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NATIONAL RESEARCH COUNCIL OF CANADA

DIVISION OF BUILDING RESEARCH

No. 371

# TECHNICAL NOTE

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PREPARED BY R. F. Legget

CHECKED BY

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SUBJECT CONCRETE TECHNOLOGY IN THE USSR

During the course of the International Symposium on the Durability of Concrete, sponsored by Réunion des Laboratoires d'essais et de Recherches sur les Matériaux et les Constructions (RILEM) in Prague, Czechoslovakia, in the summer of 1961, the writer was privileged to meet Professor Mironov and one or two of his colleagues from the U.S.S.R. Despite language difficulties we were able usefully to compare Soviet and Canadian concrete practice. Professor Mironov was particularly interested in Canadian developments regarding lightweight concrete using various aggregates. He very kindly supplied the writer with a short paper of which he had a copy describing current Soviet technology in the field of concrete. This has now been translated by the NRC translation staff and the translation is now issued in this form for private circulation to some of those interested in concrete work in Canada with whom the Division is in touch.

R. F. Legget.

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## THE DEVELOPMENT OF RESEARCH ON CONCRETE TECHNOLOGY

by

S. Mironov

Contemporary science plays an immense role in the life of society. It is an integral part of the productive forces in the process of material production. The development of large industries depends greatly on the state of science and the stage of technological development. Nowadays, industrial processes in factories, in construction and other undertakings are based on scientific achievements.

In the Soviet Union great care is taken to see that all branches of industry, including construction, are developed on a scientific basis. To this end the government invests large sums, increases the number of scientific research institutes in the country and the number of scientific workers. Institutes and laboratories are furnished with up-to-date testing equipment and apparatus.

The greatest attention is paid, of course, to the development of science in the main branches. In the Soviet Union there is much scientific progress in the development of physics, chemistry, mathematics and engineering sciences. We are witnesses to an unusual progress, a genuine revolution, in relation to the peaceful uses of atomic energy and the utilization of space. There is great progress in the scientific and technological development of such branches as heavy industry, the construction of machines and apparatus and in chemistry.

All the necessary conditions have been created for progress in the sciences and techniques of construction.

In recent years the appearance of our buildings, blocks and cities has been changing noticeably and large engineering plants and industrial buildings have been improved. Materials and designs, the production of which is growing at a brisk pace, are changing qualitatively.

Concrete and reinforced concrete have become leading materials in contemporary construction. Sectional reinforced concrete designs, especially of pre-stressed and light concretes (including cellular concretes) are being widely used in housing, industrial and other types of construction.

In 1961 fifty-one million tons of cement were produced in the USSR. The output of reinforced concrete sections in 1960 was already thirty-two million cubic meters. The production of brick, as a less effective material for contemporary construction, occupies a much less important place.

Since the economic advantages of using concrete increase as its weight per unit volume is reduced, the USSR, like other countries, is paying greater attention to the production of light concretes from porous aggregates and cellular concretes of various types.

One of the basic problems in building science is the development of high strength concretes of all types while simultaneously decreasing their weight per unit volume. In this connection further research is needed on the development of optimum compositions and hardening regimes governing the structural evolution and deformative properties of the concretes. More advanced investigations must be made into the development of a generalized theory of hardening of concretes under various temperature and humidity conditions, the theory of the strength of concrete and its resistance to corrosion in the presence of aggressive media. In this connection associated branches of science should be widely exploited, contemporary methods of research should be applied and accumulated experimental and theoretical data should be scientifically generalized.

In a number of cases it may be necessary to use heavy concretes of grade 800 or more, or on the other hand light concretes of grade 300 to 500. The use of high strength concretes leads to a reduced consumption of concrete and decreases the cost of transport and assembly.

Light concretes are becoming more and more widely used both in porous and cellular aggregates (aerated and foam concretes), and also those occupying an intermediate position between standard and cellular concretes (foamed porous clay and foamed perlite concrete).

Of the light concrete of porous aggregates the most promising are porous clay and perlite concrete, and then agloporite concrete. In view of the demand for a lowering of the weight per unit volume of these concretes to 600 to 700 kg/m$^3$ it is necessary to investigate methods of obtaining artificial light aggregates of weights per unit volume 200 to 400 kg/m$^3$.

In order to ensure further increases in the grades and a reduction of the weights per unit volume of concretes it is necessary to investigate their physical-mechanical properties, methods of mixing with the aid of high frequency vibration, the use of electric pre-heating, and autoclave processing in place of conventional steam processing.

The economic advantages of employing concretes increase with the reduction in their weights per unit volume. Therefore cellular concretes with autoclave hardening, being the lightest of all, must receive wide distribution. To prepare cellular concretes it is not necessary to organize the special production of light aggregates. These concretes in weights of 300 to 400 kg/m$^3$ are already being used as heat insulators and in weights of 500 to 600 kg/m$^3$ as combined structural and heat-insulating materials.

The further reduction in the weight per unit volume of the cellular concretes and the widespread use of ashless binders in their preparation is increasing the necessity of protecting the reinforcements against corrosion and the surfaces of parts against atmospheric effects. The study of rheological properties of the evolution of deformations in steam processing and the attainment of high-strength characteristics in cellular concrete needs intensification.

An essential complement to the cement concretes is the development of the production of autoclave silicate concretes of both the compact and cellular varieties.

In regions where there are no large aggregates, and for the preparation of thin-walled constructions, the use of sandy concretes will be developed.

