HISTORICAL DEVELOPMENT OF COMPOSITE MATERIALS

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***Abstract*—**One of the oldest scientific disciplines in the field of technical sciences is the study of building materials. Building and knowledge of materials are closely linked, and due to technical progress, it has become possible to influence the individual properties of materials. The technology range enables high processing and material properties, as well as the formation of completely new materials with predefined properties. Building materials constitute the entire complex of material components that can be both materials and raw materials for the obtaining of other building materials. Based on the application in the construction industry, they can be divided into materials of universal type (construction materials) and materials for special purposes (hydro insulation, thermal insulation, sound insulation, anticorrosive, adhesives, paints, varnishes and other).

***Keywords*—**Cement composities, nanotechnology, historical development, new materials, building materials.

I. Introduction

HISTORICAL development of building materials is reflected in the occurrences of certain materials, especially with the appearance of structural steels, and according to them they are called epochs, on the basis of the author's papers like W. B. Addis [1], T. S. Ashton [2], Iron and Steel Industry [3], A. Johnson and S. Stonehenge [4], D. Landes [5], J. J. Spoerl [6] and V. Šerifi [7]:

- epoch of wood, stone, brick, concrete and raw iron, from ancient times until 1850;
- the epoch of steel, reinforced and pre-stressed concrete, as well as the extension of the use of materials from the previous epoch, from 1850 to 2000;
- epoch of synthetic organic materials and the wide use of the most diverse composites, as well as the extension of the use of materials from previous epochs, from 2000 to the present.

Application in construction industry means knowledge of materials, knowledge of a number of facts and influencing factors, through the application of knowledge in chemistry, physics, technology, mechanics, material bending, that is, knowledge of properties and behavior of materials under certain conditions. Materials science considers influential parameters such as properties of materials that depend on composition, production technology and structure.

Composite materials represent a mechanical mixture or a combination of two or more nano, micro or macro constituents or materials that do not dissolve into one another. They can be classified into three basic categories: reinforced with particles, reinforced with fibers and layered (laminated) composite materials.

Composites can be conventionally divided into basic types, by papers of authors M. Muravljov, D. Jevtić and D. Zakić [8], M. Muravljov, D. Jevtić and D. Zakić [9], M. Muravljov, D. Jevtić and D. Zakić [10] and M. Muravljov, S. Živković, D. Jevtić and D. Zakić [11]:

- composities-agglomerates,
- reinforced composities,
- layered composities,
- materials with a mofified surface layer,
- materials treated with surface coatings.

Concrete is one of the oldest composite materials used more than any other. More than 10 billion cubic meters are built every year, that is, more than one cubic meter of embedded concrete per person, according to C. Meyer [12]. The first one who described the concrete about 25 thousand years before the new era was Vitruvius, publishing his ten books on architecture, the prominent types of aggregates that correspond to the preparation of lime mortar. For structural mortars, it recommends puffed, volcanic sand near Naples, determining the volume ratio. Examples of lightweight concrete date from the period 3000 years before the new era, according to the paper of author S. Chandra and L. Berntsson [13].

Around 3400 BC, a chipboard was appeared, which was obtained in Mesopotamia by gluing wooden pieces at different angles. In Egypt, in the period from 2181 to 2055 BC, the used layers of linen or paper poured into plaster for making a mask of death. About 1,500 years before our era in Egypt and Mesopotamia, they used natural composite construction materials, straw and wood to strengthen the mud brick used in the construction of buildings, boats and pottery. The use of mud, straw or gravel has existed for thousands of years. Ten books on architecture describing plaster, various types of lime and plaster, a cement that is similar and superior to today's portland cement that is in use, according to papers of the authors like W. B. Addis [1], T. S. Ashton [2], Iron and Steel Industry [3], A. Johnson and S. Stonehenge [4], D. Landes [5], J. J. Spoerl [6] and V. Šerifi [7].

The relative importance of the four classes of materials (ceramics, composites, polymers and metals) in mechanics and construction in function of time is shown by the time nonlinear scale in the Figure 1.

