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MAINTENANCE OF AIRFIELD PAVEMENTS MADE OF CEMENT CONCRETE WITH RESPECT TO THEIR DURABILITY

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Abstract

The issue of concrete airfield pavements maintenance is the process, the efficient performance of which may provide suitable life and air traffic safety related to thereof. Obtaining durable airfield pavement is a result of team cooperation in the following fields: suitable design solutions, applicable work technology and principles of arrangement thereof. However, fundamental link of this process is the high level of engineering culture related to construction maintenance during its whole "lifespan". Each pavement must comply with requirements according to principles of "construction limit states" method expressing work safety, i.e. limit state of deformation and serviceability. Thereby, the "weakest link" within the chain of projects and actions implemented in the course of its construction process decides about safety and lifespan of pavement operation. Durability of such engineering constructions as airfield pavements, is specified by the quantity of performed "flight operations" on these pavements, within the assumed operation period. Considering, among others, principles of limit state method, the required and anticipated pavement operation period can be specified. Life aspect with reference to airfield pavements can be analysed in theory by means of application of modern material solutions. The above-mentioned aspects will be described widely in this work. Modern material solutions include modified composition of concrete intended for construction of particularly difficult sections of such pavements and structural tests were conducted for such composition, which would confirm suitability of assumed material solutions.

Keywords: *airfield pavement, pavement durability, pavement maintenance, airfield operations safety, structural tests*

1. Introduction to sustainability

Durability of engineering structures, including airport concrete pavements and paving of roads and motorways, is currently being undertaken in the discussions, publications and research works. It is considered that despite the use of high quality materials used to implement the works, and the techniques and technologies with a high degree of sophistication sustainability of these objects is not guaranteed and compatible with the user expectations. As a result, it leads to premature necessary repair, overhaul and limitations on the use, at the same time high costs. Consequently it leads to premature necessary repair, overhaul, limitations on the use and, high costs. Under the concept of sustainability of these facilities is understood the aim at all stages of the investment process to ensure a full capacity to conduct flight operations while maintaining a high level of safety during the lifetime of those objects. Service life of these structures refers to aiming at and making these structures comply with requirements within the specified period and defined technical level of maintenance. This can be achieved at all stages of investment process starting from perfect design solutions through observing applicable technological guidelines and suitable technical culture within operation time. At the same time, during operation, one should aim at provision of high safety level of aircraft operations and vehicular traffic within the area of transport routes. All the issues related to ensuring high durability of these objects and taking into account the possibility aspects of sustainable development can be presented in graphic form, for example Fig. 1.

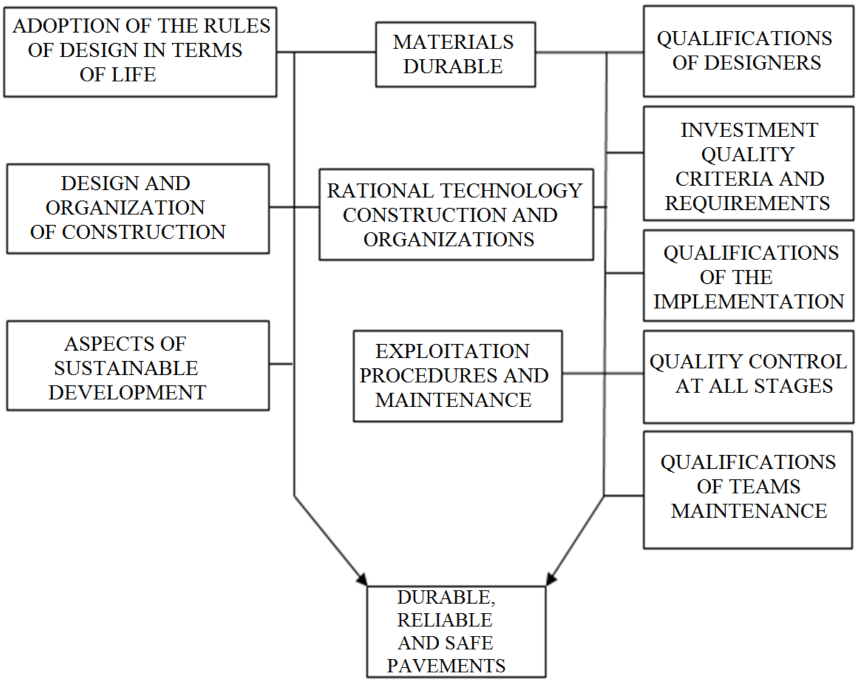

Fig. 1. Groups of issues related to sustainability conditions

Obtaining a permanent paving it is the result of appropriate design solutions, technology and organization of work and the level of technical culture related with the maintenance of the object.

