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Twenty-Five Years of Engineering and Scientific Activity of Nikolai A. Belelyubsky

(report by A. N. Gorchakov in the Imperial Russian Technical Society in 1892)


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Archival publications

A reproduced report in the Imperial Russian Technical Society was first published in the Railway Business [Zheleznodorozhnoe delo] journal in 1892. It is dedicated to the activities of Nikolai. A. Belelyubsky, a well-known bridge engineer who made a significant contribution to the development of transport engineering in Russia, and whose biography can excellently help to trace the evolution of Russian railway bridge construction in the 19th century.
The author of the report was Andrei N. Gorchakov (1836–1914), who held the positions of head of the military road department of the field administration of military logistics of the acting army, engineer of the Ministry of Railways, was a member of the board of state railways, managed private railways, and was director of the ministerial railway department.
The author's punctuation and vocabulary are preserved as much as possible in the text.

Keywords: history of science and technology, transport, Nikolai A. Belelyubsky, bridge construction, structural mechanics.

Report read on May 29, 1892, at an emergency meeting of members of III and VIII Departments of the Imperial Russian Technical Society by A. N. Gorchakov, the Chairman of VIII Department

Dear sirs! The name of our fellow member N. A. Belelyubsky enjoys in the engineering world, here and abroad, such universal fame as can only be acquired through prolific labour, and therefore we consider it our duty, in honour of the respected anniverarian, today, at the very end of his twenty-five years of engineering and scientific activity to say that we know both about him and his works.

Nikolai Apollonovich was born on March 1, 1845, in Kharkov; his father, railway engineer Apollon Vasilievich, descendant of the nobility of Penza province, is known among technicians as the designer of the project and builder of the water pipeline in Novocherkassk. N.A. received his primary education at home, in Rostov-on-Don, and then he entered the 4th grade of Taganrog gymnasium, that he graduated with a gold medal in 1862. The same year, N.A. entered the Institute of Railway Engineers, where his further education was strongly influenced by the social trend that was created in our country after the Crimean War and which was expressed, among other things, in literary movement in the natural sciences. Along with the study of special engineering sciences, N.A. showed a special interest in general education subjects and keenly followed the development of issues of general culture. In 1867, he completed a course at the Institute of Railway Engineers with honours, having been awarded a record on a marble plaque, and was retained at the same Institute as a tutor; in 1873 he was elected extraordinary professor at the department of structural mechanics, and then ordinary professor, which position he still holds. In the first years of his academic career, N.A. also gave lectures at the Mining Institute, and currently he also teaches a course on bridges at the Institute of Civil Engineers. Since 1881, he has been attached to the Ministry of Railways as an advisory engineer.

N.A. devoted his technical activities mainly to issues related to construction of bridges and the study of building materials. Its beginning remarkably coincides with the beginning of development of iron bridges of truss and lattice systems, so that to correctly characterise N.A. activity in this area, it is useful to remember the state of the art of bridge construction at the end of the sixties.

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The text in Russian is published in the first part of the issue.
Текст на английском языке, публикуется в первой части данного выпуска.

It is known that first beam iron bridges were first made at the beginning of development of railways, i. e., in the twenties. They were built as a solid wall, and the dimensions were assigned through direct preliminary experience, since at that time the theory of force distribution in parts of the beams was still little studied.

The first iron bridges with a through wall were built in the forties according to the idea of wooden bridges of the Towne system, that is, lattice bridges with flat braces; these braces were assigned only the role of filling the gap between the chords, therefore the dimensions of the braces were not determined by calculation, but they were assigned the same cross-section along the entire length of the trusses (1845). In the bridges of St. Petersburg-Warsaw Railway, the dimensions of the braces already increase as they approach the supports from the middle, although they still remain of a flat section (1864); however, at that time the benefits of using rigid braces were already partially recognised.

Simultaneously with development of lattice system bridges, the Neuville (1846) and Warren (1848) trusses, consisting of simple triangles, appeared, and in 1853 the Krumlin Viaduct, well-known in the literature, was built using this system. In 1858, Mobi proposed braced trusses with vertical posts, which obtained their greatest development in the sixties; then modifications of these types appeared, such as Schwedler trusses, parabolic, semi-parabolic (Culemborg bridge over the Lek) etc.

