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The Investigation of Various Kinds of Guardian Structures, their Economics and Technical Comparison in Some of Under Construction Buildings in Ahwaz City

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ABSTRACT: Lack of planting guardian structure in the time of drilling and excavation in high-density spots of urban is one of the issues that bring life and financial losses. In this study, various kinds of planting guardian structures by using a series of vast studies and interviewing with expert executives in different dimensions specifically it has been investigated from the point of view of construction management and has been considered the special environmental status of the city of Ahwaz. The present study is kind of a fundamental one that firstly it has been collected by studying the researches and updated articles, the presented instructions about the construction management and execution of guardian structure, and then documenting of information has been done by studying and through surveying of under construction structures, ultimately consulting with the executives and prominent professors has led us to provide solutions for choosing the best suited methods of guardian structures both economic and technical. The results of this research indicate that for any depth of excavation up to 10 meters regarding to the type of soil and the level of underground water, the suited guardian structure which is economic and technical among different methods, truss guardian structure and Reciprocal inhibition for different excavation surfaces is a good solution for the issue of construction in Ahwaz.

Keywords: Guardian Structure, Excavation, Inhibition, Construction Management

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INTRODUCTION

Nowadays, regarding to the continuous growth of population the need and demand for housing led the constructing to the industry of construction. Regarding to the restrictions of urban development, tall building, underground and multi-floor parking lots, have naturally led to deep excavations, that in the urban areas due to restrictions for deep wall, usually it has been done vertically, which it needs special attention for safety and maintaining the nearby buildings. Now for prevention of destructing deep walls we have to build the constructions that enforce its strength against the destruction of the walls that are called guardian structures which have been used in different forms including, nailing, diaphragm walls, truss structures, piling, which has been ignored due to lack of adequate information of those involved with construction industry and being unfamiliar with different methods of such structures and also the fear of paying high costs for that, and entails large losses. The excavation, planning, and execution of guardian structures in civil engineering is a vast scope and needs investigations, studies and geo-technique considerations, structural, materials, technology and execution, economic and social. As a result, we can say that the choosing of appropriate method depends on all he effective factors and it can be different in different situations. On the other hand, theories and the practical procedures of excavation and guardian structure are simultaneously effected by theoretical principles and experimental and executive considerations.

Objectives of research

The purpose of this research is to provide the best suited method by considering the advantages and disadvantages of common methods of execution of guardian structures for different levels of excavation up to ten meters depth within urban which in form of case study in the under construction buildings in Ahwaz it has been investigated. The studies in the field of the existing methods of excavation in urban areas have led us to provide simple, economic and high secure solutions and we have tried to resolve one of the construction industry issues as a practical research.

Research's background

In the research by Ramli et al. (2013) with title of the stability of the protective wall as the guardian structures of the ground, the gabion guardian structure has been studied in two walls with forms of rectangular and hexagonal that the walls are loaded by the height of 0.75, and these results have been made: the configuration of the hexagonal wall under the outcomes of changing form had more control rather than the rectangular one, which indicates that the form changing by the maintained and integrated system is more stable than a cumulative system and is a normal couple, and the investigation of the wall form changing profile in the loading spot between the sample heights of 0.35 to 0.55 vividly indicates shear

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deformation more severe than the rectangular wall in comparison with the hexagonal one.

Venkata et al. (2011) in their research have suggested the contiguous pile wall as a guardian wall, the deep excavation system due to the excavation stability that is the biggest planning criterion to prevent the collapse of the depth and also the stability which includes the pressure of the earth and also the reduction of the level of underground water for keeping the excavation area dry and also to prevent the leakage of water and the lack of sand boiling and breaking the wall and also lack of adequate space on the urban surface, the vertical deep excavations are suited.

Askari et al. (2012) in his research under the name of using the legal tension for measuring the passive seismic force in retaining walls have provided analytical solutions for investigation of the lateral passive seismic pressure force in retaining walls which based on the analytical method it is in lower limit, and also the solution has been compared with Rankine theory and the obtained results from the suggested solution is close to it.

In a research by Dehghanbanadaki et al. (2013) titled Soft soil stabilization by depth soil mixing columns in general case, he has investigated the method of depth spil mixing columns in improvement of soft soil. This research explains the concept and the theory of this method and the description of different features of soil and foundation including, instalment, the type of adhesive, stability and Bearing capacity of the composite grounds, the method of depth soil mixing column is executable either wet or dry, regarding to the features of soil and the project characteristics.

In the research by Ashrafi et al. (2012) titled the investigation of effective parameters in construction of guarding structures near the highways, and the results are as follows: in piling the road adjacent walls, due to the lack of disruption of road usage and also providing the adequate safety, it is suggested to use embroidered soil method. Using of nailing method as a trench and deep wall protection system within urban areas and restricted area is highly helpful and due to possibility of simultaneous execution in several sides of the construction site has a good speed.

