Ensuring Fire Safety of Constructions in Remote and Sparsely Populated Areas

Andrei Mashovich1, Vitaly Rusopov1 and Oleg Zaiatdinov2

1 Irkutsk National Research Technical University, 83 Lermontov street, 664074, Irkutsk, Russia
2 NUN Fire Safety Research Institute, 13 Kaiskaya-street., 664017, Irkutsk, Russia

Abstract: The article presents the results of research in the field of creating new materials to ensure the fire safety of buildings and structures under construction and reconstructed architectural monuments. The efficiency of the implementation of these materials should be based on their technological applicability, environmental friendliness and economic feasibility. The directions in the construction associated with the construction and reconstruction of wooden buildings and structures and fire protection of rotational camps are particularly of interest at present. As a result of the research, a model to substantiate the efficiency of the application of the newly developed construction materials has been developed. The engineering solutions to implement the model in order to ensure the restriction of the spread of fire have been proposed.

The existing models of economic growth are developed mainly in respect of areas with relatively high population density, logistic structure and resource base.

The formation and development of growth points in the region is performed due to the spread of innovations [1]. The major urban system where industry and a scientific base are developed and per capita incomes are the highest shows innovative activity; a wave of innovations spreads from such a point of growth to adjacent territories increasing the level of prosperity. Obviously, for most of the territories under consideration, the production of goods and services may be associated with the development of tourism, due to geographical conditions and the proximity of Lake Baikal. However, to support the successful implementation of this direction, it is necessary to create a growth driver providing interconnection with the centers of global tourism.

For the Irkutsk region, which is characterized by low population density and vast territories, at the first stage, in relation to remote areas, it is enough to organize four growth points in the following directions: the main - tourism and auxiliary - construction, food and waste processing. Activities in these areas are carried out in educational, scientific and industrial centers and now they need to be provided with systematic solution of practical problems. In connection with the territorial remoteness of business facilities related to the growth point, the main type of interaction should be remote using modern means of communication. [11].

The implementation of the set objectives will require the availability of buildings and structures that meet modern safety requirements, energy saving, comfort, etc. Currently, there is not any possibility of such construction in remote areas, for a number of reasons arising at the stages of design, financing and construction. The centralized development of priority areas in this territory, supported by economically sound projects based on mobile professional small enterprises that attract local raw materials base and human resources, will help stimulate the development of sparsely populated territories. Economic growth should be based on specialized structures that provide information, legal
and commercial support, which can be applied to a specific direction or be of a general nature. Small entrepreneurs need mainly information support in the process of choosing buildings, technologies, equipment and staffing [1].

While the development process, travel companies ensure the operation of small enterprises engaged in construction, food production and waste processing. Thus, financial flows should be mainly directed to the development of innovative tourism projects, and further - into the construction, food and environmental areas. The availability of funds will make it possible to pay promptly for construction, supplied food products, for the removal and processing of waste, that is, to make these areas profitable. It is necessary to use modern methods of financing, such as public-private partnerships, to develop efficient infrastructure facilities [2].

The modern world experience shows that the main way to create reserve to reduce cost and operating costs is to reduce mass of the structure and a high level of thermal protection of the enclosing structures. To achieve this aim, it is necessary to optimize the technological processes of building construction with a focus on the application of innovative technologies using local construction materials and meeting the needs of entrepreneurs, in terms of reducing operating costs, mainly on heating, water supply, ventilation, and power supply. Unfortunately, most of the materials widely used for this purpose are characterized by several disadvantages:

1) the service life of fibrous insulation materials (mineral wool and fiberglass plates) is 15-25 years, which contradicts the terms of the warranty durability of the buildings themselves and predetermines the repair and restoration works;

2) high-performance, in terms of the initial coefficient of thermal conductivity, thermal insulation materials, mineral wool and fiberglass plates are mainly delivered from other regions of the country, which dramatically increases the cost of thermal insulation;

3) due to the operational properties and flammability of foreign-made foam polystyrene plates, foreign experts set the service life as 13-15 years and believe that the choice of this material as thermal insulation for walling is not economically beneficial and potentially dangerous;

4) the use of polyurethane foam, extruded polystyrene foam, eco wool and some brands of products made of fiberglass plates is possible only with the observance of fire safety requirements, and therefore cannot be considered options for thermal insulation mass use.

