OPTIMAL LOCATION OF COMMUNICATION LINES AND POWER LINES ON COMMON SUPPORT

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ABSTRACT
In the energy sector of Russia, there is a growing demand for electricity. An advantageous way to provide communication and power services is the construction of overhead lines and power lines. There is a connection of new consumers to existing lines. At the intersection of communication lines and power lines, a “tangle” of wires is formed, making it difficult to carry out installation and repair work. When carrying out any work related to the installation, repair or maintenance of supports with such “tangles”, the risk of electric shock and the risk of workers falling from a height increase significantly. To reduce the complexity of maintenance and increase safety at key intersections, a constructive solution has been proposed in the form of a traverse. The proposed traverse will allow to arrange the placement of wires of communication lines and power lines at the nodes of their intersection, that is, it will allow optimization of the mutual placement of wires in space. Optimization of the mutual placement of wires in space meets the conditions for increasing the safety of work on supports and the convenience of servicing communication lines and power lines. In addition, the placement of wires using the proposed crosshead significantly improves the appearance of the supports themselves and the surrounding areas, since no “tangles” of wires are formed. To justify the feasibility of introducing the developed design, an assessment was carried out of the professional risk of injury to electricians performing maintenance work on power lines, using and without a prototype traverse. The trial operation of the traverse was carried out at 17 work sites, each of which employed 15 electricians. The experiment showed that when using a traverse, the likelihood of safe work at work sites increased. Thus, the calculations showed that the proposed design can improve the safety of electricians.

KEYWORDS*:* pillar, communication lines, power lines, traverse, safety

MSC: 90B10

RESUMEN
En el sector de la energía en sector Rusia, hay un crecimiento de la demanda de electricidad. Una ventajosa forma de proveer comunicación y servicios es la construcción de líneas aéreas y de potencia. Hay una necesidad de conexión de los nuevos consumidores a las líneas existentes . La intersección de las líneas de comunicación y las de potencia, forma un “entramado” de alambres, haciendo difícil llevar a cabo la instalación y la reparación. Al desarrollar el trabajo de instalación, reparación o mantenimiento de los soportes en este “entramado”, el riesgo de choques eléctricos y de las caídas de los trabajadores de las alturas crecen significativamente. Para reducir la complejidad del mantenimiento e incrementar la seguridad en las intersecciones clave, una constructiva solución ha sido propuesta en la forma de un transverso. El transverso propuesto permitirá ordenar la ubicación de los alambres de las líneas de comunicación y de potencia en los nodos de sus intersección, esto es, permitirá la optimización de la ubicación mutua de alambres en el espacio. La optimización de la ubicación mutua de alambres en el espacio satisface las condiciones para incrementar la seguridad del trabajo en los soportes y de la conveniencia del serviciaje de las líneas de comunicación y. Adicionalmente, la ubicación de los alambres usando la propuesta de cruzamientos mejora significativamente la aparición de los soportes por si mismos en las áreas circundantes, dado que no se formaran “entramados” de alambres. Para justificar la factibilidad de introducir el diseño desarrollado, una asesoría fue brindada a partir de los riesgos profesionales de lesiones a los electricistas quel llevan a cao los mantenimientos en las líneas de potencia , usando o no un prototipo de transverso. La operación de prueba del transverso se

desarrolló en 17 sitios, cada uno empleaba 15 electricistas. El experimento mostró que cuando se usa una transverso, la verosimilitud del trabajo sin riesgos en los sitios de trabajo se incrementó. Entonces, los cálculos mostraron que la propuesta mejora la seguridad de los electricistas.

PALABRAS CLAVE : pilar, líneas de comunicación, líneas de potencia, transverso, seguridad

1. INTRODUCTION

Growing demand for electric power is one of the main trends in the development of the electric grid complex in the whole world, including in Russia. Along with a decrease in electricity consumption in rural areas of the regions, where there is an outflow of the working-age population in search of better working conditions, the demand is growing in large cities. Within cities, electricity consumption is not uniform: energy consumption in industrial areas, in areas of construction of office and commercial real estate, residential areas can vary significantly. [1,2,3]. The most significant factors affecting electricity consumption are the mode of operation of enterprises, the way of life of the population, the duration of the working week and days off, and also climatic conditions. [4]. High rates of electric power losses in electric networks and a high degree of deterioration of the latter are among the most pressing problems of our country's power industry. According to the "Strategy for the Development of the Electric Grid Complex of Russia", the average level of losses in domestic networks is about 11% of the net energy supply. The business losses associated with the theft of electricity contribute to the indicator. Every year in Russia up to 10 ... 12 billion kW·h of electricity is stolen [1,5,6]. The greatest electrical losses in distribution networks due to their large length and branching, uneven loading of phases and low voltage of transmitted electrical energy. Since half of the distribution networks have already reached their standard period, the total deterioration of capacity in the sector is estimated at 70% [7,8,9]. These data make it very important to replace the bare wires of 0.4 kV overhead power transmission lines (PTL) with self-supporting insulated wires (SSIW). IW is a stranded wire for overhead power lines, containing insulated conductors and a supporting element, designed for fastening or suspending the wire [10,11].