The theoretical side of bridge art was only in its infancy in the forties and received little development after the experiments of Ferbairn, Stephenson, Hodgkinson, Zhuravsky and others, which they carried out almost simultaneously and mainly on bridge models. Our first experiments were made by the late Zhuravsky in 1845 and, moreover, before English studies were published. Soon the literature was enriched by Kuhlmann's report, in the journal of Austrian engineers (1851), on distribution of forces in parts of single-span trusses; in 1855, Zhuravsky's essay on bridges of the Howe[1] system appeared, then methods for calculating bridges proposed by Ritter (1861), Rekhnevsky (1861), Kuhlman (1864) were published, and finally at the same time the work of Lesslie and Schübler, translated into Russian by N. A. Belelyubsky, in the first year after completing his course at the Institute of Railway Engineers. This book received significant distribution in Russia, having gone through two editions, and the calculation methods outlined in it were used for most iron bridges, and currently they use the same work when drawing up projects of all kinds of trusses, guided at the same time by the results of further research that so many technicians have been awarded the past decade.

In this state of affairs, N.A. began his first work by participating in reconstruction of wooden bridges on Nikolaevskaya railway, which required a detailed clarification of the conditions for possibly quickly replacing them with iron bridges and, moreover, without stopping traffic on the road. This work, which was essentially very complex, required special care and required significant simplifications; the latter was achieved by bringing all bridges of the first series, rebuilt between 1868 and 1872, to five types of predominantly braced and lattice systems. A detailed report on this issue is presented in an article by N.A., published in the journal of the Ministry of Railways in 1872, from which it can be seen, among other things, that in order to rebuild 48 bridges it was necessary to draw up 26 separate designs for spans, not counting stone and metal supports. Given the comparative poverty of technical literature at that time, N.A. had to work hard to clarify the conditions for correct detailing of projects, which is confirmed by a number of articles that he published then in the journal of the Ministry of Railways, for example, in 1868 on «External force acting on bridge structures», in 1871 «Notes on bridges built and under construction», etc.

During the same period of time, N.A. compiled the essay «Novocherkassk water supply system and data for designing water supplies in 1869,» which for a long time served as the best guide in this field of technology[2], and then in 1870, he published the 2nd part of the work of Lesslie and Schübler, with an application of a method for calculating trusses according to Ritter and with many additions by a translator.

Next, in chronological order, followed the work of N.A. on drawing up designs for bridges of Schwedler system on Moscow-Brest railway (across the Berezina River, 3 spans of 25 sazhens each, and across the Neman River, 2 spans of $22^1/_2$ sazhens each) and on Kozlov–Voronezh–Rostov railway (across the Kalitva river, 1 span of 30 sazhens). These projects show that N.A. sought to spread a certain variety of bridge superstructure designs in Russia; such an intention is also seen from the above-mentioned brochure on reconstruction of Nikolaevskaya railway bridges, where N.A. reports that exclusively local conditions prevented the use of a truss system with curved chords for these bridges, which saves weight.

At the same time, designs for bridges across the river Oka were prepared on Ryazhsko-Vyazemskaya railway (4 spans of 37 sazhens each), across the river Prut on the Chisinau branch of Odessa road, and now on the South-Western railway (2 spans of 32 sazhens each) and across the river Chusovaya on Ural railway (3 spans of 40 sazhens each). The design of the first of these bridges, built in 1872–1874, was later used for the bridge across the river Ranov along Ryazansko-Kozlovskaya railway (1879–1884), and in 1882 it was published by N.A. in the form of an album. Other projects were also used in subsequent construction of

[1] Research and calculations related to braced bridges were done by Zhuravsky earlier than abroad. In the above-mentioned work, the question of shearing stresses during bending of beams is considered for the first time.

[2] N.A. published a note on the same subject in Engineering Notes for 1875, «Statistics of Urban Water Supply».

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bridges and at present it is almost impossible to indicate in what number of bridges the construction according to the original designs of N.A. was repeated.

Next in time of compilation are: a) the second series of bridges rebuilt on Nikolaevskaya railway from 1872 to 1880, it was required to draw up various projects, numbering over 30; b) Alexandrovsky bridge across the Volga on Orenburg railway and c) city bridges in Orel across the rivers Oka and Orlik, the projects of which were compiled by N.A. together with Professor Nikolai, in 1877. N.A. reported on the first bridges to the Imperial Russian Technical Society in 1874. In drawing up the projects of all these bridges, N.A. was directly involved in clarifying various issues of their construction itself.

