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IMPROVED ROAD DESIGN STANDARDS FOR THE REPUBLIC OF VIETNAM

Statement of the problem. The problem of the road design using the risk theory is considered. The main aim of the study is the account of the influence of climatic features of the Republic of Vietnam on the road layout.

Results. The climatic features of the Republic Vietnam are revealed and for three types of road surfaces the calculations of the minimum radiuses of curved lines in the layout plan are performed. The computational formulas and the calculation sequence are described. The results of the calculations were compared with the data of the guideline documents. According to the results of the minimum radiuses of curved lines taking into account the risk theory for each types of road condition exceeds values which are resulted in the guideline documents.

Conclusions. The solutions obtained permit to improve road design standards of geometrical elements of the plan and traffic safety.

Keywords: traffic safety, risk theory, road surface condition, minimum radius of a curved line.

Introduction

The continuous improvement of the transportational and operational properties of roads has to be tackled as early as at the design stage. One of the major criteria to be taken into account is the smoothness of the road which is formed in the layout and geometric design of the plan and longitudinal profile.

Insufficient smoothness of the road planned in the initial stage of design is accounted for with the modern layout technique as set out in the guideline documents which were deemed in need of improvement by lots of scholars [1].

According to the current guidelines, road design planning should be carried out so that it could cause minimum disruption and change in travel speeds and in no way compromise traffic safety and convenience. If a site makes the compliance to the guidelines impossible or would involve heavy work loads and high costs, the standards are allowed to be lowered based on technical and economic calculations. Excessive admissible standards are as specified in the table СНиП 2.05.02-85 based on design travel speeds in different road types.

Presently, these guidelines lag behind the level of the development of vehicles and do not always meet the increasing requirements to the quality of roads.

Weather and natural climatic factors heavily influence road conditions. However, existing guidelines for the design of geometric parameters of roads do not make any provisions for climatic features of a road construction site. It is therefore important to address different guidelines for road design according to local natural climatic factors.

Errors and mistakes made over the course of road design are difficult to correct during further repair and reconstruction works. The analysis of excellent as well as poorly made design solutions suggests that the smoothness of the roadway is to a large extent construction and geometric provisions and scientific reasoning behind new design approaches.

Design solutions that make provisions for climatic features and traffic safety can be made based on calculation models of the risk theory. It is increasingly used in the building structure design, transport management, road design [2].

Risks of road accidents happening due to poor design standards can be calculated. It involves theoretical research using probability theories and mathematical statistics and data of experimental tests of the hypothesis made on the nature of the distribution of the parameter under discussion.

Experimental research also gives numerical values of the parameters of the distribution law of the random value.

Many geometric parameters of roadways are specified as determined indices and strength supply coefficients are introduced to account for their statistical changes. The risk theory permits to fit in the probabilistic nature of input parameters as well as the design outcomes and results in solutions with necessary reliability levels. Awareness of road risks depending on computational states of the surface influenced by climatic features of a construction site helps boost traffic safety. This is absolutely the case for the Republic of Vietnam with lots of precipitations through the year which is adverse to traffic safety on wet surfaces.

1. Initial calculation data

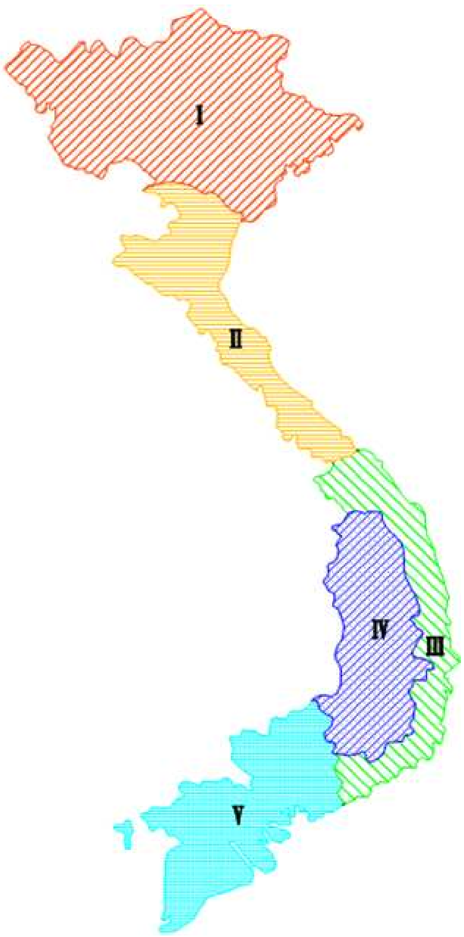
In order to design roadways, the Republic of Vietnam was divided into 5 road climatic areas from the North to the South. A separate area is a mountain area in the South. A map scheme of road zoning and description of the boundaries of road climatic areas of the Republic of Vietnam are identified in Fig. 1.