The demand for communication and communication services, as well as consumers of these services, has grown. In a large city, laying communication cables in existing sewage facilities is a complicated and often impossible task due to their congestion, high rent, and interdepartmental inconsistencies [12,13,14] The construction of new own sewage facilities is laborious, expensive and not everywhere feasible due to the current dense structure of buildings and communications. Easier to connect the subscriber via air lines. In dense urban areas, as a rule, supports have already been installed, along which overhead power lines are laid. It is more economical to connect a subscriber by laying a communication line on common pylons with an overhead power line. [2,8,15]. This is most often implemented. In the absence of a systematic, constructively developed approach to connecting new communication lines on common pillars with overhead PTL, in densely populated areas and the most busy trading locations on pillars, a tangle of chaotically fixed communication lines and power lines is formed at the junction points of intersection of overhead lines and overhead power lines. The scale of this problem is so high that in the places of nodal intersections of communication lines and PTL, any work related to the maintenance of lines, installation and repair becomes unsafe. Moreover, this situation is developing not only in the Russian Federation, but also in a number of other countries of the world [2,16,17].

2. FORMULATION OF THE PROBLEM. METHODS AND ALGORITHM FOR SOLVING

The task of the study is to solve the problem of chaotically fixed overhead communication lines and overhead power transmission lines on supports at key intersections. The solution is necessary to reduce the complexity of maintenance and improve safety in the operation, installation and maintenance of the air lines and the overhead line in the junction points of overhead communication lines and overhead power lines.

To solve the problem, you need:

- to identify the problem of non-compliance with the requirements for joint suspension of communication lines and power lines on common pillars;
- toanalyze the risks caused by non-compliance with the requirements for joint suspension of communication lines and power lines on common pillars;
- to propose a technical solution allowing to ensure safety during operation, installation and maintenance of the airlines and the overhead line at the junction points of overhead communication lines and overhead power lines.

Critical analysis of the existing technical methods of fastening communication lines and power lines to the support. A critical analysis of measures of an organizational and technical nature on joint suspension on one pillar of communication lines and power lines. Design work on the technical solution.

3. ANALYTICAL PART

Combined laying of overhead lines on common pillars with PTL leads to lines of intersection of coils from wires on pillars in nodal places (Figure 1). Such chaotically attached to the supports of the coil of wires of communication lines and power lines are not only unattractive from an aesthetic point of view, but are also a problem of ensuring security during the maintenance, repair and installation of lines.

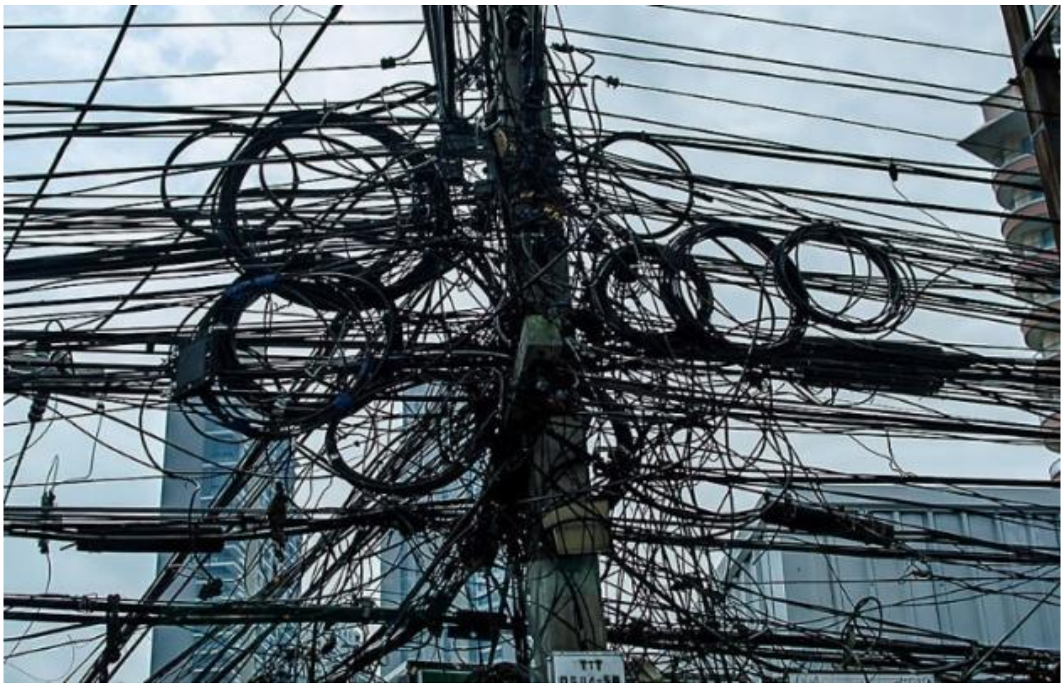

Figure 1. The appearance of the pylon in Russia

With an increase in electricity consumption and communication services, an increase in the power and number of communication subscribers, the uncontrolled and unorganized connection of new subscribers requires an immediate solution to the problem that is observed not only in the Russian Federation, but also in several other countries of the world (Figure 2).

Maintenance and repair of the overhead lines and the overhead power lines is a mandatory operational process. In most cases, the work on the maintenance of the the overhead lines and the overhead power lines is carried out at a height and refers to the traumatic work with a consistently high proportion of serious and fatal injuries [18,19]. Labor protection rules for work at heights [20] imply a number of organizational and technical measures, the implementation of which should minimize the number of accidents associated with work at heights. Technical measures to ensure the safety of work at heights include safety systems. It consists of [21]: a) anchor device; b) a leash (safety, for holding, for positioning, for sitting position); c) connective-shock-absorbing subsystem (slings, ropes, carbines, shock absorbers, retractable type of protection, means of protection against falling of the slide type on a flexible or rigid anchor line).Requirements for joint suspension of the overhead lines and the overhead power lines on common pillars in the Russian Federation are set out in the Rules for the Installation of Electrical Installations (Chapter 2.4. Overhead transmission lines with voltage up to 1 kV). There are requirements for the overhead lines and the overhead power lines for ensuring trouble-free operation in the transmission of electricity over the overhead power line and the transmission of a telecommunication signal over the overhead line. The requirements are aimed at ensuring the electrical safety of workers during the installation, repair and maintenance of communication lines and electricity.

