Research on factors affecting highways passing through mountain and mountain areas

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Abstract. In this article, flood floods affecting automobile roads and natural disaster relapse on maps using geoinformation systems. The flood consists of forecasting the arrival. The impact of floods on highways was considered from the studied factors. Flood (Flood current) - a stagnant mud or mud rock stream consisting of a mixture of water and rock fragments that suddenly appear in the basins of small mountaineers. How to increase productivity, increase movement, increase the duration of movement, reduce work time), reduce the impact of a natural disaster. Floods threaten settlements, railways, highways, and other structures. This regional model was developed specifically for Uzbekistan and offered an extremely high spatial and temporal resolution of the data. This is necessary for realistic and meaningful simulations.

1 Introduction

In the following years, climate change is taking place worldwide, impacting all areas, among which we can see the ongoing impacts on highways. Today, with the participation of relevant ministries and departments, the deputies of the Legislative Chamber are developing a draft climate change strategy for the Republic of Uzbekistan until 2030. The road map, which will be developed based on this strategy, will make it possible to purposefully implement targeted measures to adapt to climate change in our country [1].

The study of the harmful effects of climate change (flood arrival, snowdrifts, grunt kissing, rock mountains kissing) on highways and the development of measures to predict and prevent it from happening are among the pressing problems of the current day[2].

The impact of floods on highways was considered from the studied factors. Flood (Flood current) — a stagnant mud or mud rock stream consisting of a mixture of water and rock fragments that suddenly appear in the basins of small Mountaineers. How to increase productivity, increase movement, increase the duration of movement, reduce work time), reduce the impact of a natural disaster. Floods threaten settlements, railways, highways, and other structures [3].

The direct cause of flood arrival is heavy rain, heavy snow melting, absorption of reservoirs, fewer earthquakes, and volcanic eruptions.

Classification of flood flows: according to the mechanism of origin, it is divided into three types: erosive, breakthrough, and landslides [4].

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In the case of erosion, the water flow is initially saturated with soil and Foothill materials due to the leaching and erosion of the soil in its path, and then a flood wave is formed [5].

The formation of a flood is characterized by an intensive process of water accumulation; rocks are eroded at the same time, a flood occurs in saturated grunts, and the absorption of the reservoir occurs. The flood mass descends along the slope or river core [6].

During landslides, the mass of rocks saturated with water (including snow and ice) is disturbed. In this case, the current saturation is close to the maximum.

Each mountain in the region has its reasons for turbidity.

In the Caucasus, for example, they are mainly caused by rain and heavy rain (85%).

In recent years, natural causes of mud floods have been added to man-made factors, violations of the rules of use of mining enterprises, explosions during the laying of roads and the construction of other structures, deforestation, improper agricultural work, and violation of soil and plant cover [7].

When moving, the flood flow is a constant mud, rock, and water stream. In the steepest front of a muddy wave from 5 to 15 m high, precipitation forms the "head" of water [8]. The maximum height of the head of the flood stream sometimes reaches 25 m. The classification of floods based on the causes of origin is summarized below (table 1).

Table 1. Classification of flood floods based on the main reasons for their occurrence

№	Types of floods	Causes of occurrence	Distribution and origin
1	Rainy	Heavy rains, long-term rains	The most massive type of flood on Earth is formed as a result of erosion of slopes and the appearance of landslides
2	Snowy	Strong snow melting	It takes place in the subarctic mountains. This is due to the breakdown and waterlogging of snow masses
3	Ice	Strong melting of snow and ice	In high mountain areas, the origin is associated with the absorption of melt glacial
4	Volganli	Volcanic eruption	In areas of active volcanoes. Due to the largest, rapid snow melting and increased water content of crater lakes
5	Seismogen	Strong earthquakes	In the upper seismic regions. Severance of land masses from slopes
6	Limnogenis	Formation of Lake	Dam demolition in high mountain areas
7	Anthropogenic direct impact	Accumulation of anthropogenic rocks. Zero-free earthen	In places of storage of Grunt mass. Erosion and displacement of artificial rocks. Collapse of dams
8	Anthropogenic indirect influence	Violation of soil and plant cover	In areas of forests and Meadows. Erosion of pastures and river banks

2 Methods

Based on the main factors of occurrence, floods are classified as follows: zonal manifestation - the main factor of formation is climatic conditions (precipitation). They depend on the characteristics of the zone. Assembly is carried out regularly. The paths of action are relatively constant; regional manifestations (the main factor in the formation is geological processes). The assembly occurs from time to time, and the methods of action are unstable; anthropogenic is the result of human economic activity. Togland occurs where there is the greatest load on the roof. New flood basins are being established. The assembly is episodic [8].

