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To cite this article: I N Ushnitsky 2020 *IOP Conf. Ser.: Earth Environ. Sci.* **459** 032075

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Features of Operation of Highways in the Republic of Sakha (Yakutia)

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Abstract. A regional economy is greatly dependent on transport. Yakutia spans over 308,342.3 thousand hectares in Russia's North East. Winters here are long: they last eight months with temperatures down to -50-60°C; summers are short but may be as hot as >30°C. This climate requires special approaches to be livable. This paper dwells upon road transport and its operation. Road transport requires high-quality roads. Today's road vehicles are high-speed, heavy-duty vehicles; their speed and payload capacity are only expected to rise further. Yakutia's highways are a set of infrastructures: pavement, earthworks, bridges, pipes, drainage, road signals and signs, recreational areas; pontoon bridges in summer, if necessary. All of that is necessary for road to operate normally. A car road is a costly infrastructure designed to last.

1. Relevance

Today, a region needs cheaper and more efficient transport of goods, works, and services so that its people could work and live properly.

Before reforms, air transport accounted for bulk of freight; today, cars are the preferred mode of transport. In 1990, the Republic had 107,003 registered cars; in 2017, 302,975 [11]. Scientifically, cars have to meet specific requirements to be usable in the North. This study draws upon V.K. Nekrasov's papers, statistics, and the author's textbook.

2. Statement of problem

Identify the factors contributing to the year-round use of road transport.

3. Theory

At rest, a car wheel is only exposed to one force directed downwards. This is the weight of the car and of the wheel itself. Today, pneumatic wheels have different specifications depending on the manufacturer; taking the load on the road surface into account is difficult. Pressure from the wheel is carried by an air cushion. Normally, this pressure ranges from 0.2 MPa for passenger cars to 0.6 MPa for trucks. [2] The pressure causes the wheel to flatten at the wheel-road interface. The tire compression is

$$q = k Q_k$$

where k is a coefficient of tire elasticity

q is the tire compression magnitude

Q_k is the weight load carried by the tire



Air pressure in tire tube and the specific wheel-imposed pressure on the wheel track are not permanent even if the car carries the same load. On a hot sunny day when the air temperature is 30°C, the dark road pavement can be as hot as 70°C; a wheel rolling upon such hot surface will be hot as well; friction and deformation will contribute, too. This will heat the air in the tube and raise the inner pressure; the track will become smaller, resulting in greater per-unit pressure imposed on the road. Exactly opposite will happen at 50–60°C negative. Although deformation will cause some heating, the wheel will generally retain lower pressure than it would have in a heated garage; with lower tube pressure, the track will be enlarged, resulting in lower per-unit pressure. When driving a car at a high speed as measured by the outer wheels when moving along a curve, the centrifugal force and overload cause a greater pressure on pavement than cars at rest or following a straight line. This might affect the car motion negatively. $P_k = P_{kp} + Q \sin\alpha + P_j + \frac{M_{ck} + M_{jk}}{r_k} + \frac{M_{cn} + M_{jn}}{r_n}$, [6]

where: the drive-wheel tangent thrust P_k ;

Weight load created by a car or a wheeled tractor $Q \sin\alpha$;

Translational motion inertia force P_j ;

Hook force P_{kp} ;

Moment of inertia of the rotating solids (wheels) M_{jk}, M_{jn} ;

Moduli of section for the drive wheel and the driven wheel, M_{ck}, M_{cn} ;

Dynamic radii of the drive wheel and the driven wheel r_k, r_n ;

4. Practical Significance, Proposals and Implementation Results, Experimental Results

A car road is a set of various engineering infrastructures it needs to operate properly. Road safety services; coolant, fuel, and lubricant suppliers; maintenance and repair services. All of this operate for better road transport. The quality of driver training is also an important aspect. In winter, ice roads have their strength changed. It is the thickness of ice, which gradually becomes thicker as temperatures go down, the determines the maximum load capacity of transports allowed to drive on this or that ice road. Its strength has to be reassessed from time to time.

Long-term elastic modulus E_y is found by the equation:[10]

$$E_y = \frac{pD}{L_y},$$

Where p is per-unit pressure the car wheels exert on the pavement

L_y is the relative elastic strain (deflection)

D is the diameter of a circle equal in area to the wheel track, see

pD is a constant for the car used in calculation, which means that finding the deflection is enough to find the elastic modulus and estimate it from the pavement strength.

MADI research shows the long-term elastic modulus is about 3.25 times the strain modulus.

The presented materials are currently being tested as teaching aids for NEFU ADF students.

Since recently, businesses need to use heavy-duty tractor vehicles to cut their operating costs; however, ice roads and crossings are not in capacity to carry heavy vehicles.

This causes excessive damage and premature wear and tear. Restrictions on vehicle types are imposed to tie the road and car development. In Yakutia, restrictions apply to local roads and crossings on ice during mud seasons. In theory, tractor vehicles has impact on the roadway via its drive and driven wheels. In the North of the Republic or when the unpaved roads become nearly impassable due to precipitation, 4x4 wheel formula has to be applied.

The interactions of all road transport elements have to be analyzed to operate roads more efficiently. Consider a four-block road transport utilization chart to cover all the operating conditions that may apply to roads and their elements. The components of the chart are: drivers and people around (humans and animals), car traffic, road, environment. The regionally specific interaction of these elements begins as soon as the road is commissioned.

Road operation chart [10] (fig1).

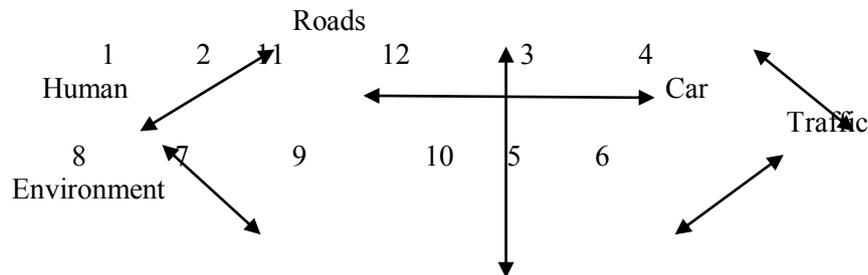


Fig. 1. Master plan of an object

The subsystems presented in the chart can be grouped as follows: 1 and 2: human and the road; 3 and 4: the road and traffic; 5 and 6: traffic and environment; 7 and 8: environment and human; 9 and 10: the road and environment; 11 and 12: human and traffic. Interaction of these subsystems is always region-specific.

5. Conclusions

The Republic of Sakha (Yakutia) is located in the Far North of Russia, which is why it has harsh climate and long winter. It is an extremely large region that goes along the Lena River, Indigirka River, etc. The area comprises large forests and tundra. The region is partly on permafrost. Construction and operation of roads should be specifically adapted to the local conditions. Road operations are designed with saving fuels, lubricants, rubber, and spare parts in mind; these costs together have direct environmental impact. Besides, every road user should have access to infrastructure.

Today, a road is a workplace for many both in winter and in summer regardless of weather, even when the road is nearly impassable due to mud in spring and torrential rain in summer or fall.

Heavy-duty vehicles can be used effectively in winter on ice crossings; however, mud season causes a temporary degradation of republican and municipal roads, whereby a medium-capacity vehicle makes more sense. Year-round pontoon platforms are suggested for more efficient ice crossing; this issue requires further research. Thus, factors that contribute to year-round road use are associated with the long 8-month winter, which causes road pavements to respond inconsistently to weather and necessitates the use of ice roads; pontoon platforms are undergoing feasibility tests and might help arrange supplies to the North, at least to some extent.

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