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A. F. LOLEIT'S ROLE IN DEVELOPMENT OF TECHNICAL SCIENCES AND ENGINEERING PEDAGOGY

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Abstract

The article is devoted to the creative path of one of the founders of the Soviet school of reinforced concrete Arthur Loleit (1868–1933). In the late XIX – early XX centuries, reinforced concrete was unknown in Russia. After graduating from Moscow University, A.F. Loleit joined the joint-stock company producing concrete where he designed complex structures made of reinforced concrete, many of which are in Moscow: the building of the Upper Trading Rows (GUM), the Museum of Fine Arts n.a. A.S. Pushkin, industrial buildings, residential buildings, etc. In 1915, Loleit left the company and began his teaching and research career. From 1923 to 1933, Loleit was a teacher of Moscow Civil Engineering Institute where he was developing a new approach to the calculation of reinforced concrete structures, put forward a new theory of calculation of reinforced concrete elements, founded one of the leading departments "Reinforced concrete and stone structures", developed Technical standards for the design and construction of concrete and reinforced concrete structures ", published textbooks and scientific and methodological manuals for students, determined the most important principle of the scientific school aimed to develop accessible engineering and practical methods for calculating reinforced concrete structures.

Keywords: Reinforced concrete, engineer, researcher, theory of reinforced concrete, teacher.

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1. Introduction

National Research Moscow State University of Civil Engineering is the oldest Russian university founded in 1921.

The university has trained more than 120 thousand specialists, achieved high professional authority, turned into a basic university in the construction industry, into the world-renowned center for training engineers and researchers. University graduates work in various regions of Russia and foreign countries.

A huge contribution to the development of construction science and Moscow State University of Civil Engineering was made by scientists, founders of scientific schools, world-famous teachers. Under their guidance, the first domestic textbooks on all construction disciplines were published, research laboratories were created, advanced technologies and building materials were developed and implemented into production. The fundamental foundations of all branches of construction science of the XX–XXI centuries were created. They developed traditions of building art and engineering skills, they transferred their knowledge to students, among whom was Arthur Ferdinandovich Loleit (Molokova, 2001).

2. Problem Statement

The article is dedicated to the Russian, Soviet engineer, scientist and teacher Arthur Loleit (1868-1933), who studied, researched and developed a new composite material – reinforced concrete, founded a scientific school of modern theory of reinforced concrete in Russia, trained engineers (Molokova, 2001).

3. Research Questions

A.F. Loleit was born in Orel on June 5, 1868. He entered Oryol classical gymnasium and graduated from it in 1886. Then he entered the mathematical department of Moscow University.

He studied mathematics, descriptive geometry, theoretical mechanics, material resistance, hydraulics, and conducted research. Under the guidance of Professor of mathematics D.E. Orlov, he published the scientific work: "The theory of hinged sections." In 1891, Loleit was awarded a silver medal. In 1891, he graduated from the University and received the 1st degree diploma in applied mechanics.

The young specialist successfully combined knowledge of theoretical mathematics, engineering sobriety, enthusiasm, and a desire to seek new technologies and solutions to complex problems. Yu.A. Guk, the director of Moscow joint-stock company producing concrete invited him to work in the project department of the company as a calculation engineer, familiarize himself with the foreign technical literature on reinforced concrete (Bosk, 2001; Le Carbusier, 1925) A.F. Loleit was very interested in this issue.

He wrote: “The issue of substantiating dimensions of the structure, in which materials with diverse natural properties, like concrete and iron, are combined into one monolith, is interesting for me...” (Lopatto, 1969, p. 22).

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He developed the building material required for Russia which was experiencing the economic recovery (Molokova, 2017).

4. Purpose of the Study

The article analyzes the creative path of Loleit who devoted his life to the study and implementation of reinforced concrete.

In MICI, he worked from 1922 to 1933. Under his leadership, in 1933, the department of "Reinforced concrete and stone structures" was founded. Loliet trained a galaxy of talented scientists: P.A. Pasternak, L.A. Katsanovich et al. (Molokova, 2001).

5. Research Methods

The basis of the study is a comprehensive analysis of activities of A.F. Loleit. Historical and problem-thematic approaches are used. The historical approach was used to determine the dynamics of the development of Loleit's scientific concepts, consider the evolution of personality of the scientist and development of his theoretical ideas and engineering projects, determine the role of his scientific and pedagogical work. The analysis of the biographical data was carried out. The problem-thematic approach was used to identify the researcher's most important achievements, their heuristic and practical significance. This approach is also effective for determining general trends in the formation of new areas of world and Russian construction activities related to the use of reinforced concrete and stone structures.