In conjunction with the increasing demand for the grades of concretes in use and the decrease in their specific weights the demand must be increased for grades of cement, the quality of all types of aggregates and also the quality of steel reinforcements.

The mean strength index of cement in the USSR is being increased from 460 to 500, and further to 600 kg/cm$^2$. Builders now need cements of grades such as 700, 800 and higher which will be used for concretes of grades 600 to 1000 and will guarantee the attainment of the required grades and specific weights of light and cellular concretes.

Taking into account the different conditions of hardening of concrete in parts and constructions the cement industry must be asked to broaden its nomenclature and, in any case, to manufacture three types of such cements:

(a) fast hardening cements for concrete hardening on the building sites without heat treatment and for winter concreting (grades 600 to 800);

(b) cements for parts subject to heat treatment at temperatures up to 100° (slag-portland cements, portland cements grades 500 to 700);

(c) cements for parts subject to autoclave treatment (sandy, nephelinic cements, with cement replaced by lime).

A number of problems are being investigated in connection with the creation of an up-to-date industry for the production and processing of aggregates for concretes of all types. Taking into account the tendency to increase the grades of concretes and towards the use of thin-walled elements, the demand for high quality crushed stone and gravel will increase. Much attention must be paid to the search for new types of porous aggregates for light concrete, and especially such very effective ones as swollen perlite, and also the aggregates for refractory concretes (chamotte, magnesite, chromite). In the field of heat-resisting concretes there remains the problem of raising their heat resistance up to 2000° and higher.

The great chemical stability and density, the small electrical conductivity and other important properties of the plastic concretes compel concrete engineers and builders to give them due attention. Researchers must aid their introduction into construction practice, and especially the successful solution of the problem of making reservoirs for the storage of petroleum products and aggressive solutions, as well as pipelines, which will be sufficiently impermeable and stable.

Investigations in the field of improving reinforcements for reinforced concrete must be directed towards the raising of strength indices, the improvement of plastic properties and the weldability of steels. They must be oriented towards centralized production of welded grids and frameworks, anchor pieces and ready-made clusters in well mechanized and automated plants.

For present-day construction hot-rolled rod reinforcements of smooth and alternating profile are needed with maximum strength of 12,000 to 15,000 $kg/cm^2$ and smooth, high-temperature hardened wire rods of alternating profile (diameter 6 to 10 mm), 16,000 to 18,000 $kg/cm^2$. Cold-drawn high-strength wire with low temperature hardening must be obtained with maximum strength of 20,000 to 25,000 $kg/cm^2$, and plies up to 30,000 $kg/cm^2$.

In addition to the methods worked out for protecting reinforcements against corrosion, we should investigate the properties and conditions of use of non-metallic reinforcements in the form of bands, sheets, tables and plies with maximum strength of the order of 15,000 $kg/cm^2$.

For modern mechanized manufacturing plants for reinforced concrete parts and large assemblies methods of wet grinding and finishing cements must be developed which will ensure more thorough hydration of the cement. This is particularly important when reinforced concrete parts are subjected to high temperatures.

Ultimately, we must look forward to the complete automation of the preparation of concrete mixtures of various stiffness, using vibration in the mixing process. Then, where possible, preference must be given to the use of stiff concrete mixtures in place of the fluid ones still being frequently used.

The application of different frequencies ensures better compaction of the concrete in the tall narrow ribs of reinforced concrete panels. With regard to the improvement of production processes, research must be directed towards the achievement of complete automation of all processes involved in the preparation of concrete mixtures and reinforcement frames, the casting of parts and the maintenance of the required heat and humidity regimes in the processing. The technology of factory production of reinforced concrete parts must be brought up near the level of such branches as metal working and machine construction.

With a view to speeding up the hardening of concrete it is necessary to use not only steaming at atmospheric pressure but also high-pressure steaming. In order to establish reasonable limits to the raising of steam pressure in autoclaves for various types of concrete using different binders, it is necessary to carry out wide investigations. All aspects must be considered; advantages from the use of low-strength binders and the wide use of industrial wastes, grades of concrete achieved, the economic effects of the change-over to the use of the boilers and autoclaves involved in high-pressure steaming. By means of physical-chemical investigations and from data on the properties of concretes hardened in autoclaves, it is necessary to establish and select the types of binders, and especially the types of cements, with respect to their mineralogical properties. Notwithstanding the experience of many years in the construction of hydro-electric and thermo-electric stations, concrete roads and the use of monolithic concrete in industrial construction, there are still many problems which have not yet received adequate scientific study.

Methods of winter concreting need improvement. Inadequate compactness, poor elasticity and the susceptibility to corrosion of concrete and reinforced concrete in various aggressive media necessitate the development of research and study into methods of protecting concretes against premature destruction, i.e. of lengthening their lives in buildings. This relates primarily to construction work in such branches of industry as white metallurgy, the chemical and hydrolysis industries, petroleum, etc. Important improvements are needed in the methodology of inspection and standard testing of materials and designs.

We must convert rapidly to the application of non-destructive methods of testing materials and designs, and in the investigation of the properties of concretes and in the associated methods of reinforced concrete construction we are changing over from small laboratory specimens to the preparation of full-scale experimental units. One or two international conferences of RILEM should be devoted to the problems involved in unifying the methods of materials testing.

In closing I should like to express my pleasure in the fact that at the sessions of the RILEM Standing Committee such important questions have been raised as the means whereby the building sciences may make progress in the study of materials and designs.

(Signed) S. MIRONOV
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