In connection with the development of tourism and the development of new territories (for example, the “Far Eastern hectare” program) there is a need to construct a large number of low-priced buildings and structures. Modern construction technologies use widely heat-insulating materials characterized by low flammability (7.8). A number of competitive advantages of application of urea cellular plastics in remote areas are as follows:

1. Possibility of production at the place of use.
2. Reduction in the volume of imported materials by 10-20 times.
3. Application in the production of local raw materials and labor resources will reduce the cost by 1.5-2 times.
4. To provide effective thermal insulation and reduce the consumption of traditional materials (brick, cement, wood, etc.) in enclosing structures.
5. Replacing polystyrene foam, penoplex and wood will increase fire safety of objects.

Taking into consideration foreign experience and the possibility of our own production of highly efficient thermal insulation material directly at the facility, it is possible to develop a concept for the construction of facilities for small and medium businesses, consisting of the following positions:

1. The shortage of investment and the increasing cost of construction materials (especially heat-insulating), considers it expedient to use high-performance innovative equipment and low-labor-intensive technology of erecting enclosing structures and their thermal protection through highly efficient material produced of local raw materials directly at the facility.

2. Priority in the field of production technology of small-piece wall products (blocks) should belong to developments that use local raw materials, but subject to supply of low-cost products of guaranteed quality.
3. The most promising is the use of local raw materials, the cost of which is currently the basis in the prime cost of production. If there is a source of local raw materials and the possibility of producing a heat insulator at innovative equipment of the facility, the wall constructions of wood, as well as wall products made of wood concrete, wood and magnominer stones can be a priority in the construction process.

4. Sand is widespread and the cheapest filling aggregate in the territory of our region. Developments in the manufacture of wall blocks and other products of sandy concrete make it possible to obtain high-quality, solid and cheap products for low-rise construction. Ensuring the thermal insulation properties of enclosing structures by their combination with low thermal conductivity foam will allow combining the processes of their construction with thermal protection, increase productivity and reduce construction costs.

To reduce the prime cost of high quality construction is possible due the use of small professional mobile teams specializing in standard projects based on energy-efficient enclosures. Based on the databases available at the growth point, it will be possible to maximize the use of local resources during construction process, to meet the customer’s wishes in the field of design and to take into account the specific features of the future production.

This way, the problem of implementation of the concept of constructing objects for small and medium-sized businesses can be solved in the medium term.

Currently, the level of provision of Irkutsk region remote areas business with modern, safe buildings and structures is no more than 5%. The spontaneous organization of one’s own business in the absence of scientifically grounded qualified assistance, along with the use of available means and limited financial resources, does not give a chance to expect significant changes in this situation.

For example, the development of the tourism industry on Olkhon Island has resulted in an uncontrolled increase in the number of recreation centers, guest houses and related facilities. The high cost of land, the ubiquitous construction of buildings and structures made of wood (V-fifth degree of fire resistance, constructive fire hazard class - C3), the lack of developed and approved territorial fire safety requirements, insufficient control during construction contributed to the occurrence of violations in the field of fire safety.

The use of combustible materials, voids in building structures, non-compliance with fire breaks regulations, electrical network overload, lack of fire-fighting water supply, windy weather lead to increased risks of occurrence and development of fires. The high density of tourist accommodation in built-up areas (see Fig. 1) in the absence of a developed fire protection system and poor information support, especially in the case of foreign visitors, can cause events resulting in their massive death.

![Figure 1. Typical for the island of Olkhon and other areas of the Irkutsk region buildings.](image)

Fire safety technology, which is based on the direct application of standard requirements of regulatory documents, is not more efficient now because typical fire safety systems that do not take into account numerous specific circumstances in some cases impede economic, profitable decisions, and in other cases are not adequate to the emerging circumstances as being ineffective.

