Universe Scientific Publishing

ORIGINAL ARTICLE

The State and the Arts of Research on Foundation Buried Depth Effect on Building Structure

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ABSTRACT The state and the arts of research on foundation buried depth effect on building structures are reviewed and summarized in detail from such aspects as static response property and dynamic response property, and a brief discussion is carried out on the future developments and studies. Different scholars have conducted research for this aspect of the issue; the conclusions vary because of differences in the conditions of the upper structure stiffness. Superstructure should consider different stiffness conditions a lot of numerical calculations, foundation depth summary obtained reaction influence on the dynamic characteristics and dynamic soil structure interaction system of law.

KEYWORDS
Buried depth
Building structure
Static response
Dynamic response

1. Introduction

Building structure in engineering practice, the effect of embedment depth on the basis of the building structure is a very important aspect. Base depths were more significant effect on the static nature of the reaction and the nature of the dynamic response of the building structure. How to choose the right foundation depth, to ensure the structural safety of buildings and premises under normal use, and strive to achieve economic rationality, namely to achieve security and economic unity, is building structures in engineering practice must be well resolved. To solve the above problem, we must first have a comprehensive and in-depth knowledge and understanding of the nature of the foundation depth of the reaction effect on the building structure. Depth on building the foundation for the structure of the problem, scholars have conducted more extensive and in-depth research. Static and dynamic nature of the reaction the reaction properties of both article from building structures of existing research progress conduct a more detailed review, and pending further studies will be briefly discussed.

doi: 10.18686/wcj.v2i1.4
Received: January 15, 2013; Accepted: March 19, 2013; Published online: May 29, 2013

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2. Effect of depth on the basis of building structures static nature of the reaction

Depth on building the foundation for the structure of the static nature of the reaction, including the impact of existing research foundation depth of the foundation bearing capacity, ground deformation (settlement), the foundation of stability and foundation stress distribution and internal forces building structure foundation Research methods used are: Theoretical analysis, experimental research and numerical simulation of three categories.

2.1. Effect of foundation depth of the foundation bearing capacity

Luan Maotian, et al. [1] said that the plastic limit equilibrium theory and the variational Combination, based on equations and ultimate load conditions to minimize the overall balance of the sliding soil, and to consider the foundation of a layer of soil properties and adhesion force distribution along the non-uniform change in the depth is derived for determining the formula layered heterogeneity ultimate bearing capacity of the relevant critical parameters were optimized, and the use of quasi-Newton algorithm for the numerical solution. Based on a number of calculations, we analyse various parameters and distribution of soil strength, foundation depth, seismic load and water table depth and its influence on the bearing capacity in combination, and the calculated and experimental results with the existing theory answers were compared. The results show that the foundation bearing capacity and approximately linearly with increasing base depth increases. Finally, the representation of the non-homogeneous ground bearing capacity were discussed, we proposed a

practical estimation method for heterogeneous foundation bearing capacity.

Pu Jialiu and Gao Muyan [2], the use of centrifuge modelling test for shallow foundations on sand foundation for a more systematic study to determine the basis of size, shape, depth and relative density of sand and damage to the bearing capacity of shallow foundations form. The results show that the bearing capacity of shallow foundation and foundation depth was approximately proportional. The paper also presents a centrifuge modelling of shallow foundations on the basis of test data to determine shallow sand foundation bearing capacity factor and shape factor approach.

Soil Foundation for the study by Li Baoqiang [3], combined with load test soil of p-s curve, limit equilibrium theory of soil, on the deformation behaviour of soil, soil bearing capacity and bearing capacity correction problems were analysed. The results show: the bearing capacity of foundation soil is not only the soil itself severe γ and shear strength parameters c, φ value function, but also closely related with its base located on the depth and width of the foundation. For γ and c, φ value of certain soil, foundation bearing capacity increases with the depth and width of the foundation increases. The author's note that, during the foundation design, should be amended in accordance with the actual underlying foundation bearing capacity of soil depth and width of the foundation of the information provided in the survey and made recommendations about the capacity correct.

2.2. Effect of foundation depth of the foundation deformation

According to Ceng Fubao [4], based on concentrated load semi-infinite body at a certain depth below the surface of the elastic (Mindlin) settlement formula solution, we derived a circular base with a certain depth by the concentrated load and uniform loads and sedimentation coefficient is calculated by the rectangular base concentrated loads, and the influence of foundation depth of sedimentation coefficients. The results given by the paper shows that the larger the foundation depth, the greater the impact on the sedimentation coefficient. Meanwhile, as the foundation depth increases, the sedimentation coefficient.