In order to identify design states of road surfaces, climatic data for Vietnam from open sources [3] was analyzed:

- an average number of rainy days — 100;
- annual rainfalls — from 1200 to 3000 mm;
- clear and bright spells — from 1500 to 3000 h;
- air temperature range— from 5 to 37 C;
- natural hazards (storms, floods) — 5—10 occurrences a year.
- relative air humidity— from 75 to 90 %;
- average relative air humidity — 80—85 %.

The analysis of climatic information suggests that a great number of rainfall and high relative air humidity are conducive to wet road surfaces in the long-term.

A wet road surface has an adverse effect on transport and operation properties of roadways and escalates the risks of road accidents.



Number of the zone	Name	Approximate geo-graphic boundaries
I	North	From the state boundary with Chi-na and Laos to the South of Wing Fook Province
II	North Central	From the North of Thanh Hoa Province and state boundary with Laos to the South of Hue Prov-ince
III	South Central	From the Northern boundary of Da Nang Province and the Northern boun-dary of Area IV to the South of Bing Thuan Provinc
IV	Mountain area	From the state boundary of Laos to the Kontum line – Zya Lai – Dak Lak – Dak Nong – Lam Dong
V	South	From the Northern boundary of Bing Fook Province and the state boundary with Laos to Ka Mau

Fig. 1. Road climatic zoning of the Republic of Vietnam

According to Prof. A.P. Vasiliev [4], a number of road accidents on wet surfaces is 1.6 times higher than on dry ones. In Russia there are also lots of “wild”, i.e. field roundabouts leading up to agricultural facilities and having no solid surface. This causes the pollution of road surfaces and as a result the surface of such roundabouts becomes dirty and slippery which increases risks of road accidents by 2.5.

The research is therefore to investigate three states of road surface, i.e. dry, clean and wet and dirty and wet.

The calculations were performed for a minimum radius of the curves in the design for the following road conditions:

– technical road type — II,
– asphalt concrete surface with a rough surface treatment;
– layout of the site permits to keep a longitudinal slope up to $10\,‰$ within the curve in the design;
– design car — a motor car.

The design travel speed was accepted based on road safety conditions for the corresponding states of road surfaces.

2. Calculation methods

The research was carried out according to the methods developed by Prof. V.V. Stolyarov [2]. The calculations were carried out in the following order.

1. Design values were identified:

– adhesion coefficient:

$$\phi = \phi_{20} - \beta_{\phi}\left(v - 20\right), \qquad (1)$$

where φ is the surface adhesion coefficient with travel speed of 20 km/h; β is the coefficient that accounts for a lower adhesion degree at a design travel speed

– rolling resistance:

$$f = f_{20} + k_f\left(v - 20\right), \tag{2}$$

where f_{20} is the rolling resistance coefficient of the surface at travel speed of 20 km/h; for a motor car $k_f = 0.00025$;

– propulsive force:

$$\mu_x = \frac{2}{K_{сц}}\left(f + i + \frac{k \cdot F \cdot \left(v \pm v_b\right)^2}{13 \cdot m \cdot g}\right), \tag{3}$$

where f is the rolling resistance coefficient; i is a longitudinal slope on the curve in the design; k is the fluidity coefficient of the drag area, m²; v_b is the wind speed, km/h; m is the mass of the car, kg; g is the free fall acceleration, m/sec².