The solution of the accumulated issues is a complicate one due to the shortage of significant funds and appropriate resources (legal, economic, political) to solve the existing problems by local
municipalities. This existing situation results in increase in social tension, expressed in the unwillingness to suffer losses, fulfilling the requirements, the effectiveness of which is not proved by practice.

For example, environmental requirements are in conflict with the need to have an external fire-fighting water supply system and the use of combustible materials during construction. Also, in the event of a fire, it is not always possible to redeploy additional forces and fire-fighting equipment to the island, due to the seasonal peculiarities of the ferry or ice crossing. In the case of a developed fire, the existing forces and fire-fighting equipment are evidently insufficient on the island, and therefore, as a rule, fires on the island are extinguished by “the whole world” as in the old days were, using adapted equipment for bringing water like vacuum machines designed for pumping sewer, thus exacerbating the already complicated environmental situation. There is usually no time left to prepare vacuum machines deliver water, and fire spreads along wooden structures rather quickly, the constant gusts of wind and the non-observance of fire breaks, contributing to the development of fire, aggravate the operational situation [3].

The construction of industrial and civil objects in remote areas was largely spontaneous in nature and developed in the context of a shortage of construction materials. The total use of wood has resulted in a high fire hazard of objects [12], and the lack of modern materials and technology has led to high material consumption and low energy-saving properties of enclosing structures. In many cases, such facilities are outdated and do not meet the requirements of safety and energy efficiency.

In an urban environment, the applied solutions have often been used for many centuries and are connected not with architecture, but with ensuring fire safety in urban planning. Modern standards and design rules for construction to limit the spread of fires impose requirements on the construction of fire barriers. Thus, in accordance with Article 37 of Federal Law No. 123-FZ of July 22, 2008, “Technical Regulations on Fire Safety Requirements”, fire barriers are divided into the following types depending on the method of preventing the spread of dangerous fire factors:

1) fire separation walls;
2) fire partitions;
3) fire separation slabs;
4) fire breaks;
5) fire (safety) curtains and screens;
6) fire-protection spray curtain;
7) fire-protection mineralized barriers.

In the historic development of cities and historical centers of settlements, the solutions that were used as early as the 18th and 19th centuries are still applied. Such an example of fire safety aimed at limiting the spread of fires is Brandmauer (Brand is a fire and Mauer is a wall). This is a blank fire wall of a building made of non-combustible material, separating adjacent buildings and courtyards and having a height greater than the height of neighboring buildings [1]. In Russia, fire walls have been regulated to be applied while construction on the basis of the relevant decree since 1736. And in 1737, in order to establish control over new constructions, in particular, in St. Petersburg, a Construction Commission was approved; and well-known architects P. Eropkin, M. Zemtsov and others [4] participated in its activity; the commission as still operating.

Figure 2 shows that bricks were used as the classic material in the construction of fire walls. Also, for example, in Irkutsk, building blocks cut from sandstone with low bearing capacity that was the reason not to use them in housing construction, were used and were very popular in the construction of fire walls due to the low cost and good fire resistance. The disadvantage of such a wall was low resistance to external factors, so most often the wall was protected with a sand-cement mortar and created an aesthetic appearance. If the wall was not protected, or the upper layer of protection collapsed, then such blocks began to collapse under the influence of the external environment, as can be seen in the example of a fire wall in Dekabr’skie sobitiya street in Irkutsk (see Fig. 3.)
Figure 2. Fire walls in cities of Tomsk, Samara and Irkutsk.

Figure 3. Made of sandstone blocks fire wall, Irkutsk.

From the point of view of roofing work, modern fire wall protection is not only an aesthetic solution, but also sometimes a more difficult task: combining two adjacent roofs with a single hermetic unit [5]. The standard solution to protect a high fire wall is a metal coating by analogy with the design of the parapet. In cases of multi-level adjacent roofs, a standard junction assembly is used. More difficult is the task of arranging a node with a low location of the dividing wall when the various roofing materials of the two roofs are in contact.

Figure 4. Fire wall construction using roofing material and metal structures.

Fire walls are widely used in industrial facilities to isolate fire compartments, in monofunctional buildings and public buildings, when blocking residential houses on adjacent land plots [6, 7, 8].