Li Zhibiao et al. [5] to analyze the interaction between raft foundation and soil Elastic Foundation. In the calculation of ground deformation, considering the influence of foundation depth, namely the use of Mindlin (Mindlin) solution in an elastic half-space interior depth effect of a force is a central foundation to solve the displacement and stress fields derived Mindlin based on the formula used by the Method corner ground deformation recurrence formula, and a corresponding finite element program. This paper analyses the interaction were typical raft foundation and layered ground on an elastic half space and soil media, discusses the considerations and does not take into account changes foundation settlement, the base reaction force and internal force base under foundation depth in both cases and further studies with increasing depth of the foundation, foundation settlement, variation of substrate reaction force and the foundation internal force, and finally some conclusions as follows:

(1) For Shallow (depth less than 115 m) of the raft foundation, without considering the foundation depth of the foundation settlement, little impact ground reaction force and the foundation internal force, and therefore cannot consider the impact of foundation depth and approximated by bussing Nai Sike (Boussinesq) solution to calculate the deformation of the foundation.

(2) When the foundation depth greater than 115m, you must consider the impact of foundation depth is calculated deformation of foundation with Mindlin (Mindlin) solution, whether it will result in large errors.

(3) With increasing depth of the foundation, foundation settlement at the bottom center decreases, ground reaction force is gradually increased, but at the moment the center of the foundation slab is gradually reduced.

Ying Yongfa and Ban Qifeng [6] consider soil and nonlinear traits infrastructure, nonlinear analysis carried out under conditions of axial symmetry of the foundation and the basis of common action. They round slab foundation on soft clay foundation for the study, the use of non-linear finite element analysis program SAP91, strength and deformation nonlinear traits soil under the foundation for a more systematic calculation and analysis. In the process of calculation and analysis, using Drucker elastoplastic model to describe the non-linear traits soil body. They studied the base plate geometry, affect foundation stiffness, boundary conditions and foundation depth of the foundation settlement and the soil in the plastic zone undertaken, the results showed that: foundation depth of the foundation settlement and the soil in the plastic zone It was carried out more significant impact, specific performance:

(1) Under load the same situation, with the foundation depth increases, significantly reduced the amount of the settlement, and tends to an extreme value.

(2) Foundation depth of its settlement with the degree of influence of the size of the load.

(3) Foundation depth of ITS settlement with T and the degree of influence of the sizeof the load.

(4) Buried deep in the depth equal basis, close to the edge of the plastic zone from the base. When the plastic zone developed to the top of the foundation and the basis of the closest edge of the plastic zone is about 012 times the diameter of the base to carry out the range of plastic zone is not great, the width of the range on the basis of damage plastic zone diameter of 012–016 times . If the soil reinforcement region, it will help to improve the ultimate bearing capacity of the foundation.

Wang Libin [7] analysed the embedded base of foundation bearing capacity and no pile foundation box itself is

deformed nature of the depth of influence, by comparison of the difference foundation bearing capacity caused by different embedment depth, quantitative analysis of foundation bearing contribution force and foundation depth increment correction to compensate for the stress increment improve the bearing capacity; analysing the depth of box foundation uneven settlement of coordination that is affecting the overall stiffness and the impact of foundation Rebound embedded recompression, and to determine the depth of foundation box decisive eccentric and horizontal loads (earthquakes, wind) made a key role in the case of research, depth of box foundation derived formula is simple, and finally, in view of a box-shaped base design status, summary buried deep influence of different basic design of the box, put forward accurate and economical determination of a box-shaped depth of foundation approach.

Bi Zhenggen [8] Based on vertical additional stress Mindlin (Mindlin) solution formula proposed simplified calculation method foundation settlement amount of one base depth consideration of the impact, which introduced an equivalent settlement factor that only the foundation depth and dimension related basis, to solve simple and suitable for engineering applications. This paper presents the regression formula equivalent sedimentation coefficients. By using this method engineering example analysis, the calculated results with the measured value of the method is closer, it has some value in engineering.

2.3 Influence of foundation depth of the foundation base stress distribution and internal forces in structures

Dombrovskij [9] through experimental research and theoretical analysis, research rectangular base embedded depth layered Foundation extreme pressure and allowed the effects of stress, the establishment of a non-linear relationship between expression and foundation depth description breaking pressure between the foundation, and by the expression test was verified.

