Parameters of the access road for disaster situations on the roads in the mountain area

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Abstract. In the article, a mathematical model for determining the parameters of the access road for catastrophic situations on highways passing through the mountainous area is developed. The reliability of the mathematical model is proven by experiment.

1 Introduction

In the event of a vehicle malfunction on mountain roads, vehicles can enter the emergency access roads and stop the vehicle to prevent a road traffic accident. Emergency access roads have a place in the active safety of vehicles.

There are three types of emergency access:

- with steep elevation, in which the car stops due to the force of resistance (gravity) to climbing;
- with high resistance, in which the vehicle is braked by the high resistance of the road surface (road surface is sandy, sheben, earthy, etc.);
- a mixed method of steep elevation and high resistance, in which the kinetic energy of the car is dissipated by steep elevation and high resistance road sections.

One of the main measures to improve safety on mountain roads is the use of the principle of speed limit optimization. First, it is necessary to normalize the speed on all dangerous sections of the road by installing appropriate road signs, and secondly, to reduce the number of collisions and accidents by developing a reasonable speed regime, and if possible, to exclude the vehicle from stopping on the roadway [1-4]. Therefore, measures such as the installation of emergency access roads, parking lots or widening the roadway in recreation areas are the most necessary conditions for ensuring safety. If such measures are not provided during the road repair, safety measures should be implemented before the repair [5-12]. However, the measures listed above cannot exclude the sudden breakdown and stoppage of cars on the roadway. Therefore, it is of economic and social importance to develop measures for the evacuation of technically faulty vehicles and to determine the distance between the installation sites of special safety lanes and their design parameters to stop cars even when the brake system is not working, as well as to prevent dangerous situations on the road at night.

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2 Methods

Mathematical modeling, experimental research, determination of average absolute and relative errors, linear correlation, and regression analysis methods were used in the research process.

3 Results and discussion

Special stopping lanes EAR are installed to stop the vehicle and ensure its safety in case of malfunctions in the braking system of the vehicle moving on the mountain roads. The distance of installation of such special stopping lanes should meet the requirements imposed on it depending on the total mass of the vehicle, speed and slope of the road. Stop lanes must stop and hold vehicles in designated lanes when the vehicle's braking system fails.

Table. Available EAR in the direction of Pop-Angren

№	l_{km}	l_{Δ}	i_{yq}, %	i_{lq}, %	l_{lu}, m	l_{le}, m	l_{ay}, m	$sand_b$, m	$sand_e$, m
1	221.85		12	12	165	7	10	1	5
2	224.1	2.25	10	14	179	5.8	12.8	-	-
3	228.8	4.7	12	5→12	153	6	12.7	-	-
4	230.9	2.1	12	5	110	5.2	11	there is	

Below is an extension of the quantities in Table:
l_{km}- the distance of EAR on the road;
l_{Δ}- the distance between EAR
i_{yq}- the slope of the road at the location of EAR
i_{lq}- slope of EAR
l_{lu}- length of EAR
l_{le}- width of EAR
l_{ay} - the width of the return area at the end of EAR
$sand_b$ - sand bed height;
$sand_e$- sand bed width;
As an example, the emergency access routes on km 253 and km 222 on the Angren-Pop route are presented in the table below.

EARat the 253rd km of Angren-Pop route. The slope of the road at the location of EAR is 12%;