2. Durable, reliable and safe pavements

Each airport and road concrete pavement must satify the principles of the limit states expressing safety and use of the structure. In the first case, this means the fulfillment of requirements for its load-bearing capacity. In the second case, in which should not occur conditions of using limit states that is an excessive deflections or cracks. Therefore, it is believed that concrete pavements especially at airports should be resistant to scratches. Not only because of the change in stiffness related to the change of its support but also because of the possible consequences resulting from the rules of safe operation. This requirement reference should be made of individual plates, and the whole structure. Regularity, which occurs in the investment process, especially at the stage of the works, is that the next steps are the result of activities performed previously, which most often are hidden. That is why on the use value of the object most frequently decides incorrectly done activity or their team. This is a classic principle of "weakest link" in the chain of activities. Knowingly specified user requirements and the principles of construction technology, standards and regulations provide an opportunity to obtain permanent structures. Durability of communication structure can be determined by the number of years of safe usage or the amount of the so-called transition "axis of account" in the case of road surfaces, or the amount of "air operations" in the case of airfield pavements. The durability of communication structures is customarily determined by number of years. There are therefore grounds to express the conviction that we are on the threshold at which developers will be required to prove the sustainability of the proposed design solutions. The contractors will be obliged to prove an adoption of the work technology and that the used of the proposed materials is relevant and meet the demands of durability design. Currently, this stability is formulated in relation to the concrete paving primarily based on the exposure class in which the surface will work. In the foreground of the durability issues of concrete paving should be considered, a frost resistance of concrete surface. With regard to the airport pavement frost resistance determines the size of the F200 SIA cycles of freezing and thawing with well-known evaluation criteria. If the stress will be determined as **S(t)**, and its strength as **R(t)** with taking into account the dispersion results the probability of damage or destruction of the structure can be expressed by the relation (1) [5], where in $\mathbf{P_k}$ is the probability of occurrence of one of the limit surface.

$$P\,(t) = P\,\{R(t) - S(t) < 0\} \leq P_k. \tag{1}$$

At the same time it should be satisfied the condition that **R (t)** > **S (t)**.

The probability of occurrence $\mathbf{P_k}$ condition is related to the shelf life of the pavement tk. It is the principle that the design is projected onto a predetermined number of operations or number of passes the axis of calculation of vehicles. The time that goes with it for the purposes of these considerations oznazono, as td at the same time for this case should be the condition $\mathbf{t_k} > \mathbf{t_d}$, and reports the probability of a certain state $\mathbf{P_d} < \mathbf{P_k}$.

3. Durability of concrete pavements in the method of limit states

As noted using the method of the limit in assessing durability, you must specify the projected life of the pavement td and a characteristic (expected) service life, which should be taken into account the probability of occurrence and intensity of all random variables.

In these issues, you can use an approach to the distributions of the size occurring in the introduction of minimum values of loads for the analysis or for take account of statistical distributions of sizes curing in this issue. This is done by selecting the appropriate partial factors, which in the absence of reliable information can be determined based on experience. Considering the above, the proposed period td can be represented by the following [5]:

$$t_d = \frac{t_k}{\Omega_t}. \tag{2}$$

In the equation (2) defines a factor, which is the product of partial factors and is greater than unity [5]:

$$\Omega_t = \Omega_{t1}\,; \Omega_{t2}\,;\, \Omega_{t3}; \ldots; \,\Omega_{t7} \tag{3}$$

Symbols in the equation (3), the following:

Ω_{t1} – the importance of usable surface and the consequences of the state border,
Ω_{t2} – the reliability of the models of computing,
Ω_{t3} – level of technical performance,
Ω_{t4} – properties of the structural system,
Ω_{t5} – environmental conditions, including climatic and environmental,
Ω_{t6} – how to use the roads, including the adoption by the surface of aircraft with higher code,
Ω_{t7} – level of technical maintenance of roads.

The number of partial factors may be increased depending on your needs and a reliable estimate of these factors.

The essence of the durability conditions during the projected service life is shown in Fig. 2. The problem of stability, in this case, referred to the concept, the technical reliability of the object, which under certain conditions can be regarded as being the same.

