9 **EN 1504-9** Principles and methods for protection and repair of concrete structures

EN 1504-9 PRINCIPLES AND METHODS FOR PROTECTION AND REPAIR OF CONCRETE STRUCTURES			
PRINCIPLE	**Relevant part of EN 1504**	**Examples of methods based on the principles**	**ADING Materials**
PRINCIPLES AND METHODS RELATED TO DEFECTS IN CONCRETE			
Principle 1 Protection against ingress	2	Hydrophobic impregnation	FASIL V
	2	Impregnation	DEKOSIL V
	2	Coating	HIDROMAL, HIDROMAL FLEKS, HIDROMAL FLEKS 1K, ADINGFLEKS, ANTIKOROZIN BB, ANTIKOROZIN BR, ADINGPOKS 1, ADINGPOKS 2, ADINNGPOKS 1B, ADINGPOKS 1BP, ADINGPOKS AKVA, ADINGKOLOR RF, DEKOSIL
		Surface bandaging of cracks	PROOFMATE-FD Foil, ADING BUTYL TAPE
	5	Filling of cracks	ADINGPOKS I, PUR-O-STOP, PUR-O-CRACK, RUBBERTITE
		Transferring cracks into joints	ADINGAKRIL, FIX-O-FLEX, PROOFMATE-EK, PUR-O-CRACK
		Erecting external panels	STIROKOL P, ADINGPOKS Sh, ADINGPOKS K
		Applying membranes	ADINGFLEKS, FIX-O-FLEX, HIDROMAL FLEKS 1K, ADINGPOKS 1, ADINGPOKS 2, ADINNGPOKS 1B, ADINGPOKS 1BP, ADINGPOKS AKVA
Principle 2 Moisture control	2	Hydrophobic impregnation	FASIL V
	2	Impregnation	DEKOSIL V
	2	Coating	HIDROMAL, HIDROMAL FLEKS, HIDROMAL FLEKS 1K, ADINGFLEKS, ANTIKOROZIN BB, ANTIKOROZIN BR, ADINGPOKS 1, ADINGPOKS 2, ADINNGPOKS 1B, ADINGPOKS 1BP, ADINGPOKS AKVA, ADINGKOLOR RF, DEKOSIL
		Erecting external panels	PROOFMATE-FD Foil, ADING BUTYL TAPE
		Electrochemical treatment	/
Principle 3 Concrete restoration	3	Hand-applied mortar	REPARATUR MALTER F, REPARATUR GLET, ADINGPOKS AKVA
	3	Recasting with concrete or mortar	EKSMAL
	3	Spraying concrete or mortar	ADINGPOKS AKVA, REPARATUR MALTER FS
		Replacing elements	ADINGPOKS K, ADINGPOKS N
Principle 4 Structural strengthening		Adding or replacing embedded or external reinforcing bars	/
	6	Adding reinforcement anchored in pre-formed or drilled holes	EKSMAL, ADINGPOKS 1, KOMPLEKSING AM
	4	Bonding plate reinforcement	ADINGPOKS K, ADINGPOKS N, ADINGPOKS Sh
	3, 4	Adding mortar or concrete	EKSMAL, REPARATUR MALTER F/FS, ADINGPOKS AKVA MORTAR Structural adhesives: AINGPOKS N
	5	Injecting cracks, voids or interstices	ADINGPOKS I, PUR-O-CRACK
	5	Filling cracks, voids or interstices	ADINGPOKS I, PUR-O-CRACK, EKSMAL
		Prestressing - (post tensioning)	/
Principle 5 Increasing physical resistance	2	Impregnation	DEKOSIL V
	2	Coating	HIDROMAL, ADINGPOKS 1, ADINGPOKS 2, ADINPOKS 1B, ADINGPOKS 1BP, ADINGPOKS AKVA, DEKOSIL
	3	Adding mortar or concrete	EKSMAL, REPARATUR MALTER F/ FS, ADINGPOKS AKVA
Principle 6 Resistance to chemicals	2	Impregnation	DEKOSIL V
	2	Coating	ADINGPOKS 1, ADINGPOKS 2, ADINPOKS 1B, ADINGPOKS 1BP, ADINGPOKS AKVA, DEKOSIL
	3	Adding mortar or concrete	ADINGPOKS AKVA