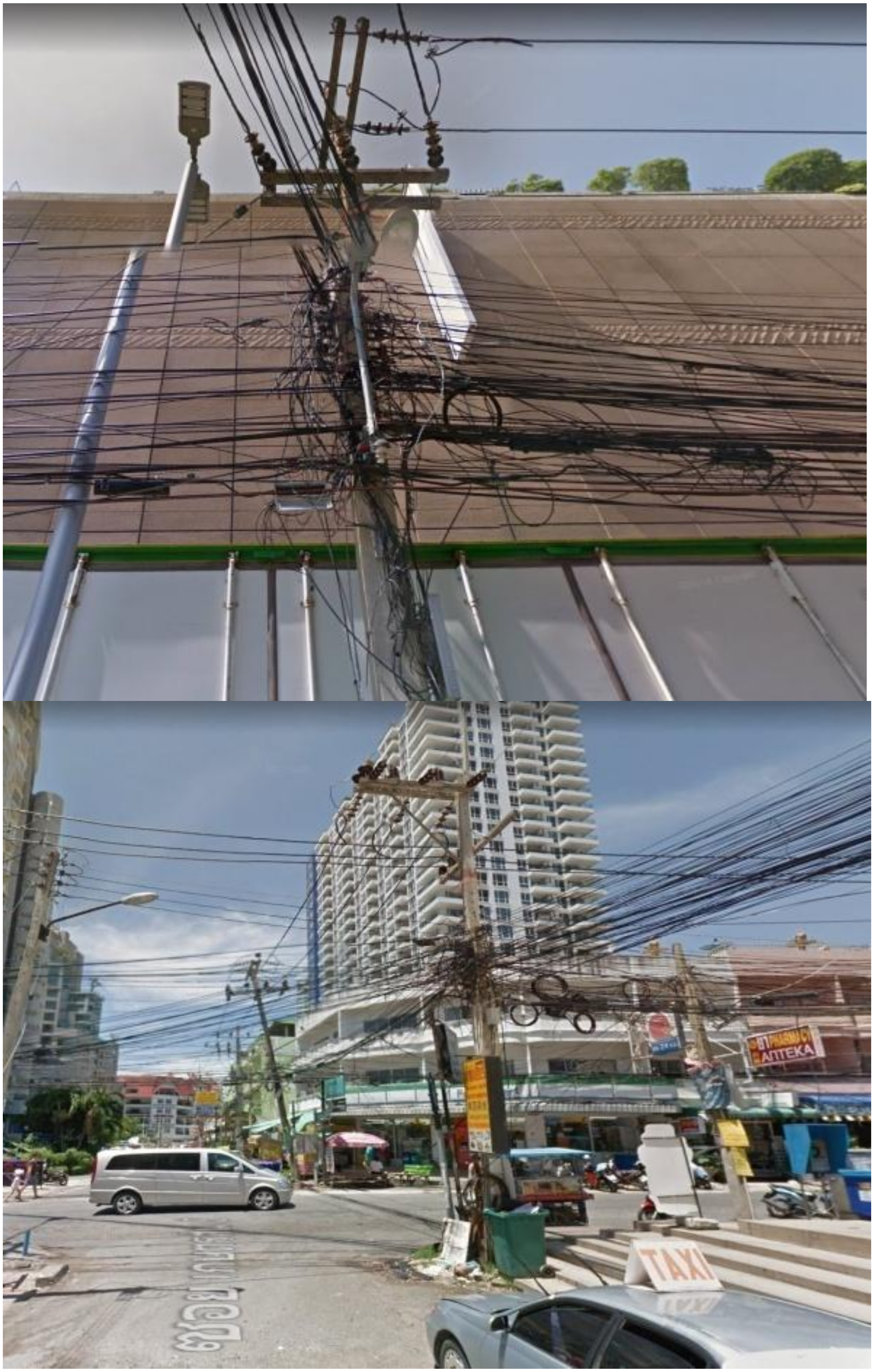

Figure 2. The appearance of the pylon in Pattaya (Thailand)