The program of this note does not allow us to dwell in detail on assessment of N.A.'s works on drawing up designs of bridge structures; the number of them is in the full sense astonishing, and it is not easy to point out another person, in any field of activity, who has suffered as much hard work. The names of many publicists and talented writers are known, who also published numerous works, but they immortalised their names only due to the fact that, due to the popularity of the very issues or subjects they described, their works are accessible to the entire reading public. Specialists are in much less favourable conditions in this regard, the range of their activities is accessible to a limited number of people, and if, nevertheless, N.A. has gained universal fame, then this, no doubt, is explained by the enormous number of structures that were executed according to his designs and which represent the tangible results of his tireless activity.

Of the works by N.A. listed above, we will mention only Verebyinsky bypass, Yaroslavl viaduct in Moscow and Alexandrovsky Bridge. The first, as it is known, was initially supposed not to be built at all, but the plan was to replace the wooden Mstinsky and Verebyinsky bridges with iron ones and, moreover, without stopping traffic. For this purpose, a contest was announced for preparation of corresponding projects, and N.A. was instructed to independently develop projects for reconstruction of the same bridges outside the competition. Subsequently, however, the need for constructing a bypass became clear again, and at the same time it was decided to build Mstinsky bridge and build Verebyinsky stone pipe according to N.A's designs, although the projects submitted to the competition were awarded prizes. There is a message about competitive projects by N.A. in the Technical Society (1874).

The best assessment of these projects by N.A. is that the late Professor Winkler found it appropriate to place some details from Mstinsky Bridge project in his famous work «Quercon-structionen». Details of construction of Yaroslavl viaduct are included in the course on bridges by Professor Nikolai.

Alexandrovsky bridge across the river Volga, which until the end of the last decade occupied the first largest (about 700 sazhens) place in all of Europe, was built according to the design of N.A. (in 1875–1880), of 13 spans of 52 sazhens each. Initially, it was planned to make 7 spans with a ride on the bottom, and the rest with a ride on the top; in this form, projects were developed and metal parts were ordered from the Belgian plant. Subsequently, when part of the iron had already been delivered to the work site, it became clear that it was necessary to construct all spans with a ride on the bottom; then N.A. was sent to Belgium to develop and resolve at the plant the issue of remaking manufactured parts. At the same time, N.A. drew special attention to the unsatisfactory technical conditions proposed to the plant for guidance in the manufacture of metal parts, which did not at all determine the relative elongation of iron during a tensile test. In this way, the technical conditions were also changed, and up to 10000 poods of iron, which was already partly at the work site, was found unsuitable for the bridge.

This incident marked the beginning of correct formulation of technical conditions for manufacture of bridge structures in our country, and everyone knows that on this issue N.A. rendered an enormous service in all his subsequent activities, both by personally developing these conditions and by their consistent development through the exchange of thoughts in international congresses and numerous meetings.

The construction of such a large bridge as Volzhsky was inevitably accompanied by a number of complications; they were resolved almost constantly with the direct participation of N.A. or on his personal initiative; this includes, by the way, the method proposed by N.A. of extending the pier onto a caisson, which was already under construction. The description of these works was published in the journal of the Ministry of Railways by the caisson-maker Reiner with an additional note by N.A. about the caisson-shoe (1881). Details of construction of Volga Bridge are placed in «Engineering» for 1880, in the education course on bridges by Professor Nikolai, in Mr. Buzzi's article

«Le pont sur le Wolga près Batraki 1887» and in other publications in foreign literature.

Work carried out almost simultaneously on construction of Mstinsky and Volzhsky bridges, as well as the Liteyny bridge across the river Neva and the Verebyinsky Bypass gave impetus to development of the cement business. From that time on, we began a systematic study of the properties of cement, to which N.A. devoted many works; with particular energy, he strove to find ways to ensure development of domestic production of cement of the best quality. Regardless of the technical development of the issue, N.A. contributed greatly to the initiative to establish a duty on foreign cement in our country, which had such a beneficial effect on improving production of Russian cement that production of this product occupies a prominent place in the factory industry of Europe. N.A.'s merit in the cement business is undoubtedly great and in itself could serve as the crown of glory for his engineering activities. N.A.'s works on the cement business were awarded an honorary diploma back in 1882 at the All-Russian Industrial Exhibition in Moscow.

