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IMPACT OF AVALANCHE FORMATION ON BRIDGES AND ROADS

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Modern bridge construction, as well as the design of new highways, sets itself the task of building new bridge structures and road sections that pass in mountainous areas where avalanches prevail, which form because of the abundance of snowfall. Preventing emergencies is possible thanks to the installation of avalanche-protection structures. The article discusses the ways of protecting bridges and highways from avalanches, describes their advantages and disadvantages. The article concludes on the expediency of applying the considered methods at the stage of designing transportation structures.

Keywords: avalanches, road and bridge design, forced avalanches.

ВЛИЯНИЕ ЛАВИНООБРАЗОВАНИЯ НА АВТОДОРОЖНЫЕ МОСТЫ И АВТОМОБИЛЬНЫЕ ДОРОГИ

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Современное мостостроение и проектирование новых автомобильных трасс ставит перед собой задачу строительства новых мостовых сооружений и участков дорог, которые проходят в горной местности, где происходят снежные обвалы. Зачастую в данных районах выпадает много снежных осадков, что приводит к лавинообразованию. Предотвратить возникновение аварийных ситуаций возможно благодаря устройству противолавинных сооружений. Рассмотрены способы защиты мостовых сооружений и автомобильных дорог от лавинообразования, описываются их преимущества и недостатки. Делается вывод о целесообразности применения рассматриваемых методов на стадии проектирования транспортных сооружений.

Ключевые слова: лавины, проектирование дорог и мостовых сооружений, принудительный сход лавин.

Introduction. Avalanches are snow masses of tens and hundreds of thousands cubic meters, which have lost their adhesion to the underlying surface and fall down the slope at high speed, leading to emergency consequences on roads and bridges. Apart from the natural factor, there is also a technogenic cause of avalanches. Poor nature management in mountainous regions (deforestation on slopes, placement of objects in open areas which are exposed to avalanches) can lead to material damage to the transport infrastructure, as well as to nearby settlements. This leads to the question about the solutions and devices, which can help to ease the impact of avalanche formation. The installation of protective structures requires highly qualified specialists, as well as extra hours of work, which lead to financial expenses [1].

Avalanche protection methods. There are two methods of avalanche protection: passive and active. During engineering and geodetic research for bridge structures and highways, which pass on them, it is necessary to establish areas that are dangerous in relation to snowfalls. This work is carried out based on the results of aerial photography and cartographic material, as well as onsite inspection. It is necessary to consider slopes with a steepness of 25-45°, on which a large amount of snow accumulates, which, consequently, comes to an unstable state [2]. Snow-holding structures are divided into rigid and flexible. The analysis of passive methods of protection from avalanches is presented below:

Building slopes with reinforced concrete shields (Fig. 1):

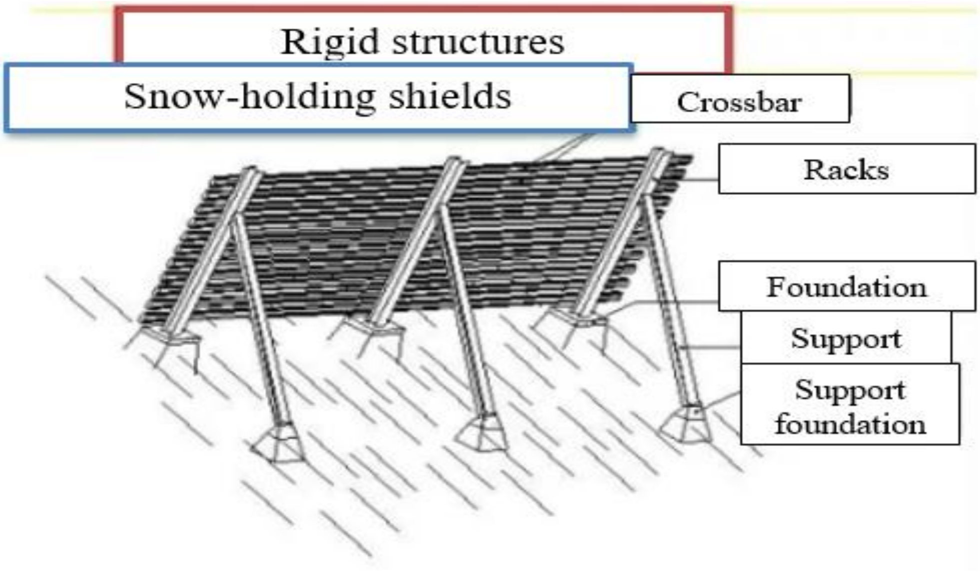

Fig. 1. General structure of snow-holding shields

Static loads act on the installed protective structures when avalanches come down. Dynamic loads can also be involved at the same time (falling of a large amount of snow at one point). Snow-holding shields are one of the ways to protect the transport infrastructure. The presented above rigid structures consist of transverse metal crossbars, racks and supports, which are located downward relative to the slope [3]. Most often, these man-made structures are built on a concrete foundation.