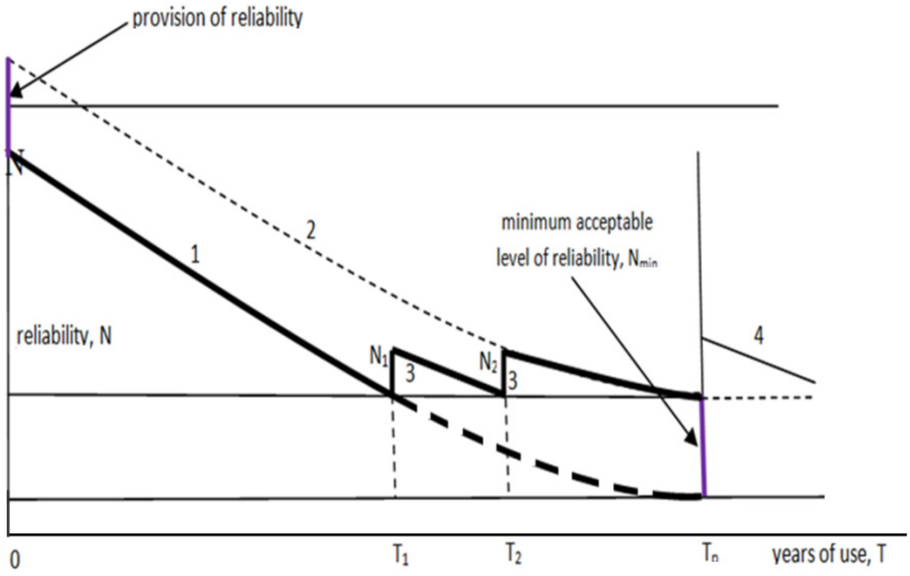

Fig. 2. Exploitation process during period of use [5]

4. Pavement durability in the production of materials

Considering the durability of the surface in terms of utility becomes the most important factor aspect of the choice and balance of the materials used components. Due to the fact that, the parameters hardened concrete during its service life determined by the choice of the components of the concrete mix and the balance between these components can be shaped consciously inter alia increasing the usable capacity of the structure. In terms of a complex concrete cement should be considered as a composite material [2, 3]. Its structure is as heterogeneous as an additional difficulty in its description. In the simplest two-component system [1] composite concrete consists of cement matrix and the inclusions. Inclusions in the form of aggregates of particles, due to their content in concrete mixture 70-75%, play a key role in the performance characteristics of hardened concrete [6]. The choice of aggregate for concrete paving or airport with the grain size to 31.5 mm taken from the rocks of considerable strength (e.g. a granite) ensures to get the concrete of higher quality. Hardened concrete parameters also affect the choice of cement. Observations made it possible to formulate recommendation that concrete mixtures intended for paving use communication CEM CEM II, depending on the type of surface and the place of installation or I. In the case of airport pavement standard [10] recommends the use of Portland cement CEM I class at least 32.5 N. The concrete mix can be used admixtures and additives, which dispensed in order to improve the concrete and consequently the value of individual endpoints of hardened concrete and its durability. In terms of new application possibilities that are not used so far additives to mixtures, it seems important that the assessment of their effect on the concrete particularly in the context of sustainability within a given surface during operation. Experimental studies have demonstrated that the formulation of far-reaching conclusions based only on test results only after 28 days of maturation are insufficient and in some cases unreliable. Due to this fact would extend basic concrete evaluation period especially in the aspect of his life of up to 56 days.

