FOUNDATIONS REALIZED IN PUNCHED HOLES FOR BUILDINGS

Monica MIREA[1], Cristina VOICU[1], Carmen PEPTAN[2]

[1] ***"Politehnica" University of Timişoara,***
[2] ***Banat's University of Agricultural Sciences and Veterinary Medicine, Faculty of Agricultural Sciences, Timisoara, Aradului Street, no. 119, RO-300645, Romania,***
Corresponding author: monica.mirea@ct.upt.ro

Abstract: *The paper presents at the beginning a synthesis of the technology for realizing foundations in punched holes, the fields of use and the advantages of this technical founding solution. It further analyses the types of equipment used and the modalities of punching the foundation holes, emphasizing their influence upon the improvement of the ground and the increase of the so-realized foundations' bearing capacity. The use of spherical or truncated cone punching equipment represents a new and original element nationwide. The first punching research in Romania was realized by the team of the Roads and Foundations Department of Timisoara, with punching equipment in the shape of truncated pyramid with the small basis on the bottom. These studies have been finalized in 12 dwelling buildings (Basement+ Groundfloor+4 Floors), located in the area of the County Hospital of Timisoara. The solution will have an impact both theoretical and practical, having numerous applications and opening new horizons in the improvement of the foundation ground by using the punching procedure, since this procedure ensures the realization of buildings on weak soils, through direct, surface foundation. The subsequent deformations under the construction loadings are minimal. The solution of realizing foundation holes through punching contributes to reducing the volume of the excavation and the materials used in the realization of foundations, to cutting down the quantities of materials needing transportation (soil, concrete, steel-concrete, wood for frames, etc.), as well as to the shortening of the execution period. All these elements have a favorable impact upon the environment, finally the costs of the investment being smaller than in the case of the known solutions. The solutions of realizing foundations in punched holes consist in forcing into the ground certain spherical, truncated cone, truncated pyramid shaped equipments (tampers) through striking or vibration. As a result of this mechanical thrust, an area of packed soil is formed around the foundation, within whose limits the mechanical strength of the ground increases and the deformability characteristics decrease. Due to the reduction of the ground deformability, the foundations realized in punched holes can transmit vertical and horizontal loadings in the conditions of small size foundations. Finally, the paper presents the advantages of using foundations realized in punched holes on soils with lower bearing capacity, for lighter building, including in the agricultural field (temporary storage halls, shelters for agricultural machinery, etc.)*

Key words**:** *foundations, punched holes, bearing capacity, hemispherical, soil.*

INTRODUCTION

Through their shape and technology of execution, the foundations in punched holes represent both a foundation solution and the improvement of the soil around the foundations, increasing their bearing capacity.

In the case when, following the analysis of the foundation ground, its physical and mechanical characteristics show a weak foundation ground, the use of classical foundation solutions may lead to costs representing 30…40% of the total construction cost .

This is why, for building on weak ground, research has been and is performed concerning the modernization of the technologies of improving foundation soils, as well as in drawing up new technologies to improve and execute foundations.

A new founding technology in the case of weak foundation soils is based on executing foundation holes through punching. This technology ensures a rational use of the ground's

bearing capacity reserves, realizing in the same time an improvement of its physical and mechanical characteristics.

The punching technology of foundation holes can be applied both to civil and industrial buildings and to agricultural constructions such as temporary storing halls and shelters for agricultural machinery. The finally adopted building solutions differ depending on the stratification of the foundation ground and the type of resistance structure.

The punching technology has less impact on the environment than the indirect founding solutions which should be applied when the soil appropriate to founding is found deeper than 5m. This method of realizing foundation holes contributes to reducing the excavated volume and the quantity of materials used in the foundations, to lowering the quantities of materials needing transportation (soil, concrete, formworks wood, etc.) as well as to shortening the execution period. All these elements impact favorably upon the environment, finally the investment costs being much lower than in the case of other known solutions.