One of the most important benefits of such structures is the fact that they work well in areas where avalanches occur and are able to withstand snow piles up to 4.5 meters high. The biggest disadvantage is the dead load of the structure, which reaches up to 200 kg per running meter.

Construction of snow barriers (Fig.2):

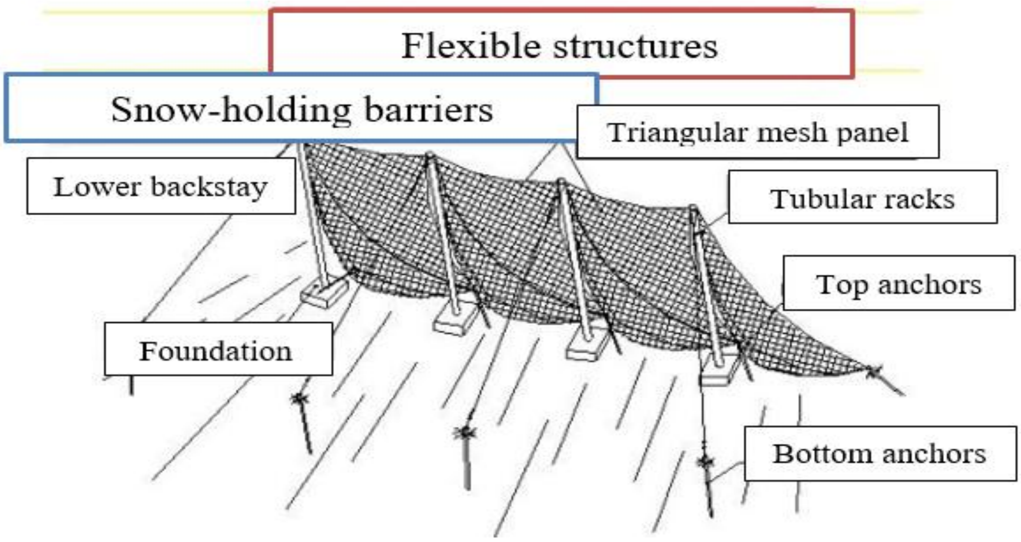

Fig. 2. Illustrative diagram of snow-holding barriers

This method ensures maximum safety for both human life and transport infrastructure. Figure 3 presents the components of the protective structure. There is also a list of the main advantages used in practice not only in the Russian Federation, but also in European countries.

