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# The Use of Sheds for Thermal Management of the Permafrost Bases

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**Abstract.** The article analyzes the use of various types of sheds as an effective measure for thermal management of the permafrost soils. It also analyzes the possible structural designs of sheds for railway and highway roadbed and the effectiveness of their thermal influence on frozen conditions.

## 1 Introduction

Over half of Russian territory is located in the permafrost zone. However, this area is not uniform in its natural environment. It is very diverse in its climatic, permafrost soil, landscape and other conditions. Type of construction and building structures is different in each zone, where absolutely different measures contributing to the temperature conditions stabilization are rational for implementation. Therefore it is necessary to develop new measures, to improve the old ones and to find areas of their rational application.

[1, 2] present the systems of approach to the classification of various measures. Different types of sheds may be one of the effective measures for thermal management of the permafrost soils. In summer, sheds allow to protect soils from precipitation and solar radiation and thus reduce heat influx, and in the winter - from snow deposits and thereby to increase the cold flow (to increase the efflux of heat) into the base soils. Despite the self-evident's seemingly of appropriateness of sheds, in fact the practical realization of this event is not self-evident and it's connected with a number of practical difficulties. Shed's operating efficiency depends on following factors:

- design of engineering structure. Efficiency of sheds for railway's and road's embankments depends on the steepness of slopes, berms presence, the width of the main site and etc.;

- geographical location of region. The structure of sheds depends on presence of wind and therefore movement of snow masses (for example, the north of Western Siberia) or its absence (eg, Central Yakutia).

- constructive solution of shed. Shed must have durability equal to the durability of the structure itself, but when you do so, complements shed cost can increase significantly.

In connection with the above, the relevance of the development of such a topic (development sheds for different conditions) is determined, on the one hand, the efficiency

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sheds, and with another - lack of practical developments. This article is an attempt to somewhat fill this gap.

## 2 Review

The idea of shed using in order to generate the required heat and humidity regime appeared not only at the dawn of mankind, but generally at the beginning of all life. The most visible effect of using sheds in terms of permafrost soils was obviously reached by applying the ventilated underground spaces, the details of which are presented in [3] (usage within the Trans-Baikal railway in 1907) and which have found a wide use by now.

The use of sheds on permafrost for other building structures also took place in the middle of the last century. N.N. Romanovsky suggested using sheds as anti-icing measures. [4] Sheds are also known to be applied for dams [5].

In order to find the efficient ways of thermal management, theoretical studies led by V.S. Lukyanov were widely deployed in the 50 - 60s by CSRIC. The studies were devoted to thermal regime of the railways and roads in the permafrost. A variety of measures, including sheds were analyzed. Effectiveness of the sheds use is covered in [6]. Afterwards, the possibility of sheds using was analyzed in [7]. At the same time, other researchers were as well engaged into sheds application, for example, V. G. Kondratyev [8, 9, 10]. Sheds were also used abroad: in China [11, 12], in Alaska [13].

Thus, thermal effect that is obtained when using sheds is undeniable.

## 3 Description of the research and developed designs

The main problem lies in the embodiment of the sheds. Shed is an integral part of the engineering structure, which should function throughout the entire service life of the structure. Therefore, it should be constructed as thoroughly as a bridge or a culvert. At that point it becomes expensive and often already uncompetitive in comparison with other structural measures. That is why there is a problem of finding the way to simplify the sheds.

Let us examine the peculiarity of the sheds usage in relation to the conditions of a railways roadbed. One of the effective ways lies in the replacement of overall sheds with the local ones. Fig.1. shows various sheds designs.

Fig. 1 presents a shed in accordance with patent [8]. It contains the load carrying elements 1, completely enveloping the embankment 2 and obstruction clearance 3. The carrying elements 1 are mounted on the bearings 4. Continuous coating 5 is laid on the carrying elements 1. Snow deposits 6 in winter, solar radiation and rainfall in summer are held up by the shed over the entire surface of the embankment, which allows to dramatically reduce the temperature of the permafrost soils.

The advantage of this technical solution is that it achieves the maximum protection against the harmful effects of: snow drifts, solar radiation and rainfall.

The disadvantage of it is the high cost of the structure. The carrying elements 1 have a rather large span (about 25 - 30 m), and are located above the rolling stock. Consequently, the structure should be sufficiently robust (like a bridge), able to withstand the wind and snow load, dead load, etc. The design can be simplified by several times (Fig. 1b) [14]. The principal difference from the previous design is that the load carrying elements 1 are located below the transport passage. Firstly, it dramatically reduces the level of design responsibility, and secondly, the span decreases (by 2 - 3 times), which consequently reduces the material consumption by 4 - 9 times. As for effectiveness, it is practically the same as that of the first design (see Fig. 1a).