MATERIAL AND METHODS

The punching technology for foundation holes consists in realizing them not by digging as in the classical solution, but by introducing into the ground, through vibration or beating, an equipment (called hammer or vibro-hammer), having the shape and the size of the foundation. In order to increase the thrusting effect of the soil, both in beating and in vibration punching, the general shape of the punching equipment is a truncated cone or pyramid with the large base at the top.

After applying this technology, an impression with the shape and size of the punching equipment appears on the ground. This impression will constitute the foundation hole in which the monolith foundation will be realized or the prefabricated foundation will be placed. Around the realized foundation, laterally an in depth a packed soil area is formed, in which the mechanical resistances are improved and the deformation properties are reduced, therefore, foundations realized in punched holes are able to convey the loadings to the foundation ground, in the conditions of reduced sizes.

In order to increase the bearing capacity of these foundation systems, at the bottom of the foundations a bulb can be realized in added granular material, introduced in one or several portions, each portion being compacted with the working equipment that realized the punched impression.

Also in order to increase the bearing capacity of the foundations realized in punched holes, but also in order to eliminate the drawbacks brought by the repression at the surface of the punched hole edges, an anti-pressing plate can be realized at the top of the foundation; the size of the plate goes beyond the contour of the upper base of the foundation in the punched hole.

The punching technology of the foundation holes can be realized through beating of through vibration.

The **beating punching** is a procedure in which the hole is realized following the repeated fall of a 1…3 ton hammer from a height of 3…5m. When prefabricated foundations are placed in the punched holes, the former can be used as punching elements to realize the holes subsequently ensuring a better contact between the prefabricated element and the foundation ground. In this case the prefabricated element needs to be adapted to lifting and maneuvering.

Figure 1 shows the working stages of a foundation realized in a punched hole through beating:

- **stage I** when the punched hole is realized in the needed dimension following the repeated free fall of a hammer from a certain height;

- **stage II** consisting of the partial filling (1/3) of the punched hole with added material to realize the bulb which subsequently will be compacted with the same hammer;

- **stage III** corresponds to the variant in which the realization of a larger bulb is required, case in which the added material is introduced in 2…5 successively compacted portions;

- **stage IV** consists of realizing the monolith cast foundation or the mounting of the prefabricated foundation in the bulb punched hole.

Figure 1 b shows the working stages of a foundation executed in a punched hole realized through **vibration**. These are similar to those of the beating punching, the difference being marked by the fact that the hammer is introduced in the ground by vibration instead of beating. In this case the added material for the bulb will fill the punched hole.

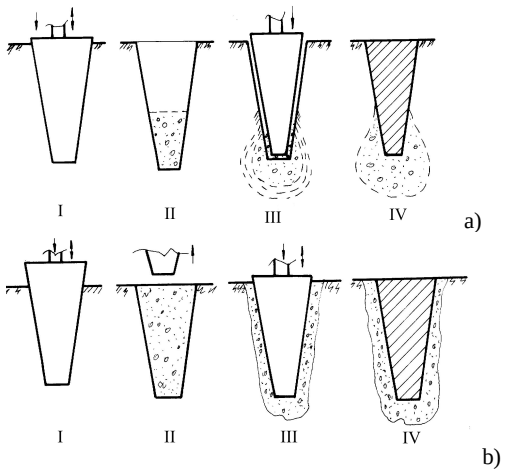


Figure 1: Foundations realized in punched holes: a) through beating; b) through vibration

It can be noted that in the vibration punching the added material is distributed on the whole depth of the hole, and the area of packed soil is less expanded in depth under the base of the foundation, in exchange offering a better lateral packing of the foundation ground and the possibility of ensuring a good drainage of the ground around the foundation.