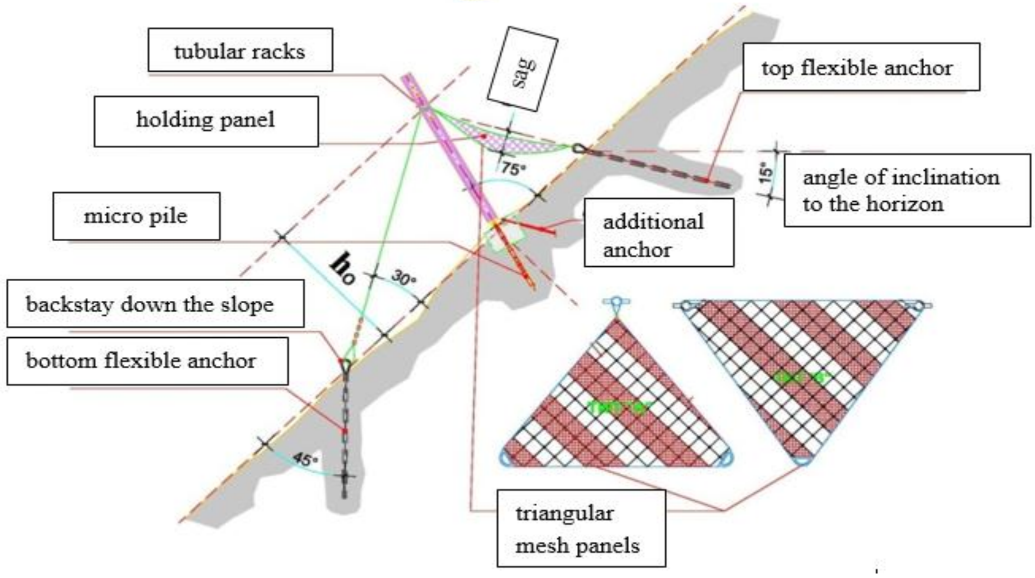

Fig. 3. Sectional diagram, as well as the main parts of the barrier

The connection of the rack to the foundation has a hinge connection, which easily reacts to changes in the external parameters of the avalanche [4, 5].

The main parts and elements are:

— holding panel (consists of: steel mesh fabric in the form of triangular panels);

— supporting structure (racks);

— fastening system (steel cable which are installed in a way which allows to transfer tension from the retaining curtain and the supporting structure through the foundation to the base);

— anchoring system.

The advantages of this method of protective structure:

— almost maintenance-free system;

— good resistance to dynamic loads;

— does not require expensive construction of access roads;

— can be installed in the zone of avalanche initiation, preventing its descent at the initiation stage.

Disadvantages:

— costly installation;

— requires highly qualified personnel in this area.

At this time in the Russian Federation, this method of protection is very popular.

Descent of an avalanche of subcritical mass into an accumulation pit, followed by melting of the snow mass by heating pipes installed in them.

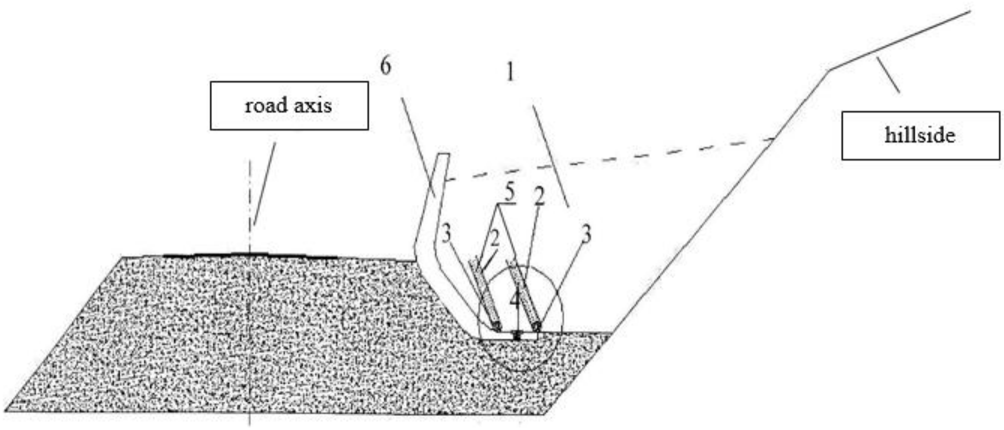

Fig. 4. Layout of the main elements of the protective structure

This method of protection is mainly suitable for protecting bridge structures and highways passing along them. The technical result of the proposed technical solution is as follows: reduced labor costs, increased efficiency due to automatic operation, increased safety [6].

The presented method includes: descent from a snow slope of a subcritical mass into an accumulating recess (1), on the bottom of which heating pipes (5) are laid parallel to each other, inside which there are heating elements (3). A weight sensor (4) determines the subcritical mass as an avalanche descends. After that, the element, which is responsible for melting snow in automatic mode, turns on, with the subsequent removal of the snow mass. With a gravity equal to or more than 170 kg/m^2, the sensor (4) sends a signal to the heating elements (3), which are connected to the power source, and turns them on, and with a gravity less than 170 kg/m^2, the sensor automatically turns off and heating stops.

This reflector also has such a role as preventing snow from falling on the roadway when the gravity of the avalanche is over 170 kg/m^2.

The analysis of active methods of protection from avalanches is presented below:

Anti-avalanche system GAZEX. This system monitors snow accumulation and initiates forced avalanches using the explosion effect of a mixture of oxygen and propane [7].

