Abstract

The evaluation of the bearing strength characteristics of floor strata under the loads of overlying rock mass acting during an excavation process is one of the important factors in strata control of any underground mine. The main objective of this research finding is concerned with the experimental and FEM analysis of bearing characteristics of weak floor coal measure strata (massive, jointed and layered) of limited and varying thickness. Analysis of stability (mainly bearing strength and settlement) under a footing on regularly bedded, jointed and layered model rock mass is done using physical simulation technique and FEM analysis. A simple method to estimate bearing strength of both intact and jointed rock mass under circular, square and rectangular footings is proposed. The laboratory results obtained from the plate loading tests as carried out using the proposed method closely matched with the results obtained from the series of in-situ plate loading tests (under similar conditions as in the case of model plate loading tests) conducted on weak floor strata in longwall gateroads in a highly mechanized underground coal mine in India. The influences of various geotechnical properties and superimposed joint and weak layer on the bearing strength are determined through plate loading test on simulated floor strata representing intact, jointed and layered rock mass behavior model. Model plate loading tests were carried out for varying geotechnical conditions of weak floor strata using different sizes and shapes of footing plates. The load exerted by the plate on the floor strata was assumed to be uniformly distributed.

From the scale model test it was found that for the same plate size of different shapes, square footing offers maximum bearing strength and minimum settlement. With increase in the footing plate size for all the geometrical shapes of footing plates, the floor bearing strength (q_s) decreases considerably and at the same time footing settlement also decreases. So optimum base plates of the effective support systems must be chosen which can provide maximum bearing strength without causing a floor punching. The experimental results strongly supported the earlier field investigation conducted by Yu et al. (1992).

In jointed and layered rock mass conditions, the floor bearing characteristics analysis were carried out by considering the parameters like orientations of joint and weak layer with respect to the direction of loading, variations in the joint sets (joint spacing) and the layer thickness (as a function of footing plate width). The location of footing plates with respect to joint and weak layer were also varied.

The results indicate that the bearing strength is significantly related to the locations and orientations of joint and the weak layer present in the model rock mass. Results of model plate bearing test further indicate that moisture content (MC), the ratio of plate width to the rock mass thickness (B/T) and the angle of internal friction (φ) are the most critical parameters influencing the bearing strength of rock foundation.

Correlation and regression analysis among the floor bearing strength and various geotechnical properties of the model floor strata were conducted using SPSS 10 statistical software package. Using the most influencing parameters such as c/σ_c, N_φ/MC, and B/T ratio, with the help of linear regression statistical analysis, an equation (Eq. 5.14) was established for the approximate estimation of the floor bearing strength of weak massive floor strata from the available values of index properties.

Non-linear FEM analyses of floor bearing characteristics (under the similar conditions as in the case of laboratory investigation) were carried out using ANSYS 6.1 FEM software package. The "Drucker - Prager criterion" for non metal plasticity were followed as failure criteria. The footing settlements correspond to the maximum applied bearing pressure on floor strata (for different sizes and shapes of footing plates and their locations and also under varying strata conditions) as obtained from the experimental results and FEM investigations are compared and the maximum deviation was observed as 32 % whereas the minimum was less than 1 %.

Key words

Bearing Strength, Settlement, Foundation, Floor Strata, Physical Modeling, Equivalent Material Modeling, Simulation, Floor Stability, Finite Element Modeling, Ground Control, Allowable Bearing Capacity, Factor of Safety, In-situ Bearing Test, Footing Plate, Similitude Modeling, Spread Footing, Jointed Rock Mass, Plate Loading Test, Soft Rock, Model Scale,