CONTRIBUTIONS TO THE CONSTRUCTION OF RIGID ROAD SURFACE COURSE

PHD. STUDENT: ING. RADU POPA
COORDINATORS: PROF.DR. ING. SORIN DAN

- SUMMARY -

The thesis it is structured in six chapters, a bibliography and a photo appendix. **Chapter 1. Introduction** analyzes the importance of the researched topic in this doctoral thesis, taking into account the motivation of the research, namely the need for in-depth studies on concrete components and technology in order to ensure sustainable solutions for road paving.

Chapter 2. The development of road concrete in the 21st century includes a complex bibliographic study, which reviews notions on the types of road pavement used, types of fibers used in the composition of concrete, presented in correlation with the characteristics that fibers transfer to concrete. It concludes with the statement that dispersed reinforcement materials lead to raising the physical-mechanical parameters of road structures, and their proportion of mass addition and how they achieve good adhesion to the mineral skeleton, binder and other additives decisively influence the durability of surface course of the roads. Fibers constitute the discontinuous phase in the mass of road pavement and have the role of reinforcing the finished product but also the role of filling the interstitial spaces between the granular fractions due to the reduction of porosity and surface stresses that develop at the interface of the components. This will lead to a reduction in the risk of micro-cracks and therefore early deterioration of road pavement.

Chapter 3. Criteria for establishing the sustainability of a concrete, considers sustainability defined as a concept based on environmental, economic and social aspects and is one of the key aspects of the construction sector, which must be well considered in the 21st century. Durability is directly related to structural performance, considering features such as safety and utility.

The chapter defines the characteristics to be taken into account when it is stated about a material used in construction that it is sustainable, if it meets the following criteria:

- it is energy efficient;
- it is economical;
- the process of obtaining it involves a rational use of natural resources;
- is recyclable / reusable;
- no waste is produced during the manufacturing process, or the resulting amount of waste is very low;
- it is easy to procure / produce, close to the place of its subsequent use;
- implies a limited water consumption during the technological manufacturing process;
- does not present risks for human health;
- increased flexibility in design.

Chapter 3 also presents the decision-makers in establishing the sustainability of a building material, concluding, from this point of view by presenting a number of seven concepts that must be the basis for establishing the sustainability of a material used in construction .

Chapter 4. Laboratory determinations on concrete with fibers, is based on a wide experimental program made by the author of the doctoral thesis, on recipes for concrete with metal, polyurethane and glass fibers. The aim of the experimental program was to obtain a composition with at least satisfactory characteristics in terms of its mechanical strength, so that it can be used on a large scale in the upper layer of roads.

The experimental study performed on reinforced concrete dispersed with steel fibers led to the conclusion on the increase of tensile strengths when the reinforced concrete with metal fibers is in the compressed area. This result is significant for the research carried out in this doctoral thesis, because the main purpose of using the studied concrete is that of rigid road pavements, more precisely, as an upper course layer.

The steel fibers were wrenched off in the yield area of the test specimen, leading to the conclusion of a superficial adhesion between the matrix and the fibers.

In the case of samples made of fiberglass concrete, when performing the bending tensile test, a superior strength is obtained when the reinforcement

layer is in the tensioned area. It is also found that, although the first crack appears at about 30% of the value of the breaking force, due to the glass fibers present in the matrix, the cracking is significantly delayed, crack 2 and 3 appearing very close to the maximum force. The fibers prevent the cracks from opening, which leads to the impression that the sample is not destroyed.

When performing experimental tests on fiberglass compositions, various technological problems appeared such as:

- partial rupture of the fibers in the mixer;
- the need to control the tendency of agglomeration of glass fibers as well as their uniform distribution in the concrete mass.

The addition of fiberglass can lead to an increase in mechanical tensile strength by bending, when the reinforced layer with fiberglass is positioned in the compressed area, by about 1.5 - 7% compared to the control concrete.

For concrete with polypropylene fibers, tests were performed on three types of such fibers, a total of 10 compositions, namely: RoNet- fibrillated polypropylene fibers, Ro White- polypropylene monofilament fibers, Readymesh PF 540- polypropylene macrofibers .

The conclusions of the experimental program on reinforced concrete dispersed with polypropylene fibers are presented by analyzing the behavior of the samples tested for bending, having a layer of 5 cm thick, reinforced concrete with different types of fibers, the layer being positioned either in the compressed area or in the tensioned one. Table 15 in the doctoral thesis shows the load-bearing capacity obtained on all 10 different studied compositions. It is observed that the maximum value of the load-bearing capacity is obtained, as expected, in the case of dispersed steel fiber reinforcement.