Wang Jieguang [10] that has a certain depth of the foundation, the basis of the bottom surface where there is a shear plane between two parts soil. He used the transfer matrix method derived analytical expressions above shear stress, and respectively, for concentrated load, circular and rectangular uniform load and uniform load bar several different loads and other forms of research discussed above shear stress foundation additional stress distribution. The results show that: the shear stress makes diffusion foundation degree vertical additional stress increases, while making the vertical additional stress load decreases near the center.

Chen Su et al. [4,11] for rectangular base with a certain depth in the sedimentation coefficient calculation formula established by the concentrated loads when programmed to calculate, based on the proposed foundation depth consideration case basis to calculate the impact of the internal forces of elastic foundation beam method. Small results calculated using this method show that the foundation depth when considering the impact of the foundation beam computed without considering the internal force than when the base effect of depth.

Wang Shijie et al. [12] In the case of the circular are loads of cloth, for example, discussed the basis of relative depth of foundation on the vertical superimposed stress that, under different conditions of relative depth, use foundation on the vertical superimposed stress and use loads on the surface of an elastic half-space Using Boussinesq 's loads on the elastic half-space inside Mindlin (Mindlin) solution calculated between (Boussinesq) solution corresponding calculated results difference. The results show that when the base is relatively small depth, the use of the Brinell formula and Ming's foundation formula obtained in vertical superimposed stress difference is not large, and the relative depth is smaller, the smaller the difference between the two; when the base is relatively large depth, the use of the Brinell formula foundation on the vertical superimposed stress than with Ming's formula to obtain the corresponding results obtained much greater, and the greater the relative depth based on the difference between the two is also becomes.

2.4. Effect of depth on the basis of the structural stability of the building

Zhang Zaiming and Chen Lei [13] application of BGI-STAB hospital development program, and the 25th floor of 15-storey buildings on the site were the level of stability against sliding under earthquake action, foundation depth research on affect the stability of high-rise buildings. During the analysis, soil conditions, groundwater level as well as earthquake and other factors are in accordance with "the negative principle" in value. The results prove the one hand buried deep building foundation does have a strong impact on the sliding stability of the building, but also that, when the seismic intensity of 8 degrees, under the premise of level ground and horizontal distribution of strata, for 25 buildings layer below, just follow the norms to meet the strength and foundation settlement control requirements, even though the underlying buried very shallow, the safety factor is also 114 or more, to meet the requirements of stability against sliding.

Han Xiaolei et al. [14] using the classical soil mechanics theory, consider eccentric loads, joint action horizontal load and vertical load and foundation depth of the impact of the high-rise building with a box (raft) foundation conducted seismic action checking analysis of foundation stability analysis include: anti-ground horizontal sliding stability checking, checking the structure of the overall overturning stability, the foundation of anti-slide stability of the whole checking and checking basic inclination. Obtained by analyzing the following conclusions: the case when using natural foundation in soft soil bearing capacity

to meet the requirements for compliance with "reinforced concrete design and construction of high-rise building structure" (JGJ3-97) specified level of high aspect ratio building, at seven degrees or octave earthquake, even if the underlying buried depth is zero, it does not produce overturning, sliding or foundation instability, and the inclination of the foundation will not exceed the provisions of existing norms. Therefore, based on the natural foundation embedment depth should not make hard and fast rules, but should be considered on specific practical situations.

3. Effect of depth on the basis of the nature of the dynamic response of structures

Depth on the basis for the dynamic response of structures in nature, including the basis of existing research on the dynamic characteristics of the building structure depth (the natural cycle and natural frequencies) generated when the dynamic response (displacement and acceleration) and the earthquake, the ground subsidence earthquake effects, research methods used in the theoretical analysis and numerical simulation based.

Feng Xinneng [15] for the high-rise building some soil on the basis of depth under different circumstances, be calculated separately input dynamic response under seismic wave analysis, research foundation embedment depth on dynamic response of superstructure. Research indicates:

(1) Foundation depth change does not affect the basic cycle of soil and superstructure work system.

(2) High-rise building foundation base corner with increasing depth of increases, while horizontal displacement based foundation depth increases and decreases, and ultimately reflected in the top of the building with the increasing displacement of the depth of the foundation and save small.