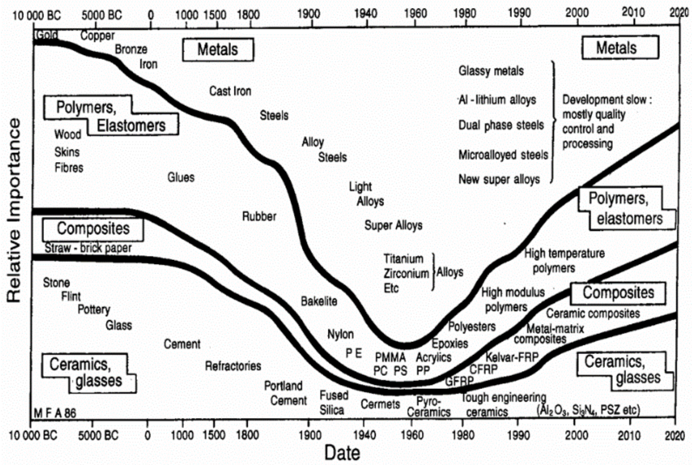

Figure 1. A schematic diagram showing the importance of four classes of materials (ceramics, composites, polymers, and metals) in construction over time on a time scale nonlinear scale (Source: Ashby, 1987)

II. THE FIRST APPLICATIONS OF COMPOSIT MATERIALS

Mongols were the first who invented composite materials around 1200 and used bamboo, silk, tendon from cattle, bones and horns, pine resin to make arches and arrows.

The chemical revolution occurred in the period from 1870-1890 and then they are formed by the polymerization of a new synthetic (polymeric) resin and the possibility of transforming from a liquid to a solid state in a cross-linked molecular structure. In 1930, the beginning of a new era for resins and composites as a whole, in 1936 patented unsaturated polyester resins by Carleton Ellis became the primary choice in the production of composites, thus producing high performance resins, such as epoxy resins, by papers of the authors W. B. Addis [1], T. S. Ashton [2], Iron and Steel Industry [3], A. Johnson and S. Stonehenge [4], D. Landes [5], J. J. Spoerl [6] and V. Šerifi [7].

The development of plastics dates back to the early 1990s, primarily are current vinyl, polysterene, phenolin and polyester. In 1907, the Belgian chemists Leo Baekeland discovered a bakelite, thus creating the first transfer lever for Rolls Royce cars. The combination of cellulose and bakelita have provided new results for commercial purposes. The property of electrical impermeability and heat resistance in electrical insulators, radios and telephone cabinets, kitchen products, jewelery, flow tubes, toys, is a large application of bakelite made of synthetic components. By the Chemical Society of America, bakelite is designated as a national chemical label and as the first synthetic plastic in the world, by the author's papers W. B. Addis [1], T. S. Ashton [2], Iron and Steel Industry [3], A. Johnson and S. Stonehenge [4], D. Landes [5], J. J. Spoerl [6] and V. Šerifi [7].

Owens Corning launched the polymer industry with reinforced fibers and the emergence of the first glass bell, during 1935. Thus, a composite fiberglass composite and the first textile material made of glass fibers or the production of new lightweight composites in combination with new synthetic or polyester resins. There was a new revolution in the navigation world. After that, in 1947, a fully composite car body was created and tested, where the production of molded bodies developed into dominant forms in automotive and other industries. Pultrusion production method is modeling that originated in the early 1950s, designing vacuum bags, as well as large coils for large rocket engines. Today's application is used in the production of liner components, such as ladders and slats.

The first carbon fibers were patented in 1961 and contributed to the development of numerous industries, where maritime and air traffic with their industries predominated.

The infrastructural application of composites in Europe and Asia began in the late 1970s and early 1980s, but are not available for use in large construction projects. A more serious application began in the 1990s where the buildings were built: the composite pedestrian bridge in Scotland, the part of the reinforced concrete bridge in West Virginia, then the part of the traffic bridge in Kansas and others, by the authors' papers as W. B. Addis [1], T. S. Ashton [2], Iron and Steel Industry [3], A. Johnson and S. Stonehenge [4], D. Landes [5], J. J. Spoerl [6] and V. Šerifi [7].

The development and application of resins with better properties of refractory and corrosion-resistant materials are noticeable.