2. A minimum radius of the curve in the design was calculated in relation to a 50% risk:

$$R_M = \frac{v^2}{127 \cdot \left(\sqrt{\phi^2 - \mu_x^2} + i_b\right)}. \tag{4}$$

3. Average squared deviations of the above calculated parameters were calculated:

$$\begin{gathered}\sigma_v = 0,05 \cdot v + 0,5;\\ \sigma_i = \sqrt{0,02 \cdot i};\\ \sigma_f = 0,3 \cdot f;\\ \sigma_{\mu x} = \frac{2}{K_{cw}} \cdot \sqrt{\sigma_i^2 + \sigma_f^2 + \left(\frac{k \cdot F \cdot v}{6,5 \cdot m \cdot g}\right)^2 \sigma_v^2};\\ \sigma_\phi = 10 \cdot \phi \cdot \left(1 - \phi^2\right) \cdot \left(\frac{v+5}{v^2}\right).\end{gathered} \tag{5}$$

4. Average squared deviation of a minimum radius of the curve in the design:

$$\sigma_M = \frac{v}{127 \cdot \left(\phi_i^2 - \mu_x^2\right)}\sqrt{4 \cdot \left(\phi_i^2 - \mu_x^2\right) \cdot \sigma_v^2 + \frac{v^2}{\phi_i^2 - \mu_x^2}\left(\phi_i^2 \cdot \sigma_\phi^2 + \mu_x^2 \cdot \sigma_{\mu x}^2\right)}. \tag{6}$$

5. An admissible accuracy of split and construction works was determined:

$$\sigma_R = \sqrt{(\alpha + \beta \cdot u)^2 + 0{,}1^2}\ , \qquad (7)$$

where u is the subintegral function accepted to be dependant on admissible risks; α and β are the coefficients of the equation depending on the surface type and design travel speed.

6. A required radius of the curve in the design is given by

$$R = R_{м} + u \cdot \sqrt{\sigma_R^2 + \sigma_M^2}\ . \qquad (8)$$

The calculated values were compared to minimum admissible ones as set out in the guidelines. Design standards and numerical values of the design parameters of the roadway for Russia and the Republic of Vietnam are in [5].

3. Calculation results

As a result of the calculations, minimum admissible radii of curves for three design states of road surfaces of the Republic of Vietnam were obtained. The calculation results are in Table below.

Table

Minimum admissible radii of curves in the design for different states of road surfaces

Design state of road surface	Design travel speed, km/h	Minimum radius of the curve in the design according to СНиП, m	Minimum radius of the curve according to the risk theory, m
Clean dry	120	800	1083
Wet dry	75	195	325
Wet dirty	55	125	235

The calculation results suggest that the methods set forth by V.V. Stolyarov permit to integrate the international risk assessment scale with a parameter in question. In general engineering practices, risk is a probability of a negative event happening (for roadways these are road accidents).

According to V.V. Stolyarov [2], if there is a connection between the road design elements and risks involved in its operation is not known, professional and personal qualities of a designing engineer are central to the design outcomes. If they have an optimistic nature, design solutions they come up with will involve high risks since no matter what the solution is, an optimist will tend to think a number of road accidents on the roadway element will be insignificant. In contrast, a pessimist will persist in accept such road parameters that would keep risks to a minimum or a natural level out of fear of a mistake being made. Both solutions will turn out to be subjective and non-economical since the first will give rise to an increasing number of road accidents and reduce the life cycle prior to the major repairs being carried out and the second one will involve unreasonably high construction costs.

The risk theory permits to find an optimal and objective solution based on the analysis of the connection between qualitative and quantitative characteristics of an element being designed, i.e. a compromise between losses and effect [2].

Conclusions

1. Based on the analysis of climatic information on the Republic of Vietnam, major design states of road surfaces that affect traffic safety were found. Three states of road surfaces are found to be clean dry, clean wet and wet dirty.

2. For three states of road surfaces, design adhesion coefficients and rolling resistance were determined using which minimum radii of curves in road design planning were identified.

3. Based on the design formulas of the risk theory set forth by V.V. Stolyarov, minimum radii of curves in the design of three road surface states were calculated. Design values are different from those set out in the guidelines because they account for a random nature of such factors as travel speed, longitudinal slope, accuracy of split and construction works.

4. The calculation results suggest that in atrocious weather conditions in order to provide driving safety, minimum radii of curves in the design need to be increased as identified in Table.

5. The use of mathematical apparatus of the risk theory permits to obtain design solutions that completely account for climatic features of the Republic of Vietnam and maintain traffic safety for different road surface types.

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