Kuai Xingcheng et al. [16,17] using substructure method, and using one for a rectangular ground-based discrete model of foundation. Tube structure seismic response analysis, the foundation discrete model considered the depth of foundation of. This paper established the finite strip method. Lateral stiffness matrix structure, considering the structure and foundation of dynamic equilibrium conditions, the establishment of a superstructure-foundation-soil coupled system of equations of motion in the time domain. Based on the above equations of motion of a high-rise tubular structures were calculated under dynamic incident response time history of seismic wave analysis, and discusses the different venues, the effects of different seismic input and foundation depth and other factors on the seismic response. Calculations show that in the depth range of basic regulatory requirements, increasing the depth may be appropriate to reduce the displacement of the vertex structure, but reduced the magnitude is not large, namely on the basis of depth consideration of foundation - rise structure structure dynamic interaction of Effect of dynamic response is not significant.

Zhang Guodong [18] established the analytical methods of soil-structure interaction system dynamic characteristics frequency response function method. Application of this method on the dynamic characteristics of soil-structure interaction system on an elastic half space were calculated and analyzed, and the actual site conditions, the hierarchical nature study and nonlinear effects and depth of soil on the basis of interaction system dynamic behavior. The results show that under the same site conditions, the impact of buried depth on the basis of the natural frequencies of interaction system is not significant.

Li Peizhen and Lv Xili [19] using the finite element analysis program ANSYS, for a Shanghai area by the soil-box foundation. Structure interaction system consisting of high-rise buildings, were calculated three-dimensional seismic response of the input seismic waves, taking into account soil-structure interaction analysis, calculate dynamic constitutive model of Middle-earth body equivalent linear model uses, use sticky-spring artificial boundary as the lateral boundaries of the soil, and to study the position of soil boundaries, soil properties, foundation depth, foundation and superstructure stiffness form factors on the dynamic interaction system dynamic characteristics and seismic response. The results show that: with the structure of the building foundation depth increases, the natural frequency interaction system also increases, while the peak acceleration and displacement response of the upper structure are correspondingly increased (displacement reactions reduce swing weight translational component basically unchanged, while the elastic deformation of the component is increased, the results showed the three superimposed increase the total displacement reaction).

Chen Guoxing et al. [20] briefly describes the generation mechanism of seismic subsidence building foundation, discusses the simplified calculation method of multi-storey buildings seismic settlement amount estimated and discussed the base pressure of the building, ground motion intensity and foundation depth, size, form changes the amount of ground subsidence magnitude earthquake impact, given the preliminary seismic subsidence of the foundation of these factors affect the amount of the basic law. The results showed that the amount of ground seismic subsidence decreases with increasing depth of the foundation.

4. Summarized existing research results

Through the foundation depth the impact of the building structure to summarize existing research results and summary, several conclusions can be obtained as follows:

(1) Basic foundation bearing capacity increases with increasing depth of approximately satisfy the linear relationship between the two.

(2) On the basis of depth of ground deformation related to the size and depth. When the foundation depth is small, its impact on the ground deformation is not obvious; and when the foundation depth is large, its impact on the

ground deformation more significant, with the increase in foundation depth of the deformation of foundation decreases.

(3) Foundation depth of the foundation and the basis of the stress distribution in the reaction force of the impact and influence of the law on foundation deformation of the same.

(4) In calculating the impact of ground deformation basis whether to consider the depth of time and stress distribution foundation essentially reflects the difference Mindlin (Mindlin) solutions and Using Boussinesq 's (Boussinesq) solution to calculate the results.

(5) The stability of the building structure foundation depth has a significant impact.

(6) Interaction system dynamic behavior on the basis of the depth of the soil and the composition of the upper structure and dynamic response, the results of most scholars believe the depth of the changes on the basis of dynamic characteristics of system interaction is not obvious, but its impact on the dynamic response interaction system is relatively significant displacement reaction interaction system will increase as the foundation depth increases.

5. Further study of the issue

In view of the existing research results, the research foundation depth of the foundation bearing capacity aspects, ground deformation and stress distribution in the ground has been relatively mature, so in the future pending further studies focused on two aspects as follows:

(1) Basic Table on the structure and stability of the foundation of the building. You should consider the soil body interaction foundation and superstructure of the building structure and foundation stability analysis. At the same time, to consider how the earthquake is a problem worthy of study.

(2) On the dynamic characteristics and dynamic response of the upper body and the soil structure interaction system consisting of foundation depth. Different scholars have conducted research for this aspect of the issue, the conclusions vary because of differences in the conditions of the upper structure stiffness. Superstructure should consider different stiffness conditions a lot of numerical calculations, foundation depth summary obtained reaction influence on the dynamic characteristics and dynamic soil structure interaction system of law.

Conflicts of interest

These authors have no conflicts of interest to declare.

Authors' contributions

These authors contributed equally to this work.

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