Salkhordeh (2008) has investigated the different methods of the reduction of the instability probability in excavations due to enhancing the safety in construction sites and after investigation of the methods, he reached to the result that before choosing the way of stabilization, the geo-technique studies must be done properly and by a proper analysis the results of the experiments and the dominant status on the project (residential, non-residential, the high or low level of underground water and etc.) to choose the appropriate system consistent with more safety of the construction sites and even nearby environment.

MATERIAL AND METHODS

Theoretical foundations of research

Different techniques of guardian structures are for prevention of excavation instability, which each of them regarding to the type of soil, the depth of excavation, the sensitivity of the nearby buildings, the conditions of the project and the justifiability of economic choice and by those who involved with the excavation projects in execution. The important factors of causing instability in excavations (before applying the necessary measures) can be as follows: if the soil of the excavating location to be clay or high moisture, the soil of the wall due to getting air dried and this factor caused cracks on the soil. In this case the probability of excavation instability is possible and if the soil of the excavating area is dry clay, the soil of the excavation wall will decrease its stability against the increasing of moisture in rainy times and if the soil of the excavating area to be sand with a low percentage of clay, the soil in the excavating wall can be collapsed with a pretty small vibration or due to the lateral forces during the earth quake, the excavation instability is highly possible.

Types of stabilization methods

Nailing: In this method, after excavation of the first stair (The sustainability of the soil must be about 1.5 meters) the first nailing row will be executed and then a thin concrete layer named Shotcrete, and at the end the head plate and bolt will be closed there. This procedure will be continued until the final level excavation, the advantages of this method are the high execution speed of this method, the pretty low cost in comparison with other guardian structure methods, appropriate with vast range of soil types, safety and trust can be pointed. Also in this method, the excavation is done stage by stage from top to bottom. In this stage with the aid of special excavation machineries, the horizontal wells will be excavated in the excavation walls. Then, pre-tensioned cables will be put inside these wells and by injection of concrete in the end of the wells; we will pile these cables in soil completely. Then the cables will be pulled by special jacks and the end of the cables will be piled on the surface ply of the excavation, then concrete will be injected in the mentioned wells. After concrete hardening and gaining its adequate strength, the cables will be released from their jacks. This action causes the existing pre-tensioned force in the cables to pressurized the soil and as a result the soil becomes denser and denser and lowers its collapse and at the same time that the collapse force is transferred to the inside soil of the excavation and the final body soil act as a guardian structure and bears the collapse of the opposite body soil. The advantages of this method is the improvement of the mechanical features of the soil due to the injection of concrete inside the wells and also the soil pre-tensioned in result of using the around soil of the excavation ply for piling the soil collapse and reduction of the rate of soil collapse due to the improvement of the mechanical features of the soil, the disadvantages of the Tie-back method are also the usage of opposite body soil of the excavation wall is a necessity, therefore, in cases that the opposite soil is under the a building or in the privacy of the neighbor or in the privacy of the utilities and municipal passages, we cannot use such method or it is full of such restrictions.

Diaphragm Wall Method:

In this method, first with an aid of special excavation machineries we will excavate the guardian wall. Then, simultaneously we fill up the hole with slurry betonies and concrete to prevent the collapse of wall soil of the excavated area. Then we place the shelves of the

armatures of the guardian wall in the excavated area of the wall which is already made. Then we do the concreting of the wall. The advantages of this method are: The diaphragm wall also acts as the guardian structure of the excavation and either during the using of it as retaining wall. Diaphragm wall specifically for excavations and holes with long length is recommended and of its disadvantages we can mention the below items: in small volumes the cost of execution is very high, the excavation machineries needs more working space and in case of having spatial restrictions between two sides of the wall, it will be impossible to execute this method or it is a tough task.

Reciprocal Support Method:

This method is suited for small width excavations. In this method, first in both sides of the hole, in determined distances we excavate holes. The length of these holes is equal with the depth of the hole with addition coefficient of 0.25 to 0.35. This added depth is due to fulfillment of fixity of the bottom end of the profiles that are placed in the wells. Then we place steel profiles inside these wells in accordance with the measurements and executive plans. The length of these profiles is usually considered such a way that the bottom end of them will be placed a little upper than the top level of the hole. Then we join the bottom parts of both vertical profiles with the help of beams and trusses to each other, this action causes that both vertical profiles to aid each other for more stability. After that, we perform the operation of excavation gradually.