EN 1504-9 PRINCIPLES AND METHODS FOR PROTECTION AND REPAIR OF CONCRETE STRUCTURES

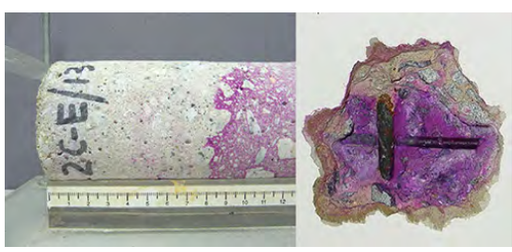
PRINCIPLE	Relevant part of EN 1504	Examples of methods based on the principles	ADING Materials
PRINCIPLES AND METHODS RELATED TO REINFORCEMENT CORROSION			
Principle 7 Preserving or restoring passivity	3	Increasing cover with additional mortar or concrete	EKSMAL, REPARATUR MALTER F/FS
	3	Replacing contaminated or carbonated concrete	EKSMAL, REPARATUR MALTER F/FS, Structural adhesives: AINGPOKS N
		Electrochemical realkalisation of carbonated concrete	/
	5	Realkalisation of carbonated concrete by diffusion	/
		Electrochemical chloride extraction	/
Principle 8 Increasing resistivity by limiting moisture content	2	Hydrophobic impregnation	FASIL V
	2	Impregnation	DEKOSIL V
	2	Coating	HIDROMAL, HIDROMAL FLEKS, HIDROMAL FLEKS 1K, ADINGFLEKS, ANTIKOROZIN BB, ANTIKOROZIN BR, ADINGPOKS 1, ADINGPOKS 2, ADINNGPOKS 1B, ADINGPOKS 1BP, ADINGPOKS AKVA, ADINGKOLOR RF, DEKOSIL
Principle 9 Cathodic control		Limiting oxygen content (at the cathode) by saturation or surface coating	/
Principle 10 Cathodic protection		Applying an electrical potential	/
Principle 11 Control of anodic areas	7	Active coating of the reinforcement	REPARATUR PENETRAT
	7	Barrier coating of the reinforcement	ANTIKOROZIN E
		Applying corrosion inhibitors in or to the concrete	/

2.2.10 EN 1504-10 Site application of products and systems, and quality control of the works.
Last part of the standard EN 1504 gives requirements for substrate requirements before and during application including structural stability, storage, the preparation and application of products and systems for the protection and repair o concrete structures including quality control, maintenance, health and safety, and the environment.

2.3 Reparation project includes five basic sections:

- Analyze and determination of causes for structure damages and conditions.
- Determination of adequate principles for protection of concrete structure according to EN 1504, as well as selecting proper methods for restoring structures stability and functionality of the object.
- Selection of proper materials and systems for reparation/protection of concrete structures, as well as methodology for application.
- Defining methodology for substrate preparation in order to achieve required durability and effect from the materials/system for reparation and protection of concrete and reinforcement.
- Defining systems for safety during reparation works and for environmental protection.






1. Analyze and determination of causes for structure damages and condition
There are numerous methods for determining structure condition divided in three groups:
- Non-destructive methods that are based on visual assessment of the condition of the concrete surface, locating possible cracks, exposed reinforcement and its condition, damaged or degraded surfaces.
-Tests based on chemical analyzing in order to determine level and depth of carbonation process, chlorides content, etc.
-Invasive methods involving drilling of concrete cores in order to determine concrete strength characteristics, as well as level and depth of degradation processes.

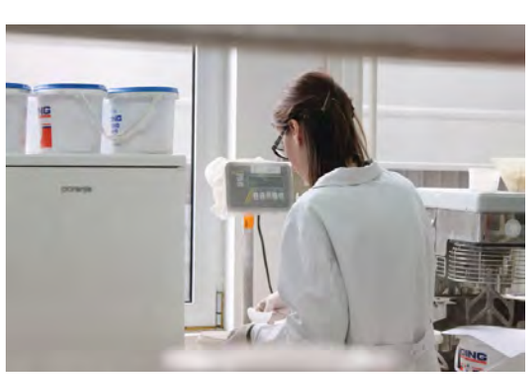
2. Determination of reparation and protection methods for restoring structures stability and functionality of the object. Depending on the results from testing of concrete structure condition, extend and level of concrete and reinforcement degradation, appropriate principles and methods are chosen for reparation and protection of the structure in regulation with EN 1504-9 in order to get a successful reparation.

