Substantiated and interrelated technical tolerances needed in regulatory documents on the construction of automobile roads and their geodetic support

L A Pronina, Yu V Stolbov, A I Uvarov and N A Parkhomenko

FSBEO HE OmSAU

E-mail: la.pronina@omgau.org, yuv.stolbov@omgau.org, ai.uvarov@omgau.org, na.parkhomenko@omgau.org

Abstract. The necessity of a regulation of substantiated and interrelated technical tolerances through regulatory documents regarding the construction of automobile roads and their geodetic support is proven. The discrepancies in the requirements for the implementation of construction and geodetic works in the arrangement of the structural layers of road pavement foundations and coatings are pointed out. The regulation of accuracy standards in the construction of automobile roads, which does not correspond to the basic principles of probability theory, mathematical statistics and the theory of mathematical processing of measurements, is given as an example. In the case of exploitation of road-building machinery with automatic systems for the maintenance of leveling points, the execution of level runs with a class III accuracy is recommended, while in the case of exploitation of road-building machinery without automatic systems, the execution of level runs with a class IV accuracy is recommended.

1. Introduction

Nowadays in construction industry, the accuracy of the geometric parameters in the construction of buildings and structure is one of the main indexes of their quality.

In accordance with the requirements of GOST 21780-81 [1], during the design planning of buildings, structures and their individual elements, as well as during the development of technologies, the production of elements, and the construction of buildings and structures, the necessary means and rules of technological accuracy should be observed and applied in the production. The tolerances of the geometric parameters of the elements of buildings and structures are regulated in state technical standards (in Russian ‘GOST’), construction norms and regulations (‘SNiP’), sets of rules (‘SP’), and construction and planning documentation. The main regulatory document for the construction and operational acceptance of automobile road since January 1, 1985 has been SniP 3.06.03-85 [2], and since from July 1, 2015 its updated version, i.e. the set of rules CP 78.13330.2012 [3].

At the present time, in case of new construction, the main regulatory document for operational acceptance of roads is CP 78.13330.2012, while in case of reconstruction of previously built roads, the current one remains SniP 3.06.03-85 [2]. With the introduction of CP 78.13330.2012, accuracy regulations in the construction of automobile roads are significantly increased if compared with SniP
This particularly concerns the regulation of the accuracy standards of the altitude position (heights) of the structural layers of the road pavement bases and coatings.

If the assurance of the accuracy of the horizontal position did not cause particular difficulties in SniP 3.06.03-85 and does not as well in CP 78.13330.2012, then to ensure the required accuracy of the altitude position it is necessary to regulate through regulatory documents substantiated tolerances for the deviation of heights from the design project values at all stages of the execution of geodetic works and construction of automobile roads. This is primarily related to the assurance of the evenness of the structural layers of the bases and coatings of automobile roads as one of the main indexes of the quality of their construction.

In the normative documents SniP 3.06.03-85 and CP 78.13330.2012, the acceptable values of deviation from the project design ones for the construction-finished structural layers of bases and coatings are given without differentiation between them when performing geodetic and construction works. In order to ensure the regulated altitude position of the structural layers of the road pavement bases and coating, substantiated technological tolerances are required at the different stages of the construction of automobile roads.

2. Substantiation of the necessity of substantiated and interrelated technical tolerances in regulatory documents

According to the works [4–6], it is necessary to substantiate the norms on the accuracy of geodetic works: for the execution of level runs along the routes of automobile roads with the establishment (outside the area of excavation during their construction) of working benchmarks every 500 meters; the recovery of the leveling points (heights) of pickets on the road routes from the working benchmarks; the detailed staking of the leveling points (heights) of the surfaces of the structural layers of the road pavement bases and coatings; the geodetic control of the altitude position of the surfaces of the structural layers of bases and coatings for the operational acceptance and the quality assessment of their arrangement.