6. Findings

For more than 23 years (from 1891 to 1915), A.F. Loleit worked for Moscow Joint-Stock Company owned by Yu.A. Guk. Under his leadership, the Joint-Stock Company became an advanced engineering company designing and constructing complex structures made of reinforced concrete (e.g., the pipe over the embankment of Moscow-Kazan Railway). Reinforced concrete was used to construct them. In his report "A brief outline of the general theory of the Monier system and its importance for the development of technical knowledge", Loleit (1895) proved that reinforced concrete is not just a combination of concrete and iron, but a new material in which concrete and iron form one indissoluble whole.

In 1896, the 16th All-Russian Art, Trade and Industrial Exhibition was held in Nizhny Novgorod. It became a site of great experiments. A.F. Loleit demonstrated possibilities of reinforced concrete on two works: the 45-meter reinforced concrete bridge over the tram tracks and the entrance to the exhibition, a 32-meter concrete arch located between two entrance towers above the visitors' heads, demonstrating high strength and reliability of reinforced concrete. There was no similar structure in Russia at that time (Molokova, 2017).

At the Exhibition, Loleit met V. G. Shukhov, the developer of mesh constructions. An example of cooperation between A.F. Loleit and V.G. Shukhov was the construction of the Upper Trading Rows in Moscow (GUM), where they designed and constructed floor structures over three trading lines: these

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were cylindrical glass vaults on metal structures. Loleit designed thin concrete transitional bridges. At the beginning of the twentieth century, visitors were afraid of walking along them – their arched structures seemed too unreliable (Molokova, 2017).

Gradually reinforced concrete began to be used in Russia. The Guk's company received many orders: 1899 – 26 reinforced concrete pipes were constructed under the embankment of Vitebsk – Zhlobin railway; 1900 – reinforced concrete vaults were built over a wine cellar in Moscow; 1902 – hollow reinforced concrete walls were built in the workshops of the Joint-stock company to test their strength (Lopatto, 1969).

The ever-increasing role of reinforced concrete required engineers capable of applying new material. In his article "The Monier System" (1903), Loleit proposed to study reinforced concrete in construction schools, award authors for the most interesting works on the theory of reinforced concrete (as cited in Lopatto, 1969). In 1912–1913, a new discipline "Reinforced concrete structures" began to be taught in Russian construction institutes (Molokova, 2017).

By 1903, great practical experience on the use of reinforced concrete structures had been accumulated in Russia, but there were no regulatory documents on the calculation and rules for these works and qualified control over their quality, which led to numerous accidents.

In 1903, Loleit developed rules for the production of reinforced concrete structures and described them in the works "On the Strength Factor of Reinforced Concrete Structures" (Loleit, 1905) and "On the Rules for Acceptance of Reinforced Concrete Structures" (Loleit, 1906).

Loleit showed the dependence of the calculation results on the adopted method which suggested calculating bending reinforced concrete elements by the stage of destruction. These conclusions were based on the results of numerous tests that showed excellent convergence of the experimental and calculated values of the breaking load (Loleit, 1905). All the experiments formed the basis of his works published in 1930–1933.

The report by Loleit (1906) "On the rules for acceptance of reinforced concrete structures" and its significance for science and practice of construction can hardly be overestimated. The main problems of reinforced concrete were covered.

In 1904, A.F. Loleit designed and supervised the construction of reinforced concrete vaults at the Museum of Fine Arts n.a. Emperor Alexander III (A.S. Pushkin Museum of Fine Arts), since the designs were complex and required precise control over the construction of the entire building (Molokova, 2017).

In 1907–1908, the manufacturer A.I. Morozov ordered to design beam-free reinforced concrete floors over the workshop of the Bogorodsk-Glukhovsky manufactory with an area of 6400 square meters.

For many years, the topic of beam-free reinforced concrete floors became the subject of research for Loleit.

Working on the project, A.F. Loleit developed his own method of calculating floor structures based on the theory of elasticity. He proceeded from the fact that bezel-less floors are a constructive system in which a smooth floor slab rests on columns with an expanded capital. Such a scheme changed the nature of the interior and the facade tectonics. The direct support of the plates on the capitals of the columns is a feature of this design scheme. The popularity of beam-less floors began to increase. They

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have been widely used in the construction of multi-storey warehouses, refrigerators, meat plants, garages. Such ceilings are economical in buildings with a square grid of columns and large temporary loads.