Anchorage:

In this method, for piling the movement and collapse of the soil, by using some special establishments, we will get assistance from the wall soils. First, in the margin of the field which is located for excavation, in determined distances we excavate holes. The depth of these holes is equal with the depth of with a little addition for end bottom concrete piles of these holes. After excavation of these holes, we place I and H shaped profiles inside them. Due to fulfilment of fixity and adequate piling for these profiles, we determine the depth of these profiles with a coefficient of 0.25 to 0.35 of the depth of the hole, we continue lower than the pit floor elevation inside the pile part and in the end of the profiles, we establish ramus. Then, we do concreting the end bottom pile, which its armatures have executed and placed already. Thus, the steel profiles will be piled in the piles and the steel profiles will be piled in the soil with piles either. After the execution of the above stages, the operation of excavation will be executed stage by stage. At this stage, after excavating to its depth, for prevention of soil collapse, by using special excavating machineries, we excavated horizontal wells in the body of the hole with diameters between 10 to 15 centimetres. Then, we place armatures inside the wells and then inject concrete inside them. The advantages of Anchorage method are: the mechanical features of the soil will be improved due to the injection of concrete inside the wells. Therefore by doing so, in addition to getting help from the soil near the ply for prevention of soil collapse, the rate of soil collapse will be reduced due to the improvement of the mechanical features of the soil.

The Guardian structure cannot be placed in arena. Available soil will be used for inhibition of cupped wall and its disadvantages could include following items: using body of adjacent soil of cupped wall is required. So in some cases that adjacent soil is under a building or in neighbour's privacy or urban thoroughfares. This method cannot be used or it may has some limitation. Due to the necessity of operation implementation step by step, long time will be needed. However, this may not pose in huge projects but on the contrary, it's possible to decrease the total time of the project especially with correct management.

Truss Rakers:

This method is one of the most suitable and common method of guardian structure implementation in urban areas. To applying this type of guardian structure, initially we will dig wells in the location of the vertical truss members which is located adjacent to the cupped wall. Then we will within candles within the candles and will put the vertical member in to the candle and then will concrete the candle .After hardening of distal concrete the vertical member will be fixed to the candles and then the soli enclosed between vertical and horizontal member of truss will be removed step by step from across the wall and each step, horizontal and diagonal member of truss are gradually installed to complete the truss and its advantages are as follows:

- its suitable for all pits located in urban areas
- it has more flexibility in terms of implementation in different condition
- it's possible to reuse the truss
- it's so single and there is no need to any expertise and specific system

And its disadvantages are as below: its speed of implementation is less than other developed methods. Trusses get more spaces and there is a possibility of removing of some parts of soli by Manual methods.

Under Pinning

To increase the capacity of building's foundation bearing, the point underpinning or fine candles armed to underpinning method in sensitive places that has the possibility of subsidence has been used. Feature of this method of resisting is in limited spaces. Underpinning method is the method for reinforcement and fixing foundations of an available building or other structures in construction and in some cases that the original foundation doesn't have adequate strength and resistance or building usage has been changed or adjacent building's constructions needed digging and drilling and underpinning will be available so this method can be used. Some kinds of underpinning methods are as follow:

1- Strengthening with the massive concreting of foundation

2- Diagonal Chenaje of available underpinning

3- Strengthening by tiny candles

RESULTS AND DISCUSSION

Evaluation of case study

Initially, in this study several kind of guardian

structures have been compared from structure management point of view and then with their assessment and expressing the case studies which included all places of Ahvaz in terms of locational situation ,the most suitable guardian structure for different level of digging is proposed .It would be noted that for lots of varieties of digging such as Digging, soil type, soil mechanical parameters, land location, the groundwater level amount, the extent of availability of materials, season of work , the possibility or impossibility of use of machinery, the specific circumstances of adjacent structures, Different sections and steel profiles of the Digging, form of plan and, declaring administrative fee of these structures ,in terms of number and figure doesn't have technical justification and it brought in Table 1 just for familiarity of the reader, range of executive prices for each kind of guardian structure which is collected from top executive companies of this profession in 2014 and it classified in type of low, average and high.

Table 1. Classification of implementation costs (m–RLS)

Implementation costs based on Square meters	Cost equivalent
From 2500000 to 5500000	Low
From 5500000 to 8500000	Middle
From 8500000 to 1150000	High

If guardian structure methods will classify in terms of technical and economic view based on above table, it is as follow then:

1- Nailing method with low and average cost is suitable for rigid and very rigid, compacted sandy rigid or with some adhesion which has the ability of implementation urban construction.

2- Truss method with a low cost is suitable for several types of soils and also is applicable for common urban construction

3- Method of inhabitation with column with average cost is suitable for rigid and very rigid, compacted sandy rigid and there is a possibility of implementation in common urban constructions.

4- Method of piling with average and high cost is suitable for types of soils but pilling has some problem in rigid and hard soils and due to the devices 'value, its used less in urban construction .

5- Diaphragm wall method with high cost is suitable for types of soils up to 20 meters and high underground level and this method is not common due to device's velum in urban construction.