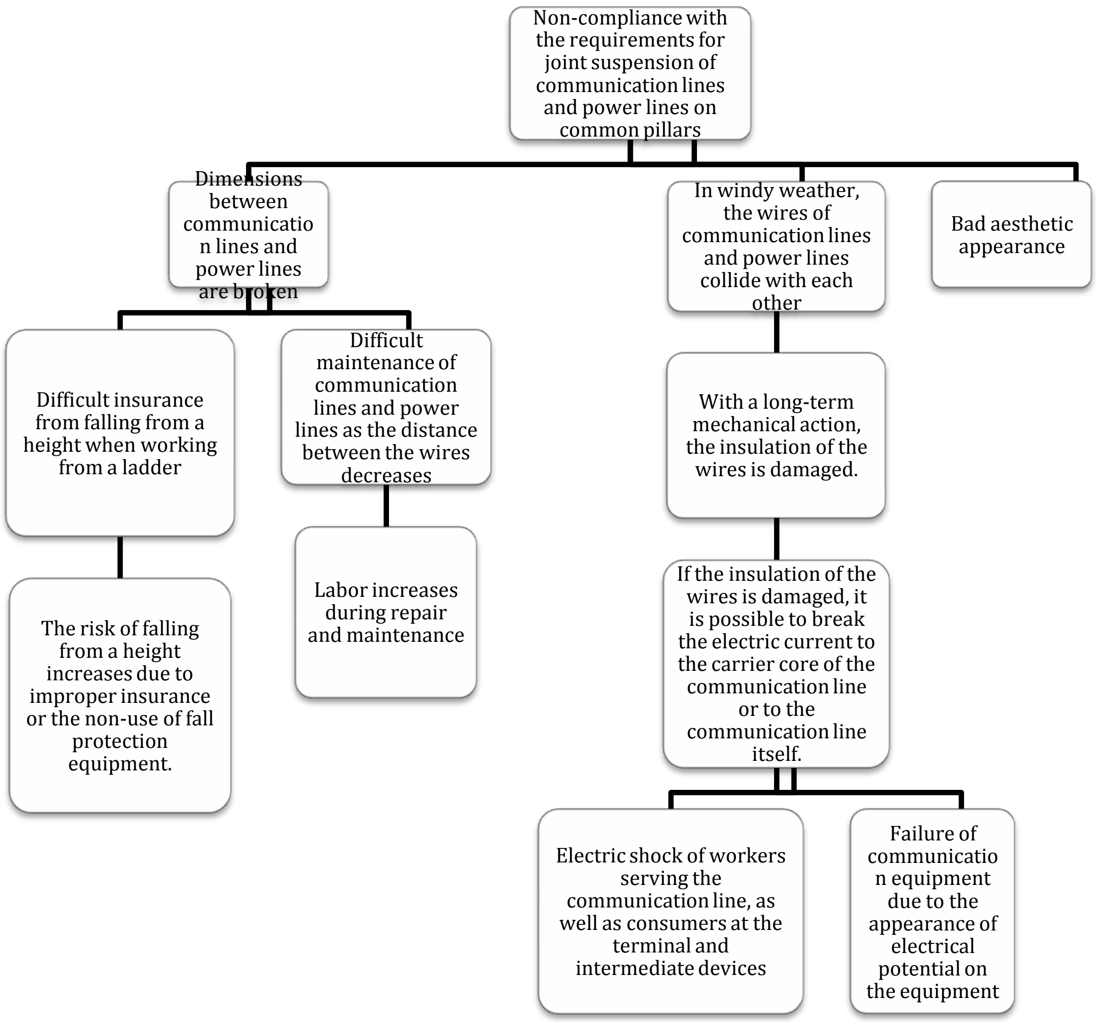

Figure 3. The tree of the occurrence of events (emergency situation, accident incident) with non-compliance with the requirements for joint suspension of the overhead lines and the overhead power lines on common pillars

Analyzing the state and scale of the coils of wires on the pillars, we come to the conclusion that it is impossible to insure with the necessary safety rules above the place of work in this situation. Using a car lift does not solve the problem of accessibility to attachment points. Thus, during installation, repair and maintenance of supports with coils of wires there is a risk of electric shock, the risk of falling from a height of workers, the risk of failure of communication equipment [18,22]. The tree of the occurrence of events (emergency, accident) in case of non-compliance with the requirements for joint suspension of the overhead lines and the overhead power lines on common pillars is shown in Figure 3. Difficult maintenance of communication lines and power lines as the distance between the wires decreases. Installation of OPL by means of SSIW wire is carried out using linear fittings for SSIW. On OL pillars, various SSIW attachment schemes are applied for functional purposes. In the production of linear fittings produced for fastening SSIW. If you have up to ten attachment points on a OPL or OL support, there is nothing terrible. But the number of mounting points is limited, the mounting of the anchor bracket requires space and the support itself has finite dimensions. Knowing the height of the pillars, the minimum allowable distance of the SSIW from the ground, and the width of the anchor brackets, we can calculate how much wires can be hung on one OL support. Then you need to make an adjustment to account for the actual conditions of installation work.

The installer can fix the anchor bracket not close to the other, the direction of the wires may differ from the ideal scenario, the availability of the mounting location of the SSIW for the installer with each new SSIW decreases. Therefore, at the nodal intersections, problems arise in the points of attachment of SSIW wires, shown in Figures 1 and 2 [23, 24]. Theoretically, it is possible to attach four brackets to the four points of attachment on a pillar in one plane. But not always the direction of transmission of the cable coincides with the available directions. The number of attachment points limits the small perimeter. If you increase the perimeter of the place of attachment, then the number of attachment points in one plane will increase. A two-tiered crosshead design of various geometric shapes is proposed, which increases the number of attachment points in one plane, and by adding a second frame to the crosshead design, it is possible to simultaneously attach overhead lines and overhead power lines to this crosshead. It is proposed to install such traverses at key intersections of overhead communication lines and overhead power lines.