5. Technological possibilities to increase the durability of concrete pavement

Bearing in mind the need to increase the durability of airport pavement of cement concrete are particularly intense impact of hot combustion gas stream that came from the issuance of aircraft engines, were carried out properly programmed research. The analysis were two sets of cement concrete (SA and SB). Material compositions concrete mixtures were analysed in each case pure Portland cement clinker - CEM I 42.5 N HSR and coarse aggregate in the form of granite grit with a grain size to 31.5 mm. The composition of the mixture SB considered part of the ceramic additive in an amount of 10.5% as a replacement for a fine aggregate. The chemical composition of the additive included and distinguished significantly from the composition of aggregate replaced. Given the role of aggregates in the concrete mix, in the context of the development of mechanical parameters of hardened concrete, and the specific characteristics addition it was found that it plays an important role in shaping the desired operating/utilities parameters. It was expected that the detailed parameters of the proposed supplement, i.e. high strength and resistance to the effects of changing temperature conditions are likely to increase the resistance of concrete to the different weather conditions. Assessment of the resilience of cement concrete intended for use as pavements in the context of extended life is made of differentiation into two-group classification. The scope and research methods in each group distinguished for the duration of the care and the way the impact of reduced and elevated temperatures. The composition of concrete series SA was coarse aggregate in the form of granite grit with a maximum grain size to 31.5 mm, aggregate fine a grain size of 0/2 mm, CEM I 42.5 N - HSR, water and additives to ensure obtaining the desired consistency of the concrete mix and the content of air pores. The composition of SB concrete part of fine aggregate (10.5%) was replaced by the ceramic additive. The ratio w / c is assumed to be 0.37. Concrete Series 1 have matured over a period of 28 days under the conditions of standards by [7, 8] (temperature 20 ° C and relative humidity> 95%), and then were used for laboratory tests. Concrete Series 2 and 3 after the 28-day period of care - fully corresponding to the requirements of the standard [7 and 8], another 337 and 1,797 days worked in real environmental temperatures from exposure to sunlight, rainfall, varied temperature and fluctuations of temperature in daily cycles. Registered average air temperature over the study period was 8.1ºC. Relative humidity at 79% and the amount of light at 720 mm. Registered average air temperature over the study period was 1,797 days in the summer 14.8ºC, during the winter -4.2ºC. Relative humidity of 71% and the amount of rainfall at 425 mm.

In assessing changes in mechanical properties of concrete were referred maximums by destructive forces [9] obtained in mechanical tests for concrete series 1 to series concrete parameters 2 and 3 different extended period of maturation in real conditions. Mean values of compressive strength, which is one of the key measures of quality concrete pavements are shown in Fig. 3.

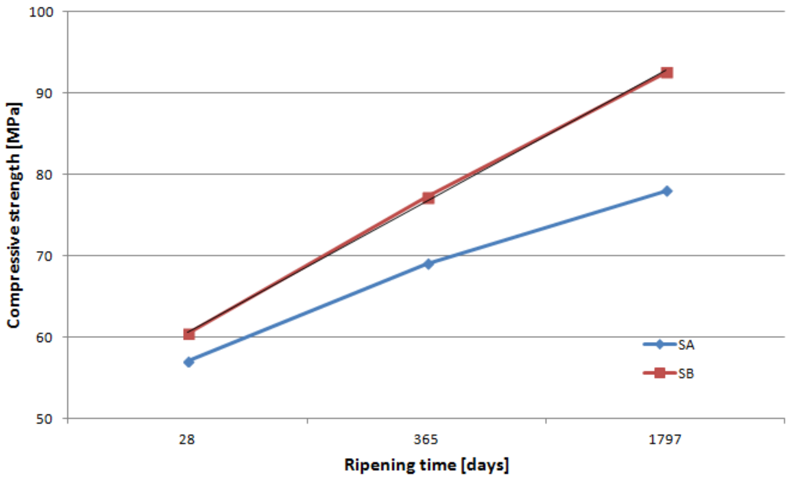

Fig. 3. The dependence of the compressive strength characteristics of the period of curing

Assessment of compressive strength showed that the SB concrete in all three analysed cases, regardless of the duration and conditions of curing characterized by the most favourable results. Average strength of SB concrete maturing over 28 days is higher by about 6% than the SA concrete. For second test series, an increase is 11% (8.2 MPa) and for third series is 16%. It was found simultaneously reducing absorbability of concrete specimens with the proposed addition from 3.2% after 28 days to 2.6% after the longest study period. The results of laboratory tests for SB concrete series are characterized by favourable values of mechanical parameters, allowing you to formulate a theory about the positive impact of the ceramic addition on the parameters of durability of concrete paving. Due to the fact that about the final characteristics of hardened concrete during its service life decides internal structure of the composite of the construction of the internal composite and relations between these components. Indispensable tool in the evaluation of the complex are modern devices using the electron beam to observe changes in the internal structure of materials, i.e. SEM. Observations in the scanning electron microscope of the individual materials SA and SB series showed a strong differentiation. Samples of concrete cared in conditions specified by standards showed differences in the characteristics of air pores and the construction of the interfacial transition zone, which influences the final parameters of hardened concrete (Fig. 4).