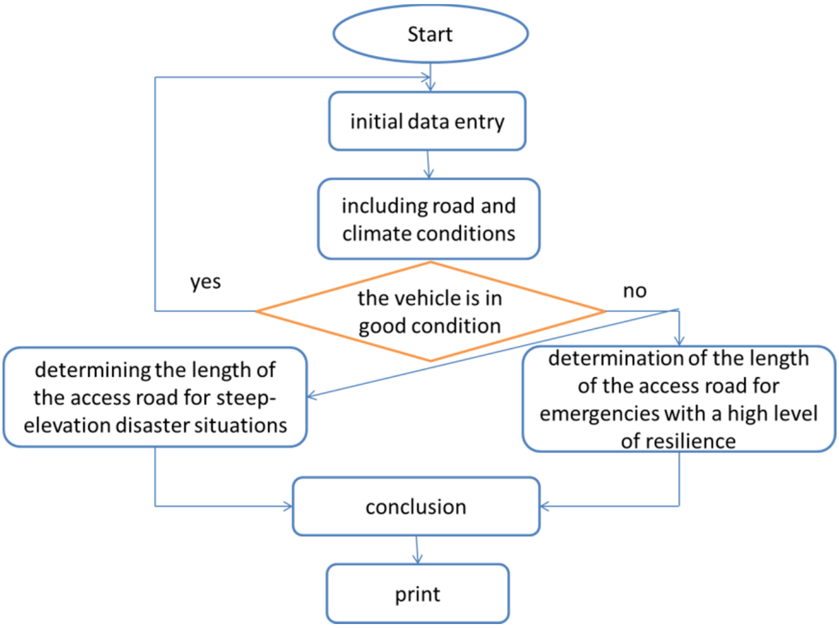
Pop-Angren route EAR at 222 km. The slope of the road at the location of EARis 12 %;

The slope of EAR is 14 %;
The length of EAR is 176 m;
The width of EAR is 7 m;
The width of the return area at the end of EAR is 10 m;
There is no sand bed at the end of EAR;
Type of pavement of EAR: soil gravel

The length of EAR is 165m;
The width of EAR is 7m;
The width of the return area at the end of EARis 10m;
At the end of EAR there is a sandy bed;
Type of pavement of EAR: soil gravel

Mathematical model of determining the length of emergency access roads for different conditions was implemented in **MatLab Simulink software.**

Mathematician of the model working algorithm:



$$E_к + E_п = E_т$$

of the "Emergency access road" can be determined by taking into account the damping of the kinetic energy of the vehicles from the road gradient due to the resistance forces acting on the vehicles when moving down the mountain roads.

$$E_k = E_п$$

$$\frac{M_a {V_a}^2}{2} = (P_f + P_n + P_V + P_u) S \cos\alpha$$

$$S_L = \frac{M_a {V_a}^2}{2(M_a g sin\alpha + kF{V_a}^2 + f M_a g cos\alpha)}$$

S_L - length of access road for catastrophic situations, m;
P_u- inertia force of the car, N;
P_V - air resistance force, N;
k - air resistance coefficient;
F, - frontal area of the vehicle, m^2;
V_a - car speed, m/s;
M_a- mass of the car, kg;
P_n - uphill resistance force, N;

g - gravity acceleration, m/s ^{2};
a - emergency access road slope angle, degree;
P_f - wheel rolling resistance force, N;
f - rolling resistance coefficient.

"Emergency access roads" have their place in the proactive safety of vehicles. In case of failure of the vehicle's braking system while driving on mountain roads, special stopping lanes and emergency access roads are installed to stop the vehicle and ensure its safety .

The variation of the length of the "Emergency access road" for steep-elevation disasters depending on the slope angle is shown in Fig. 1.

Fig. 1. Graph of dependence of the length of EAR on the slope angle

The change of the length of the emergency access road depending on the angle of its slope is presented in Figure 2 when the vehicle speed at the entrance to the "Emergency Access Road" is 50, 60, 70, 80, 90, 100, 110 km/h.

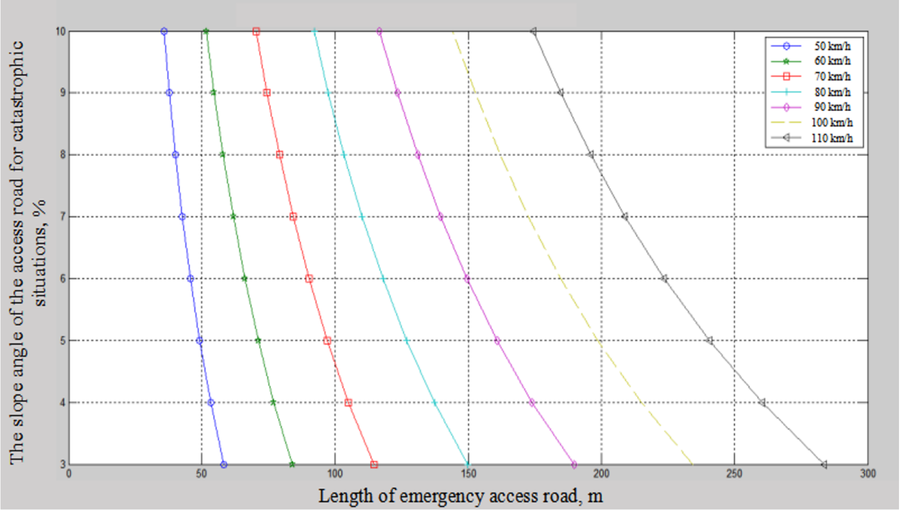


Fig. 2. The dependence of the length of EAR on its slope angle in different speeds of the vehicle