In the regulatory documents on road construction SniP 3.06.03-85 and CP 78.13330.2012, the accuracy of the structural layers of the road pavement bases and coatings is regulated depending on the road category, the application of road-building machinery with and without an automatic system for the maintenance of leveling points (heights), leveling steps, while in SniP 3.01.03-84, Geodetic works in construction industry [7], and its updated edition CP 126.13330.2012 [8], the accuracy of geodetic measurements is regulated taking into account undeveloped or built-up areas. In these regulatory documents a discrepancy between the requirements for the implementation of construction and geodetic works in the arrangement of the bases and coatings of automobile roads can be observed. In CP 78.13330.2012, the acceptable discrepancies of the altitude position of bases and coatings from design project values are regulated with a confidence probability of P=0.90, while in CP 126.13330.2012, their geodesic support is provided for with a control of P=0.95; 0.99 and 0.9973, where during the transition from the marginal errors to the RMS (divisor) and back from the RMS to the marginal (multiplier) respectively t=2.0; 2.5 and 3.0. Therefore, reasonable as well as interrelated tolerances for construction and geodetic works in the arrangement of bases and coatings of automobile roads are needed.

In the regulatory documents, a regulation of the norms of accuracy in the construction of automobile roads which does not correspond to the main provisions of probability theory, mathematical statistics, and the theory of mathematical processing of measurements can be observed [9, 10]. It is a well-known fact that during the erection of buildings and structures, the discrepancies (errors) of geodetic and construction works are basically subject to the law of normal distribution. The examples of incoherence in the regulation in SniP 3.06.03-85 of the acceptable deviation of the altitude position (heights) of the surfaces of the bases and coatings in their arrangement with the exploitation of road-building machinery with and without systems for the maintenance of leveling points are reported in the work [11].
The same situation can be observed in CP 78.13330.2012, too, as regards the regulation of the acceptable deviation of the altitude position (heights) of the surfaces of the bases and coatings of automobile roads.

For example, in the arrangement of the bases and coating of automobile roads with the exploitation of road-building machinery without an automatic system for the maintenance of leveling points (heights), in CP 78.13330.2012 the accuracy norms are doubled if compared to SniP 3.06.03-85, and it contemplated that 90% of the deviations of heights can be as high as $\delta_n=\pm 25$mm, while the remaining 10% can be as high as $\delta_n=\pm 50$mm. Thus, the RMS errors of the altitude position of the surfaces of the structural layers ($m_n=\delta_n/t$, where $t=1.645$ with $P=0.90$) will have the values $m_n=25/1.645=15.2$mm, and the maximum acceptable deviations (limit error), according to the “three sigma rule”, will be $\delta_{pd}=15.2 \times 3=45.6$mm, but not $\delta_n=\pm 50$mm (regulated in CP 78.13330.2012).

The substantiation of tolerances in the construction of automobile roads depends also on the methods applied in their calculation, that is it takes into account those factors that affect the accuracy of the technological processes for the arrangement of the structural layers of the road pavement bases and coatings. Technological processes in the arrangement of road pavements are characterized by the coefficients of their accuracy in the execution of construction and geodetic works, and hence by the confidence probabilities of the assurance their regulated tolerances from design project values as well.

In literature published until 2016 [12, 13, 14], it is indicated that during the construction of automobile roads the execution of level runs should be carried out by means of technical leveling. At the present time, electronic total stations and digital levels are widely used in the construction of automobile roads, and trials about their application and research are presented in [15-18].

The calculation methods for construction and geodetic works are presented in the works [4] taking into account the accuracy of the technological processes for the arrangement of the bases and coating of automobile roads, while in the works [5, 6] the substantiation and assurance of the accuracy of the detailed staking of the level points of the structural layers of the road pavement bases and coatings, the recovery of leveling points (heights) of pickets on the routes of automobile roads from working benchmarks, and the execution of level runs along the route or through the route are carried out.

According to the works [5, 6], in accordance with the regulation of acceptable deviation in the surface heights from design project values in CP 78.13330.2012, in the construction of roads with the application of road-building machinery with automatic systems for the maintenance of leveling points, the execution of level runs with a class III accuracy is necessary, while with the exploitation of road-building machinery without automatic systems the execution of level runs with a class IV accuracy is needed.

3. Conclusion

The necessity of the regulation of substantiated and interrelated technical tolerances in regulatory documents has been proven. The execution of level runs with a class III accuracy in the construction of roads in case of exploitation of road-building machinery with automatic systems for the maintenance of leveling points, and of level runs with a class IV accuracy in case of exploitation of road-building machinery without automatic systems has been proposed.

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