The massive use of composite materials begins in the period from 1990 to 2000 in industry, construction and transport, that is, in production and construction. As a cost-effective substitute for traditional materials such as metals and modified thermoplastics, industrial designers and engineers have begun producing thermoset composites for various components of different types of equipment, the needs of construction, electrical and transport industries. Composite materials from the button to the more serious parts of the electrical infrastructure were available to consumers, where a more secure delivery of electrical energy.

In the mentioned period, the development of IT technology and the increasing use of commodity materials is noticeable. It is increasingly being applied in the sectors of the automobile industry, aircraft, for the production of various tools, in medicine and infrastructure. The first 3D carbon fiber printer, then full line hardware, consoles and insulators, is being created.

In the mid-2000s, the development of 787 Dreamliner tested composites for high strength began. The use of composites in nanotechnologies begins.

The interest of the governments of many countries to advance the production of composites has become great and these investments are seen as the future of the eco-friendly development of the society, where a solution for new fibers and resins will be found to create more applications in the production of new composite materials. Environmental resins will find application in the recycling of plastics and polymers, where they will get stronger, better quality, lighter and ecological products.

The use of ERP composites has already found its way to participate in the construction of a marina, automobile and airspace. There is a huge potential for an important technological breakthrough in architecture and construction, especially in constructions, where advantages in design, durability, less weight, corrosion resistance and other important properties are observed, according to the authors' papers of W. B. Addis [1], T. S. Ashton [2], Iron and Steel Industry [3], A. Johnson and S. Stonehenge [4], D. Landes [5], J. J. Spoerl [6] and V. Šerifi [7].

The introduction of fiber composite material in the chassis production process has been a turning point in the advancement of Formula 1, carbon fiber composites, which are now used in many parts of the F1 car (in almost 85% of the materials), were first introduced in 1980 in the F1 team McLaren. The composite material from which the body of the car is made must be extremely strong and resistant, especially when hitting. In addition to carbon fiber in the automotive industry for the production of Formula 1, popular polymer fibers are: aramid fibers, "Zylon" and oriented polyethylene filaments "Dyneema" (Figure 2), papers by the authors S. M. Kurtz [14] and G. Li and X. Wu [15].

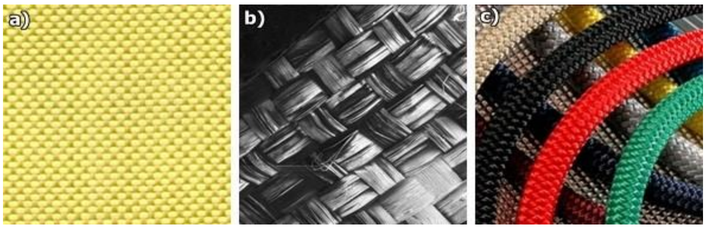

Fig. 2. Polymer fibers: a) Aramid fibers; b) „Zylon“; c) „Dyneema“, according to author's papers of S. M. Kurtz [14] and G. Li and X. Wu [15]

In Belgium, during 1988, PP (polypropylene) fibers are formed which provide better adhesion of the substrate material, substantially greater elasticity, tensile strength and better compactness. Increased water resistance, reduces the effects of frost and water prevents the appearance of micro-cracking on the surface of concrete or mortar. Today's application is great in construction works on the manufacture of cement screeds, plastering walls, industrial floors, fireproof concrete, installation of concrete elements, by the authors' paper of S. Chandra and L. Berntsson [13].

The second half of the 20th century is the beginning of the research of multifunctional materials, which simultaneously possess good electrical and magnetic properties, that is, multiferoids: ferroelectrics (materials in which under the action of the electric field comes to polarization) and ferromagnetics (materials in which magnetization occurs under the action of a magnetic field) (Figure 3), the papers provide a more detailed view of the authors like: M. Fiebig [16], T. Kimura, T. Goto, H. Shintani, K. Ishizaka, T. Arima and Y. Tokur [17] and G. A. Smolenskii and I. E. Chupis [18].