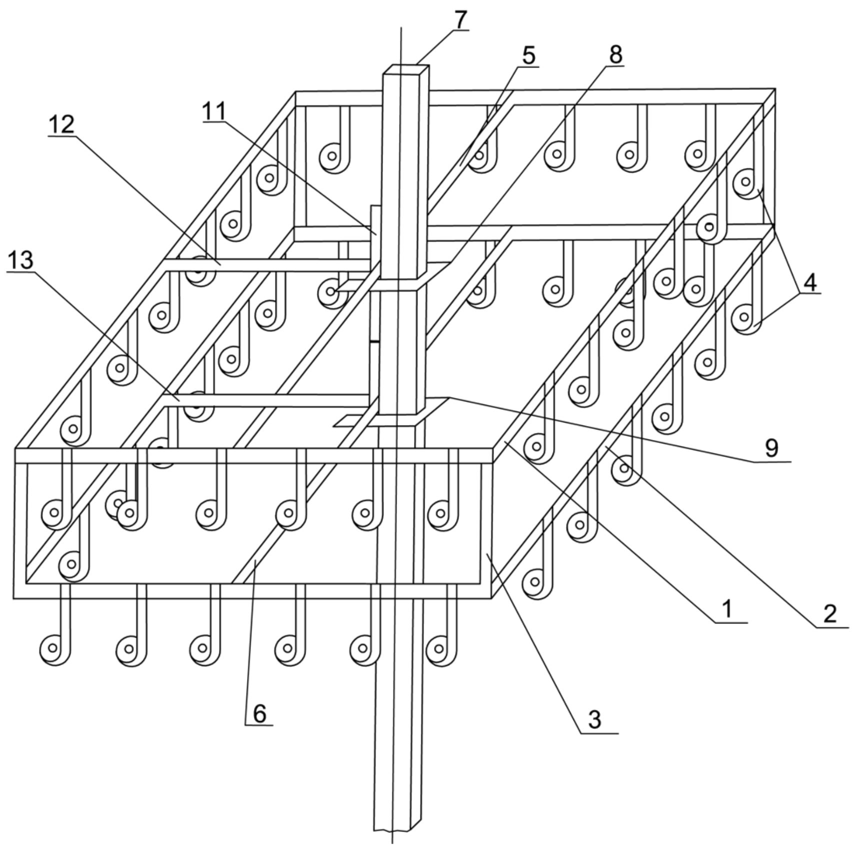

Figure 4. Two-tiered traverse

A two-tiered traverse on the pillar consists of two frames (upper 1 and lower 2) of rectangular shape, connected at the corners by bridges 3 and made of an angular profile. Along the perimeter of the frames 1 (upper) and 2 (lower), the anchor brackets 4 are fixedly fixed for fastening the armature of the overhead line and the overhead power line. Inside each of the frames 1 and 2 in the middle are fixedly fixed crossbars (respectively 5 and 6), made of an angular profile, designed for fixing the traverseto pillar 7. Each frame 1 and 2 is fixed to pillar 7 by clamps 8 and 9 with bolts 10. In the middle the crossbars 5 and 6 are perpendicular and fixedly attached guides 11 on both sides of the pillar 7, made of an angular profile and designed for stability of the mounting of a two-tiered traverseto the pillar 7. Inside the frames 1 and 2, stiffeners (respectively 12, 13) are installed, made of an angle profile connecting structure of frames 1 and 2 with beams 5, 6.

The device works as follows. Two identical rectangular frames located at a distance of 0.5 meters or 1.5 meters (depending on the fastening of the wires of the overhead line and the power line). The presence of two parallel frames located makes it possible to fix the wires of an overhead line and an overhead power line on

one cross-beam, which ultimately organizes these lines. Two-tiered traverse to the support is mounted on the top of pillar 7.The traverse is attached to the pillar with clamps 8 and 9 through the crossbars 5 and 6.Clamps 8 and 9 are fixed to the rails 5 and 6 with bolts 10.Frames 1 and 2 are composed of the crossbar 5 and 6 and stiffeners 12,13.In each frame to the rails 5 and 6 perpendicularly fasten the guides 11 on both sides of the pillar7.The presence of metal bonds inside the frames ensures the rigidity of the whole structure of each frame and the stability of the entire two-tiered traverse on the pillar in the horizontal plane. The presence of multiple anchor brackets 4 on each frame (1 upper and 2 lower) allows this crossbar to attach to it a plurality of wires of an air communication line in one plane and an air power line in another plane, which makes it possible to fasten communication lines and power lines on one support increases throughput on a single pillar7. Anchor brackets 4 allow you to attach various types of wire clips. The design of the traverse allows you to lay wires through it in any direction (transit, corner, perpendicular).
The qualitative distinguishing feature of a two-tiered traverse on a support from other traverses is the ability to attach overhead lines and overhead power lines to a two-tiered traverse at the same time: to one frame - communication lines; to another frame - power lines. The set of attachment points allows you to set the traverse in the nodal points of intersection and passage of wires of overhead communication lines and overhead power lines. The design of the traverse arranges in one plane the place of fastening the wires to the support, which provides access to the maintenance and repair of the pillar and the wires passing through it. Free access to each place of fastening wires creates a safe working environment when laying new lines, repair and maintenance of wires. The use of this traverse in public places creates a more aesthetic look [25,26]. To traverse could fit into any architectural appearance of the city, it can be of different geometric sizes and shapes: two-tier, three-tier, and so on. Depending on the place of installation, the traverse may have a decorative element characteristic of this place. The traverse can be made so that it not only will not spoil the appearance, but also due to various decorative and symbolic elements can be useful in public places of the city.