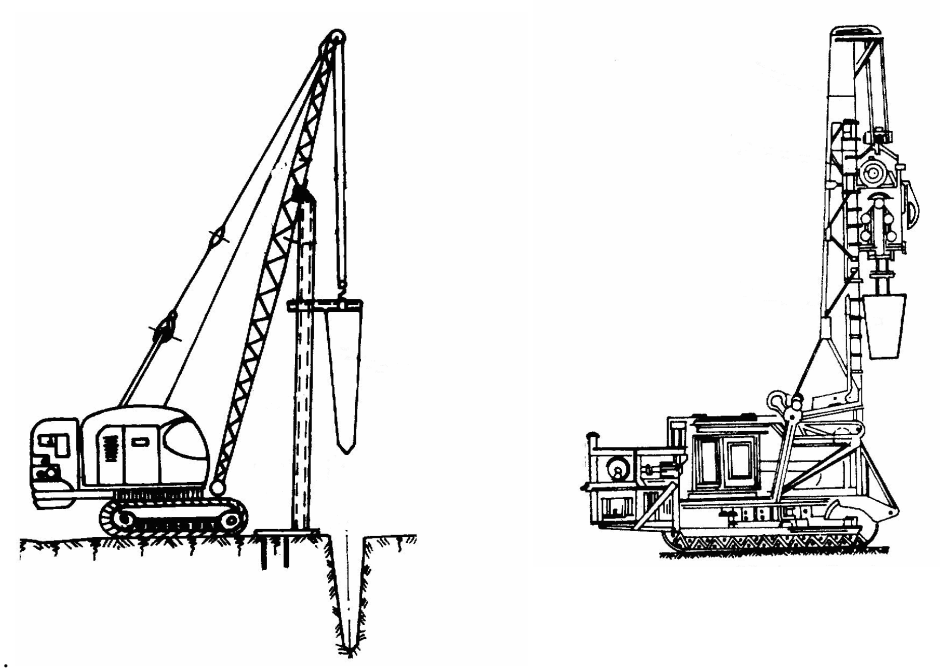
The beating punching is recommended in the case of cohesive soils with $Ic \leq 0,4$ and the vibration one for non-cohesive soils (loose sands with $I_D \leq 0,4$), the non-homogenous fillings, silty sands, clayey sands where the packing degree of the soil is influenced by the favorable effect of the vibrations.

Specific punching equipment is used for the technology. In the case when the foundation holes are punched by beating, there is the advantage of using a large range of existing lifting gear as carrying equipment. The attachment to this gear of the beating equipment of device does not require its alteration. Figure 2 shows the principle drawings of beating and vibration punching equipments.

The punching equipment beards the name hammer in the case of beating punching, respectively of vibro-hammer in the case of vibration punching. The general shape of the punching equipments is truncated pyramid with the large base at the top.

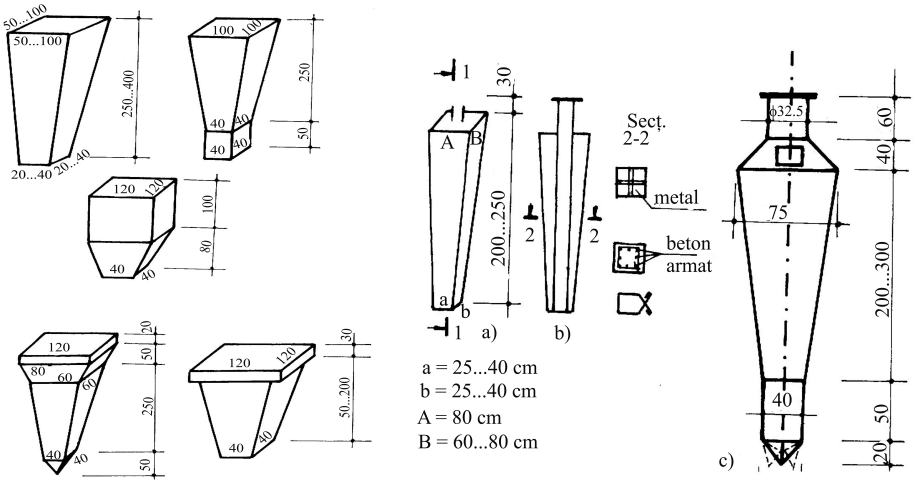
Figure 3 presents some shapes and sizes of the hammers used in beating and vibration punching.

