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Research Paper

Numerical investigation on the bearing capacity of two interfering strip footings resting on a rock mass

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ABSTRACT

The problem of bearing capacity of footings on rock is the subject of some researches in the recent years. However, the authors are not aware of any published paper about the effect of nearby footings on bearing capacity of rock foundations. This paper focuses on numerical analysis of the ultimate bearing capacity of two interfering strip footings resting on a rock mass, obeying the modified Hoek–Brown failure criterion. This criterion is applicable to intact rock or heavily jointed rock masses that can be considered homogeneous and isotropic.

The rock mass was assumed to behave as a perfect plastic material and obeys an associated flow rule. The effects of Hoek–Brown parameters including geological strength index (GSI), material constant for intact rock (m_i), and uniaxial compressive strength of intact rock (σ_{ci}), on the bearing capacity of multiple footings were studied. For different clear spacing between the footings (S), the ratio of the failure load for an interfering new footing to that of a single isolated footing were determined. The results were compared with those available in the literature.

1. Introduction

Evaluating the ultimate bearing capacity of rock masses is essential for heavy structures like dams and bridges. Closely spaced footings may occur on rock masses in the form of isolated and strip footings, pier foundation and grillage footing. Various structures may be constructed on rock masses. Among them, the foundations of bridge piers usually have interference with each other. As a result, the bearing capacity of such foundations is affected by their adjacent foundations. The ultimate bearing capacity of two interfering strip footings resting on soils was studied theoretically [1–4]. Results of these studies show that when two strip footings approached closely enough, failure zones beneath the footings affect each other and ultimate bearing capacity significantly increased.

In order to study the effect of the interference of two footings, a number of experiments have also been carried out by various researchers [5–7]. The obtained results generally show lower efficiencies than those predicted by the theoretical analysis of Stuart [1]. Recently Mabrouki et al. [8] conducted series of numerical analyses using the finite difference code, FLAC, to evaluate the influence of the interaction between two nearby shallow strip footings on the ultimate bearing capacity. The obtained results were in good agreement with the solutions presented by Hazell [9]. Hazell used the method of characteristics and experimental modeling to study the interaction between a pair of parallel shallow rough and smooth strip footings on sand.

It is well known that failure criteria of most rocks are non-linear. In the present paper non-linear failure criterion of Hoek–Brown [10] was used for numerical modeling. This criterion is applicable to intact rock or heavily jointed rock masses that can be considered homogeneous and isotropic. Rock masses with "small spacing" can be regarded as an isotropic medium. The concept of "small spacing" was proposed by Serrano and Olalla [11] in order to quantifying the validity of using Hoek–Brown failure criterion for bearing capacity evaluation.

Important studies were carried out to assess ultimate bearing capacity of rough strip footings rest upon rock masses [12–17]. Nevertheless, the authors are not aware of any published paper about the bearing capacity of two interfering foundations resting on a modified Hoek–Brown material. In this context, the present work seems to be among the pioneer contributions in the domain.

In this paper, a series of numerical computations using the distinct element code UDEC are carried out to evaluate the influence of the interaction between a pair of shallow strip footings on the

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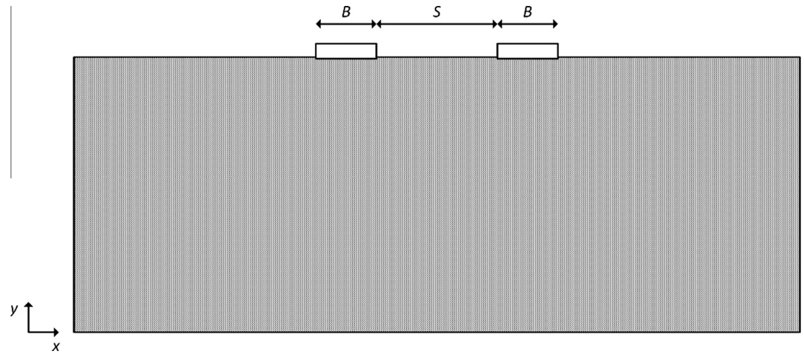

Fig. 1. Problem geometry.

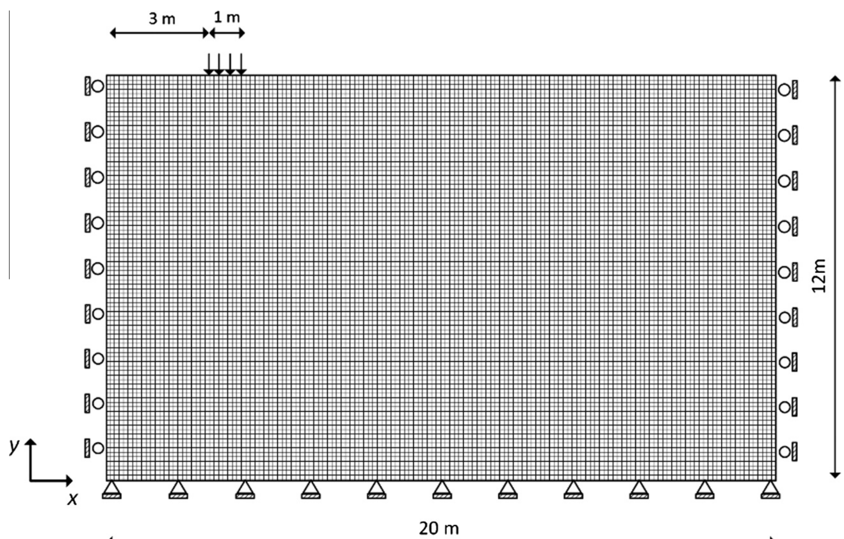

Fig. 2. The boundary conditions of the models used in the analyses, the case of $S/B = 6$.

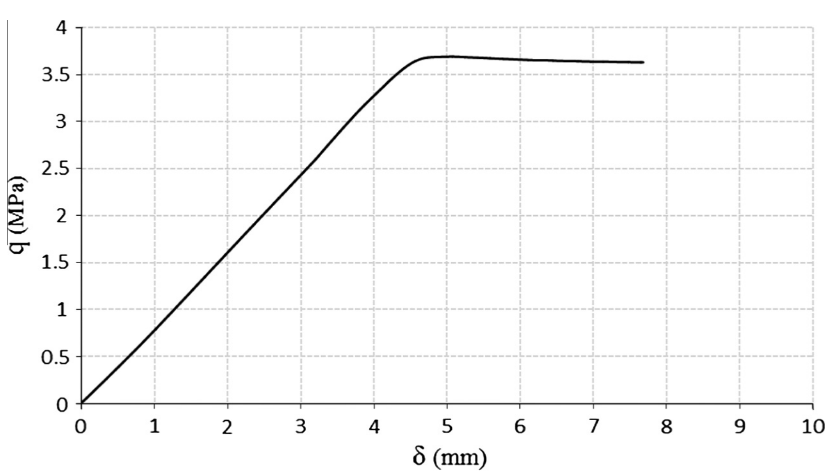

Fig. 3. The load–displacement curve from an analysis run ($B = 1$ m, GSI = 30, $m_i = 10$, and $\sigma_{ci} = 10$ MPa).

ultimate bearing capacity of a rock mass. In order to study interfering effect of two adjacent footings, an efficiency factor for two rigid rough footings, subjected to centered vertical loads is defined and calculated. Efficiency factor was defined as the ratio of the failure load for an interfering new footing to that of a single isolated footing. Using the Hoek–Brown failure criterion, effects of different Hoek–Brown parameters including the geological strength index (GSI), material constant for intact rock m_i, intact rock uniaxial compression strength σ_{ci}, and rock unit weight on the bearing capacity of interfering footings are studied. Results of this paper are presented in different curves that can be used in practical applications.