5. RESULTS

The problem characteristic of densely populated areas has been revealed, which consists in the fact that on aerial supports in junction points of intersection of an air communication line and an air transmission line a coil of randomly fixed wires is formed. With an increase in the coil of wires, the operation of jointly suspended wires becomes not safe, the laboriousness of the maintenance and repair of the air line and the overhead power line increases, and the aesthetic appearance deteriorates. Safety analysis during work during installation, repair and maintenance of pillar with coils of wires showed that there is a risk of electric shock, the risk of falling from a height of workers, the risk of failure of communication equipment. A tree for the occurrence of events has been built (emergency, accident events) when the requirements for joint suspension of communication lines and power lines on common pillars are not followed. The solution to the problem is possible in the application of the geometrical design of the crosshead, which provides a greater number of attachment and separation points of the overhead line and overhead power line along different planes. Moreover, the geometric shape of the traverse can have a variety of design elements.
An important task for substantiating the implementation of the developed design is to assess the reduction in the professional risk of injury to workers. Professional risk assessment can be carried out using different methods, their choice is often determined by the possibility of obtaining reliable data on working conditions of workers and the quality of expert assessments. The matrix approach to risk assessment is distinguished by comparative simplicity [27]. The statistical approach takes time to accumulate observation results but allows you to get the most reliable results. To solve this problem, a trial operation of the traverse was carried out at 17 work sites, each of which employs 15 electricians, where there is a need for frequent lifting to a height for the purpose of work. The estimates of the probability of injury before traverse and after its use were compared, the observations were given for two years, i.e., 1 year work was carried out without using the developed design and 1 year when it was applied. Table 1 shows data on injuries of workers before and after the use of the developed traverse. Data on injuries to electricians were obtained in the course of a study on the use of the developed traverse on the basis of the South Ural State University [28,29].

Table 1. Injury statistics of electricians

The name of the site	**Number of injuries**	
	Before applying the traverse	**After applying the traverse**
1	**2**	**3**

The name of the site	Number of injuries	
	Before applying the traverse	**After applying the traverse**
1	**2**	**3**
Work site 1	1	0
Work site 2	4	2
Work site 3	3	2
Work site 4	7	2
Work site 5	5	3
Work site 6	2	2
Work site 7	4	2
Work site 8	4	2
Work site 9	3	1
Work site 10	4	2
Work site 11	5	3
Work site 12	4	2
Work site 13	5	3
Work site 14	3	1
Work site 15	4	1
Work site 16	6	4

Let us define, by what law of distribution the random variable (number of injured) changes and compare probabilities of traumatizing on sites of works before and after use of a traverse. The type of distribution is determined by the method based on the determination of the characteristics of the distribution form: asymmetry coefficient and coefficient of kurtosis [30].

$$\gamma_a = \frac{\mu_3}{S^3}, \quad \gamma_э = \frac{\mu_4}{S^4} - 3$$

where μ_3 - the third central moment of empirical distribution

$$\mu_3 = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^3$$

μ_4- the fourth central moment of empirical distribution

$$\mu_4 = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^4$$

S^2 - standard deviation

$$S^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2;$$

$\bar{x}$ - average value of a random variable

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i .$$

Before applying the traverse

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i = 4$$

$$S^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2 = 2{,}1 \Rightarrow S = 1{,}46$$

$$\mu_3 = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x}_n)^3 = 0$$

$$\mu_4 = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x}_n)^4 = 12{,}5$$

$$\gamma_a = \frac{\mu_3}{S^3} = 0$$

$$\gamma_э = \frac{\mu_4}{S^4} - 3 = -0,25$$

After applying the traverse

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i = 2$$

$$S^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2 = 0,93 \Rightarrow S = 0,96$$

$$\mu_3 = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x}_n)^3 = 0$$

$$\mu_4 = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x}_n)^4 = 2,37$$

$$\gamma_a = \frac{\mu_3}{S^3} = 0$$

$$\gamma_э = \frac{\mu_4}{S^4} - 3 = -0,27$$

Table 2. Permissible values of form indicators for various distributions [30]

Distribution	**Valid values for indicators**	
	γ_a	$\gamma_э$
Normal	0	0
Triangular	0	-0,6
Uniform	0	-1,2
Symmetrical exponential peaked	0	0,75…22
Before applying the traverse	0	-0,25
After applying the traverse	0	-0,27

Based on the calculation results, it turned out that the recorded injury cases of electricians have a distribution close to normal. The probability of accidents may be determined using the distribution function [30]:

$$F(x) = \int p(t)dt = \frac{1}{\sqrt{2\pi}\sigma}\int_{-\infty}^{x} \exp\left(-\frac{(t-m)^2}{2\sigma^2}\right)dt \cdot$$

The probability of safe work before and after using the traverse was calculated for the studied working conditions. Before the use of the traverse, the probability of safe operation in the work areas was 0.019 after the introduction of the traverse, the probability of safe operation increased to 0.15. The calculations showed that the proposed design can improve the safety of electricians. The use of a constructive solution implements a modern international approach of continuous improvement of the state of working conditions in practice and meets the principles of reliability [31] and efficiency of labor protection measures [32] that is, it solves a certain optimization problem. Assessment of the likelihood of injury to electricians at the experimental site with an experimental traverse and without traverse showed that the proposed design can significantly increase the safety of workers.

6. CONCLUSION

The design of the traverse can provide a greater number of attachment and separation points of the air line and the overhead power line on different planes. This makes it possible to comply with all the necessary safety requirements for the joint suspension of an overhead line and an overhead power line on common pillars. The geometric shape of the traverse can be different and have design elements that will fit into the surrounding view of the city and public places. The optimal placement of communication lines and power lines on common supports assumes a rational placement in the space of wires (which is solved constructively by using a traverse), provides the convenience of servicing communication lines and power lines, and increases the safety of operating staff. A comparative assessment of the likelihood of injury to groups of electricians in experimental plots with and without traverse confirmed that the proposed design will significantly increase the safety of workers. The installation of a traverse at the intersection of communication lines and power lines will facilitate work at altitude and will reduce the risks presented in the Tree (Figure 3) of the occurrence of events (emergency, accident, accident) in case of non-compliance with the requirements for joint suspension of OL and PTL on common supports. All of the above allows the implementation of the risk management process, which has become more important at the international level [33].

