Public easements` establishment for forest fund lands during seasonal roads` designing

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Abstract. The article focuses on question of public easements` establishment for forest areas intended to accommodate seasonal roads as temporary structures. On one hand, seasonal roads are transport routes, which location changes every season. At the same time, they have features of real estate items as they are inseparably linked with the ground surface, and their movement without disproportionate damage to appointment is impossible. In both cases season roads require immediate strategic decisions, concerning their construction and operation. Due to the fact that seasonal roads are distinctive for territories of the northern regions, they are most often located on the forestry fund lands. That’s why the question of territory planning while designing of such objects in difficult natural conditions is one of the most difficult in civil engineering, geodesy, land and forest law. Relevance is determined by need of increasing efficiency of the forest fund land use during designing of these real estate items, taking into account their specificity. The aim of research involves advanced technology of designing work’s development for seasonal roads. This technology gives opportunity of first-ever defining possible changes of seasonal roads` boundaries by results of field measurements of physical and mechanical soil properties.

1. Introduction
Today need of solving territorial distribution problems of transport infrastructure objects has been determined by requirements of socio-economic development of any country, as well as the Russian Federation. At the same time, issues related to cadastral works in relation to linear objects remain the most difficult in the sphere of land and property relations. Current situation is justified by considerable length of these objects, and therefore by territorial distribution on a large number of land parcels, which belong to different categories of land, including the forestry fund lands.

Consequently the Government of the Russian Federation proposed to realize the technology of establishing a public easement aimed at simplifying the construction, reconstruction, overhaul and operation of linear objects in land and property complex management (Federal Act No. 341) [1].

Enactment of the above-mentioned law is connected with the fact that process of registration and coordination of linear objects’ construction, most often on the forestry fund lands, is a resource-intensive and long-term action. According to art. 21, para 1 of the Forestry Code of the Russian Federation, the construction, reconstruction and operation of objects, which are not related to the forest infrastructure creation on the forestry fund lands, are permitted for electric power lines, communication lines, roads, pipelines and other linear objects, as well as facilities, that are technological part of these objects [2].
Establishment of the institute of public easement’s law excludes satisfactory settlement under conditions of objects’ passage on each particular forested land parcel, as well as allows to ensure construction without using land withdrawal [3]. Moreover, land withdrawal is economically unjustified, because seasonal object doesn’t always prevent use of forested land parcel for its purpose. Currently the concept of public easement has been clarified: in fact, it becomes the right of legal entity to ensure territorial distribution of socially important objects. Besides, modern resource-saving technologies of building and preserving forest roads contribute to mitigating the negative impact of transport on natural ecosystems [4].

Establishment of public easement boundaries contributes linear objects’ territorial distribution, provided that interests of all landowners and land users are taken into account by fees and compensatory damages in the result of its establishment. In general terms, this procedure excludes cadastral and registration actions for neighboring forested land parcel.

In spite of the fact, that above mentioned provisions solve all kinds of atypical problems with regard to transport infrastructure objects, the process of construction and operation of seasonal roads on forestry fund lands is not regulated in any statutory instrument. In such case seasonal roads are changeable transport routes of certain direction and are classified as temporary structures.

2. Methods and Materials
The location of seasonal roads is influenced by physical and mechanical soil properties, numerical coefficients of which are determined as result of year-round stationary observations of temperature and humidity modes, base deformation of roadway at specially organized posts and test areas [5]. The field stage of research involves carrying out engineering surveys in the form of geodetic, geological and hydrometeorological works. These studies are included in the list of functions of the Department of Land and Property Relations of The Federal Road Agency and are carried out within its experimental laboratories’ competence [6].

As a result of field stage, lists of road axes coordinates in accordance with the operational seasons of 2011-2018 (figure 1) and information about numerical indicators of humidity, stability, freezing depth, bearing capacity of the soil were obtained.

*Figure 1.* Seasonal roads’ lines with reference to the cartographic image of the metric scale 1:200000 and to the cadastral plan of the territory: the red color indicates the line of 2016-2017 years, purple - 2011-2012, blue - 2007-2008, yellow – middle line.
In-office stage work is carried out with use of spatial analysis method, according to materials of engineering survey and is interpreted taking into account the experience of road designing and construction during past operational seasons. In order to quantify the width of the public easement area, mathematical modeling has been carried out, allowing to predict location of the object. As the final stage with application of analysis of seasonal axes’ proximity the construction of buffer zones as public easement’s zones is performed. Coordinates of its boundaries are determined on the basis of soil characteristics obtained as a result of engineering survey.

