IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

A Comprehensive Literature Survey on The Structure-Soil-Structure Interactions

Harshit Bhadrasen[1], Abhay Kumar Jha[2], Rajeev Singh Parihar[3]

[1]Research Scholar, Department of Civil Engineering, Lakshmi Narain College of Technology, Bhopal (M.P.)

[2,3]Professor, Department of Civil Engineering, Lakshmi Narain College of Technology, Bhopal (M.P.)

ABSTRACT

A strong foundation is necessary for any structure. A building's foundation is the part of the structure that is in charge of spreading the weight of the building across a large area of soil without exceeding the earth's ultimate bearing capability and keeping the whole structure from sinking too far. The term "foundation" is often used to describe the substructure upon which a building is set. "Foundation bed" refers to the stable base upon which it rests. Soil quality matters for a building's stability. When deciding what kind of dirt to use as a building's base, it's important to keep a few things in mind. There are a variety of methods to categorise the soil that is utilised as a building's foundation. This paper reviews the recent researches being carried out in the field of Structure-soil-structure interactions (SSSI) in order to aid the strength of foundations in different soil systems.

Keywords: building foundation, Foundation bed, Soil quality, building stability, Structure-soil-structure interactions (SSSI)

INTRODUCTION

The building's foundation will be affected by the kind of soil it is built on. There are several factors to consider while choosing the soil for a building's foundation. Soil foundations used in building may be classified in a number of ways. Clay is a poor choice for constructing foundations because of its propensity to move when it dries or becomes wet. This might lead to uneven flooring as a consequence of fractures or fissures in the structure. The deeper the foundation is buried in a clay soil, the more stable the structure will be. The big particles of sand as well as gravel help this soil to swiftly drain water (that is favorable for buildings). Keeping less water in building reduces the likelihood of it shifting or developing structural or non-structural fractures as a result of shifting. In addition to being more stable, compacted sand as well as gravel are an excellent choice for a foundation. Limestone, sandstone, and other kinds of rock all have a high carrying capacity, making them good choices for foundations (which make this type of foundation ideal for the larger buildings). Bedrock is the layer of rock that lies under the soil's surface. Because of its optimum proportions of sand, silt, and clay, loam is the greatest soil type for building. For sustaining a foundation, it is a perfect combination of all of their greatest attributes. In general, loam does not undergo large changes in size or shape when exposed to water, and this makes it an excellent soil for growing plants. Building on loam has one possible downside, which may and should be screened out before construction begins.

Peat is made up of rotting plants and/or organic debris and is often found in bogs as well as other wetland environments. Because of how easily it may move and how little it can bear, it's a poor choice for a foundation despite its ability to store a lot of water. Peat soil may be used for construction, however the resulting structure is very vulnerable to fractures and other sorts of damage. As with peat, silt's propensity to hold water for an extended period makes it an unsuitable foundation material. Silt expands and shifts as a result of this property; the construction is left without support and subjected to recurrent, long-term stress. Structural damage or failure might result as a result of this. Construction should be done using dirt that is more appropriate for the project.

LITERATURE REVIEW

[1] (Mkrtychev et al., 2015) considered the dependability calculation of a multi-story structure under operational and the seismic loads, as well as the interaction of the base facilities. The basic quantitative feature of the reliability - the chance of failure - was created to measure the reliability of the structures under an action of some “random seismic activity”. A computer model of a 5-story building with only a “cross-wall design plan” was constructed for statistical testing. The stiffness as well as strength properties of the building and soil foundation were evaluated in the course of solving problem of measuring the reliability.

[2] (Nazarimofrad et al. 2016) calculated the “seismic response of an irregular multi-story structure with active tendons” using a mathematical model presented in this research. Changes in the stiffness, structural mass, as well as damping matrices are then used to create the SSI effect. Using active tendon and the LQR method, the model is used to calculate the “seismic response of ten-story structures”. At each storey, the building is described as a structure made up of components connected by stiff floor diaphragms that have 3 degrees of freedom: lateral displacements in the 2 perpendicular directions as well as rotation around a vertical axis. When a building is built on soft soils, the results reveal that the active tendons have little influence on the lowering of structural reaction.