In conclusion of the review of N.A.'s activities for the period up to the eighties, it is necessary to point out that a quick look at the projects he compiled in sequential order gives a clear idea of the historical course of development of the bridge industry in Russia, and, of course, it is easy to grasp the gradual improvement of structures and the desire of N. A. to achieve the most rational detailing.

This circumstance is of very significant importance, since it marks a very definite direction, expressed in the fact that, by means of an appropriate arrangement of bridges, the tension of the parts must be achieved in accordance with theoretical calculations, and, if possible, there is the need to free them from the so-called additional stresses. Back in 1871, in the preface from the translator to the work of Lesslie and Schübler, N.A. drew attention to the fact that the main conditions affecting the weight of the bridge structure, and therefore its cost, include careful design and the choice of appropriate interfaces.

N.A. tried to fulfill this condition with due rigour, and in later projects he used design features for this purpose.

The bridges designed by N.A. during the described period of time comprise a more or less limited number of different types. In his publication «The upper structure of the bridge of 20,00 sazhens bracing system of 1881» N.A. reports on this matter that «these conditions, under which it was necessary for the most part to design the upper structure of bridges, were reflected in some uniformity in types, compared with foreign bridge practice, where there was more convenience and scope for trial implementation of all modifications of the main systems; but, on the other hand, the repetition of types and the desire to simplify execution contributed to a more rigourous development of details that were quite suitable in practice».

The beginning of the eighties was marked in the engineering world by the most intense movement of theoretical studies of bridge structures, and not only the laws of statics, but also the general position on the theory of elasticity, the beginning of the smallest work, and the principles of possible movements during deformation began to be taken as the basis for calculations of distribution of forces in their components. The studies of Castigliano (1879), Mohr, Winkler (1881), Frenkel (1882) opened up the possibility of detailed clarification of various conditions that accompany the existence of bridges but are not explicitly taken into account when drawing up projects. Other works of technical scientists Weyrauch, Laundhart, Gerber, Winkler, Cherepashinsky and others revealed the influence that variability of stresses that manifest themselves in them under the influence of variable external forces has on the strength of parts. N.A. compiled a brochure about these studies in 1888 entitled «Calculation of stresses subjected to variable loads, etc.» This is followed by the study of questions about the influence of dynamic loads on bridge structures (Rezal), about additional stresses in parts of the trusses, depending on rigidity of the connection of the nodes, on the often allowed centering [alignment violations] of them (Azimont, Manderla, Winkler, etc.), on the complete and off-central attachment of transverse beams, from temperature changes, etc. All these studies indicated that circumstances not taken into account when drawing up designs of through trusses are accompanied by manifestation of additional stresses, which, in their magnitude, often exceed the main stresses corresponding to static calculations. At the same time, it turned out that the use of new calculation methods for everyday practice is almost impossible, due to the extreme complexity of the calculations required. This circumstance, as well as the fact that no matter how thorough the methods proposed for such calculations by famous scientists, these methods are still not distinguished by unconditional accuracy, prompted N.A. in further design to treat with even greater rigor the chosen path, expressed in development of such structures in which the causes of additional stress would be eliminated.

Compiled in this way, in the period from 1881 to 1884, N.A. bridge projects – Ekaterinoslavsky across the river Dnieper, across the river Ingulets on the Ekaterininskaya railway and across the river Uvod, on the Shuisko-Ivanovskaya railway, are distinguished by their precise observance of the central connections of parts of the trusses and connections. The first of these bridges, about 590 sazhens long, is built in two tiers, for carriage passage and for railway communication, consists of 15 spans of 38 sazhens each, and metal entrances. A description of this and Inguletsky bridges was published in «Engineering» for 1881: in «Vochenschr. d. osterr. Jng. und Arch-Ver.» 1884, briefly in the work of Professor Haseler «der Bruckenbau» and in some other publications. Bridge over the river Uvod, single-span one of 50 sazhens long, oblique, with an upper curved belt; a detailed description of it was published by N.A. in a brochure with an atlas of drawings, entitled «Renewal of the bridge across the river Uvod 1884», which contains, among other things, interesting data on construction coefficients of this bridge, reported by N.A. also in «Rigasche Ind. Zeitg.» for 1884

Simultaneously with the designs of these three bridges, N.A. drew up a design for a bridge across the Obvodny Canal of Nikolaevskaya Railway and sketches for continuation of the Kyiv Canal across the river Dnieper chain bridge for the highway department, but these projects were not implemented due to local considerations. Then, with direct participation of N.A., designs for other bridges were made on Ekaterininskaya Railway, as well as on the Polesie Railways and across the river Psel on Kharkov-Nikolaev railway, the Shwedler system, and he also explained all sorts of complications that in most cases accompany bridge construction work.