The boundary conditions within the analysis period must be available to carry out thermal simulations. Long-term climate simulations can be used as boundary conditions to calculate the temperature conditions within road pavements. This analysis used the climate model REMO-UBA with the emission scenario A1B (Jacob 2005) [9]. This regional model was developed specifically for Uzbekistan and offered an extremely high spatial and temporal resolution of the data. This is necessary for realistic and meaningful simulations [10].

Emission scenarios describe the boundary conditions of the climate projections. The scenario assumes that the future world's development is accompanied by very strong economic growth [11]. The world population will increase until the middle of the century and then decline. The use of new technologies will increase, emphasizing the development of efficient systems. This will cause regions to converge economically, resulting in a homogenization of incomes. The A1 scenario family can be divided into three groups that describe alternative paths of technological change in the energy systems [12]. The group is divided into three further sub-groups (A1FI, A1T, A1B). For scenario A1B, it is assumed that a balanced use of fossil and non-fossil energy sources takes place [13].

Based on the results of climate simulations, characteristic input data for the thermal simulation were determined for each district in Uzbekistan (the smallest territorial unit). For this purpose, area-averaged data sets were calculated from the node data of the climate model. The input data generated synthetically are representative of the respective district, whereby local extremes could not be taken into account sufficiently well due to area-averaging [14].

The climatic parameters directly affect the temperature conditions in road construction. For the following calculations of the service life, these conditions must be known during the time of use. For this reason, a thermal model was developed to simulate the temperature conditions in the depth of the road construction using climatic data. The model focuses on achieving a very high spatial and temporal resolution of the simulation results [6].

The structures for asphalt road constructions in Uzbekistan usually consist of an asphalt pavement package with several functional layers, an unbound frost protection layer, and the subgrade [8]. The basic design of the thermal model is shown schematically in Figure 1. To calculate the temperature distribution within the road structure, the energy balance for the road construction must be formulated that describes the heat conduction in the road layers down to the subsurface, the irradiation from the sun and the sky, and the convective heat transfer between the road surface and the ambient air.

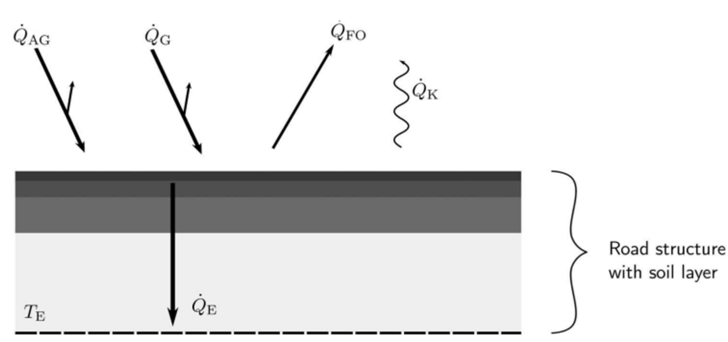

Fig. 1. Radiation balance of road construction.

Classification by strength (by flowing solid mass): 1. Strong (strong power)with bringing more than 100 thousand m3 materials. They occur once every 5-10 years. 2. Average capacity for bringing materials from 10 to 100 thousand m3. They occur once every 2-3 years. 3. Low-power (low-power), removing materials less than 10 thousand m3. They occur every year, sometimes several times a year [15].

The short-wave global radiation Q_G emitted by the sun and the long-wave atmospheric counter radiation Q_{AG} form the incoming radiant heat flux and are partially absorbed by the road surface. The road structure reflects a portion of these heat fluxes. Due to the temperature of the road surface, the radiant heat flux Q_{FO} is emitted. In addition, a convective heat flux Q_K is transferred by the air movement between the surroundings and the road surface. The remaining absorbed energy is dissipated as a heat flow QE conductive into the ground (Clauß et al. 2019) [16].