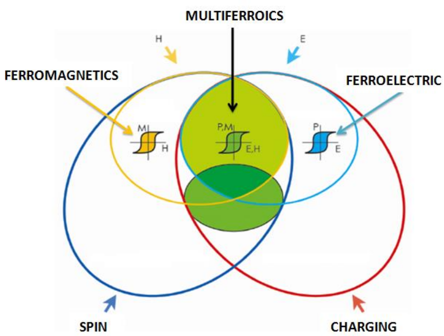

Fig. 3. Schematic representation of the response of ferromagnetic, ferroelectric and multiferoxic materials to the effect of the applied field, a more detailed presentation in the author's papers of M. Fiebig [16], T. Kimura, T. Goto, H. Shintani, K. Ishizaka, T. Arima and Y. Tokur [17] and G. A. Smolenskii and I. E. Chupis [18].

III. NEW TECHNOLOGY INSPIRED BY IMITATION AND REPRODUCTION OF SOLUTION FROM NATURE

The new science that has found its place in the production of a composite is biometrics that represents the imitation of models, systems and elements of nature for the purpose of solving complex human problems. The new technology is inspired by imitation and reproduction of solutions from nature at macro level and on nanoscale.

In the last few decades, a major trend has been created by the application and development of nanotechnology. Alongside the creation of new materials, the dimensions of which are several nanometers in size, the trend of miniaturization of electronic components and devices has been developed. metakaolin

Steel is the main constructive material in which improvements have been achieved by the addition of copper nanoparticles between the steel grain boundaries, which is low-carbon steel of high performance with high corrosion resistance. Sandwik Nanoflex TM is a new stainless steel developed by the technology team of the Sandwik Nanoflex Materials Technology firm, has high performance (corrosion resistance, workability and wear resistance) and is suitable for applications where the construction should be easier and more stiffened.

Soviet scientists have developed a polymer-like plastic with microcapsules that contain a body-renewing substance, so appeared a material that repairs itself. Cracks are the biggest concern of many structures and pose a major problem of stability and survival of the construction, where the invention of rehabilitating polymers opens new chapters of modern construction. This opened the way for the formation of nanoarmed concrete. Carbon nanotubes (CNT, carbon nanotubes) are the first examples of nanoarmed concrete, they are insoluble in water and represent a better option in reinforcing metals.

In Serbia, at the Faculty of Civil Engineering, University of Belgrade, a detailed presentation is given in papers of D. Jevtić [19], D. Jevtić and T. Vojnović Ćalić [20], D. Jevtić, D. Zakić, A. Savić, and V. Šerifi [21], D. Jevtić, D. Zakić, A. Savić, and V. Šerifi [22] and T. Vojnović Ćalić and D. Jevtić [23]. At the beginning of this century were carried out numerous studies of micro-reinforced plasters and the use of steel fibers, glass fibers, synthetic or polymeric fibers, as well as organic fibers, where improvements in the engineering properties of mortar were confirmed. The addition of armature in the form of fiber began in the early 1960s, which was then reflected in the modern development of fibers. Prior to that, straw, jute and animal hair were added to plaster and concrete. Today's application is reflected in the use of natural organic, glass, mineral, carbon, polypropylene and various other synthetic fibers. The properties of micro-reinforced plasters were tested in numerous laboratory studies at the Faculty of Civil Engineering in Belgrade, where a small aggregate of 0/4 mm thickness and binders (most commonly cement) were used, micro-fiber fibers (from 0.1% to 5% and 1- 2 kg/m^3) to the total volume of freshly installed mortar, as well as the use of superplasticizier additives for the compactness of fresh mortar mixtures with vibration. The use of mineral additives was present, first of all, the addition of electrofilter ash, pucolan, metakaolin, slurry and obtained favorable results for the purpose of their application. The research has confirmed the improvement of the properties of plaster compared to ordinary mortars, resistance to cold, wear resistance, and corrosion resistance of mortar. Results are obtained that fully meet expectations and suggest using the design and construction of floor slabs, outer concrete surfaces, tunnels, interior and exterior of residential premises, roads and airport runways and other. Micro-reinforced plasters have a growing application in construction, a detailed view is given in the papers of D. Jevtić [19], D. Jevtić and T. Vojnović Ćalić [20], D. Jevtić, D. Zakić, A. Savić, and V. Šerifi [21], D. Jevtić, D. Zakić, A. Savić, and V. Šerifi [22] and T. Vojnović Ćalić and D. Jevtić [23].