For this purpose, N.A. made repeated trips to work sites and factories, in Russia and abroad, where he had the opportunity to study, among other things, the properties of a new material that was emerging at that time called cast iron, which N.A. with amazing persistence then tried to spread it for use in bridge structures. In this matter, N.A. undoubtedly took full initiative and, due to him, the properties of cast iron were examined in our country through numerous tests and discussions in various commissions of specialists in such detail that the results achieved in Russia gave very significant instructions for correct development of manufacturing and processing conditions of cast iron. Currently, this material has almost replaced wrought iron, which was previously extremely widespread, and our cast iron, which has significant softness, is superior in quality to foreign ones. The development of an issue of such serious importance as distribution of new material gave rise to extensive correspondence on the conditions for the use of cast iron, to which N.A. made many valuable contributions. In 1882, he published an article on the same issue in the Technical Collection «On the use of cast iron, instead of welding», in 1884 in «Zheleznodorozhnoe Delo» «Rhine factories. Unloading platform. Experiments on beams made of cast and wrought iron», and in 1885 N.A. published the article «Cast Iron. Should we be afraid of it and how should we treat it?

In the same 1885, N.A. completed the publication of his «Course on Structural Mechanics», in which the theoretical side of the subject was developed with a critical assessment of various studies up to modern times, and practical instructions serve as a valuable tool for application to business. In general, this course is not only a guide for students, but also a reference book for engineers. The same position is occupied by the works published by N.A. in 1886 under the title «Mechanical Laboratory», which contain numerous results of tests of building materials carried out by him personally, or with his direct participation, for the period from 1875 to 1886. This book, appreciated by experts in a worthy manner, contains abundant material for guidance in drawing up technical specifications, and for checking scientific research (works of Cherepashinsky and others).

N.A. began his activities in the Mechanical Laboratory of the Institute of Railway Engineers, as its head, 20 years after its construction, namely, in 1873; its equipment at that time was very meager, and the very consciousness of the need to test building materials was still very weak. The laboratory is now completing its second 20th anniversary. A simple comparison of the degree of its development in these two periods is enough to evaluate the strength of the tireless energy of the venerable hero of the day in this part of his field. N.A. placed the laboratory at the height of the current position of the best testing stations in Europe, with which it is at the same time in direct contact through periodic relations between N.A. and their most famous representatives (Tetmeier, Bauschinger and others). By popularising the works of the laboratory, N.A. managed to give it the significance of a school, around which our factory and other local laboratories are grouped, and which spread general awareness of the need for correct organization of trial studies of materials on site, for any kind of outstanding construction. In this activity, N.A. did not miss a single case that could be used to develop the issue of normalizing the conditions of suitability of building materials. Thus, he took an active part in the exchange of thoughts at international congresses on development of uniform testing methods: in Munich, Dresden, Berlin, and Paris; the results of the meetings were promptly published by him in many reports, including his «Uniform Test of Building Materials 1887» Then, with N.A.'s characteristic liveliness of character, he persistently put the results of the meetings into action. Interesting reports and numerous notes in various publications were reported annually to N.A. about the activities of the Mechanical Laboratory, such as, for example, about the testing of iron and cast iron for a bridge across the river Ranova, about the cement issue, about testing stone materials for frost, etc.

Next, in chronological order, follows the work of N.A. in 1885–89 on drawing up designs for bridges across the river Volga on Nikolaevskaya railway and across the river Belaya on Samara-Ufimskaya railway. The peculiarity of these bridges is arrangement of the hinged connection of transverse beams with trusses, which achieves complete elimination of additional stresses in trusses from the influence of deflection of transverse beams; in addition, other details were developed in accordance with the conditions for possible elimination of secondary wall stresses (absence of wide braces, centralisation of nodes, etc.). The model of the hinged connection of transverse beams on these bridges won a medal at the Edinburgh Exhibition in 1890, and the complete design of the bridge over the river Volga was published by N.A. with a brief description.

