Abstract

Influence of geotechnical and structural factors on the stability of selected landslides in the area of the Carpathian flysch

The dissertation consists of seven chapters, which present an innovative methodology for forecasting the impact of geotechnical and structural factors on the stability of landslides in the Carpathian flysch. The methodology developed here is based on the artificial intelligence method in the form of neural networks utilizing numerical modelling. The inputs and outputs are geotechnical and structural factors of the individual cases describing the road designed in the landslide conditions.

The methods of securing landslides applied here are based on expert knowledge. There is no system solution regarding the design of road infrastructure in the Carpathian flysch. In addition, there are no systematic, objective approaches that would form the basis for designing transit routes at the Carpathian flysch landslides. Currently, there is no methodology for forecasting effective geotechnical and structural parameters that may guarantee the stability of road infrastructure in the Carpathian flysch landslides. That, above all, has been the author's motivation to undertake work aimed at solving this problem.

The initial chapters are dedicated to the recognition of the issues of road infrastructure design along the landslides in the Carpathian flysch. The second chapter discusses landslide problems in southern Poland, including the impact of elevated water levels on the development of the landslide process. Particular attention is paid to roads at risk of landslides and the importance of recognition landslides for the planned road infrastructure. The applicable guidelines for designing roads in landslide areas in terms of the subsoil parameters are presented in the third chapter.

The fourth chapter presents a description of the work methodology. The process of collecting and processing data used in the dissertation is described and the areas covered by the research are presented. The methodology is focused on the numerical analyses and neural simulations the author has performed.

The fifth chapter contains the results of numerical calculations of the stability of the analysed landslide areas located in the Podkarpackie Voivodeship along the planned S19 expressway, which is a part of the European route "Via Carpatia" connecting Klaipeda in Lithuania and Thessaloniki in Greece. The results of the total of 1052 stability analyses for several dozen landslides have been used here. Several design cases have been considered, including the natural geometry of the slope shape, the execution of a road excavation with six variants of the excavation slope inclination, the structural protection of a landslide and/or excavation slope in the form of ground nails, ground anchors, foundation piles or a combination of all the above-mentioned methods. All calculations have been carried out assuming two levels of the groundwater table. The first one was determined at the stage of field research and the other – the maximum one determined individually for each landslide based on the results of piezometric tests. The numerical analysis carried out here include changes in the geotechnical factor, which is the level of the groundwater table, and two structural factors – the inclination of the road excavation slope and the applied structural protection.

The sixth chapter presents the results obtained from the author's algorithm using the artificial neural networks approach. Based on the collected input and output data comprising geotechnical factors characterizing the subsoil and structural factors related to the designed road infrastructure, the total number of 192 neural networks have been built, each with different architecture and learning parameters. The results of the best trained networks are presented here.

The summary of the dissertation is presented in chapter seven. The author selected the SNN #19 neural network, which coped best with solving the assigned problem. The mean squared error for the SNN #19 neural network is equal to 0.0064 (see Table 6.1). The values of the coefficients of determination, which take the highest values of all of the developed neural networks, look favourable for this network. For samples from the training set, the coefficient of determination is equal to R^2=0.9582, and for all samples used in this neural network, it is equal to R^2=0.9215 (Figure 6.12). The model of the artificial neural network selected here makes it possible to forecast geotechnical and structural parameters characterizing the stable road infrastructure in the landslide areas of the Carpathian flysch. The research and analyses carried out in the work allowed the author to formulate her own coefficient of design efficiency, which assesses the effectiveness of the protection measures applied to the landslide area intended for road infrastructure. This coefficient determines whether a landslide or area at risk of mass movement following a road construction requires structural protection as it is based on user-defined parameters characterizing the slope.

The methodology proposed here, utilizing the combined tools of numerical modelling using the finite element method and artificial intelligence in the form of neural networks, seems to be very effective and enables assessing the impact of geotechnical and structural factors on the stability of road infrastructure in the Carpathian flysch. The developed neural algorithm can be a useful source of knowledge for designers and it may significantly contribute to improving the quality of design decisions made in relation to road infrastructure in landslide areas located in the Carpathian flysch.