Bearing in mind the results of the tests carried out at the Faculty of Civil Engineering in Belgrade, based on the above data, one can draw a general conclusion that, for example, the steel fibers fully meet all the necessary conditions for application in the form of microarmature in cementitious composites. It contributes to a significant improvement in the individual mechanical properties of the composite (primarily the shear strength, but also the bending strength), and in particular the improvement of the deformation properties (toughness and ductility) of microarmed concrete and mortar. In this regard, the composites reinforced with the subject fibers can be used in a number of areas of construction, and above all in the case of cement screeds, industrial floors, prefabrication of concrete elements, open concrete surfaces, foundations of machines, concrete safes, as well as in other cases when required concrete is of increased toughness and ductility. The results of the micro-reinforced plasters unambiguously show a significant improvement in the mechanical properties of the series produced with the addition of micro-reinforced, in relation to the standard series. Thus, the addition of steel fibers in the amount of 60 kg / m3 (0.45% relative to the volume), in combination with the type additive superplasticizers, gave it at all ages greater strength in both bending and pressure. In addition, better effects were observed in bending strength (32-58% increase), but also the strength at the pressure was significantly increased (increase of 17-36%). From these results, a significant increase in mechanical strength is observed even after the 28 days of the composite, so that, for example, after 90 days of strength at pressures in cement composites, the use of steel fibers increased by as much as 25%. This effect can be explained by the presence of silicate dust, which contributes to the subsequent increase in strength by subsequent chemical reactions of pucolanization. As far as the micro-reinforced mortar is concerned - the composite prepared with the addition of monofilament polypropylene fibers, one can draw a general conclusion that the fibers in question contribute to a certain extent by reducing the overall deformation of the shrinkage, and that this effect is more pronounced when using both large quantities of fibers and fibers of a larger length - ie. microarmature with higher factor values of shape (l/d). This conclusion is valid for both mortar based on standard river sand, as well as mortars, with, for example, crushed bricks as an aggregate.

Bearing all the foregoing in mind, it follows that mortars based on brick fractured with the addition of polypropylene fibers can be successfully applied in the manufacture of cement screeds, then as facade mortars, and also as thermal insulation or acoustic insulation mortars (microarmature can somehow improve the thermal and acoustic properties of plaster, but the basic effect of its application in this field is indirect and consists in increasing the ductility, resistance to different influences and generally the durability of the subject composites), a detailed presentation is shown in the papers of D. Jevtić [19], D. Jevtić and T. Vojnović Ćalić [20], D. Jevtić, D. Zakić, A. Savić, and V. Šerifi [21], D. Jevtić, D. Zakić, A. Savić, and V. Šerifi [22] and T. Vojnović Ćalić and D. Jevtić [23]. Also, the subject microarmed composites in question could, in view of their favorable properties, be found to be used as fire-resistant plasters, a more detailed presentation is given in the authors' papers of M. Muravljov and M. Uljarević [24], M. Muravljov, D. Jevtić and D. Zakić [8], M. Muravljov, D. Jevtić and D. Zakić [9], M. Muravljov, D. Jevtić and D. Zakić [10] and M. Muravljov, S. Živković, D. Jevtić and D. Zakić [11].

As for the durability of cement composites, as one of the most important properties, it can be increased by acting in the direction of making mortar or concrete as little as possible porosity, which means using low enough water when making concrete. High homogeneity of concrete, a very high level of mechanical strength and a high degree of waterproofing can be achieved only by correct selection of aggregates and granulometric composition, choice of type and optimal amount of cement, increased hydration, efficient incorporation, and application of various chemical additives to the concrete through which is affected to the microstructure of the composite.

Chemical additives to the concrete of the plasticizier or superplasticisier type, possibly additives of the seal type and additives with simultaneous effect of aerating and plastification will directly affect the modeling of the pore space and the pore layout in the cement-concrete composite structure. Certainly, it is necessary to take into account the compatibility of chemical additives with the cement used, as well as of the possible harmful substances of the chloride type, present in chemical additives.