Thus, the technology is experimental-theoretical and involves geographical prediction method to determine the future position of the seasonal road and geographic information method, with which it’s possible to create data banks on the basis of information received from organizations, which keep track of seasonal roads. The cartographic method provides opportunity to visualize geographical location of the object.

3. Results and discussion

Construction of study objects is carried out on territories, where it’s not feasible to create paved roads. Their roadway is destroyed due to difficult engineering and geological conditions during one operational season. Therefore, seasonal roads have life cycle, which is not specific to other real estate items [7].

There are numerous seasonal roads’ superimpositions on neighboring land parcels, most often forest fund lands during seasonal roads’ designing [8]. As a result of seasonal roads’ studying, as a separate type of transport infrastructure, it’s revealed: as for territorial distribution of constant linear objects, for seasonal roads the spatial basis in the form of land parcels is also determined. Taking into account the change of measured points’ coordinates of seasonal roads, there is discrepancy between boundaries of land parcels under the road and the object with its changing location.

To optimize land organization for seasonal roads and to plan their rational use we need adjustment of their boundaries. Assuming that the adjustment timing distribution occurs according to Poisson’s law, the probability of seasonal road boundary stability will be equal:

$$P_t = \exp \left( \frac{-t}{T_{av}} \right),$$

where, exp – base of natural logarithms; $t$ – time period of public easement boundaries’ correction, years; $T_{av}$ – road’s life cycle, for seasonal roads this factor is equal to 1 year.

In compliance with boundaries’ stability with the probability of 0.9 - 0.95, it’s necessary to specify them every 0.05 years, that is economically inadvisable. Therefore, buffer zones with a special legal regime should be established to avoid repeated preparation of land management documents.

Due to figure 1, it’s possible to note a divergence of lines, that is connected with specifics of the object of seasonal existence. It can be explained with the changing location of an object depending on soil conditions, topographic features, relief characteristics.

Creation of the image of the average line is carried by method of perpendiculars on points which location is determined by extreme seasonal lines. It’s necessary to receive the first indicator – deviation of each line from the drawn average line.

Knowledge of position of the average line in the presence of communication of indicators of certain physical characteristics with coordinates of each her point can be used for forecasting the position of border lines in the set buffer zone. Each point correspond to certain results of the studied indicators.

We need to determine by carrying out an analytical research of each lines’ groups with a binding to values of their deviation. Distribution of indicators of zones is only the assumption so far, his scientific justification is possible by a clustering method. Each seasonal line is characterized by soil conditions. These observations need to be broken into “k” number clusters. Parameters should be considered with average line and should be spread out on clusters (groups). The main aim of statistical research is to
find out dependence between deviations on points of lines of different seasons and physical parameters. For future clustering it's offered to establish the following zones: maximum, average divergence and minimum divergence.

The term "divergence" offers to designate distance between points of extreme axes regardless of a season. There is the result of research for lines of the highway for the season 2011-2012 as an example. It is obvious that such researches have been conducted for each of seasonal line (figure 2).

![Figure 2: Result of carrying-out of analysis for the road’s line for the season of 2011-2012: with intervals of values of depth of ground freezing.](image)

The distribution of indicators’ values is uneven. Certain groups and classes are obviously allocated. For further calculation, matrix with 9 values is used: 8 numerical indicators, which are characterized soil properties and a distance equal to seasonal road lines’ deviation from zero. As test values have different dimensions, data was previously standardized, that is, the difference between the numerical index of a particular cell and the mean value was determined. A standard deviation separation is performed to eliminate the dimension and align the spread. Scientific justification for indicators distribution is given using clustering method. As a result of spatial analysis of geotechnical maps compiled for design area of the seasonal road route, it was determined that for each previously defined area indicators varied in following ranges (table 1).

| №  | Soil condition average mark | Units of measurement | Zones of seasonal lines’ divergence |
|----|-----------------------------|----------------------|------------------------------------|
|    |                             |                      | Minimal divergence (0-23 m) | Average divergence (24-67 m) | Maximal divergence (68-84 and more m) |
| 1  | Humidity                    | %                    | 10 | 11 | 11 |
| 2  | Density                     | g/cm²                | 12 | 7  | 15 |
| 3  | Total volume content of ice | %                    | 40 | 30 | 32 |
| 4  | Depth of ground freezing   | cm                   | 30 | 44 | 29 |
| 5  | Bearing capacity of soil    | kg/cm²               | 6.1| 5.2| 4.3 |
| 6  | Proof of soil stability     |                      | 4  | 4  | 6  |
| 7  | Average temperature of soil freezing | °C | -0.5 | -0.8 | -0.3 |
| 8  | Speed of soil heaving       | mm/d                 | 10 | 12 | 11 |
| 9  | Driving resistance          | MPa                  | 0.55| 0.87| 2.86|
Using the results of longstanding engineering and geological survey, as well as using the cluster analysis method, we determine the possible value of axis divergence for the maximum recorded indicators of soil characteristics for each previously identified zone of seasonal axis divergence. Thus, the maximum possible divergence indicators have been determined for each zone (table 2), which will determine the boundaries of the buffer zone.