Heat transport occurs between the individual layers of the road pavement as a result of thermal conduction. The implementation within the 1D layer model is realized by the Finite Volume Method (FVM). It is assumed that the temperature distribution in the depth direction is subject to continuous change, but constant temperatures TE (Figure 1) occur within a plane of the respective layers. This assumption is possible due to the large width and length concerning the depth, so boundary influences can be neglected. Considering time-varying boundary conditions in transient simulations requires the consideration of the heat storage capacity of all layers and the associated specific materials [17].

Using the hourly values of the simulation results of the climate model, the average annual near-surface air temperature was calculated, and the deviation from the long-term mean value for the period 1960 to 2020 is shown in Figure 2. This analysis reveals that moderate temperatures have been simulated in the past. From 2020 onwards, the influence of climate change increases significantly and there is a continuous rise in mean annual near-surface air temperature until the end of the century. The trend shows that a significantly higher thermal load will be expected on the transport infrastructure in the future [18].

Classification of flood basins by flood frequency characterizes the intensity of development or its selectivity. According to the frequency with which flooding occurs, three groups of flood basins can be distinguished: 1. High flood activity (once every 3-5 years and with frequent repetitions); 2. Average flood activity (with repetitions every 6-15 years); 3. Low flood current activity (repeated once every 16 years or less).

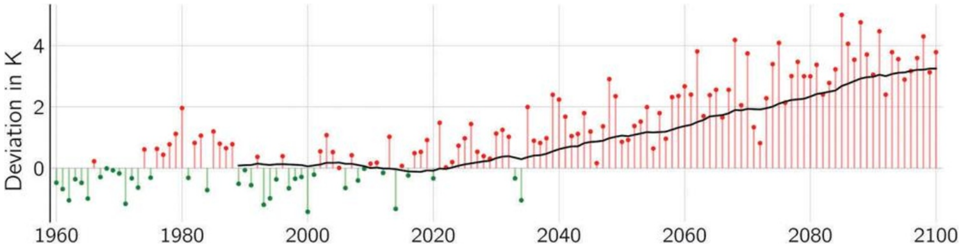

Fig. 2. Annual near-surface air temperature.

Villages are also classified according to their influence on structures: 1. Low-power-small washing areas, partial clogging of the water tap holes. 2. Medium-strength-strong washing, complete blockage of holes, damage, and breakdown of buildings without foundation. 3. Strong-great destructive power, demolition of bridge farms, destruction of bridge supports, stone buildings, and roads. 4. Catastrophic-complete destruction of buildings, road sections in combination with road pavement and structures, and burial of structures under sedimentary rocks [12].

Sometimes the classification of basins by the height of the sources of water bodies is used: 1. High mountain. The origin is higher than 2500 m, the size of the cutting from 1 km2 is 15-25 thousand m3 per village; 2. Middle Mountain. Sources lie within 1000-2500 m. The removal volume from 1 km2 is 5-15 thousand m3 per flood; 3. Low mountains. Sources are lower than 1000 m, and the volume of current output from 1 km2 is less than 5 thousand m3 in one flood [19].

Uzbekistan Republic of Central Asia region, these region temperate sount chastining continental sector and the important area of relatively monotonous climate distinguished by. The greatest precipitation falls on the northern slopes of Tien Shan and the southeastern part of Kunlun.

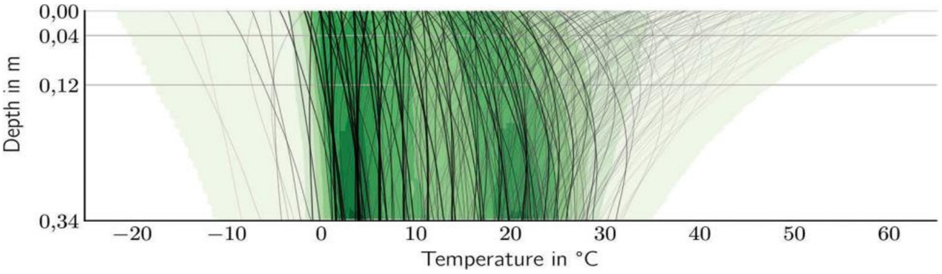

Fig. 3. Mean temperature profiles; the green background shows the range of temperatures within a road construction.