The application of mineral additives such as slag, pucolan, silicate dust, or metakaolin may also influence the microstructure of concrete as a composite, but also to improve the corrosion resistance, that is, durability in a precisely determined percentage. The above additives also influence the quality of the transitional - transit zone between the grains of aggregates and cement stone, and thus the improvement of waterproofness and durability of concrete.

High-strength cementitious composites, which are increasingly used today, are defined only on the basis of their mechanical properties - the compressive strength at a certain (usually 28-day) age, and the numerical value of this strength is changed over time. Thus, for example, in the 70's of the last century, the pressure at 40 MPa was called high, while later years, through the intensive development of theory and concrete technology, the stance prevailed that this strength was over 60 MPa. Of course, in order to achieve this strength, a thorough knowledge of the structure of concrete and mortar, the factors that affect it, and the process of hydration and its kinetics, on the one hand, was needed. On the other hand, the very development of high-strength cementitious composites has also accelerated the synergy of the chemical industry and construction, ie, progressive development of chemical additives to concrete, especially plasticizers and super plasticizers.

By adopting the structuralist concept, according to which the structure of composites determines to a large extent its properties (which, in the case of concrete and mortar, consists of a macrostructure, a microstructure and a transition zone between aggregates and cement stone), the basic task of engineers and technologists is to find a way how to affect the porosity of the composite, its inhomogeneity and micro cracking - both in the hydrated cement paste, as well as in the transient zone.

Basic operating modes, if wanted to obtain a composite of high mechanical strengths, move in the following directions:

- physical activity, consisting in the application of low water-cement factors, using additives to the concrete of the plasticizer and superplasticizier type,
- production of composites with the additives of so-called silicate soot, or silicate dust (silica fume), which acts both on the physical and chemical basis,
- production of composites by autoclaved hardening, with application of silicate dust and superplasticiziers.

By way of the first method, the strength can be obtained at a pressure between 60-80 MPa, the other 80-110 MPa, and the third and over 150 MPa.

In addition, it is important to note that the selection of component materials is a very important step for the preparation of high strength composites. This primarily means that the type, class and amount of cement plays an important role, and therefore CEM I (without mineral additives) is mainly used for this purpose, and its quantity is over 400 kg/m^3. The cement class also plays a role in the sense that the higher class (eg. 52.5) gives more strength, according to the famous Skramtajev law. The mineral composition of cement is also important, in particular the amount of artificial mineral C3A present, as it is generally believed that the lower content of C3A gives better rheological properties of the fresh composite (first of all, the smaller fall of the "slam").

As far as the aggregate is concerned, the quality, the size of the maximum grain, and especially the physical and mechanical properties must be taken into account. The best results are obtained using quartz, quartzite, granite type aggregates, with a compressive strength of more than 200 MPa. If we are talking about the size of the maximum grain, the rule is that, as the required strength of the composite is higher, the size of the maximum grain of the aggregate should be proportionally reduced. For example, for composites with a s strength of over 125 MPa, the recommended maximum grain aggregate should range between 10-14 mm. In order to obtain better composite performance, it is advisable to use a larger number of aggregate fractions.

As the strength of the composites depends, inter alia, on the amount of cement, the water-cement factor and the degree of hydration, a low water-cement factor can be achieved by using additives to the concrete of the plasticiziers and superplasticiziers type. Historically, in the 1960s the most commonly used sulphonated naphthalene-formaldehyde condensate, first produced in Japan under the commercial name "Mighty 150", and later in the United States under the terms "Lomar D" and "Sikament". This additive was used as a 42% aqueous brown solution, with a specific mass of about 1200 kg / m^3. At about the same time, in West Germany, a melamine-formaldehyde condensate superplasticizier was developed, under the commercial name "Melment L 10". It was concerned on 20% aqueous light yellow color solution, a specific weight of about 1100 kg/m^3. In addition to these, superplasticiziers based on ligno-sulponate (for example, "Mulcoplast", Canada) were used in this period, more detailed in M. Corradi, R. Khurana and R. Magarotto [25].