3. Concrete and steel reinforcement substrate preparation. Standard EN 1504 classifies methods for preparation of concrete substrate and steel reinforcement for reparation.- Concrete substrate preparation:
Complete volume of degraded or damaged concrete must be removed until solid substrate is exposed. Process of removal includes multiple methods such as hydro-demolition, sand-blasting, mechanical demolition, etc.
- Steel reinforcement preparation:
All degraded or unstable concrete parts that surrounds steel reinforcement must be removed. Existing and new steel reinforcement must be cleaned from all traces of corrosion and pollution.
It is desirable to protect it by applying an anticorrosive coating in accordance with EN 1504-7. The newly laid layer of concrete or repair mortar, as well as the surface protection materials must of course provide protection of the reinforcement during further exploitation.



4. Selection of proper materials and systems for reparation/protection of concrete structure, methodology for application.
At the very beginning of the reparation process, engineers must estimate field conditions and available resources – available products, skilled workers, tools and equipment. Concerning concrete reparation, appropriate materials are chosen according to substrate condition and required adhesion strength, available equipment for hand and mechanical application, concreting, using ready-mix mortar, curing on newly-applied reparation materials, cracks reparation, expansion joins, anchoring injection. Concerning steel reinforcement, materials are chosen for corrosive protection of existing and new rebar.

5. Quality control and environmental protection.
During the realization of the project, complete reparation process must be supervised. Supervision includes testing substrate condition, quality control of the applied materials, quality control of the application works, fulfilling measures for safety during work, and finally control if condition of the structure after reconstruction if it is fulfilling requirements from the reparation design and the investor requirements.

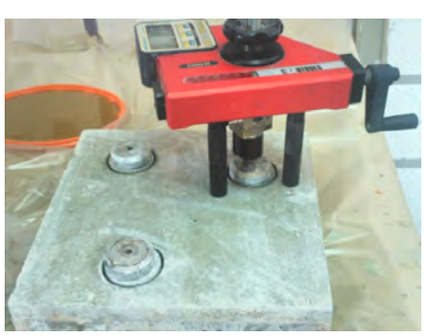

3. ADING – PRODUCTS AND SYSTEMS FOR REPARATION AND PROTECTION OF CONCRETE STRUCTURES - ACCORDING TO THE STANDARD EN 1504

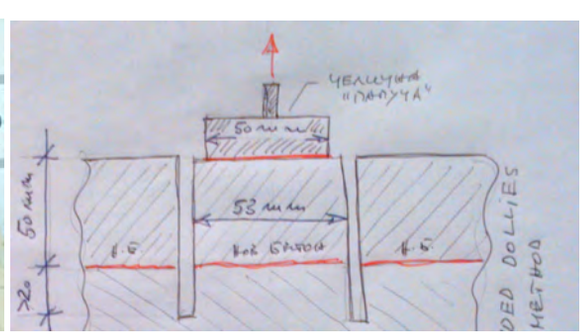
EN 1504-2	
HIDROFOB 21	*Silane-siloxane based material for hydrophobic impregnation of concrete surfaces*
FASIL V	*Silane-based solution without solvents, for waterproof impregnation*
ADINGPOKS AKVA	*Epoxy-cement based coating/mortar for reparation and surface protection*
ADINGPOKS 1P	*Low-viscosity two component epoxy based primer. Used for impregnation of porous concrete surfaces.*
ADINGPOKS 1PV	*Low-viscosity two component epoxy based primer. Used for impregnation of porous concrete surfaces. Used for moist surfaces.*
ADINGPOKS 1P EKO	*Low-viscosity two component epoxy based primer. Used for impregnation of porous concrete surfaces. Solvent-free.*
ADINGPOKS 1B EKO	*Two component epoxy based material. Used for coating of exposed and damaged concrete surfaces. Solvent-free.*
ADINGPOKS 1 EKO	*Two component epoxy based material. Used for transparent coating of exposed and damaged concrete surfaces and preparation of epoxy-based reparation mortars. Solvent-free.*
ADINGPOKS 2 EKO	*Self-leveling epoxy based material. Used for coating of exposed and damaged concrete surfaces. Solvent-free.*
ADINGSTATIK	*Electrically conducive epoxy based coating material.*
HIDROMAL FLEKS	*Two component material based on cement and polymers. Used for waterproofed coating of exposed and damaged concrete surfaces.*
HIDROMAL FLEKS 1	*Two component material based on cement and polymers. Used for waterproofed coating of exposed and damaged concrete surfaces. High elasticity and performances.*
ADINGFLEKS	*High elasticity acrylic-based waterproofing coating.*
ANTIKOROZIN S	*One component material based on cement and polymers. Used for waterproofed coating of exposed steel and concrete surfaces.*
ADINGPOKS TER	*Two component epoxy and tar based material. Used for coating of highly-exposed concrete surfaces.*
ANTIKOROZIN BB	*Anticorrosive protection coating, based on water-dispersion. Used for protection of exposed and repaired concrete surfaces. Solvent-free.*
ANTIKOROZIN BR	*Anticorrosive protection coating, based on synthetic resin and solvents.*
ADINGMARKER	*High-durability protection coating, acrylic-based. Used for protection and marking of exposed concrete and asphalt surfaces. Solvent-free.*
ADINGMARKER P	*High-durability protection coating, based on synthetic resin and solvents. Used for protection and marking of exposed concrete and asphalt surfaces.*
ADINGMARKER RF	*Protection coating, based on synthetic resin and solvents. Used for protection and marking of exposed concrete and asphalt surfaces.*
DEKOSIL	*Transparent impregnation material, based on synthetic resin and solvents. Used for protection and surface stabilization of exposed concrete surfaces.*