Methodology for assessing the economic risk of floods at Moscow State University: Taking into account the risks associated with preparing risk groups, measures can be taken to identify risks. Risk-as well as the consequences of risk if the potential is a threat [20]. Among them, one can highlight the expert assessment and the common point assessment. Another group of risk assessment methods includes those that assess the likelihood of consequences. They are usually based on theoretical and statistical research. Risk is based on the statement that it is a function of influencing, vulnerability, and protecting an object from dangerous natural influences.

Assessment of individual and collective flood risk: today, there are very few scientific studies on flood risk assessment. A.L. Shniparkov et a [4]. For the first time, the individual and collective risk of flooding across Russia was assessed on a small scale.

3 Results and Discussion

The following indicators are used to assess the risk of flood floods:

- The likelihood of human death due to flooding in a certain area during the year. The indicator is the risk of individual flooding.
- The likely number of flood victims in a given area during the year. The indicator is a collective risk.

The formulas for calculating individual and collective risks take into account their dependence on quantitative indicators of flood activity, such as the frequency of flow flows, the duration of the main period, the influence of the area and social factors (population size and density, population size, vulnerability of the population in space and time, mortality rate).

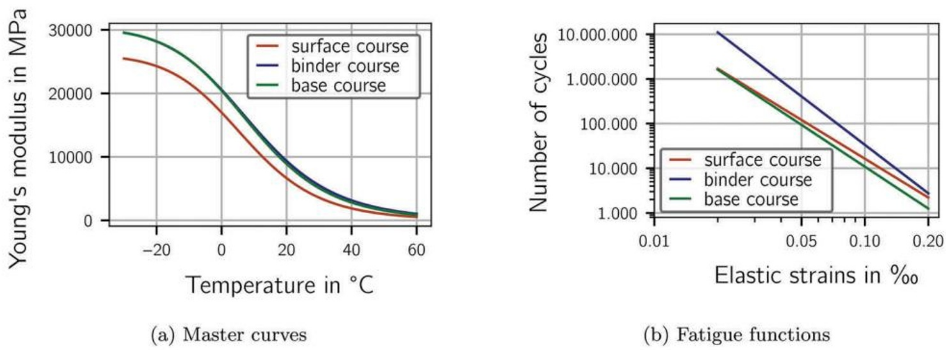

Fig. 4. Material parameters of the asphalt mixtures used at a load frequency of 10 Hz.

The results of the thermal calculations show that, analogous to the increase in the near-surface air temperature, there is also a rise in the temperatures in the asphalt surface course.

Figure 5 shows the changes for a hypothetical road pavement in the cities of Uzbekistan. The average temperature in the asphalt surface layer from 1960 to 2020 was simulated to be 12.8 °C. From 1960 to around 2030, the temperature level was roughly equal, with fluctuations of up to 1.0 °C in the long-term average. Like the near-surface air temperature, there is a continuous increase in the core temperatures in the asphalt surface course from around 2030. At the end of the century, a deviation of more than 4.0 °C in the long-term mean could be projected.

Further analyses of the simulation results have shown that thermal stresses are not uniform in Uzbekistan. The effects of climate change are locally specific and also lead to regional influences on the temperature conditions in road pavements. However, the areas have in common that temperatures within road structures will continuously increase in the coming decades.

This means that low temperatures will not occur as often, and it is assumed that there will be an intensification of freeze-thaw cycles as a result.

The simulation results continue to show that high temperatures and extreme values will increase significantly. The development of very warm temperatures (0.99 quantile value) presented in Figure 7 shows that a continuous increase in extreme values must be expected from the 2020s onwards. Based on the assumptions of the climate simulations, there is an extreme rise of high temperatures in asphalt pavements in the middle of the 21st century. The increase in high temperatures will continue to lead to longer exposure to the road structure.

