Abstract

Natural sandy soils always show highly different properties such as ingredientcomposition, gradation, particle characteristic and internal fabric, causing significant differences in mechanical behavior within small to large strain range. Calcareous sand is a special construction material which is commonly used in the reclamation projects in marine areas. Due to its marine organismorigin, the grain characteristic of calcareous sand is different form from that of silica sand, behaving in the extremely irregular grain shape with the a high particle angularity. It has been proved that natural sediments exhibit fabric anisotropy, especially for sandy soils. During the deposition process of a granular material with non-rounded grain shape under gravity, the long axis of the grain tends to be parallel to the horizontal direction, leading to the formation of a highly anisotropic soil fabric. In this thesis, a calcareous sand from Persian Gulf was tested in a series of static and dynamic triaxial tests. The effects of initial fabric, particle characteristic, gradation and fine content on the mechanical properties of the calcareous sands are investigated. The small strain stiffness (G_0) is an important elastic soil parameter indicating the deformation or the seismic response of the ground. The anisotropic small strain stiffness of granular materials has been studied extensively in the last decades. Most of the studies were only conducted on the measurement of the anisotropic stiffness and the factors affecting this mechanical behavior were not well investigated. In this thesis, the initial fabric, particle size, gradation and fine content are studied as the variant variables affecting the small strain stiffness of the calcareous sands. Firstly, in order to make laboratory samples having various initial fabric, a literature review on the sample preparation method is given and five methods as air and water pluviation, dry and moist tamping and dry funnel deposition are selected for this study. The new pluviators were specially designed for the air and water pluviation methods respectively. In order to figure out the difference in fabric induced by the sample preparation method, X-ray tomography tests were performed on the samples prepared following the five methods and the differences in the homogeneity and fabric anisotropy were analyzed from the microscopic view. The scan results show that the air pluviation samples exhibit the highest fabric anisotropy. The fabric anisotropy of the five samples can be ordered as: air pluviation > water pluviation > dry tamping > moist tamping > dry funnel deposition. For the uniformity, it is concluded that the zones close to the sample boundary show lower densities for all the preparation methods. The air pluviation and dry tamping samples are respectively the least and the most affected by the boundary. Along the height, the sample prepared by the air pluviation method shows the highest homogeneity. The density decreases and increases from the top to the bottom for the water pluviation and dry funnel deposition samples respectively. The density in the samples prepared in layers shows variation along the sample height and the fluctuation is the most significant in the dry tamping sample. Concerning To investigate the effect of particle characteristic and gradation, several sands with the artificial gradation were prepared with the materials sieved from the original calcareous sands. Similarly, the sand-fine mixtures with the variouvarious amounts ofs fine contents were prepared by mixing the original calcareous sands with the sieved calcareous fines. The small strain shear modulus on both the vertical and horizontal planes were evaluated by the multidirectional bender element tests. Then the stiffness anisotropy was obtained. It is was found that the initial fabric, particle size and fine content have significant impact on the anisotropic stiffness of the calcareous sands. Calcareous samples prepared by the air pluviation method possesses the highest anisotropic ratios. The lowest stiffness anisotropy exists in the samples prepared by moist tamping and dry funnel deposition methods. The difference induced by the initial fabric can be explained by the X-ray tomography results. The less prominent stiffness anisotropy is found in calcareous sands with smaller particle sizes and the effect of the coefficient of uniformity (Cu) on the stiffness anisotropy is negligible. The equation proposed by Hardin and Black (1966) for predicting the small strain stiffness of soils was

updated for the calcareous sands in this study. The sample preparation method has a slight impact on the constants in the Hardin equation, concluding that the sample having a stronger fabric has larger A and m but lower n. The modified Hardin equation is applicable for the anisotropic consolidation tests. The fine content has significant influence on the small strain stiffness of the calcareous sands, showing that the shear modulus decreases with the increase of the fine content before the threshold. The stiffness anisotropy decreases with the increase of the fine content and drops faster after the threshold fine content. Finally, the constants in the Hardin equation are updated by taking the fine content into account. The difference induced by the initial fabric can be explained by the X-ray tomography results. In this thesis, the models for predicting G_0 are updated by taking into account the over-consolidation ratio (OCR) and the fine content (FC). For sand-fine mixtures, three models are introduced and modified and their prediction ability is compared. To further study the initial fabric on the mechanical property of the calcareous sands, the K0 consolidation tests and the undrained monotonic and cyclic loading tests were performed on the samples prepared by different methods. The influences of the initial fabric on the coefficient of earth pressure at rest (K0) and the undrained strength under monotonic and cyclic loadings were evaluated. It is shown that the values of K0 and the liquefaction resistance of the calcareous sands are highly affected by the sample preparation method. Test results show that the air pluviation and moist tamping samples own the highest and the lowest K0 respectively. All the samples at medium loose and medium dense states show strain hardening subjected to the undrained monotonic loading. The air pluviation samples are more contractive than the other samples at the phase transformation points and the moist tamping samples exhibit an over-consolidated behavior. In the cyclic loading tests, the air pluviation and the moist tamping samples exhibit the highest and the lowest liquefaction resistance. The cyclic undrained strength of the water pluviation and dry tamping samples is close, which is higher than that of the dry funnel deposition samples. It is also concluded that explaining differences in the mechanical properties from the fabric discrepancy induced by the sample preparation method is not comprehensive. Other factors such as homogeneity and stress history should be considered. In a conclusion, this study mainly investigates the factors affecting the anisotropic small strain stiffness and the role of initial fabric in the mechanical behavior of the calcareous sands. Of particular importance is that the results show a referential value for the evaluation of the soil property in situ based on the laboratory data. Therefore, oneit should bear in mind that underestimation or overestimation of soil state may happen if an improper sample preparation method is selected, especially for the sandy soils.