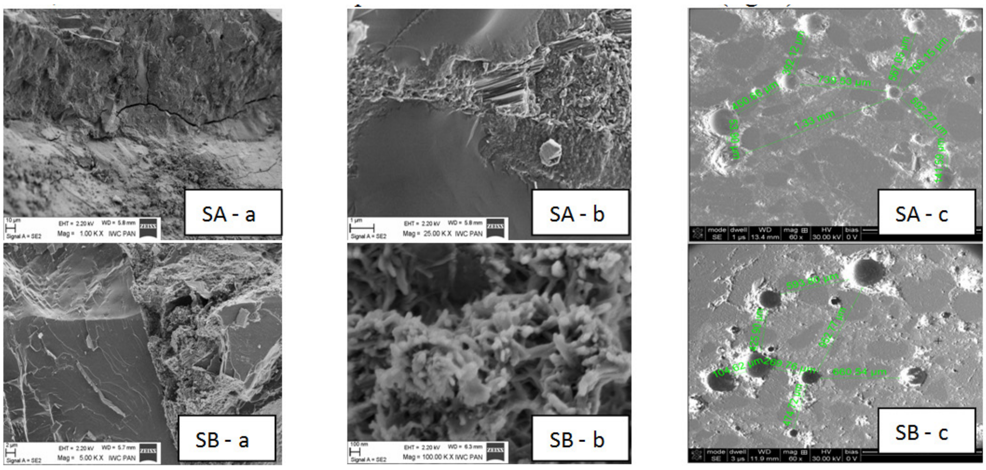

Fig. 4. Differentiation of the internal microstructure of concrete SA and SB series after the first study period [4]

The presence of micro cracks in the interfacial transition zone between aggregate and cement matrix (a) in the SA preparation of concrete influence on the reduction of technical parameters, manifested by a decrease in the strength. Different hydration products in specimens SA and SB, especially occurring ettringite crystals (b) in concrete without the additive compounded pre-degradation of the concrete material. A significant influence on the final performance is also the content and distribution of air gaps, whose characteristics in SB concrete (c) are definitely more favourable.

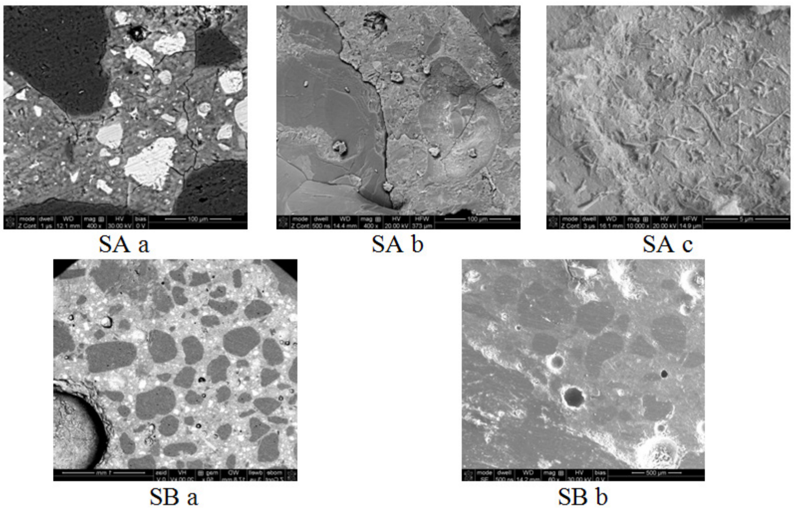

Fig. 5. Differentiation of the internal microstructure of concrete SA and SB series after the third study period

The samples were subjected to extended curing processes in a more adverse environmental conditions, even in a third study period, in the case of SB concrete preparation, are still more favourable characteristics. SEM observations of these preparations showed no significant changes in relation to concrete after 28 days. There has been a singly occurring micro cracking in the cement matrix, but what is very important from the point of view of assessing the strength there are no cracks in the interfacial transition zones (Fig. 5). Participation and size of micro cracks occur in the structure of the preparation of concrete – BA is much higher, and crack widths reach up to ten micrometres. In the case of SA, concrete preparation prevails developed crystallization of ettringite, which is quite clearly reflected in the strength values obtained.

Summary and conclusions

The proposed technology and material solution taking into account the addition of ceramic in aggregate composition affect positive changes in the microstructure of hardened concrete. This is achieved in this way, prolonging safe working conditions, especially in areas exposed to high temperatures, which in many cases reaches a level of over 200ºC on the concrete surface.

Each concrete airport or road pavement has its "potential sustainability", which is the result of many complex, determined and variables technical and human resources. Stability of these structures is the most desirable technical and economic category. The process of designing the surface on a predetermined durability is possible by using, among other things, half-probabilistic limit state method. The practical criteria for sustainability of these structures are dependent on the further development of analytical methods and priorities in decisions related to the quality of investment.

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