The projects of the superstructure of bridges with a ride on top, drawn up by N.A., should also be attributed to the same period, resp. 10, 25 and 30 sazhens, for Rzhevo-Vyazemskaya railway, also used on Samara-Zlatoust railway, and then they became widespread as types. The trusses of these bridges are of a lattice system in which some braces work in compression and tension; the dimensions of these braces are consistent with the above theoretical studies based on Weller's experiments.

Achieved by N.A. for bridges across the river Volga of Nikolaevskaya railway, across the river Belaya and other thoroughness in development of projects, when the question of improving bridge structures received lively movement in the eighties, seemed to him not quite sufficient, if we take into account that by arranging expedient pairings of parts, multi-braced trusses, containing an excess of elements connecting nodes, cannot themselves be free from additional stresses unforeseen by static calculations. As a result, N.A. began in 1887 to develop a truss in which the number of parts, being sufficient, would not be more than the number that corresponds to the possibility of correctly determining the forces in them, but the main condition of static equilibrium. Such a system of trusses was compiled by him and used when developing a project for a city bridge across the river Volga in Tver, the construction of which has not yet begun.

According to the above design, the trusses are assumed to be parabolic, with two working systems of braces, ending in the middle of the span with the only post in the entire truss. This system appeared as a result of our independent clarification of N.A.'s intended task. Subsequently, studies of trusses of exactly the same system were published in foreign technical literature, which, as it turned out, was already known abroad. In 1888 in «Rigasche Ind. Zeit.» N.A. dedicated the note «Aus der Praxis des Baues eisernen Brucken» to the memory of the late Winkler, in which, together with descriptions of more remarkable bridges in Russia, a message was made about the Tverskoy project of the bridge across the river Volga with statically determined trusses. In the same year, N.A. published a report about this bridge in the journal «Engineer» under the title «From bridge practice». These sketches, according to the author, represent the result of his memories in the Caucasus «at the foot of Beshtau, where, far from daily, fussy activities that could not tolerate delay, he was involuntarily drawn to look back at the past and understand a little about it, to remember his path passed through a period of feverish railway activities in Russia, and remember those who have already passed their entire earthly journey».

The above system of trusses makes it possible to have a completely accurate idea of distribution of forces in their parts, but the very calculation of such trusses requires numerous calculations, due to the fact that in any cut made in this truss there are more than three parts. This circumstance prompted N.A., during subsequent development of the next project, to use another type of statically defined truss of a possibly simple system. An opportunity soon presented itself: in 1890–91 he developed a project for a highway bridge across the river Neman near Olita in which the trusses consist of simple isosceles triangles without any racks, with a curved upper chord; transverse beams of the roadway are laid, using hinges, with the lower chord in the space between the braces; the bracing braces are lattice triangular pipes, fixed in the planes of the braces at their ends.

Just towards the end of preparation of this project, a disaster occurred with Menchenstein Bridge in Switzerland, which, as is known, was built from trusses of a similar system. Obviously, N.A. must have had the idea of the need to carefully clarify the conditions that ensure the strength of the structure according to the project he was drawing up at that time, depending on the instructions introduced into engineering science by the collapse of Menchenstein Bridge, as if in reward for numerous victims of this unfortunate case. A closer comparison of both projects and a detailed study of the details developed in them revealed the complete inconsistency of the last bridge, while in the project of the Nemansky Bridge N.A., sensitive to all kinds of design improvements, did not find it necessary to make any changes.

As a further example of the use of a statically defined truss, one can point to N.A.'s participation in discussion of the issue of choosing a system for a city bridge in Smolensk, and N.A. developed, among some options, a sketch of the structure of this bridge according to Gerber system; but, due to local conditions, N.A. believes that it will not be profitable to implement this sketch. However, in general, apparently, one should not yet draw the conclusion that an exclusive right of citizenship should be established for statically defined trusses. Thus, N.A. is currently developing a project for a city bridge across the river Viliya, in Vilna [Vilnius] to which it is proposed to apply a system of superstructure similar to bridges across the river Belaya on Samara-Ufa railway and across the river Volga on Nikolaevskaya railway, i. e. with two-diagonal semi-parabolic trusses. Giving complete justice to statically indefinite trusses with regard to correct distribution of forces in them, N.A. at the same time finds it possible to further use correctly designed statically indefinite trusses that have proven strength.