The need and relevance of using fire barriers is confirmed by the time and is caused by the need to apply this solution in the development of Siberia and the Far North to construct rotational camps [9] (Verkhne-Chenskoye gas condensate field, Yarakhtinskoye oil and gas condensate field and similar objects). As well as in remote areas where there are a large number of houses made of wood, and new ones are being built [10].
Therefore, the relevance of application of fire barriers remains at the present time.
We will analyze the recommended requirements of regulatory documents on the arrangement of fire barriers.

Fire safety requirements for the construction of blocked residential buildings

While construction, the requirements set out in SP 55.1330.2011 [11] “Single-family residential buildings. Updated edition of SNiP 31-02-2001” should be fulfilled, namely:

In the design and construction of blocked residential buildings, measures should be taken to prevent the spread of fire to neighboring residential blocks and fire compartments, bypassing fire barriers.

To achieve this aim, made of combustible materials fire walls must cross all the structures of a building. At the same time, fire walls of the 1st type according to the Technical Regulations on Fire Safety, dividing a house into fire compartments, must rise above the roof and stand for the outer facing of the walls by at least 15 cm, and when used in the floor, with the exception of the roof, materials of combustibility groups GZ and G4 - rise above the roof by not less than 60 cm and protrude beyond the outer surface of the wall by not less than 30 cm.

Fire walls separating the dwelling blocks of a building may not cross the roof and exterior wall cladding, provided that the gaps between the fire wall and the roof, as well as between the fire wall and wall cladding, are tightly filled with non-combustible material for the entire thickness of the fire wall. The direct horizontal distance between any openings located in adjacent fire compartments should be at least 3 m, and in adjacent residential units - not less than 1.2 m.

When adjoining the outer walls of adjacent residential blocks or fire compartments at an angle of 135 or less, a part of the outer wall forming this angle with a total length of at least 1.2 m for adjacent residential blocks and at least 3 m for adjacent fire compartments should be designed in such a way so that it meets the requirements for an appropriate fire wall.

The built-in parking for two cars and more should be separated from other rooms of the house (block) by partitions and ceilings with a fire resistance rating of at least REI 45.

However, there are only few necessary and affordable materials and technologies. Existing technologies and materials are expensive (modern brick, fire-resistant panels, certified partition walls made of flame-retardant gypsum plasterboard with non-combustible insulation of different manufacturers; the use of water curtains, irrigation systems, etc. has high specific weight, high cost and requires more additional construction costs than previously existing ones [Article 37, Federal Law No. 123-FZ dated July 22, 2008, “Technical Regulations on Fire Safety Requirements”, SP 5.13130.2009].

In blocked buildings of class F1.4, adjacent residential units should be separated by blind fire walls with a fire resistance rating of at least REI 45 and a fire hazard class of at least K1.

Necessity for fire-resistant partitions

According to the SP 2.13130.2012 "Providing Fire Resistance of Objects of Protection", the evacuation routes (common corridors, halls, foyers, lobbies, galleries) should be separated by walls or partitions located from floor to floor (floor) [12].

These walls and partitions should adjoin the blind sections of the external walls and not have open openings that are not filled with doors, hatches, translucent structures, etc. (including above suspended ceilings and under raised floors). Translucent structures in these partitions and walls should be made
of non-combustible materials. The intersections of the indicated walls and partitions by engineering communications must be sealed with materials of the NG group.

These walls and partitions in public and administrative-residential buildings with a height of not more than 28 m are allowed to be designed with non-standardized fire resistance.

In public and administrative buildings with a height of more than 28 m, specified walls and partitions (including those made of translucent materials) should be provided as for class K0 with a fire resistance of at least EI 45.

Located at the facilities of classes Φ3.1 and Φ3.2 of the premises of industrial, warehouse and technical purposes (kitchens, bakeries, final processing, cutting, storerooms of combustible goods and goods in flammable packaging, etc.), with the exception of the premises of categories B4 and Δ, are separated by fire partitions of at least type 1 and ceilings of at least type 3, and are separated from visitors for an area of 250 m² or more by fire walls of at least type 1. Filling of the openings for giving out food and receiving dirty dishes from the hall for visitors is not standardized.