EN 1504-3 - Products and systems for constructive and unconstructive reparation	
EKSMAL 1	*Ready-mix, self-leveling reparation mortar with compensated shrinkage, used for structural reparation – grouting of sections with thickness 5-20mm. (Strength class R4)*
EKSMAL 4	*Ready-mix, self-leveling reparation mortar with compensated shrinkage, used for structural reparation – grouting of sections with thickness above 20mm. (Strength class R4)*
REPARATUR MALTER F1	*Cement-polymer based reparation mortar, PP-fibers reinforced, with compensated shrinkage, used for structural reparation of concrete structures with thickness 3-7mm. (Strength class R3)*
REPARATUR MALTER F2	*Cement-polymer based reparation mortar, PP-fibers reinforced, with compensated shrinkage, used for structural reparation of concrete structures with thickness 7-15mm. (Strength class R3)*
REPARATUR MALTER F4	*Cement-polymer based reparation mortar, PP-fibers reinforced, with compensated shrinkage, used for structural reparation of concrete structures with thickness 10-20mm. (Strength class R4)*
REPARATUR GLET	*Cement-polymer based material, used for surface skimming of repaired concrete surfaced*
REPARATUR MALTER FS2	*Cement-polymer based fast setting reparation mortar, PP-fibers reinforced, with compensated shrinkage, used for structural reparation of concrete structures with thickness up to 20mm. Applied by shotcreting (Strength class R4)*
REPARATUR MALTER FS4	*Cement-polymer based fast setting reparation mortar, PP-fibers reinforced, with compensated shrinkage, used for structural reparation of concrete structures with thickness up to 40mm. Applied by shotcreting (Strength class R4)*
HIDROMAL	*Ready-mix cement based concrete waterproofing and protection material*

EN 1504-4 - Products and systems for structural bonding	
ADINGPOKS N	*Epoxy adhesive without solvents, for a bond between old and new concrete*
ADINGPOKS K	*Three-component epoxy sealant without solvents*
ADINGPOKS Š	*Tree-component fast-binding epoxy adhesive with excellent adhesion*

EN 1504-5 - Products and systems for grouting	
ADINGPOKS I	*Epoxy adhesive without solvent, for a bond between old and new concrete*
INJEKTING K	*Admixture for cement-based grouting mixtures, mixture for grouting of prestressing tendons and mixtures for grouting and reparation*
INJEKTING K2	*Admixture for cement-based mixtures, mixture for grouting of presstressing tendons and mixtures for grouting and reparation*
PUR-O-CRACK	*Elastic material of polyurethane-base, used for sealing of cracks in constructions and provides waterproofing*
PUR-O-STOP	*Elastic material of polyurethane-base, used for preventing further penetration of water through cracks in constructions and provides waterproofing*
RUBERTITE	*Elastic three-component acrylic gel for grouting*





EN 1504-6 - Anchoring steel reinforcement	
EKSMAL 1	*Ready-mix, self-leveling reparation mortar with compensated shrinkage, used for structural reparation – grouting of sections with thickness 5-20mm. (Strength class R4)*
ADINGPOKS I	*Epoxy-resin based injection material suitable for application by injection under pressure. Used for structural repairs.*
KOMPLEKSING AM	*One-component fast setting cement based material for grouting*

EN 1504-7 Protection of corrosion of steel reinforcement	
REPARATUR PENETRAT	*Pre-coating (primer) used for improving the bond between old and new concrete or cement mortar*
ANTIKOROZIN E	*Two-component, solvent-free epoxy coating used for protection of steel surfaces*



3.2 ADING SYSTEMS FOR REPARATION AND PROTECTION OF CONCRETE STRUCTURES

Usually, because of the complexity of the reparation works, materials for reparation and protection are used as a system. In cases like these, it's also better to prove the functionality as a system.