[3] (Ann Sunny Alice Mathai, 2017) examined the interacting process of the stresses as well as strains created between the structure as well as the soil field is involved in a building structure in contact with the soil. Because there is a significant interplay between the components of building structure as well as the soil field, the reaction of the "Piled-Raft Foundation system" to structure is quite difficult. "Finite Element Analyses" utilising ANSYS v17.0 are used to analyse the soil-structure interaction of structures built on “Piled-Raft Foundations”. The corresponding stress as well as building settlement are calculated. The research was carried out by simulating a structure with and without dirt. The interplay of the soil field, building foundation, or the superstructure has a significant impact on the structure, according to the findings.

[4] (Bolisetti et al. 2018) conducted "Soil-structure interaction" (SSI) analysis using the linear techniques in frequency domain as well as an essential step in the computation of the seismic demands in the nuclear structures. For low-intensity shaking, these approaches should provide accurate response forecasts, but their suitability for intense shaking which results in a highly “nonlinear soil, structure, or the foundation response” is unknown. For such circumstances, nonlinear (time-domain) SSI analysis may be used, although it is rarely done owing to a lack of knowledge among the engineers, analysts, and regulators. The study describes a "nonlinear time-domain SSI analysis" approach that uses a commercial “finite-element code”. For a linear SSI analysis including low intensity earthquake shaking, it is compared to SASSI, a frequency-domain algorithm. For a high intensity shaking, a nonlinear analysis using the "time-domain finite-element code" LS-DYNA is explained, and the findings are compared to those from the “equivalent-linear analysis” in SASSI. The nonlinear as well as the equivalent-linear responses are vastly different. The nonlinear effects of strong shaking, such as sliding, gapping, and elevation, are the greatest near soil-structure interface, as these can be represented by equivalent-linear approaches.

[5] (Lago et al. 2019) made the goal of their article is to provide an overview of the basic design techniques for “tall building dynamic modification devices”. There are extra criteria and standards for the construction of tall structures equipped with the “dynamic modification devices” than in the regular building design. Considering that several devices, such as TLD, TMD, as well as TLCD, are not yet included in the national codes, the relevant literature as well as major international building codes are examined. Each of the four major categories of “dynamic modification devices”—distributed, active/semi-active/hybrid, mass, and base isolation—has a step-by-step approach based on the papers analysed. It is possible to use these techniques as a starting point for the construction of a tall structure using these devices. The relevance of the dynamic modification devices in this sector means that retrofitting older structures is also a priority. For the dynamic modification device design, algorithms and the non-algorithm-based methods may be used in chapter's final section.

[6] (Alonso et al. 2020) exposed the isolated footings on the soils to "water content-related volume" variations may be studied using a simple technique presented in this work. 2D modelling of "thermo-hydromechanical processes" in the soil and the atmosphere, as well as a computation of system stiffness, is used in this technique. The structure is also modelled. Soil-structure interaction may be idealised using an equivalent springs model derived from the aforementioned features, allowing for the calculation of the foundation movement variations over time. Building damage resulting from foundational angular distortion may be evaluated using these tools.

[7] (Ibrahim et al. 2021) subjected a 10-story reinforced concrete framed building sitting on a raft foundation to an in-depth 3-D "finite element analysis" in the study. Ten metres of silty clay are followed by 40 metres of thick sand in the soil profile. Plan dimensions of soil block examined in the study are 100m x 100m. Moving point loads are used to represent the train loads. The building's proximity to the railway track is evaluated at various distances. There is an investigation on the impact of train speed as well as distance from building on the structure's foundations. As a way to reduce vibrations from trains, mitigation methods such as open trenches or foam-in-filled pits are being examined. To reduce train-induced vibrations transferred to the soil and neighbouring buildings, these measures were effective. Acceleration was reduced on average by 61.29 percent when employing in-filled foam trench mitigation and by 57.39 percent when using open trench mitigation methods.

[8] (Nasab et al. 2021) made shock retrofitting for the buildings with a soft first floor the focus of this research. Methods of analysis for a soft first-story building, such as the site effect and the “soil-structure interactions” as well as "viscoelastic dampers" (VEDs), are detailed. “Nonlinear dynamic analysis” is used to analyse the seismic performance of the building under various soil conditions. For low shear wave velocity site classes, a soil-structure system is more susceptible to earthquakes and requires more retrofitting than a permanent foundation system, according to the analytical findings. VEDs greatly reduce the risk of structural collapse when the structure is placed on the soft soils, according to a fragility study that takes into account soil-structure interactions.