Located in the objects of cultural and entertainment purposes, premises for industrial and technical purposes (premises of technological service of the demonstration complex, workshops, restoration, kitchens, switchboard, etc.), storage rooms (storerooms of combustible goods and goods in flammable packaging, bookstore, etc.), with the exception of premises of category Δ, are separated with fire partitions of at least type 1 and ceilings of at least type 3, unless otherwise indicated.

At class Φ3.4 facilities, archives of X-ray film on a nitrocellulose (celluloid) basis with a capacity of up to 300 kg should be placed in rooms enclosed by fire walls and type 1 ceilings. The indicated archives with a capacity of more than 300 kg should be located in separate buildings, and the distance to neighboring buildings should be at least 15 m. In one and the same fire compartment of such archive, no more than 500 kg of film can be stored.

5.5.7 Located in facilities Φ3.4, Φ3.5, Φ3.6 industrial premises (laboratories, preparation of medicines, workshops, etc.), as well as storage facilities (pantries of drugs and medicinal materials, storerooms inventory, combustible goods and goods in flammable packaging, etc.), technical premises, with the exception of premises of categories B4 and Δ, are separated with fire partitions of at least type 1.

The food processing units provided for in facilities Φ4.1, Φ4.2, Φ4.3 are separated with fireproof ceilings and walls of at least type 2. Industrial and warehouse premises, technical premises (laboratory rooms, training rooms, workshops, storerooms for combustible materials and materials in flammable packaging, library bookstores, server rooms, switchboards, etc.) with the exception of B4 and Δ categories, are separated with fire partitions of not lower than the type 1 and floor slabs of not lower than type 3.

Administrative and residential premises can be located in the annexes of industrial buildings.

Annexes the fire resistance of which is of degree I and II are separated from industrial buildings the fire resistance of which is of degree I and II with type I fire partitions.

Annexes the fire resistance of which is below degree II, as well as annexes to industrial buildings the fire resistance of which is below degree II and annexes to the rooms and buildings of categories A and B are separated with type I fire partitions.

Annexes the fire resistance of which is of degree IV of class C0 may be separated from industrial buildings the fire resistance of which is of degree IV of classes C0 and C1 with type 2 fire partitions.

Administrative and residential premises can be located in the inserts and built-in structures of industrial buildings of categories B, Γ and Δ:

- I, II, and III degrees of fire resistance of C0 class of fire hazard;
- IV degree of fire resistance of all classes of fire hazard.

6.1.43 Inserts are separated from the production premises with fire walls of the 1st type.

Inserts are permitted to be separated from the production premises of categories B1-B4, in buildings of I and II degrees of fire resistance classes C0 and C1, III degree of fire resistance class C0 with fire partitions of the 1st type:

in buildings of III degree of fire resistance of class C1 and IV degree
of fire resistance classes C0 and C1 - fire walls of the 2\textsuperscript{nd} type.

Built-in structures should be accepted if there are not more than two floors and separated from the production premises by fire walls and fire separation slabs type 1.

Built-in structures are permitted to be separated from the production premises of categories B1-B4, Г and Д:

- in buildings of I, II degrees of fire resistance of classes C0 and C1, III degree of fire resistance of class C0 with fire partitions of the 1st type and slabs of the 2\textsuperscript{nd} type;
- in buildings of the III degree of fire resistance of the class C1 and IV degrees of fire resistance of the classes C0 and C1 - fire walls of the 2\textsuperscript{nd} type and fire separation slabs of the 3\textsuperscript{rd} type.

**Requirements for the design of fire partitions**

Enclosing structures with the use of gypsum plasterboards can be used in buildings for various purposes and fire resistance, number of storeys and structural schemes erected in different regions of the country, including seismic areas, while satisfying the relevant regulatory requirements.

Table 13 CII 55-101-2000. "Enclosing structures with the use of gypsum sheets" presents the limits of fire resistance of partitions, depending on the design.