In the case of prefabricated foundations, even the prefabricated element can be used to punch the foundation hole.



a) b)

Figure 2: Equipments used for punching: a) through beating; b) through vibration.



a) b)

Figure 3: Shapes and sizes of: a) hammers; b) vibro-hammers

RESULTS AND DISCUSSIONS

The proposed solution consists in realizing the foundation holes through punching with the help of a spherical hammer. In the realized hole a semi-sphere prefabricated foundation will be introduced or a monolith foundation will be placed. The spherical punching element (hammer) has a good cooperation with the foundation ground leading to its improvement, both in depth and laterally.

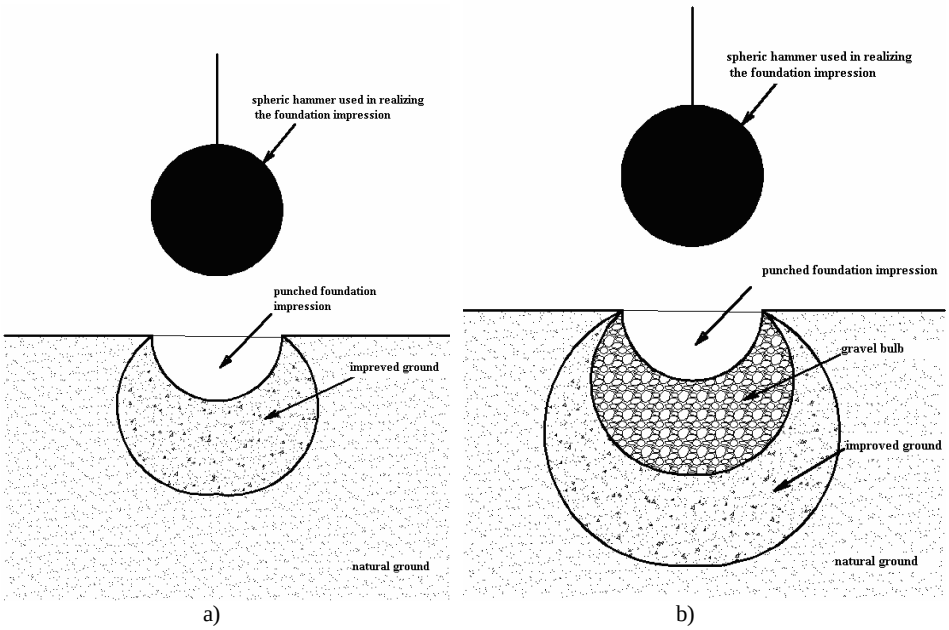


Figure 4: Realization of semi-sphere foundation holes through punching:
a) realization of the foundation hole; b) realization of the granular bulb

As a spherical punching element a metal demolition ball can be used. In this case, through repeated free falls from a certain height, on the same spot, an impression is created on the ground which constitutes the hole of the so-called foundation, placed this time on improved soil – figure 4a (with physical and mechanical characteristics clearly superior to the natural ground ones, that is a much higher bearing capacity). In the case when this impression, after realization, is filled with coarse added material, through its repeated free falling, the spherical hammer will realize a new impression which will be the foundation hole – figure 4b. This time the foundation will be placed on ground improved with added granular material (gravel, crushed stone).

The semi-sphere or semi-sphere with anti-pressing plate foundations, realized in punched holes, can be used as insulated foundations under poles (figures 5 and 6) or as continuous foundations – figure 7 (or discontinuous – figure 8) under walls for civil, industrial or agricultural buildings placed on weak foundation soils down to 2 – 4m. Also, in the same situation, these elements can be used to realize insulated foundations under poles when these are tied through reinforced concrete girdles (figure 5).