A new generation of chemical additives - polymers based on carboxylic ether of polymers (polycarboxylates) appears in the 90s of the last century. The advantage of these additives is to maintain slump and for more than 90 minutes, even at elevated ambient temperature. Namely, they also have side chains which are connected with the polymeric structure, and thus make possible the maintenance of consistency over time due to its steric effect, i.e. keeping particles at a certain distance.

The new functional groups of monomers serve as the so-called, parachute slowing down adsorption and thus maintaining sagging. Superplasticiziers that are now on the market are completely adapted to the type of cement and its mineralogical composition.

Silicate soot (dust), which occurs under different names ("condensed silica fume", "silica fume", "microsilica", etc.), represents amorphous silicon dioxide (S_iO_2), which occurs in the production of silicate and ferrosilicate alloys. The specific surface of this fine material, determined by the BET method, is from 11-40 m^2/g. Grains of silicate dust are spherical and can be up to 100 times smaller than cement grains. The average size of these particles is 0.1 μm, which significantly increases their specific surface and allows their "thick packing" between the grain of cement (physical activity). In principle, silicate soot is added to high-strength concrete in a relatively small percentage (8-12% relative to the weight of the cement), whereby the necessary amount of water is significantly increased - and practically all kinds of chemical additives of the type of superplasticiers are added to these composites.

In addition to physical activity, silicate soot as a pucolic supplement works on a chemical basis - by bonding calcium hydroxide formed during the hydration of the alite and the belite. The addition of S_iO_2 in the hydration products reduces the pore size and the thickness of the boundary layer (transition zone) between the cement paste and the aggregate. Also, better adhesion is achieved of the cement aggregate gel and the present reinforcement in concrete.

Such systems are often referred to in the literature as DSP ("Densified systems containing homogeniously arranged ultrafine particles"). In the subject systems, the achieved microstructure is considerably more compact and homogeneous compared to conventional concrete of the usual strength. Also, the contact layer (transition zone) is reduced thickness and increased compactness due to the formation of a number of smaller $Ca(OH)_2$ crystalline chaotic orientations.

As already mentioned, the connection between the aggregate and the cement stone is closely related to the migration of $Ca(OH)_2$ of calcium hydroxide, which is deposited on the aggregate grains surface and partially crystallized, and partly transferred to $CaCO_3$ calcium carbonate, also in crystalline form. These products, deposited on the aggregate grain surfaces, condition the appearance of very important Van Der Vals' forces, which are the main factor in adhesion of aggregates and cement stone, more in paper of Vasusmitha R., Srinivasa Rao P. [26]. As these forces are proportional to the sizes of the contact surfaces, the strength of the contact zone at any point depends on the size of the present pore. Thus, the adhesion between the cement stone and the aggregate depends on both the thickness of the contact zone and the developed surface of the grain aggregate, more details in the paper of M. Corradi, R. Khurana and R. Magarotto [25].

On the basis of numerous experimental investigations, it can be concluded that flying (electrofilter) ash can be successfully applied with the construction of composites of mortar and concrete. In addition, the percentage of cement replacement with ash, as well as the properties of the ash itself, will depend on the physical and mechanical properties of the starting composites - both in fresh and in harsh condition. In order to eliminate the influence of the type of cement on the investigated properties of mortar and concrete prepared with the addition of fly ash, wherever possible, instead of composite materials, "clean" portland cement should be used, i.e. cement without mineral additives nanosilica.

In these tests, in principle, an increased need for water was established in order to achieve the same consistency of the composite, which is related to the relatively large fineness of flying ash. This most often leads to a decrease in the volume of the composite, as well as to the reduction of the values of the early strengths, in relation to the etalon (composites stored without the addition of ash). This is completely in line with the results of research by other authors in more details by M. Corradi, R. Khurana and R. Magarotto [25], R. Vasusmitha and P. Srinivasa Rao [26], A. Karamoozian, M. Karamoozian and H. Ashrafi [27], M. Khrapko [28], G. D. Schutter [29]. On the other hand, due to its pucolic properties, fly ash contributes to the improvement of the mechanical properties of mortar and concrete at the age of more than 28 days, more in the papers of M. Aćić and D. Jevtić [30], D. Jevtić [19], D.