For example, a constructive solution: “a single metal frame with a filling of non-flammable preformed mineral wool with a density of 40 kg/m\textsuperscript{3}, thickness of 50 mm, and a covering with one layer of plasterboard sheets on both sides. [13,14]. The sheets are fixed to the frame with screws. The joint between the adjacent sheets is sealed with special putty", it gives the fire resistance of EI 45 in the case of gypsum plasterboards and EI 60 in the case of fire-proof plasterboard [13, 14].

Table 13 shows the fire resistance limits of gypsum plasterboards (GKL) (fire-proof plasterboard GKLO) partitions with a thickness of 12.5 mm with joints between adjacent sheets, embedded with Fugenfüller putty, obtained on the basis of structural tests according to GOST 30247.1. In accordance with the opinion of VNIIPo of the Ministry of Internal Affairs of the Russian Federation dated December 21, 1999, these partitions according to the fire hazard assessment of the TIGI KNAUF partitions with plasterboard sheets are referred to the fire hazard class KO (45).

Formulation of the research problem

Despite the development of fire-fighting science, along with modern methods and techniques of ensuring fire safety, methods of limiting the spread of fire, such as fire walls, fire partitions, replacement of flammable construction materials to non-flammable, remain in demand.

Methods to solving this problem

Fires, accompanied by the spread of flame through the voids of building structures (Siberia hotel, Irkutsk, building of the Internal Affairs Directorate of the Samara region, Ostankino television tower, Moscow, etc.), results in death of people and destruction of material values. According to the UGPS Ministry of Internal Affairs of the Russian Federation in Moscow today, about 30% of the total housing stock are buildings with voids. There are more than 150 similar buildings in Chita, more than 400 buildings in Irkutsk, and 540 in Ulan-Ude. Many of these buildings are of historical value and are places of mass gathering of people. In Moscow and St. Petersburg, Firex-500 and Termostop foam were developed to fill the construction voids. The applied technologies are not disclosed, and performance of work in the regions of Siberia and the Far East due to involvement of outside specialists will lead to an unjustified increase in the cost of fire protection.

A technology to fill voids has been developed based on materials circulating in the production sector of the Irkutsk Region. Foam formation is carried out by mechanical foaming or by evolving the gas phase as a result of chemical processes. Samples of self-expanding compositions based on silicate materials (STP), expanding, are able to seal cracks, voids and isolate the accident site in hard-to-reach places (blockages, cable tunnels, mines, construction voids, etc.).
A two-component inorganic-based foaming material forms a lightweight foam structure. The initial composition consists of a dry part (20–55%) and a liquid binder (45–80%), which are mixed immediately before use. The technology includes the preparation of the mixture by mixing of two components for 3-25 minutes, pouring the mixture into the building structure, where it is swelling, foam formation and curing.

When using the fire-retardant foam, it is necessary to exclude ingress of atmospheric precipitation. It is recommended to perform the preparation of fire retardant foam at air temperatures above +80°C. The process of foam formation is characterized by increase in the initial volume by 2-20 times (regulated by the ratio of components), that should be considered to avoid overspending of materials and an increase in the cost of fire protection.

Curing of fire-retardant composition depends on the ambient temperature and ranges from 5 minutes to 8 hours.

Characteristics of silicate hardening foam:
1. Non-flammable. (GOST 30244-94 “Building materials. Flammability test methods”).
2. Strength limit: in compression is from 0.207 to 0.350 MPa
   - for bending from 0.1502 to 0.2338 MPa.
3. The coefficient of thermal conductivity is from 0.0621 to 0.1246 W / (m K).

The use of wastes of metallurgical and mining industries will reduce the cost of preventive activity by 2-3 times.

On the basis of silicate hardening foam, it is possible to manufacture products: for high-temperature thermal insulation, cladding panels, structural fire protection, building material of foam concrete class. Wastes of silicon production, mining and gold industry is used as basic materials. The final product is non-flammable and non-toxic, and is characterized by good thermal insulation and sound insulation properties.

If necessary, the products made of silicate hardening foam can be used for recycling after grinding.

The launch of pilot production will help to solve the problems of large-scale transition, averaging and stabilization of the properties of various wastes. Preliminary calculations showed that with a processing volume of about 100 tons of waste per year, pilot production would be profitable, and products would be competitive.