6- Tai-back method with high cost is suitable for medium to high clay and sandy soils and for implementation it needs expertise and special equipment.

7- Reciprocal inhibition technique with low cost is suitable for all types of soil and its implementation is common in urban constructions.

In some case studied which have been done in Ahvaz, based on obtained statistics from soil's speculations by Laboratory of soil mechanics of Khuzestan province, 4 items have been selected that had highest differences in terms of soil and underground water levels and in terms of technical and economic points of types of guardian structures and by consideration of implementation condition such as labor force, limited space of work in construction high density areas. Cost, time and quality for different depth of digging up to 10 meters which is part of half deep digging, the guardian structure adapted with dig is proposed which is shown in Tables 2 - 5.

Table 2. First Case Study of Nabovat alley in Ahvaz

Groundwater Level: 2 meters	**Speculations Place: Nabovat Alley**	**Case study No. 1**	
Guardian structure offer (Are numbered in priority order)		**Soil Type**	**Depth Meter**
1- Reciprocal inhibition implementation with Technical rules		Rigid clay	0-2
1- Reciprocal inhibition (Crooked or horizontal) 2- truss structures in case of meeting the requirements		Rigid clay	2-4
1- Reciprocal inhibition (Crooked or horizontal) and shotcrete 2- Truss structures and shotcrete 3- Nailing		Very rigid clay	4-6
1- Reciprocal inhibition and shotcrete 2- Truss structures and shotcrete 3- Nailing with two layers of shotcrete or performing Nile and anchor		Rigid clay	6-8
1- Reciprocal inhibition and shotcrete 2- Truss structures and shotcrete 3- inhibition 4- pilling		Rigid clay	8-10

Table 3: Second Case Study of Mellat Alley in Ahvaz

Underground water level: 2 meters	**Speculations location: Mellat Alley**	**Case study No. 2**	
Guardian structure offer (Are numbered in priority order)		**Soil Type**	**Depth Meter**
1- It's sustainable with consideration of supervisor's approval. 2- Reciprocal inhibition implementation		Very rigid clay	0-2
1- Reciprocal inhibition (Crooked or horizontal) 2- truss structures in case of meeting the requirements		Very rigid clay	2-4
1- Reciprocal inhibition (Crooked or horizontal) structures in case of meeting the requirements and shotcrete 2- truss structures in case of meeting the requirements and shotcrete		Rigid Clay	4-6
1- Reciprocal inhibition structures in case of meeting the requirements and shotcrete 2- truss structures in case of meeting the requirements and shotcrete 3- Nailing with two layers of shotcrete for more- strength of wall		Rigid Clay	6-8
1- Reciprocal inhibition and shotcrete 2- Truss structures and shotcrete 3- Inhibition 4- pilling		Rigid Clay	8-10

Table 4. Third Case Study: University settlement

Groundwater Level: 2 m	**Speculations Location: University settlements**	**Case study number 3**	
Guardian structure offer		**Soil Type**	**Depth Meter**
1- stepped excavation and implementation of heels foundation 2- Inhibition implementation with technical rules		rigid clay	0-2
1- stepped excavation and implementation of heels foundation 2- Reciprocal inhibition (Croocked or horizontal) in necessity of shotcrete 3- Truss structures in case of necessity of shotcrete		Average clay	2-4
1- Reciprocal inhibition and shotcrete 2- Truss structures and shotcrete 3- Berlani wall 4- pilling		Average clay	4-6
1- Reciprocal inhibition and shotcrete 2- Truss structures and shotcrete 3- Berlani wall 4- pilling		Average clay	6-8
1- Reciprocal inhibition by fixing the wall (meshing and shotcrete) 2- Truss structure by fixing the wall (meshing and shotcrete(3- Berlin Wall and boarding or meshing and shotcrete between columns 4- pilling		Sandy sediment	8-10

Table 5. Fourth Case Study-Way bureau area

Groundwater level: 2.7 m	**Speculations Location: Way bureau area**	**Case study number 4**	
Guardian structure offer		**Soil Type**	**Depth Meter**
1- Reciprocal inhibition (Crooked or horizontal) structures in case of meeting the requirements and shotcrete 2- truss structures in case of meeting the requirements 3- and shotcrete		Soft clay Micro soil	0-2
1- stepped excavation and implementation of heels foundation and shotcrete 2- Reciprocal inhibition (Crooked or horizontal) in case of necessity of shotcrete 3- truss structures and in case of necessity and shotcrete		Soft clay	2-4
1- Reciprocal inhibition and shotcrete 2- Truss structures and shotcrete 3- Berlani wall 4- pilling		Average clay	4-6
1- Reciprocal inhibition and shotcrete 2- Truss structures and shotcrete 3- Berlani wall 4- pilling		Average clay	6-8
1- Reciprocal inhibition by fixing the wall (meshing and shotcrete(2- