Experimental study of a shallow strip footing on geogrid-reinforced sand bed above a void

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ABSTRACT: Underground voids located in the failure zone of a structure's footing decrease the bearing capacity and increase the settlement of the footing. This paper presents results from laboratory-model tests of strip footings supported by reinforced sand beds above a continuous void to investigate the potential benefits of using a replaced reinforced sand layer to bridge the void. The parameters studied in this testing programme include the relative density of the replaced sand, the void embedment depth and the number of reinforcement layers below the footing base. The results demonstrate that the bearing pressure and footing settlement significantly improved as the three parameters above were increased due to arching of the soil mass overlying the void. With unreinforced sand, the undesirable structural effects of the void can be eliminated only by using sand with a relative density of 72% for a void embedded at a depth of around 3.5–4 times the void's diameter (*D*). The effects of voids embedded at depths of 3*D* and 2*D* can be mitigated using four layers of reinforcement at relative densities of 57 and 72%, respectively.

KEYWORDS: Geosynthetics, Reinforced soil, Underground void, Bearing pressure, Footing settlement, Strip footing

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1. INTRODUCTION

The presence of voids under structures warrants special attention as voids may cause serious structural damage or present potentially fatal hazards. Voids may occur as a result of mining, tunnelling, water and gas networks or old conduits. Figure 1 shows an example of a void beneath the foundation of an old building.

When faced with the task of designing a foundation above a void, geotechnical engineers will generally consider a number of alternatives, which include: (1) filling the void with acceptable material, (2) using piles or caissons to bridge the void and to let the soil or rocks at the bottom of the void bear the load, (3) excavating and establishing a foundation at the bottom of the void, and (4) relocating the foundation so that it is placed away from the void. Of these alternatives, relocation (alternative 4) is only practical if sufficient space is available. The other alternatives (alternatives 1, 2 and 3) can be considerably expensive and are sometimes impossible or infeasible to achieve. Studies on the stability of foundations located above voids are scarce in the available literature; only a few investigations related to this subject are available (Baus and Wang 1983; Badie and Wang 1984; Wang and Hsieh 1987; Wang *et al.* 1989).

Baus and Wang (1983) used the finite element method to investigate the bearing capacity of continuous footings subjected to static vertical central loads. The test results indicated that the bearing capacity decreases as the distance between the void and the footing decreases. Badie and Wang (1984) performed a theoretical and experimental analysis of a model footing above clayey soil to investigate the stability of spread footing situated above a continuous void. The results of this study implied that a

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