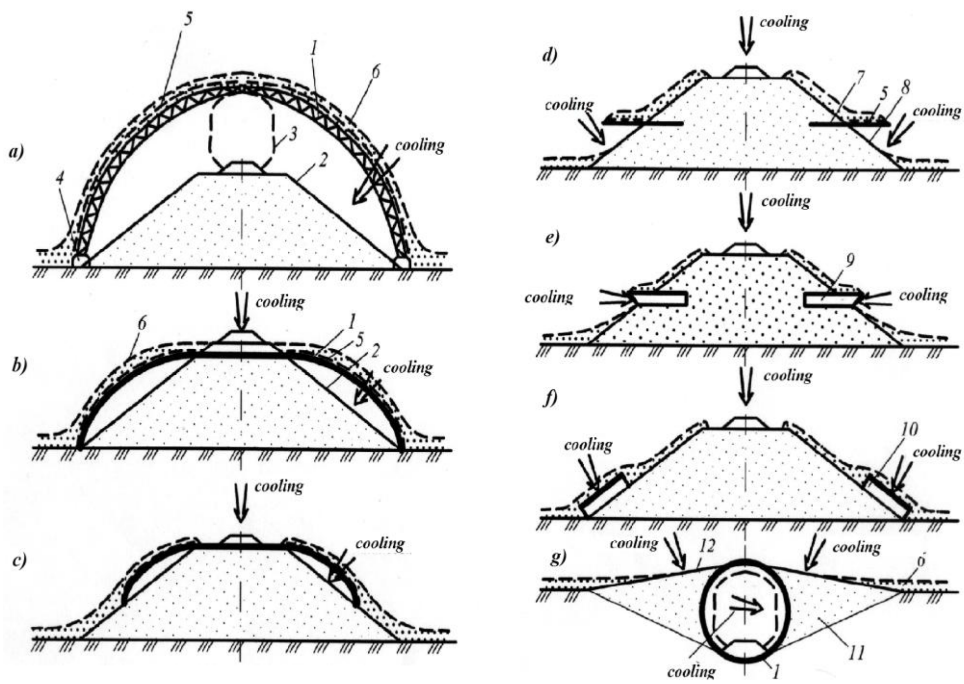


**Fig. 1.** Various schemes of sheds: a, g – overall; b – zonal; c, d, e, f – local

This is because within the primary platform of the embankment there is practically no snow in any climatic zones (both in regions with a strong transport of snow, and in regions with no transport of snow). And snow is the major factor that influences the temperature regime. The peculiarity of the Fig. 1b scheme is that instead of the bearings 4 (see Fig. 1a) the use of a cantilever rigid-fixing is implied: load carrying elements 1 are introduced into the upper part the embankment body 2.

But the maximum possible actuating quantity is not always needed. Often it is enough to partially improve the situation in order to provide the required temperature regime. Thus, local sheds become expedient. The first scheme of local shelter is shown in Fig. 1c. It mostly repeats the scheme of Fig. 1b, so it does not require explanation.

Fig. 1d [15] is a diagram of the local cantilevered shed. Supporting cantilever elements 7 are stacked during the process of soil layers placing. Deck 5 is placed on the supporting elements 7 on the outer side of the embankment.

This type of sheds is suitable for regions with a lack of snow drift (e.g. Central Yakutia). In this case, the part of the slope surface 8 is called bare (with no snow there). This surface is enough to provide the desired temperature regime. Fig. 1e presents a very effective scheme of the local shelter. [16]

When stacking the layers, the pipes with penetration of about 4-5m are placed in the embankment body. The pipes diameter is about 1m, the distance along the embankment - about 10m. On the degree of effectiveness, it is close to the scheme of Fig. 1d, but is simpler to install and is reliable in operation. Fig. 1f, [18] gives a scheme of the shed in the form of a sill hollow covering 10. In regions with a strong snow transit excavation it is very difficult to construct cavities: they are buried with snow, and passage is impossible. In this case, the use of a tunnel type cavity is possible.

We return to the scheme of an overall shed (see. Fig. 1a), but the supporting structure 1 envelopes only the obstruction clearance, so the cost is immeasurably lower.

The design in Fig.1g [19, 20] comprises a supporting structure 1 made of, for example, the corrugated steel elements.