TYPES OF FOUNDATION AND THEIR USES

The following is a list of common kinds of building foundations:

1. Shallow Foundations

As a general rule, shallow foundations are broader than they are deep. Spread or the open footings are other names for shallow foundations.

Both kinds of foundations have advantages and disadvantages, but shallow foundations are more cost-effective. They're the most prevalent since they don't need a lot of digging or drilling into the ground.

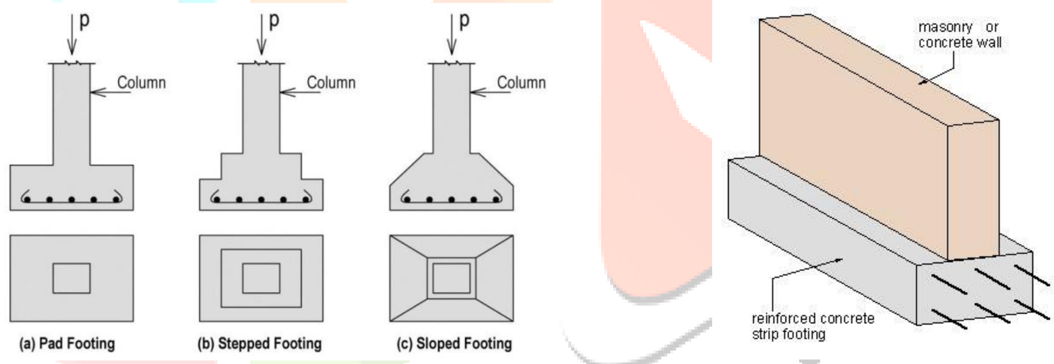
Buildings with shallow foundations are beneficial when weight of the structure isn't excessive and the earth can support the weight at a short depth.

Types of Shallow Foundation

- **Isolated Spread Footing**

As it is the most cost-effective option, this is most generally used as well as the most basic shallow foundation. Convey as well as distribute concentrated loads, such as those induced by columns or pillars, in shallow structures. They are often used in the construction of more mundane structures (typically up to 5 stories).

At the base of section, an isolated footing serves as a foundation. There is a foundation for each part. They transmit the weights from column to earth in a simple manner. It might be square, rectangular, or even round. Non-reinforced and reinforced materials may be used in the construction of this structure. Non-reinforced footings, on the other hand, need a higher footing stature to properly distribute the weight. They must only be used if it is absolutely certain that no more settlements will take place beneath the whole building in the future. Large weights cannot be oriented on spread footings. In order to reduce twisting and shearing capabilities, it is supplied.



(a) (b)

Figure -1 (a) Types of Isolated Footing (b) Wall Footing or Strip footing

- **Wall Footing or Strip footing**

"Continuous footing" is another term for the wall footing. This kind is used to distribute the weight of the structural or the non-structural load-bearing walls in such a way that the soil's ability to support that weight is not exceeded. It follows the wall's course. Wall foundations are typically 2-3 times as wide as the wall itself.

An uninterrupted slab strip runs the whole length of the wall as a foundation for the footing. Wall foundations may be constructed from a variety of materials, including brick, stone, reinforced concrete, and so on. For block walls, the foundation consists of many bricks, the least of which is usually twice as wide as the wall above. The counterbalances can be 15 cm, and the course statues may be 30 cm, because of the stone masonry walls. The footings are somewhat bigger than block divider footings in this regard. This form of reinforced concrete foundation may be used if there is a large pile against the wall or if the soil has a limited bearing capacity.

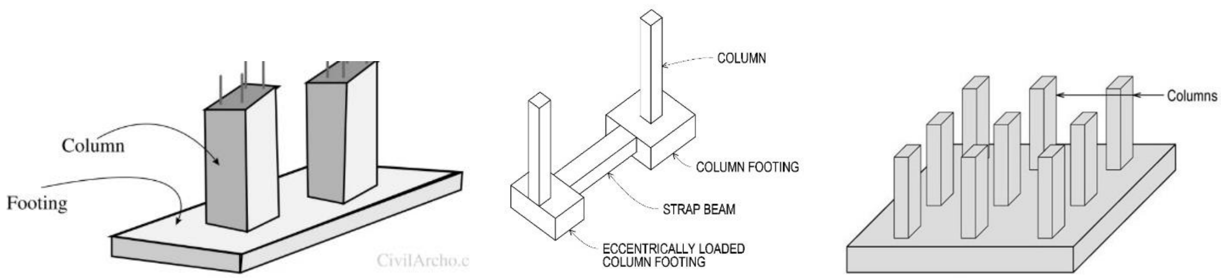
- **Combined Footing**

The isolated as well as the combined footings are very similar. It is possible to create combined footing when structure's columns are precisely positioned or soil's bearing capacity is low as well as their footing overlaps. To put it simply, it is a combination of numerous footings that makes use of different balances in the single footing depending on the requirements of the structure.