In 1905, Loleit developed and constructed bezel-less floors of a four-story warehouse of dairy products in Moscow (1908–1909). In parallel, analytical work on the theory of reinforced concrete T-sections was being carried out. Since that time, reinforced concrete has been used instead of steel and wood. It was a new structural form of reinforced concrete. Under the guidance of Loleit, more than 20 thousand square meters of such floors were constructed. In 1910–1912, A.F. Loleit tested flush-mounted ceilings, bringing them to destruction. As a result, comprehensive data on this new form of reinforced concrete structures were obtained. A.F. Loleit said about the advantage and cost-effectiveness of beam-free floors.

Loleit developed and put into practice the construction of spatial reinforced concrete structures in the form of arches (shells) of double curvature. These designs can be found in the Cathedral of the Holy Apostles Peter and Paul in Moscow. In 2004–2008, the large-scale restoration of the cathedral was carried out (Mirzoyan, 2015). Currently, this beautiful and unique building is an active cathedral and an object of cultural heritage of the peoples of the Russian Federation.

In 1907, Loleit developed a project for a fan-shaped ceiling for the ceiling of the Trekhgorny brewery in Moscow, designing fan arches on a grid measuring 9.1 x 9.1 meters with lights 6 meters in diameter.

Constant technical improvements and an increase in demand for the products of this enterprise increased the raw materials production volume. In 1909, in Moscow Loleit managed the construction of a reinforced concrete elevator with a capacity of 3,500 tons of grain at the Trekhgorny brewery. Loleit identified the negative effect of excess water on the strength of concrete structures. The factory buildings are of great scientific value.

A.F. Loleit was also engaged in research work. All tests on structures and materials provided an enormous theoretical basis for his scientific work. He published a number of articles: “A new type of reinforced concrete T-sections” (1908), “On the effect of excess water on the strength of reinforced concrete structures” (1909), and “Beamless floor structures” (1912) (as cited in Gvozdev, 1933).

In March 1912, the XIVth Congress of Russian technicians and breeders on cement, concrete and reinforced concrete business was held in Moscow. Based on the results of the congress, a collection of reports was published. In his report, Loleit, suggested arranging hollow flat reinforced concrete floors (Molokova, 2001).

In 1913, at the meeting of the Russian Society for Testing Materials in Moscow, A.F. Loleit made a presentation “On the theory of calculating beam-free floors”, illustrating it with photographs of objects built under his guidance, and proposed a new double-track system for reinforcing plate-beam floors with pre-prepared grids.

In 1914, Loleit decided to leave the construction company. At that time, the engineer had vast designing experience, he was one of the recognized experts in this field. A.F. Loleit decided to share knowledge and experience with the younger generation of engineers. In 1916, A.F. Loleit began teaching at the School of Painting, Sculpture and Architecture in Moscow, where he taught a course in structural mechanics and reinforced concrete. He taught at Moscow Civil Engineering College, military

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construction courses, MHTS (Moscow Higher Technical School) (Molokova, 2001). Along with teaching, he designed reinforced concrete structures for the construction of the Volga shipyard.

From 1915 to 1917, Loleit took part in the construction of the legendary and one of the oldest automobile manufacturing enterprises in Russia – the AMO plant (the automobile factory named after I.A. Likhachev). The company was founded in 1916 as part of the government program.

Since 1918, Loleit sought to make the construction cheaper. The main goal of architects and engineers was the development of new types of buildings using inexpensive building materials, including reinforced concrete structures. Loleit participated in the design and construction of building based on new model projects (e.g., the house of Mosselprom in Kalashnikov Lane in the center of Moscow). By 1917, due to the difficult economic situation, only five floors of the building had been erected. In 1923–1925, the house was built on two more floors according to the project by D.M. Kogan and V.D. Tsvetaev. It was crowned by a hexagonal tower with battlements, built in 1925 according to the project Loleit. The tower gave the building a modern look. The building was called the first Soviet “skyscraper” due to its corner part with a height of 11 floors. It was intended for warehouses and offices of Mosselprom, the food trust of the Moscow Council of the National Economy. The building was decorated with bright advertisements. The words of one of them belonged to V.V. Mayakovsky: "Nowhere except as in Mosselprom." The building is a monument of constructivism (Ikonnikov, 1984). In 1998, it was reconstructed. Mosselprom's advertisement appeared again on its facade.