![Figure 5](image-url)  
*Figure 5. Sample forms made of suggested material.*

Developments are created taking into account the possibility of their practical implementation in small and medium-sized enterprises, which will outweigh the costs of the research. The use of local raw material base, industrial wastes, as well as the social significance of the carried out research make this direction relevant. Depending on the allocated funding, development is carried out in parallel or in
priority areas. Taking into account the existing developments in the raw material base and the experience of applied research and development work on the manufacture of such types of products, in the case if there is a customer, the time required for the implementation of developments will not exceed one year.

This development can be used to implement all of the above issues: manufacturing modern firewalls, filling the voids of building structures, erecting internal partitions, etc., which will improve the fire safety of existing buildings in remote areas at minimal costs.

References

[1] Mashovich, A., Ruposov, V., Moskvitin, V., Developing a model of effective growth for small and medium business for sparsely populated and remote areas within the framework of the green economy concept (based on the example of the Irkutsk region) 2018 MATEC Web of Conferences 212,08011

[2] Mashovich, A., Ruposov, V., Moskvitin, V., DEVELOPMENT OF TECHNOLOGY OF PRODUCTION OF POWLINES FOR CONDUCTING WORKS WITH THE USE OF LOCAL TYPES OF RAW MATERIALS IN LOW-POPULATED AND DISTRICT AREAS // Izvestiya vuzov. Investments. Building. The property. 2018. Vol. 8. No. 3 (26). pp. 112-121.

[3] Zaiatdinov, O., Mashovich, A., Gavrishchuk, V., Ruposov, V., Modern and traditional ways of ensuring the fire safety of tourist industry objects in relation to Olkhon Island // Baikal Science: Ideas, Innovations, Investments: Collection of materials of the All-Russian Scientific and Practical Conference - Irkutsk: FGBOU VO IRNITU. 2018. - pp.84-90

[4] Eropkin, P., Zemtsov, M. etc. Fire regulation in construction: history and modernity / Fire magazine. March 2013 No. 3 pp.30-37.

[5] OPTIMAL PROTECTION OF BRANDMAUER // Roofing and insulating materials. 2017. No. 5. pp. 38-39. https://elibrary.ru/download/elibrary_32635083_25111367.pdf

[6] Fire regulation in construction: history and modernity / Fire magazine. March 2013 No. 3 pp.30-37.

[7] Sędłak B., Kinowski Ja., Sulik P. CRITICAL PLACES REGARDING FIRE INSULATION OF GLAZED CURTAIN WALLS TEST SPECIMENS // Bezpieczeństwo i Technika Pozarnicza. 2017. T. 45. № 1. pp. 38-50.

[8] Sharupich, P., Sharupich, S., Sharupich, V., Sharupich, T., Korolev, S. SPACE-PLANNING SOLUTIONS FOR FIRE-PREVENTIONAL WALLS - GREEN-BRANDMAUERS. FIRE FIGHTING MEASURES OF MULTILEVEL INTELLECTUAL LIVING SELF-PURPOSE HOUSES SERIES SIW 142-T-S-A-N // Uspekhi sovremennoi nauki. 2016. Vol. 4. No. 11. pp. 44-53.

[9] Federal Law No. 123-FZ dated July 22, 2008 Technical Regulations on Fire Safety Requirements.

[10] Kuznetsova, E., Alimov, L., Voronin V., Sobolev, G., Grigoriev, M. OPTIMIZATION AND FORECASTING OF THE PROPERTIES OF CAST CONCRETES WITH THE USE OF WASTE OF STONE PROCESSING // Scientific and Technical Bulletin of the Volga region. 2013. No. 6. pp. 347-349.

[11] SP 55.1330.2011 Single-family residential houses. Updated edition of SNiP 31-02-2001

[12] SP 2.13130.2012 Providing fire resistance of objects of protection.

[13] SP 4.13130.2013 Fire protection systems. Limiting the spread of fire on the objects of protection.

[14] SP 55-101-2000. Enclosing structures using plasterboard sheets.