3.2.1 SYSTEMS FOR PROTECTION OF PEDESTRIAN SIDEWALKS ON BRIDGES AND OTHER EXPOSED CONSTRUCTIONS

Ading's systems for protection of pedestrian roads are based on coatings of epoxy and methacrylate base. Systems like these additionally protect the surface of concrete so it can be resistant to slippery, and are used as a final coating on surfaces with standard signalization colors. This system protects the concrete that is exposed to:

* Mechanical impacts: pedestrian traffic, bicycle traffic, medical wheelchair etc.
* Aggressive physical and chemical impacts
* Atmosphere impacts on horizontal surface: rain, snow, ice, direct exposure of sun rays and UV radiation.
* Direct exposure of ice and salts.
* Exposure of carbonation

In accordance to the required protective effect of the system, the degree of exposure of the construction, type of construction and risk of occurrence of cracks, there are two certified systems for designing pedestrian roads.

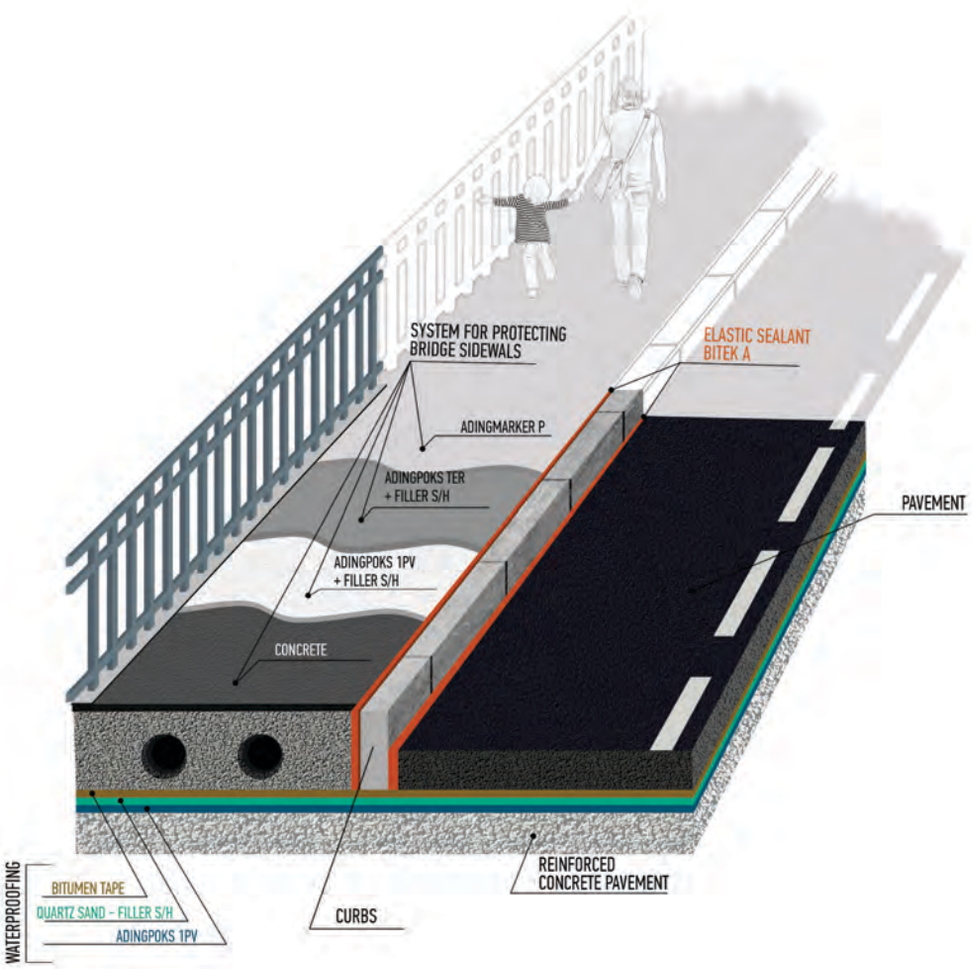
Structure and type of systems for finishing of pedestrian roads:

System 1 – Basic system

- Epoxy primer Adingpoks 1PV – one layer
- ·Quartz sand – Filler C/X (0.3-0.8mm)
- Methacrylate final coating Adingkolor RF – two layers