Combined footings are the foundations which are shared by more than one column. Combination footings come in a variety of shapes and sizes, including slab, rectangle, slab and beam, raft, as well as strap beam. Some of them are rectangular in form; others are square. In order to ensure that all loads are evenly distributed throughout the footing, the centre of gravity of the footing area must be aligned with the centre of the total loads.

- **Cantilever or Strap Footing**

It is similar to combination footings in that strap footings are used. Strap footing is being considered or chosen for the same reasons as the combination one. Each column's foundation is created separately and joined by a strap beam in strap footing. A strap beam is often used to link an external footing to an inner footing when edge of the footing could not be extended over the property line.



(a) **(b)** **(c)**

Figure-2 (a) Combined Footing (b) Cantilever or Strap Footing (c) Raft or Mat foundations

- **Raft or Mat Foundation**

When other types of foundations, such as shallow or pile, are not an option, raft or the mat foundations are employed. As a general rule, if the bearing capacity of the soil is insufficient, the weight of structure is dispersed over a vast area, or structure is constantly exposed to stress, it is best to use reinforced concrete. Typically, a T-beam slab or a reinforced concrete slab is used as the raft's foundation. The whole basement floor slab serves as foundation in this form of construction. There is an equitable distribution of the structure's weight over its surface. Raft is the name given to this design because it resembles a boat floating on a sea of earth.

2. Deep Foundations

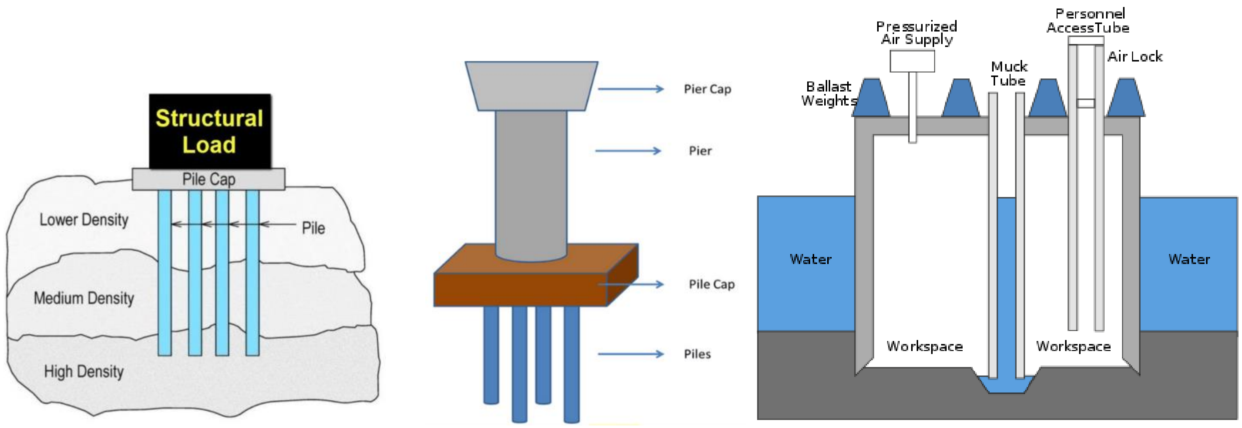
When constructing on sand or any other soft soil, then deep foundations are necessary to support the weight of the structure. Foundations should instead be built deep below or even underwater so that they may make touch with the earth's stronger layers. Examples include bridges, piers, dams, and other structures that have to be built underwater while maintaining their integrity. Large constructions need the use of deep foundations in this situation.

Types of Deep Foundation

- **Pile Foundation**

This style of deep foundation is termed as a "pile". As a means of reducing costs and ensuring that loads are transmitted to the deeper layers of the earth, deep foundations are employed.