It remains to be mentioned that in the recent period of time under consideration, the question arose here and abroad about adapting railway bridges to allow heavy eight-wheeled steam locomotives to cross them. For this purpose, as calculations showed, it became clear that many parts of the bridges needed to be strengthened. This kind of work, provided that movement is maintained without interruption, of course, presents numerous difficulties and is expensive. This circumstance could not escape N.A.'s attention, and he began to clarify possible simplifications in this matter. Then his note appeared in the journal of the Ministry of Railways entitled «Bridge Studies» and his message was published in the «News of the Meeting of Railway Engineers» for 1890 under the title «Stress in Beams and Strengthening Bridges.» In the works of these N.A., having clarified the meaning of oblique stresses in beams with a solid wall, he drew attention to the possibility of easing the requirements for strengthening bridges.

In conclusion of the report on N.A.'s participation in the bridge business, it is necessary to once again recall that the railway bridges built in our country in the last 25 years were mostly made according to N.A.'s designs, and to date no significant damage has been found in their trusses. Comparative statistics of data on bridge collapses convinces us that our bridges were built in this regard under generally better conditions than abroad. The major damage to the spans of bridges that occurred during the specified period of time relates only to those bridges that were built without the participation of N.A.

After presenting the work of N.A., expressed in drawing up designs for bridge structures and in developing various conditions associated with this matter, it is necessary to say a few words about N.A.'s activities in other related areas.

As a professor at the Institute of Railway Engineers, he gained the reputation of a first-class teacher and demonstrated his activity in this field using a teaching method that is little practiced in our country, which, however, stems from the characteristics of N.A.'s lively, responsive nature. Regarding N.A., it can be positively stated that he constantly teaches, and not only the students. He disseminates every novelty, feature or interesting idea that emerges during a joint discussion of technical issues in special meetings with amazing speed, thus making available to others everything that is known to him and to outstanding technicians in the art of engineering. Numerous requests made to N.A. by various persons regarding the technical doubts encountered are explained to him, to the best of his ability, with the liveliest participation, and, moreover, with full respect for the comments made to him. This is a worthy, bright trait that distinguishes the venerable professor, but, apparently, is still little appreciated among us. In more difficult unexplained questions, N.A. resorts to a meeting with foreign luminaries of engineering art and on this occasion he has extensive correspondence with them, containing very valuable opinions of modern authorities on the issues of bridge construction that most interested Russian technicians.

N.A. provided many services to the Imperial Russian Technical Society, of which he has been a member since 1867, i. e., also 25 years. For the last fifteen years he has given annual reports in the field of bridge practice and building materials research; many of these reports were published in the «Proceedings of the Technical Society»; in addition, he was involved in commissions formed at the Society to study rail steel, on the cement issue, etc. He made numerous reports in other societies, for example, in the Assembly of Railway Engineers, in the Society of Architects, in various provincial and foreign technical societies; Among these reports one can name a message about the new material xylolite, about experiments carried out by N.A. on iron that had been in use for a long time, about experiments carried out under his supervision on Monnier concrete, etc. Since 1889, N.A. has been an honorary member of German Technical Society in Riga, and since 1890 a corresponding member and honorary member of the Society of Civil Engineers in Paris.

Finally, N.A., responding with heartfelt sensitivity to all the needs of the student youth, takes an active part in the committee of the society for the benefit of needy students at the Institute of Railway Engineers and is a member of the same society at the higher women's courses.

Dear sirs! Given the numerous number of works and such multifaceted activities of N.A., it is, of course, difficult to present any detailed overview of this activity in a quick report or in a journal article; much has to be mentioned in passing or nothing at all must be said due to insufficient time and information. Thus, the information presented to you now, without a doubt, does not sufficiently remind us of the well-known, numerous works of the tireless N.A. implementing these works, together with the happy well-being of all the structures completed according to his designs, one cannot help but come to the conclusion that the merits of N. A. are great. Future biographers, of course, will have more means to treat his works with due appreciation and, without a doubt, will indicate the real position of this scientist among the outstanding people of recent times. All that remains for us is to warmly welcome the respected celebrant, express to him our deep respect, his fellow members of the Technical Society, and wish him to preserve his characteristic tireless energy for many years to continue his precious work for the benefit, pride and glory of our Fatherland.

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