System 2 – Full system

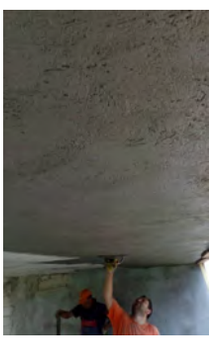
- Epoxy primer Adingpoks 1PV
- Quartz sand – Filler C/X
- Coating – skim coating of tar and epoxy base Adigpoks TER
- Quartz sand Filler C/X (0.3-0.8mm)
- Methacrylate final coating Adingkolor RF – two layers

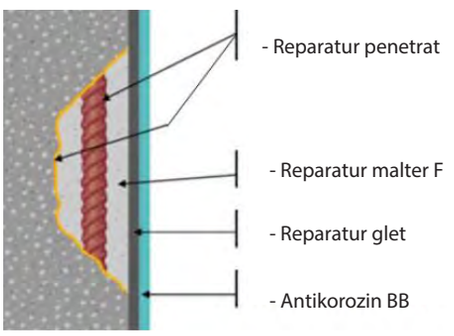


3.2.2. ADING SYSTEM FOR PROTECTION OF REINFORCED CONCRETE BRIDGE CONSTRUCTIONS

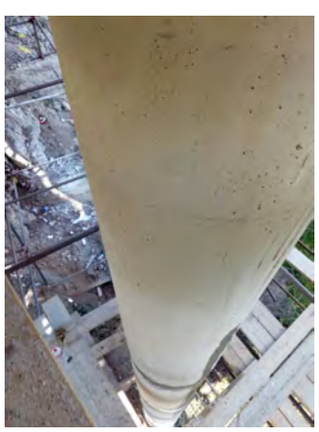
Because its function, bridges and other construction of similar road infrastructure (viaduct, overpass etc.) are exposed to intense physical and mechanical impacts, carbonation, impact from ice, salts and other chemical impacts. For protection, Ading has designed different systems for reparation and protection of some specific parts of bridge constructions.









- Protection against corrosion for reinforcement – REPARATUR PENETRAT;
- Primer for bond between old-new concrete – ADINGPOKS N;
- Mortar for structural reparations – REPARATUR MALTER F or EKSMAL;
- Final coating for protection from carbonation and impacts from ice and salts. Depending on the aggression, number of materials for final coating can be used:
ANTIKOROZIN BB, ANTIKOROZIN RB, ADINGPOKS AKVA and ADINGPOKS 1B.



** Protection of AB bridge structures from the action of carbonation ANTICOROSINE BB*

3.2.3 SYSTEMS FOR WATERPROOFING OF BRIDGES

Experience show that the deficit or poorly applied waterproofing materials are a common cause for occurrence of damages of bridge constructions. Ading offers systematical solution for installing waterproof materials of bridges under the road construction. The system for waterproofing contains an epoxy coating – Adingpoks 1B/Adingpoks 1PV with the layer of quartz sand. Bitumen tracks for waterproofing are installed above the concrete substrate. As a final layer, over the bitumen tracks, the road construction made of asphalt is installed. With the following order of materials, the complete system for waterproofing provides a long-lasting protection of the reinforced-concrete constructions from further penetration of water and other aggressions. and makes the road construction


* Consequences of improper waterproofing



*Installation of waterproofing

It is also very important to be careful to properly install the expansion joints, water canals, gutters etc. Company Ading, has accumulated experience in this field, and can provide technical support in designing and executing specific details of the work process.





* Installation of expansion joints

3.2.4 ADING SYSTEM FOR PROTECTION OF TUNNEL CONSTRUCTIONS

Reinforced-concrete structures which are part of the road infrastructure, as well as the road tunnels that are exposed to a high degree of carbonation (because of the high concentration of CO_2) and chemical aggression caused by chlorides, sulfates and etc. Additionally, the modern European regulations for traffic safety, especially in tunnels, require a special system for marking the surfaces – using signal and traffic colors, longitudinal horizontal tracks, marking the exits for evacuation and etc.

Depending on the type of tunnel, damage intensity of the construction and exposure, there are a several systems for reparation and protection that can be used.

System 1

For reparation and protection of the secondary tunnel construction, cement-based reparation mortar and protective coating on acrylic and methacrylate resin.

Methodology of work fulfillment:

- Preparation of substrate – It's required to clean complete concrete substrate with water under pressure, so that unstable layers of concrete and stains can be removed.
- Protection and waterproofing of the construction joints between concrete sections – If there are significant cracks near the concrete joints, they need to be repaired with the use of long-lasting elastic sealant FIX-O-FLEX, or with grouting with an long-lasting elastic sealant PUR-O-CRACK. If there is an active water penetration in the construction, it's necessary to seal it with an polyurethane expansion material PUR-O-STOP or with a fast-binding cement material UBRZUVAČ Č.