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[1] BAHRAMI M.R., (2016): A novel design of an electrical transmission line inspection machine, **Lecture Notes in Mechanical Engineering**, none, 67-73. DOI: 10.1007/978-3-319-29579-4_7

[2] BARINOV V.M. and KIESEWETTER D.V., "Experience in enhancing the reliability of operation of power cable lines in St. Petersburg"10th International Conference - 2016 Electric Power Quality and Supply Reliability, PQ 2016, pp. 55-58. DOI: 10.1109/PQ.2016.7724089

[3] BELKO V.O., BOGDANOV M.V., and PLOTNIKOV A.P., "Investigation of chip-film capacitors pulse dielectric strength" Proceedings of the 2019 IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering, ElConRus 2019, art. no. 8656648, 2019, pp. 796-799. DOI: 10.1109/EIConRus.2019.8656648

[4] BIYATTO E. V., SHARMANOVA G. YU. and PRIVALIHINA K. K., "Zavisimost' elektropotrebleniya ot vliyaniya razlichnyh faktorov" Analiz potrebleniya elektroenergii po OES i energosistemam 2012–2014 gg. // Molodoj uchenyj, 2015, №6, pp. 126-129, URL https://moluch.ru/archive/86/16264

[5] CAMPIAN C., CHIRA N., IUHOS V., POP M., and VATIN N., "Structural Upgrading of Steel Columns for Overhead Power Lines"Procedia Engineering, 165, 2016, pp. 876-882. DOI: 10.1016/j.proeng.2016.11.787

[6] CHERNOVA E., BYCHENKOVA V., KOTOVA N. and PUPYKIN K., "Automation of processes of temperature modes control in security system based on HACCP principles "IOP Conference Series: Materials Science and Engineering, 497 (1), 2019. DOI: 10.1088/1757-899X/497/1/012108

[7] ELISTRATOV V.V.and DENISOV R.S., "Optimization of hybrid systems 'operating modes based on renewable energy"2019 16th Conference on Electrical Machines, Drives and Power Systems, ELMA 2019 –Proceedings. DOI: 10.1109/ELMA.2019.8771684

[8] FILATOV D.L., GALICHINA A.A., VYSOCZKY M.G., YALUNINA T.R., DAVYDOV V.V. and RUD V.Y., "Features of transmission at analog intermediate frequency signals on fiber - Optical communication lines in radar station." Journal of Physics: Conference Series, 2017 917 (8), DOI: 10.1088/1742-6596/917/8/082005

[9] GOST 839-80 Provoda neizolirovannyye dlya vozdushnykh liniy elektroperedachi. (2002, sentyabr 1). Retrieved iyun 5, 2018, iz sayt "Internet i Pravo": http://internet-law.ru/gosts/gost/22928/

[10] GOST R 52373-2005 Provoda samonesushchiye izolirovannyye i zashchishchennyye dlya vozdushnykh liniy elektroperedachi. (2008, mart 1). Retrieved iyun 5, 2018, iz sayt "Internet i Pravo": http://www.internet-law.ru/gosts/gost/5369

[11] IDRISOVA J. I., MYASNIKOV V. N., ULJANOV A. I. and BELINA N. V., "Increasing the efficiency of labor protection in the enterprise." The 32nd International Conference on Information Networking, 2018, pp. 585-588. Chiang Mai, Thailand.

[12] IQBAL S., CHOUDHRY R. M., HOLSCHEMACHER K., ALI A., and TAMOŠAITIENĖ J., "Risk management in construction projects" Technological and Economic Development of Economy, 2015, 21(1), pp. 65-78. https://doi.org/10.3846/20294913.2014.994582

[13] KAVERZNEVA T. T. and SENCHENKO V. A., Patent No. 167281. Rossiya, 2016.

[14] KHATUNTSEVA E. A. and KHATUNTSEV A. B., "Analiz osnovnykh tendentsiy razvitiya setey svyazi na telekommunikatsionnom rynke Rossii. " T-Comm: Telekommunikatsii i transport , 2016, pp 71-74.

[15] KOZLEY S. V., and KHATSEVSKY K. V., "Aktualnyye voprosy energetiki. " Materialy Mezhdunarodnoy nauchno-prakticheskoy konferentsii. Problemy ekspluatatsii kabelnykh liniy 10/0.4 KV, 2017 (pp. 56-60). Omsk: Izdatelstvo: Omskiy gosudarstvennyy tekhnicheskiy universitet.

[16] KOZLOVSKY V.N., PETROVSKY S.V., VAKHNINA V.V. and SKRIPNUK D.F., "Determination of the causes of the excess of the level of electromagnetic interference from the ignition system using an intelligent diagnostic system" Proceedings of the 2019 IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering, ElConRus 2019, art. no. 8657322, pp. 569-573. DOI: 10.1109/EIConRus.2019.8657322

[17] LI J., BAO C. and WU D., "How to design rating schemes of risk matrices: A sequential updating approach"Risk Analysis,2018, 38(1), pp. 99-117

[18] MICHELI D., GIUSTI A., DELFINI A., PASTORE R., VRICELLA A., MARCHETTI M., TOLOCHKO O. and VASILYEVA E., "Electromagnetic characterization of advanced nanostructured materials", 2016 Proceedings of the International Astronautical Congress, IAC.