Methodology for multi-criterion assessment of flood risks: let us consider in more detail the procedure for constructing a flood risk index using the idea of the method of summary indicators (XKU), the basis of which is Listed in the works of N.V. Khovanova [5]. The characteristics of the flood can be characterized by sufficient completeness, taking into account the following relatively independent initial characteristics: x_1 is flood basin areas (F), x_2 is slope of the flood dressing divider Basin (H), x_3 is the diameter of the largest stone, carried by the stream (D), x_4 is Flood transition speed (V), x_5 is maximum flood flow (Q_{max}), x_6 is population density in the region (ρ).

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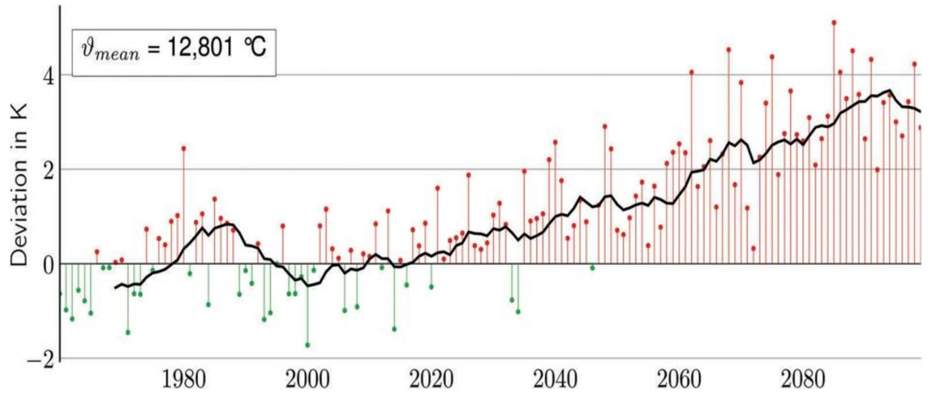

Fig. 5. Annual mean temperature of the asphalt surface course

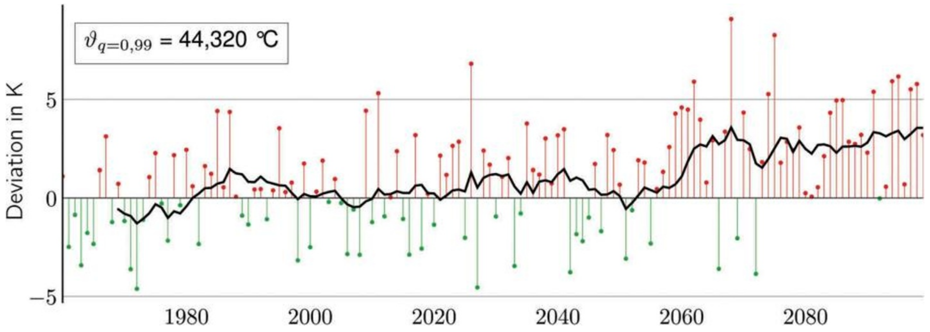

Fig. 6. Annual 0.99 percentile temperature of the asphalt surface course

4 Conclusions

High-resolution climate data were processed for the analyses, and the thermal conditions in fictitious transportation systems within Uzbekistan were calculated based on the synthetically generated data sets. The climatic changes from 1960 to 2100 were evaluated using the extended approach for determining relevant temperature conditions according to the method of the Mean temperature profiles (Clauß 2021), and the resulting service life was calculated for different periods. To detect the influence of the climate, the boundary conditions of the calculations were defined as constant in the analyses so that the deviations could be derived from the climatic conditions alone.

The results show that a considerable influence could be determined throughout Uzbekistan.

Areas in the south are particularly affected, but central Uzbekistan also suffers from a considerable reduction in the damage-free service life of asphalt road pavements.

From the findings of this study, it can be concluded that it is essential to develop adaptation strategies for asphalt transportation infrastructure. It is conceivable that the materials used and the construction structure will be adapted to the local traffic loads and climatic conditions. It is important that the input data used for service life predictions are not based on historical data but are derived from forecasts and climate projections. The safety level to be achieved can be selected via the boundary parameters, such as choosing a suitable emission scenario. Furthermore, computational design procedures must be adapted for climate change.

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