- Reparation – Skimming of concrete substrate. All serious defect, damages and segregation of concrete surfaces are required to be mechanically reopened /expanded/ and filled (repaired) with the use of REPARATUR MALTER F or REPARATUR GLET

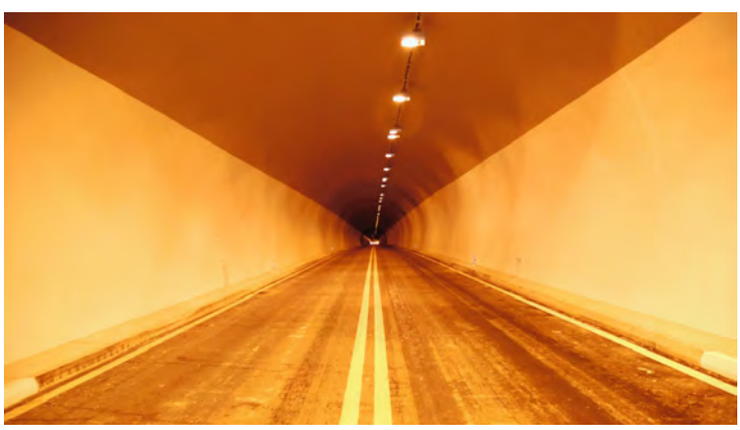

- Protection of concrete surface – The final repaired concrete surface needs to be protected with the use of a protective coating of acrylic base ANTIKOROZIN BB or methacrylate ANTIKOROZIN BR. The protective coating can be applied by hand (with a brush or roller), or with a machine for spraying (*airless pump*).


System 2

Used for securing a high degree of corrosion protection on the secondary tunnel construction, based on epoxy skimming layer and a final coating on epoxy or acrylic base.

Methodology of work:

- Preparation of substrate – It is required to clean the whole concrete substrate with water under pressure, so that unstable layers of concrete and stains can be removed.
- Reparation or protection of concrete surface – The whole concrete surface of the tunnel walls, up till 3,0 m height, needs to be coated with mortar based on water-epoxy resin and cement ADINGPOKS AKVA. The material most effectively can be applied with a machine spraying.
- Final coating – The coated concrete surface needs to be marked with the planned signal colors with the use of a coating made of acrylic base ANTIKOROZIN BR or АНТИКОРОЗИН ББ.



System 3

Reparation and protection of hydro-technical tunnels.

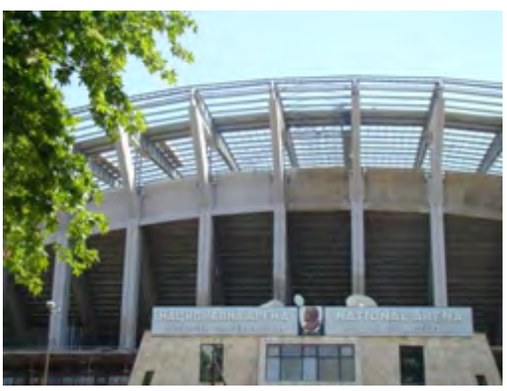
* Hydro-technical tunnels are specific constructions that are used for water transportation. In a number of cases, these tunnels are constructed as a part of mines or hydro-technical constructions used for water transport that contains chemical aggression substances and can cause mechanical abrasion of the concrete. Because of these reasons the protection of the concrete is of a big importance.

Methodology of work fulfillment:

- Preparation of substrate – It's required to clean the whole concrete substrate with water under pressure, so that unstable layers of concrete are removed. If in the lower half of the tunnel there is extreme erosion in the water bed, as well as chemical contamination and exposed reinforcement, it's necessary to additionally remove the degraded concrete and to replace the corroded reinforcement.
- Replacement of the degraded concrete with new concrete for reparation.
- Protection of concrete surfaces – the final repaired concrete surface needs to be impregnated and protect with coatings on epoxy resin base ADINGPOKS 1PV. The most practical way to apply the material is to do it with a machine spraying in two layers. Alternatively the final coating and protection of the water bed (especially old tunnels and tunnels that transport drinkable water) can be fulfilled with a rigid coating on cement base – HIDROMAL.