[19] MOISEEVA V.D., Sbornik materialov I Vserossiyskoy molodezhnoy nauchno-prakticheskoy konferentsii. Vvedeniye v energetiku. Primeneniye SIP v selskikh elektricheskikh setyakh, 2014 p. 56. Kemerovo: Izdatelstvo: Kuzbasskiy gosudarstvennyy tekhnicheskiy universitet imeni T.F.Gorbacheva.

[20] NAZAROV S.A., PÉREZ E. and TASKINEN J., "Localization effect for dirichlet eigenfunctions in thin non-smooth domains" Transactions of the American Mathematical Society, 368 (7), 2016 pp. 4787-4829. DOI: 10.1090/tran/6625

[21] OREL N.D. and AVER'YANOV YU.I., "Metodika issledovaniya faktorov motivacii k soblyudeniyu trebovanij bezopasnosti elektrotekhnicheskim personalom" V sbornike: Bezopasnost' zhiznedeyatel'nosti glazami molodezhi sbornik materialov V Vserossijskojstudencheskojkonferencii (s mezhdunarodnym uchastiem): v 2 tomah. Ministerstvo nauki i vysshego obrazovaniya Rossijskoj Federacii; YUzhno-Ural'skij gosudarstvennyj universitet (nacional'nyj issledovatel'skij universitet), Kafedra bezopasnosti zhiznedeyatel'nosti, 2019, pp. 268-272.

[22] Osnovnyye prichiny travmatizma. (2002, yanvar 1). Retrieved iyul 24, 2018, iz Okhrana truda i bezopasnost zhiznedeyatelnosti: http://ohrana-bgd.narod.ru/proizv_19.html

[23] POPOV A.V.,. SAYARKIN K.S and ZHILENKOV A.A., "Analysis of perspective models of artificial neural networks for control of robotic objects" Proceedings of the 2018 IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering, ElConRus 2018, 2018-January, pp. 958-961. DOI: 10.1109/EIConRus.2018.8317248

[24] POPOV R. V., "Sbornik trudov vosmoy mezhdunarodnoy nauchno-tekhnicheskoy konferentsii.Energetika: Upravleniye, kachestvo i effektivnost ispolzovaniya energoresursov [pod red. N.V. Savina]. Voprosy proyektirovaniya volokonno-opticheskikh setey na baze sushchestvuyushchikh vozdushnykh liniy elektroperedach", 2015 pp. 469-471. Blagoveshchensk: Izdatelstvo: Amurskiy gosudarstvennyy universitet.

[25] Prikaz Mintruda Rossii ot 28.03.2014 N 155n (red. ot 20.12.2018) "Ob utverzhdenii Pravil po okhrane truda pri rabote na vysote". (2014, Mart 28). Retrieved dekabr 2, 2016, iz "KonsultantPlyus": http://www.consultant.ru/document/cons_doc_LAW_169008/

[26] PUSHENK O S. L.and STASEVA E. V., "Analiz i profilaktika proizvodstvennogo travmatizma pri vozvedenii vysotnykh zdaniy i vypolnenii rabot na vysote." Vestnik Volgogradskogo gosudarstvennogo arkhitekturno-stroitelnogo universiteta. Seriya: Stroitelstvo i arkhitektura, 2016, pp. 157-165.

[27] Rasporyazheniye Pravitelstva RF ot 03.04.2013 N 511-r (red. ot 29.11.2017) "Ob utverzhdenii Strategii razvitiya elektrosetevogo kompleksa Rossiyskoy Federatsii". (2013, Aprel 3). Retrieved Iyun 5, 2018, iz "KonsultantPlyus": http://www.consultant.ru/document/cons_doc_LAW_144676/

[28] ROMANOV V.N. and KOMAROV V.V., Teoriya izmerenij. Analiz i obrabotka eksperimental'nyh dannyh: ucheb. Posobie, SPb.: SZTU, 2002, 127 p.

[29] SENCHENKO V. A., "Bezopasnost na vysote: vozdushnyye linii svyazi. Sanepidkontrol." Okhrana truda № 3 , 2016, pp. 37-42.

[30] SENCHENKO V. A., KARAUSH S. A., KAVERZNEVA T. T., PUSHENKO S. L. and STASEVA E. V., "Sovershenstvovaniye tekhnicheskikh sredstv bezopasnosti pri vypolnenii rabot na vysote." Vestnik Volgogradskogo gosudarstvennogo arkhitekturno-stroitelnogo universiteta. Seriya: Stroitelstvo i arkhitektura, 2017, pp. 98-106.

[31] SENCHENKO V. A.,. PUSHENKO S. L, STASEVA E. V. and SENCHENKO A. V., Patent No. 185033. Rossiya, 2018.

[32] SVETLAKOVA A., KAVERZNEVA T., TARKHOV D.and BELINA N.,. "Analysis of tools for assessing the terms of working environment of foreigners." International Scientific Conference on Energy, Environmental and Construction Engineering, 2018.

[33] ZAJNISHEV A.V., KRUGLOV G.A., AVER'YANOV YU.I. and POLUNIN G.A., “Prognozirovanie sostoyaniya proizvodstvennogo travmatizma v elektroenergeticheskom komplekse rossijskoj federacii na osnove analiza dinamicheskih svojstv matematicheskoj modeli proizvodstvennogo kollektiva“ Politekhnichesk