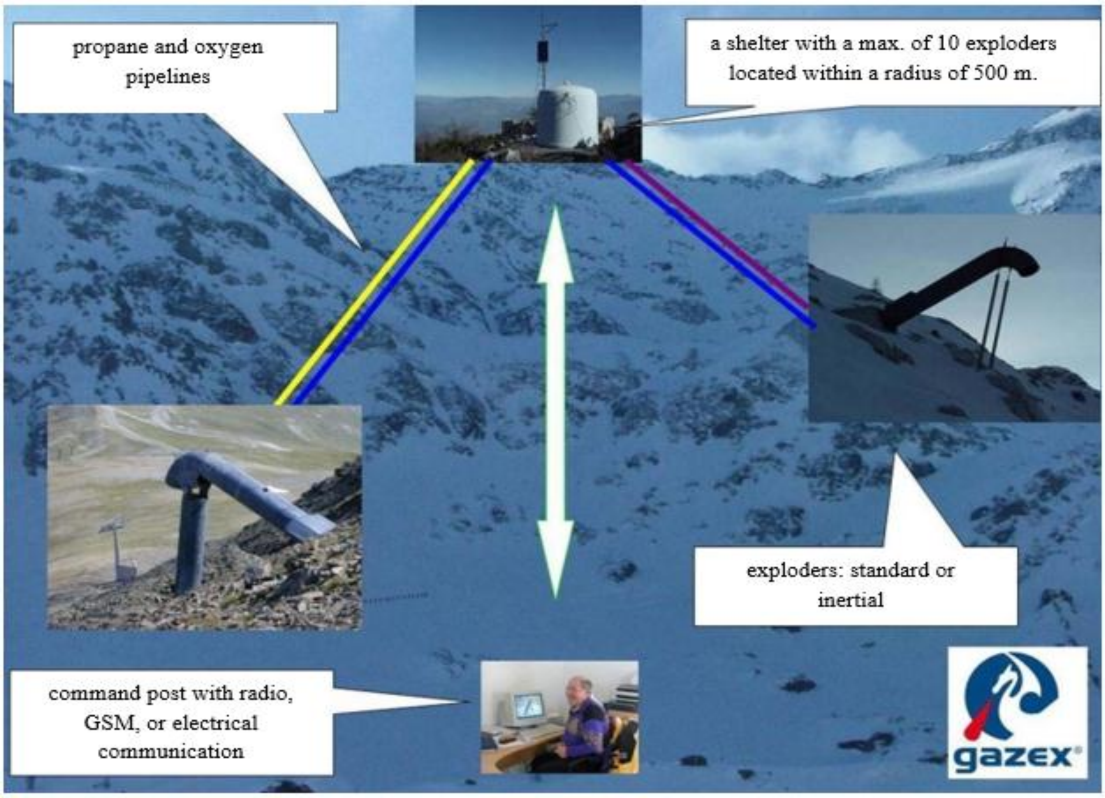

Fig. 5. GAZEX system design.

GAZEX system, composition of its system:

Shelter – a place, which contains propane and oxygen tanks, valves, electrical and electronic control systems.

An exploder is an explosive device where an explosion of a gas mixture is produced from an electric fuse. When installed on rocky ground, the front is reinforced with rods that are anchored in epoxy resin, and the base is placed on a concrete foundation. When building on soft soils, the anchor systems of the rods are replaced with counterweights that are attached to the exploder.

Fig. 6. Exploder

Two lines for oxygen/propane. They connect with shelters and exploders.

System operation principles:

By the beginning of winter, the shelter is loaded with gas cylinders. The system operation is programmed, and the operator gives a command to ignite the gas mixture using a code. The valves are opened by radio command, the exploder is filled with a gas mixture, the mixture is automatically ignited with the help of a sealed ignition system, and in the next instant, an explosion occurs. The signal from the seismic sensor on the computer screen confirms the explosion and the avalanche. After that, the operator (his room can be at any distance from the object) can request the next avalanche-hazardous location from the computer.

The benefits of the described method are the following:

— profitability, since the cost of 1 shot of an exploder with a volume of 1.5 m^3 is equal to 50 rubles. About 30 shots are fired per year, depending on weather conditions;

— preliminary avalanches at a pre-agreed time prevents further possible accidents on the roads and reduces the amount of snow that can fall on the elements of the bridge structure

Disadvantages:

— presence of explosives can be dangerous.

Conclusions. The article discusses the main methods of avalanche-protection structures for road bridges and highways, their advantages and disadvantages, as well as general schemes of the devices. The use of the proposed methods will provide an automatic mode of protection of roads and bridges from avalanches, increase the efficiency, safety of work, reduce labor intensity and cost, eliminating the use of road equipment for cleaning the route. Thus, it is necessary to consider this factor at the design stage.

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