Backfill soil 11 bounds the structure on the sides. The upper surface 12 is raised above the snow deposits in natural conditions. In regions with a strong transport of snow, the surface 12 becomes bare of snow and the cooling process passes through it. The cooling is also carried out through the tunnel passage cavity (assuming that the length of a tunnel makes the cold air aeration possible).

We can distinguish the following groups of sheds in relation to the railway and highway roadbed:

– on the degree of coverage of the cross section of the roadbed: overall (which cover the entire cross-section of the embankment or cavity), zonal (covering one or more elements of the cross-section, but not the entire cross-section), local (located in separate parts of the cross-section);

– on the degree of continuity: continuous and non-continuous (i.e. constructed with intervals);

– on the nature of the location in relation to the outer surface of the roadbed cross-section: external sheds (located on the outer surface side) and internal ones. The internal sheds can include the pipes inside the sloping part, as well as, for example, the horizontal layers of the thermal insulation from the side of a slope;

– on the scheme of bearing: closed (for example, in the form of a corrugated structure of the tunnel, laid instead of a cavity), pillar-type (arch or frame semi-closed profile with upright pillars) sill-type (e.g. box-shaped section structures, laid on a slope), cantilever-type (sheds on a horizontally stacked elements in the sloping part of the embankments or cavities);

– on the nature of air circulation under the shed: with the augmented thrust or with natural convection.

To test the effectiveness of local sheds (as in Fig. 1d), a series of thermal and physical calculations was run.

Fig. 2 shows the obtained dependence of the temperature tc in the center of the embankment foot (on its axis) on the relation b/ hem (b - width of the primary embankment platform, hem - height of the embankment) for the sheds of various width. The calculation results show that effectiveness of the shed is quite significant: even in the worst case, the soil temperature becomes low enough (-0,75°C).

The next effect turned out to be very interesting. When applying several local sheds installed with some spacing, the effectiveness increases in comparison with the case where sheds are arranged directly adjacent to each other.

Curves 3 and 4 in the Fig. 2 show the effectiveness of using two sheds of 2m in width arranged side by side (curve 3) and installed with the spacing of 2m (curve 4). In the latter case, the effectiveness is higher by 30%.

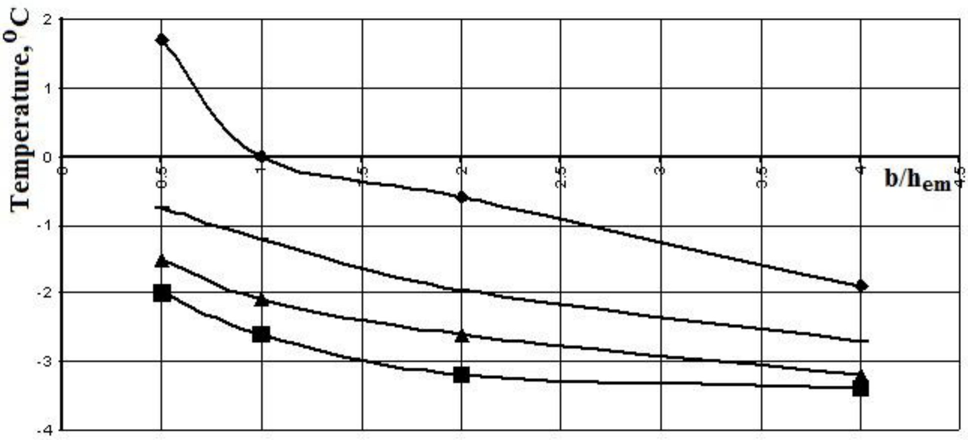


**Fig. 2.** Dependence of the temperature tc on the level of the embankment foot (on its axis) on the relation b/hem:1 – with no sheds; 2, 3 – with the shed of 2,4m respectively; 4 – with two sheds of 2m, constructed with the 2m spacing

## 4 Conclusion

The study of different types of sheds from the perspective of thermal influence effectiveness showed the following:

- overall closed continuous external sheds are more appropriate only for cavities in regions with strong transport of snow (when the cavity is covered with snow). Embankments have a primary platform with dramatically decreased snow thickness in all the regions, so the use of the shed for embankments in this region is ineffective;
- zonal continuous external sheds within the slopes are appropriate for embankments in the regions with strong transport of snow;
- zonal or local (as calculated) internal and external non-continuous sheds constructed within the sloping part are suitable for Central Yakutia – both for cavities and embankments;
- apart from the artificial sheds, it is also appropriate to use the natural sheds in the formation of calculated temperature conditions in the soil bases. Those can be, for example, the span of the bridge, the culvert or ventilated underfloor spaces in buildings (especially in regions with low transport of snow).

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