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Durability and Sustainability of Concrete Structures (DSCS-2018)

SP-326

Editors:
Vyatcheslav Falikman, Roberto Realfonzo,
Luigi Coppola, Petr Hàjek, Paolo Riva

American Concrete Institute
Always advancing

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Preface

Modern construction is unthinkable without concrete, the world production and consumption of which is about 10 billion m3 per year. Given the steady growth of the world's population by 2050, it is expected to double this volume, which will undoubtedly be significantly affected on energy consumption and increase global CO_2 emissions.

Concrete is perhaps the most universal building material since the beginning and development of civilization. It is sufficient to recall the Great Wall of China, the palaces and temples of Ancient India, the pyramids of Ancient Egypt, the unique buildings of Romans, made with the use of lime-pozzolanic binders. Universality of concrete is defined by simplicity and convenience of its production, rather low cost, structural integrity and homogeneity, durability and a long service life under various aggressive environments.

However, the concrete image is sometimes not favorable. It is associated with greater labor intensity of construction works and dismantlement, massive structures, a large impact on the environment in connection with the s consumption of not renewable natural resources. The same perception is greatly facilitated by the fact that, according to Gigaton Throwdown Initiative, "the cement industry is responsible for about 5 to 7% of total CO_2 emissions, or 2.1 Gt per year." Indeed, when producing cement clinker about 0.9 t CO_2 / t clinker are produced. Taking into account the annual increase in the production and use of Portland-based cement (more than 4.1 million tons per year) that is the main binder used in the production of concrete, this fact poses a significant threat to humanity as a whole. According to the Intergovernmental Panel on Climate Change (IPCC), actions are necessary to reduce carbon dioxide emissions because in about 30 years CO_2 concentrations is expected to reach 450 ppm – a dangerous point above which irreversible climate change will occur on our planet.

Since concrete will remain the main building material in the future, it is expected that if new ways and mechanisms to reduce the environmental burden by at least 50% will be not found, it is not possible to maintain the existing level of impact.

This problem is so deep and serious that there is hardly a single way to solve it. There is a need for an integrated approach, several complementary activities that provide some synergy.

Until recently, the main efforts were aimed at improving technological processes and reducing the consumption of clinker through the production of blended cements, as well as the creation of new types of binders. Active search for alternative binders has led to the development of sulfoaluminate-based cements; alkali-activated materials and geopolymers (slag, fly ash, metakaolin, etc.), efficient and fairly water-resistant magnesia cements; phosphate cements (ammonium phosphate, silicate phosphate, magnesium phosphate etc.), cements with calcium halogen-aluminate and the so called low water demand binders.

With the advent of high-performance concretes and new technologies, the possibility of a radical increase of the cement factor in conventional concrete due to the use of high-performance superplasticizers and other chemical admixtures, dramatically reducing the water consumption of the concrete mixture; active mineral additives such as micro silica, metakaolin, fly ash, finely ground granulated slag, etc., as well as a variety of inert fillers that can improve the functionality of concrete mixtures, such as fine limestone.

Strictly speaking, “pozzolanic effect” and “filler effect” are easily combined and provide a certain synergy.

The potential for reducing cement consumption in concrete production is still undervalued. This is due to certain fears of decreasing the corrosion resistance of concrete and durability of reinforced concrete structures, since the great bulk of the existing standards is prescriptive and sets the minimum cement content in concrete under specific operating conditions.

Reinforced concrete structures of buildings and constructions, as a rule, initially, shall have the design strength and sufficiently long service life because their construction often requires a significant investment. The durability of these structures, however, is determined by different ageing processes and the influence of external actions, so their life will be limited. As a result, many structures need to be repaired or even replaced in fairly short time periods, resulting in additional costs and environmental impacts. Therefore, there is a need to improve the design principles of structures taking into account the parameters of durability and thus achieving a sufficiently long service life.

Development of the concept of design of structures based on their life cycle, “environmental design”, including a holistic approach that optimizes material and energy resources in the context of operating costs, allow us to completely revise our ideas about structural concrete construction.

It should be noted that many recent developments in the field of life cycle analysis (LCA) are aimed at expanding and deepening traditional approaches and creating a more complete description of the processes with the analysis of sustainable development (LCSA) to cover not only the problems associated mainly with the product (product level), but also complex problems related to the construction sector of the economy (at the sector level) or even the general economic level (economy level).

The approach to “environmental design” is based on such models and methods of design, which takes into account a set of factors of their impact on the environment, based on the concept of “full life cycle” or models of accounting for total energy consumption and integrated CO_2 emission.

All of this could become a basis for the solution of the global problem – to contain the growing burden on the environment, providing a 50% reduction in CO_2 emissions and energy consumption in the construction industry. Hence a special sharpness P. K. Mehta’s phrase acquires: “...the future of the cement and concrete industry will largely depend on our ability to link their growth for sustainable development...”

The above-mentioned acute and urgent problems form the basis of the agenda of the Second edition of International Workshop on “Durability and Sustainability of Concrete Structures – DSCS-2018,” held in Moscow on 6 – 7 June 2018 under the auspices of the American Concrete Institute, the International Federation on structural concrete and the International Union of experts and laboratories in the field of building materials, systems and structures. The selected papers of this major forum, which brought together more than 150 experts from almost 40 countries of the world, are collected in this ACI SP.

Vyacheslav Falikman and Roberto Realfonzo
Chairs of the Organizing Committee

Luigi Coppola,Petr Hajèk and Paolo Riva
Members of the Organizing Committee

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