In 1925, Loleit published his textbook “The course of reinforced concrete for technical schools. Fundamentals of theory and design”. Simple language helps readers understand everything that was described on the pages of the book.

In 1925–1927, architect G. B. Barkhin and engineer A.F. Loleit designed and built the building of the Izvestia publishing and printing houses. The combination of various functions determined the complex organization of the building whose basis was the spatial cell made of reinforced concrete. From the side of the Strastnaya Square, it was perceived as a whole cubic volume. A facade is based on the canvas of the frame whose effect is determined by the asymmetric arrangement of balconies and a glass tape revealing a staircase, the contrast of deaf planes cut by round windows (Gvozdev, 1933). The building has been criticized by the professional community. Now it is part of the complex of the Izvestia newspaper publishing house. In 2012–2016, it was being restored by A. Ginzburg (Barkhina, 2018).

In 1926 and 1927 in the USSR there were two major earthquakes in Armenia and Crimea. Loleit analyzed the consequences of natural disasters in his articles "On required safety margins of beam-free floors" (Loleit, 1927); “On accounting for additional forces developing in the elements of structures during earthquakes” (Loleit, 1927). He draws a number of conclusions and makes recommendations for designers and builders in areas of increased seismic hazard.

In the 1920-1930s, the mass housing construction began in the USSR. The building was massive, faceless and inexpressive, as it was subordinated to the construction experiment. It shows us the beginning of a long path of development of industrial housing construction (Ikonnikov, 1984).

In 1927, the State Institute for the Study of Building Structures was founded. A.F. Loleit was appointed a deputy director of research. Five years (from 1927 to 1933) of persistent scientific research and experiments allowed A.F. Loleit to justify a number of new technical ideas.

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In 1932, at the meeting of the All-Union Scientific Engineering-Technical Society of Concrete Workers, he made a report: "Revision of the theory of reinforced concrete", in which he suggested abandoning methods for calculating permissible stresses and calculating critical forces. He presented a new theory of reinforced concrete in his report at the Second All-Union Congress on Concrete and Reinforced Concrete, which was held in Leningrad in February 1932. The report was published as a separate book entitled “On the selection of sections of reinforced concrete elements for critical forces.” Draft instructions." The new theory of calculation caused a wide discussion. Most concrete engineers supported A.F. Loleit.

In 1937, the methodology for calculating the stages of destruction was approved and included in the regulatory documents for the calculation of reinforced concrete structures

From 1923 to 1933, Loleit was engaged in teaching. He worked at Moscow Civil Engineering Institute. In 1930, he founded the Department of Reinforced Concrete and Stone Structures. In 1933, the department was organized in Moscow Institute of Mathematics and Architecture. The department played an important role in shaping the structure of the institute.

During his work at MICI, Loleit was engaged in teaching and developed a new approach to the calculation of reinforced concrete structures, proving that statically indeterminate structures do not work as they are designed.

Under his guidance, the most important principle of the scientific school was developed and implemented: to develop affordable engineering and practical methods for calculating reinforced concrete structures that ensure reliability of the calculation results (Molokova, 2001).

Throughout his life, Loleit developed and promoted one topic – reinforced concrete structures – slabs, arches, floors, bridges, tanks, etc. He published many scientific works, textbooks and teaching aids, which became the basis of scientific research and learning guides for students.

7. Conclusion

After the death of A.F. Loleit in 1933, his students and followers A.A. Gvozdev, P.L. Pasternak and others continued his research on the calculation and use of reinforced concrete.

All his life was devoted to the development of reinforced concrete. He built a large number of facilities, founded the department "Reinforced concrete and stone structures" which is the oldest one in MICI. By the example of A.F. Loleit, civil engineers learn to be faithful to their profession, search for new ways to develop construction science.

In memory of the scientist, conferences and scientific readings are held at MSSU. On November 30 2018, in honor of the 150th anniversary of Professor A.F. Loleit, the scientific and practical conference Loleit Readings was held. The issue was Modern methods for calculating reinforced concrete and stone structures according to limiting conditions. The conference was attended by a large number of scientists, specialists from both Russia and foreign countries (Loleit, 2018).

His ideas are relevant, scientific developments are described in all textbooks on reinforced concrete. They are being developed by modern scientists and engineers.

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