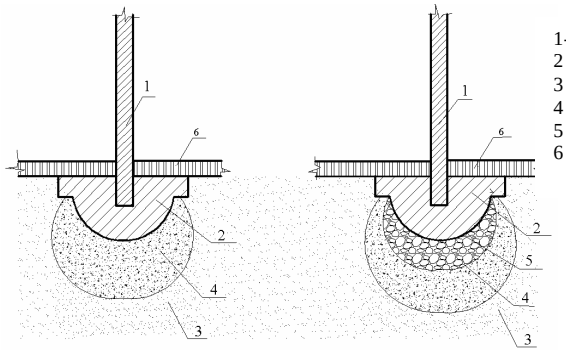
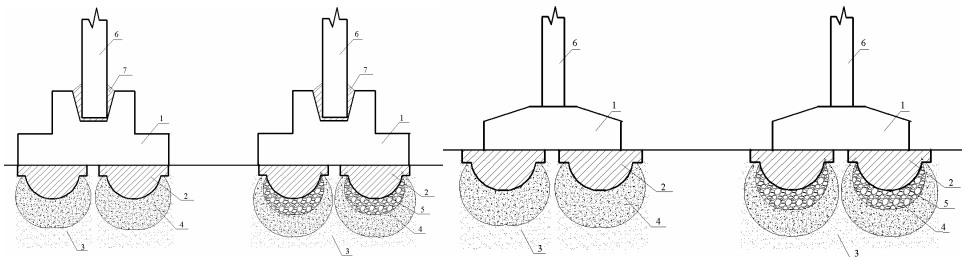


Figure 5: Insulated punched semi-sphere foundations under poles



a) b)

Figure 6: Classical insulated foundations under poles, unloading on punched foundations with or without bulbs (1- classical foundation, 2- semi-sphere with anti-pressing plate, 3 – natural soil, 4 – improved soil, 5 - bulb, 6 - pole, 7 - monolith): a) glass foundations; b) elastic foundations.

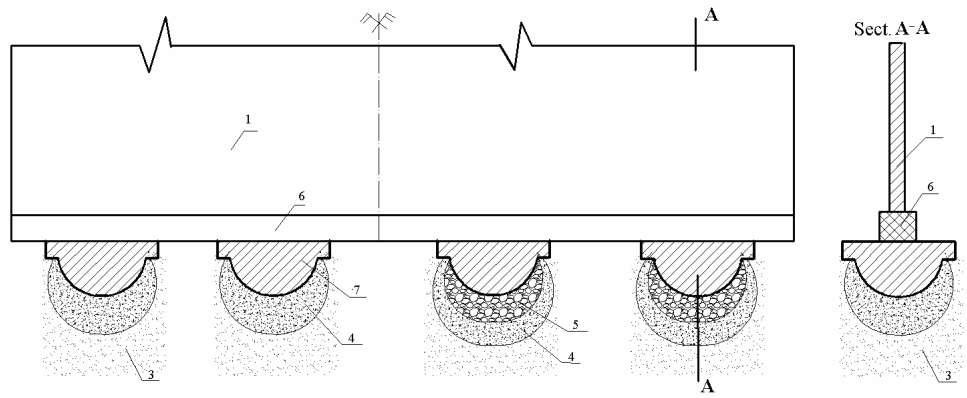


Figure 7: Semi-sphere punched foundations used for continuous foundations under walls (1- wall, 3 – natural soil, 4 – improved soil, 5 - bulb, 6 - girdle, 7 – semi-sphere with anti-pressing plate)

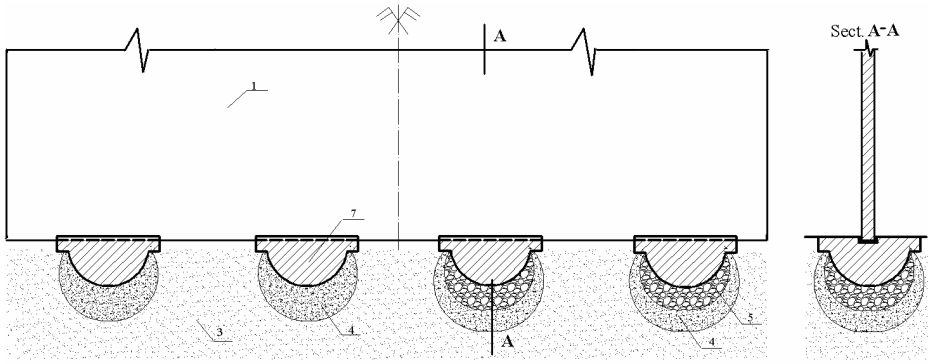


Figure 8: Semi-sphere punched foundations used in discontinuous foundations under walls (1 - wall, 3 - natural soil, 4 - improved soil, 5 - bulb, 7 - semi-sphere with anti-pressing plate)