Jevtić and T. Vojnović Ćalić [20], D. Jevtić, D. Zakić, A. Savić, and V. Šerifi [21] and D. Jevtić, D. Zakić, A. Savić, and V. Šerifi [22].

The first accelerated aging test was done in the early 1980s in the United Kingdom, when GRC Glass Fiber Reinforced Concrete (GRC) was reinforced concrete (or GFRC). The obtained parameters were shown to be accurate with respect to the longevity parameters that were subsequently realized in real terms.

The University of Dresden has proposed the use of inorganic oxides nanotybes of natural cement paste enhancers since they are more compatible with the cement-water system. CSH (calcium silicate hydrate) proved to be an ideal material, which represents an ideal mechanical reinforcement for cement paste. Research has shown that these nanotubes are very stable at room temperature and a high Young's modulus of elasticity and strength to the pressure and tensile of concrete nanotubes represent a viable alternative as reinforcement for cement paste. Carbon nanotubes were discovered in 1991 and represent one of the isomeric forms of carbon with a cylindrical nanostructure, which was discovered by Sumio Iijima. The first carbon nanotubes were discovered by L. V. Raduškevič and V. M. Lukjanovič, 1952. The discovery went unnoticed because the publication was in Russian and due to the Cold War, more details in the papers of C.-W. Baek, S.-W. Choi, H.-T. Jo and D.-H. Ryu [31], Y. Cui and C. M. Lieber [32], X. Duan, Y. Huang, R. Agarwal and C. M. Lieber [33], X. Duan, Y. Huang, Y. Cui, J. Wang and C. M. Lieber [34], V. N. Popov [35] and Wang, X.; Li, Qunqing; Xie, Jing; Jin, Zhong; Wang, Jinyong; Li, Yan; Jiang, Kaili; Fan, Shoushan [36].

Adding the nanosilica results in thickening on the micro and nanostructure, which result in improved mechanical properties. The nanoscope replaces a part of the cement, but the compactness and strength in concrete with added ash are provided in the early stages of binding. For concrete containing large amounts of ash, the nanosilica can provide a better distribution of pores of different sizes as well as filling the intermediate space between ash particles (which are larger) and smaller cement particles. The dispersion-suspension of amorphous nanosilica dioxide is used to improve segregation resistance in self-forming concrete, in more details in the authors' papers by D. Duh [37] and J. I. Tobón, O. J. Restrepo and J. Payá [38]. Oxidized multilayer nanotubes show the best improvements both in strengths (+25 N/mm^2) and in bending resistance (+8 N/mm^2) compared to reference samples without reinforcement. These strengths greatly exceed expectations, if it is known that by adding a structural steel the strength of the concrete increases by 0.5 GPa.

Alkaline-silicate reactions occur as a result of the connection of the alkaline part in the cement and silicate part that occurs in the aggregate. The use of pucolan in a concrete mix, as a replacement of a cement part, can reduce the amount of alkaline-silicate reaction by reducing alkalinity within the pore of the fluid. The fly ash provides durability and strength for concrete and simulates the use of cement. Electrolytic ash at the same time slows down the bonding of concrete, with initial strengths slightly lower than conventional concrete. Numerous impurities at the Faculty of Civil Engineering in Belgrade have shown electro-filter ash, depending on the purpose, applicable in the construction industry, and that certain properties are markedly improvements in its participation, Jevtić, D. and V. Šerifi, D. Jevtić [19], D. Jevtić and T. Vojnović Ćalić [20], D. Jevtić, D. Zakić, A. Savić, and V. Šerifi [21] and D. Jevtić, D. Zakić, A. Savić, and V. Šerifi [22]

IV. CONCLUSION

The development of new composite materials is the field in which it is most invested, regardless of the fact that composite materials have been used for thousands of years. The durability of buildings will be a challenge in the coming period, and for this achievement will require new compostable materials and improvement of the quality of already existing, more in the doctoral degree of V. Šerifi [7].

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