3.4 PRODUCTS AND SYSTEMS FOR PROTECTION OF FOUNDATION CONSTRUCTIONS, RETAINING WALLS, UNDER-PASSES , „NEW JERSEY“ BARRIERS AND OTHER EXPOSED CONSTRUCTIONS

Because of the high degree of exposure in the exploitation period, the constructions that are a part of a road infrastructure need to be monitored regularly, and need to be regularly repaired and protected. For these reason, same procedures are used including preparation activities, removing and replacing the degraded concrete and final applying of the protection coating for concrete.


For protection of the underground parts of the constructions that are in contact with underground waters, it's recommended to protect the constructions with an elastic coating of cement-polymer base HIDROMAL FLEKS.

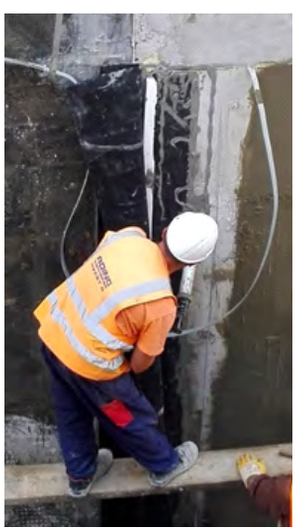

In cases when parts of the constructions need to be marked with signal and traffic colors we recommend the use of ANTIKOROZIN BR.

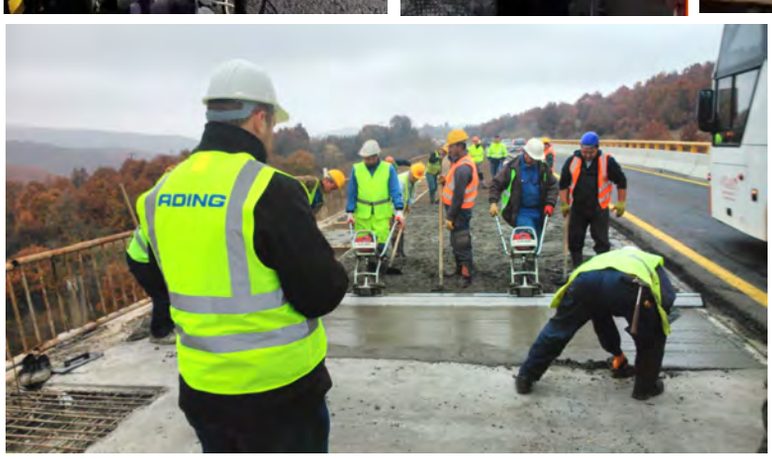

ADING – EXPERIENCE AND SUPPORT FOR PARTNERS

Technical support from institution that combines specific knowledge, with possibility of laboratory and insitu testing and finding solutions, is priceless contribution for successful completion of reparation works.

Company ADING AD Skopje, combines specific knowledge accumulated in 50 years of experience in reparation works conducted on objects including buildings, hydro technical objects, industrial objects, bridges, tunnels, factory chimneys and other specific engineering objects. Materials from ADING production program are used in different countries on three continents, and they are properly certificated according to European standard EN 1504, as well as according to the local regulation in the country where materials are used. To our partners, ADING offers professional support in every phase of the reparation project – site inspection of the object to be repaired, assessment of the condition of the structure, preparation of the technical design for reparation and protection, choice of materials and technology for reparation and professional assistance during application. Furthermore, Ading's R&D department has completely equipped and certified laboratory for testing reparation materials and systems. But most of all, Ading's professional team of engineers are at disposal in solving all problems that may occur during reparation.

In case of building new objects, ADING offers solutions for specific details concerning objects waterproofing, technology for production and casting high-performances concrete, choice of materials used for corrosive protection of concrete and steel reinforcement. Proper choice of such materials guaranties long-term proper functionality of the objects even in most inhospitable environments.





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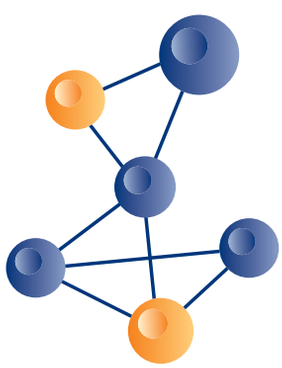
- Concrete repair
- Industrial and sports flooring
- Joint sealants
- Waterproofing
- Protective coatings
- Fire protection materials
- Adhesives
- Leveling compounds
- Decorative coatings and mortars
- Building products



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Grouting and sealing

pH 8,5

EUROPEAN STANDARD EN 1504 Products and systems for the protection and repair of concrete structures – Definitions, requirements, quality control and evaluation of conformity

AB CONSTRUCTIONS

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EN 1504

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