CONCLUSIONS

The presented foundation solution is easy to realize, efficient and wants to avoid the use of an indirect foundation much more expensive and difficult that requires specialized, high capacity equipment, which will occupy the location for a longer period of time altering the environment, both by phonic and by air pollution for the residents. Also, the space occupied by the site organization is smaller in this case than in the classical variant.

The advantages of this solution consist in the significant reduction of the expenses in comparison with the deep foundation systems, the elimination of the seasonal character of the foundation process for buildings placed on soils inadequate for direct foundation and in the case of compaction works for road earthworks.

The foundations realized in truncated pyramid, truncated cone and semi-sphere punched holes have a higher bearing capacity than the prismatic foundations with the same cross section area.

The analysis of the operational behavior of buildings with foundations realized in punched holes we can draw the conclusion showed a better time behavior. The registered settlings were much lower than the admissible values and their stabilization was quickly realized whereas the differentiated settlings were not important. Therefore, these punched foundation solutions are modern and ensure a high degree of mechanization of the foundation works, representing in the same time an efficient way of improving the foundation ground.

The prefabricated or monolith foundations realized in punched holes, especially the prefabricated ones, ensure a high degree of industrialization and mechanization of the foundation works.

By punching the foundation holes, the improvement of the foundation soil is realized both in depth and laterally, leading to the increase of the bearing capacity of the foundations realized in punched holes.

The improving effect depends also on the shape of the hammer used in punching the hole. The use for the first time of a vibration hammer (vibro-hammer) with a spherical shape presents the advantage of a more uniform improvement of the foundation ground, both vertically and horizontally, as compared to the other shapes of truncated pyramid or truncated cone used up to now. Therefore, the spherical hammers have the best results in the compaction of the foundation ground through punching, this being also influenced by the mass of the hammer and the height from which it falls.

The semi-spherical shape is easy to realize and has advantages both concerning the thrusting of the hammer into the ground and mainly in its extraction, ensuring in the same time the stability of the hole's walls at the extraction of the equipment. This shape ensures a better cooperation with the foundation soil leading to a higher bearing capacity of the foundations in compaction with other shapes of hammer.

The presence of the anti-pressing plate in the semi-sphere foundations realized in punched holes increases significantly their bearing capacity.

The punching with granular bulb also leads to the increase of the bearing capacity of the foundations.

The use of spherical or truncated cone punching equipment represents a new and original element nationwide.

The solution will have an impact both theoretical and practical, having numerous applications and opening new horizons in the improvement of the foundation ground by using the punching procedure, since this procedure ensures the realization of buildings on weak soils, through direct, surface foundation. The subsequent deformations under the construction loadings are minimal.

BIBLIOGRAPHY

1. MIREA MONICA, VOICU CRISTINA OTILIA - Experimental Laboratory Studies Concerning The Influence Of Foundation Hole Punching On The Terrain, vol. 1, Proceedings of the 11th WSEAS international conference on Sustainability in Science engineering (SSE'09), Timisoara, 2009, page 153
2. MIREA MONICA - Experimental Study Concerning The Emphasizing Of The Deformed Area And The Improving Of The Foundation Ground Around A Semi Sphere Foundation Model Realized In Bulb Punched Hole, Scientific Bulletin, transactions on civil engineering and architecture, vol. 49(63), section 1, Timisoara, 2004, page 73.
3. MIREA MONICA, VOICU CRISTINA OTILIA - Calculation Of The Bearing Capacity Of Truncated Cone And Semi Sphere Foundations Realized In Punched Holes, Scientific Bulletin, transactions on civil engineering and architecture, vol. 49(63), section 1, Timisoara, 2004, page 63.