Pile is a thin component having a limited area of cross-section relative to its length. Because the carrying capacity of the soil at the surface is very limited, it is used to transmit foundation loads to considerably deeper rock or soil layer. Pile transfers weight either through skin friction or the bearing. Piles are also used to protect the structures from uplift as well as provide structural stability against lateral or overturning forces.



(a) **(b)** **(c)**

Figure-3 (a) Pile Foundation (b) Pier foundation (c) Cassion foundation

- **Pier Foundation**

Pier is a subterranean structure which transfers greater loads than that can be borne by the shallow foundations. It is generally shallower than heaps. The pier foundation is often employed in the multi-story constructions. Because the base area for the regular arrangement is determined by plan strategy, the single pier load test is eliminated. Along such lines, it is becoming widely recognised under restrictive settings.

The pier foundation is a cylinder-shaped structural member that transmits large loads from superstructure to the ground through end bearings. Unlike piles, it can only transmit weight via bearing, not by skin friction.

- **Caisson Foundation**

In the building of dams, bridges, and other structures, caisson foundations are utilised to keep water out. It is often utilised as a foundation material for projects that need to be submerged in rivers or other large bodies of water. The caisson was selected for its portability; it can be towed to the required site and buried into position. A caisson foundation is a prefabricated hollow cylinder which is dropped to the right depth in the ground before being filled with the concrete to form a foundation. Bridge piers are the most common usage for it. There is a shortage of knowledge in the building of caissons, which makes them vulnerable to construction errors.

CONCLUSION

It is observed that relatively little research has been done to analyse the soil-foundation-structure interaction (SFSI) of various kinds of footings in rock soils, based on our literature review. You may find rocks, sand and gravel, hard sound chalk, sand and gravel with a low clay percentage, and thick silty sand in this kind of soil. Still less study has been done on the popular and accessible programme ANSYS, which is utilised by many academics and students today. A study of the literature related to the research work is a great way to gain knowledge about the subject of the thesis as well as to keep oneself updated about the latest developments in the field.

REFERENCES

[1] O. V. Mkrtychev, G. A. Dzhinchvelashvili, and M. S. Busalova, “Assessing the reliability of a multi-storey monolithic concrete building with a base,” *Procedia Eng.*, vol. 111, no. TFoCE, pp. 550–555, 2015, doi: 10.1016/j.proeng.2015.07.041.

[2] E. Nazarimofrad and S. M. Zahrai, “Seismic control of irregular multistory buildings using active tendons considering soil–structure interaction effect,” *Soil Dyn. Earthq. Eng.*, vol. 89, pp. 100–115, 2016, doi: 10.1016/j.soildyn.2016.07.005.

[3] N. P. Ann Sunny Alice Mathai Student Associate Professor, “Soil Structure Interaction Analysis of Multi Storey Building,” *IJSTE-International J. Sci. Technol. Eng.* |, vol. 3, no. 11, pp. 67–70, 2017, [Online]. Available: www.ijste.org.

[4] C. Bolisetti, A. S. Whittaker, and J. L. Coleman, “Linear and nonlinear soil-structure interaction analysis of buildings and safety-related nuclear structures,” *Soil Dyn. Earthq. Eng.*, vol. 107, no. January 2016, pp. 218–233, 2018, doi: 10.1016/j.soildyn.2018.01.026.

[5] A. Lago, D. Trabucco, and A. Wood, *Design procedures for tall buildings with dynamic modification devices*. 2019.

[6] J. Alonso, J. González-Arteaga, M. Moya, Á. Yustres, and V. Navarro, "Atmosphere-soil-structure interaction: Isolated building foundation movements induced by environmental loads," *Comput. Geotech.*, vol. 119, no. July 2019, p. 103356, 2020, doi: 10.1016/j.compgeo.2019.103356.

[7] Y. E. Ibrahim and M. Nabil, "Finite element analysis of multistory structures subjected to train-induced vibrations considering soil-structure interaction," *Case Stud. Constr. Mater.*, vol. 15, no. June, p. e00592, 2021, doi: 10.1016/j.cscm.2021.e00592.

[8] M. S. E. Nasab, S. Chun, and J. Kim, "Soil-structure interaction effect on seismic retrofit of a soft first-story structure," *Structures*, vol. 32, no. January, pp. 1553–1564, 2021, doi: 10.1016/j.istruc.2021.03.105.