**Table 2.** Maximal marks of physical and mechanical soil properties, which are measured during longstanding engineer survey, for each divergence zone.

| №   | Soil condition maximal mark     | Units of measurement | Zones of seasonal lines’ divergence |
|-----|---------------------------------|----------------------|-------------------------------------|
|     |                                 |                      | Minimal divergence | Average divergence | Maximal divergence |
| 1   | Humidity                        | %                    | 12                  | 13                 | 15                 |
| 2   | Density                         | g/cm³                | 13                  | 7                  | 19                 |
| 3   | Total volume content of ice     | %                    | 45                  | 32                 | 32                 |
| 4   | Depth of ground freezing        | cm                   | 30                  | 46                 | 34                 |
| 5   | Bearing capacity of soil        | kg/cm²               | 6.8                 | 5.2                | 4.4                |
| 6   | Proof of soil stability         |                      | 4                   | 4                  | 7                  |
| 7   | Average temperature of soil     | °C                   | -0.1                | -0.1               | -0.2               |
| 8   | Speed of soil heaving           | mm/d                 | 11                  | 12                 | 12                 |
| 9   | Driving resistance              | MPa                  | 0.61                | 0.89               | 2.90               |

As is shown in table 2, it’s possible to calculate the width of the buffer zones and, consequently, to determine the coordinates of their boundaries on the ground by establishing the relationship between the numerical values of the specified soil characteristics and the deviation value. Knowledge of the position of the central baseline in accordance to soil properties can be used to predict the position of seasonal for the next season (table 3).

**Table 3.** The projected width of public easement’s buffer zones for seasonal road on forestry fund lands.

|                                | Minimal divergence, m | Average divergence, m | Maximal divergence, m |
|--------------------------------|-----------------------|-----------------------|-----------------------|
| Results of geotechnical maps   | 0-23                  | 24-67                 | 68-84                 |
| and cluster analysis method    |                       |                       |                       |
| Adjustment according to maximal | 0-28                  | 28-79                 | 79-92                 |
| marks of soil properties       |                       |                       |                       |

Analytical study was carried out for each of the seasonal axes, as a result groups of divergence were identified. The result of cluster analysis is clear division of zones of divergence into three groups. Having information about the coordinates of points for each zone, you can indicate them on the territory.

As an illustration of carried out calculations (figure 3), there an example of buffer zone model built for the seasonal road according to the data obtained during the four operating seasons.
The solution of the problem of the location of seasonal roads on the forest fund sections is possible with the application of the forecast of the change in the location of the boundaries of the investigated objects, as well as with the establishment of the boundary of the public easement as a spatial basis, as shown in figure 3. By this means, establishment of public easement boundaries for study objects, with an appropriate legal status, avoids repeated preparation of land management documents to clarify the boundaries of adjacent forestry fund lands.

4. Conclusion

As a result of research: 1. Particular characteristics of seasonal roads as real estate items is defined; 2. Need to improve the technology of study objects’ designing taking into account the established specifics is justified; 3. Methodological approaches to the location of linear road transport objects have been studied, as well as the peculiarities of such approaches for seasonal roads; 4. Physical and mechanical soil properties affecting location changes of the study objects are revealed; 5. Factors determining soil properties are ranked according to the degree of influence on the location of seasonal roads; 6. The model has been developed to determine the bandwidth of the tap depending on the degree of influence of the factor; 7. The technology of spatial basis, defining the limits of seasonal roads’ passage has been developed; 8. GIS project has been created to map the boundaries of the buffer zone’s territorial distribution of seasonal roads.

As a result of boundaries’ establishment of public easement with for seasonal roads, their lawful location on large area comprising many forestry fund lands is arranged. Registration of public easement implies a simplified procedure for establishing the boundaries of study objects on the territory in spite of seasonal changes of the measured points’ coordinates and the presence of registered rights to adjacent land parcels.

The results of research ensure the development of existing technology for seasonal roads’ design on forest fund lands. It can become not only conceptual basis for the system of operation and management of road transport objects as real estate items, but it can also be used to improve the legal framework in land and forest laws.

The results are significant for business processes of land management organizations, correct work of territorial bodies of the Federal Service of State Registration, Cadastral and Cartography, as well as
for the territorial bodies of the Federal Road Agency of the Russian Federation during seasonal roads' management.

References

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