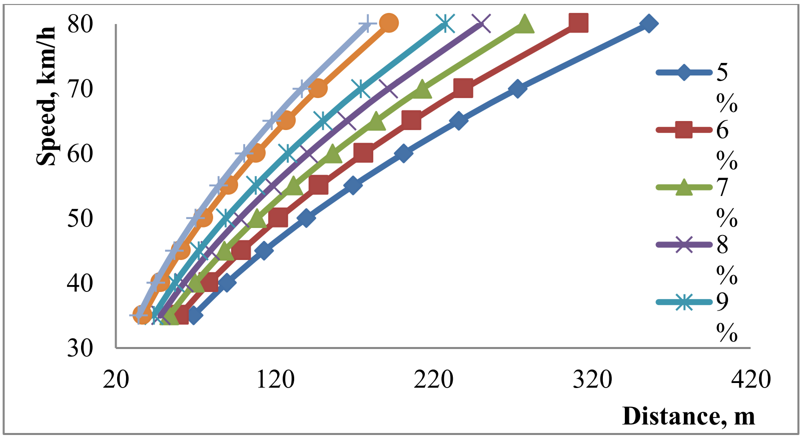


Fig. 3. Dependence of the access road slope for emergency situations on the vehicle entering speed

Figure 4 shows the relationship between the speed of the vehicle entering the length of the EAR, the length of the EAR and its slope angle in 3D view.

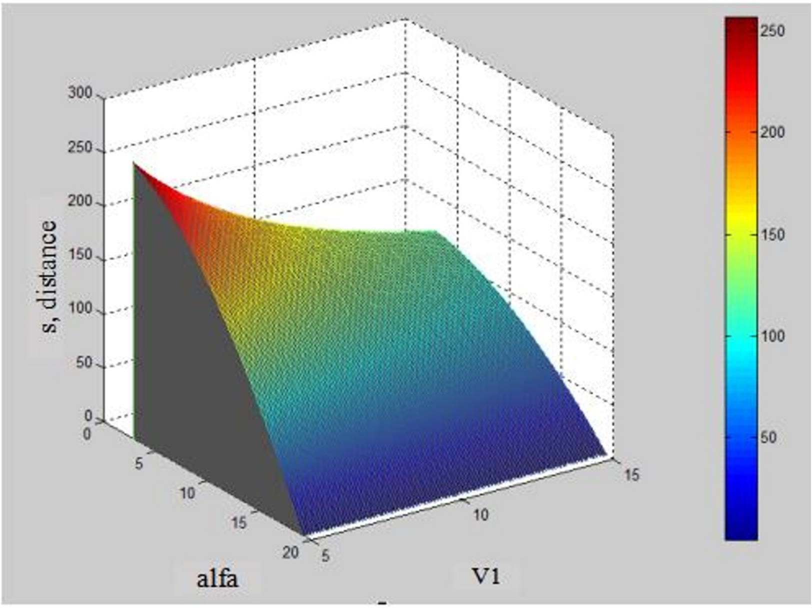


Fig. 4. The relationship between the vehicle speed at the entrance to the length of the EAR.

The length of the EAR and its slope angle, vehicle speed in 3D view

4 Conclusions

The parameters of EAR special stop lanes installed in Kamchik pass to stop the vehicle and ensure its safety in case of malfunctions in the braking system of the vehicle moving on the mountain road were analyzed.

A mathematical model was created to determine the length of emergency access roads for different conditions .

It was determined that the length of the steep (gravitational) “Emergency Access Road” depends on the slope angle.

The relationship between the speed of the car, the slope angle of the road and the length of EAR was determined.

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