Chapter 5, entitled: Case study - Timișoara concrete platform, presents the second part of the experimental program which consisted of the restoration of a rigid road pavement area in Timișoara, Calea Șagului, no. 142 / A at the entrance to the Dacia-Renault car park. At the mentioned location, the concrete platform was replaced in parts. Thus, on an area of 27 square meters, the existing concrete was completely stripped and replaced with a reinforced concrete dispersed with steel fibers type HE55 / 35, ie on a thickness of 20 cm. Another section with an area of 18 square meters, was completely stripped and replaced with a reinforced concrete dispersed with polymer fibers. A section was completely stripped and replaced with a control road concrete. The last

sections, with an area of 24 square meters, were partially stripped by road, ie on a thickness of 7-8 cm and replaced with a layer of reinforced concrete dispersed with polymeric fibers, respectively with steel fibers. It should be noted that, for the protection of the newly poured concrete, Kraft paper was applied over the first two experimental sections over the existing compacted ballast layer, and in the third case, in order to ensure the adhesion between the existing and the new concrete, an additive was used, Sikalatex.

In order to establish the durability and behavior over time of the fiber concrete used in the rehabilitation of the before mentioned road pavements, in addition to the visual observations made over a period of 5 years, the method of core extraction and testing was chosen.

The tested cores were extracted 28 days after the construction of the platforms, respectively at 5 years. The analysis of the obtained results led to the conclusions:

- there is an increase in tensile strength over time by splitting all types of concrete, this is in line with the literature in the field;
- in the case of reinforced concrete with metallic fibers with a thickness of 7 cm, the resistance obtained is similar, both at the age of 28 days and after 5 years, with that obtained on reinforced concrete with polymeric fibers on the entire thickness of the road surface. The introduction of metal fibers in the composition of road concrete leads to doubling their tensile strength;
- in the case of the use of polymeric fibers for the dispersed reinforcement of road concretes, an increase of approximately 15% is observed in the case of reinforcement dispersed over the entire thickness of the road surface, compared to the reinforcement only of the wear layer, and in the case of those reinforced with fibers metallic 15%. This conclusion is significant when considering the cost / benefit ratio in establishing road repair / consolidation solutions.

The last chapter of the thesis, **Chapter 6. Conclusions and personal contributions** summarize the results obtained in the theoretical and experimental studies presented. Thus, the following conclusions of this doctoral thesis can be deduced:

- Increasing the durability and sustainability of concrete structures, by reducing the cost of repairs and maintenance, by increasing the tensile strength of concrete made of fibers, as well as by the possibility of removing, even if not completely, reinforcement, is a major objective of research in the field civil

engineering. During construction, the difference in fuel consumption for the production of asphalt compared to concrete is huge. This is mainly due to the energy required to heat the asphalt materials.

- As a disadvantage of these concretes we can mention the increased initial cost of the component materials, namely the addition of fibers, but this disadvantage is lost over time by increasing durability. These concretes prove to be effective in the construction of bridges, road pavements, tunnels or pipes.
- Experimental tests performed on concretes reinforced with various types of fibers, may be the basis for establishing the main directions for optimizing the compositions of these concretes.
- Fiber-dispersed reinforced concrete must have a carefully established composition, a rigorously observed mixing technology, because, in a fiber-dispersed reinforced concrete material more or less evenly distributed and at short distances from each other, the spacing of the fibers affects the properties it.
- It was found that if two different casting batches with the same volume percentage of Vf fibers are compared with fibers of the same type and diameter, the average distance between the fibers is different and their fiber reinforcement will be considerably different.
- The high cost of the materials in the composition, as well as the fact that an increased quality control on concrete and aggregates is necessary is a major disadvantage of fiber concrete. The use of fibers helps to change the properties both in the fresh concrete stage and in the hardened concrete phase, which makes fiber concrete a more versatile material to be used for a variety of applications.
- The experimental results obtained on the five types of fiber concrete studied in the doctoral thesis are in accordance with those presented in specialized papers in the country and abroad.

Summarizing the material presented above, the main personal contributions are:

1. Preparation of a representative bibliographic study for this field of research, illustrated by the bibliography list.
2. Making a short history of the use of fibers, respectively of reinforced concrete with fibers, in constructions.

3. Carrying out a wide program of experimental research on dispersed reinforced concrete with 5 different types of fibers, with the addition of different fibers, so a total of 10 recipes of reinforced concrete dispersed with fibers.
4. Optimization of the technology for mixing concrete with tested fibers.
5. Carrying out a practical study by using reinforced concrete dispersed with metal fibers and polymer fibers, respectively, when rehabilitating a platform in Timișoara.
6. Monitoring the behavior over time, for a period of 5 years, of the rehabilitated platform.
7. Making a fiber concrete that can be used in road pavement, which stands out for its increased durability.
8. The study has as beneficiaries the construction engineers from our country involved in all stages of road paving, to whom the data presented in this doctoral thesis can provide useful information about the behavior of fiber-reinforced concrete. Thus, concrete mixtures with a superior behavior can be designed. This knowledge can help to achieve more sustainable roads, where operating costs can be reduced, so that over time we can speak of an economic gain.
The capitalization of the results was done by publishing 8 ISI listed articles, one of which in a magazine, together with members of the Department of Civil Constructions and Installations of the Faculty of Constructions, Poltehnica University of Timișoara.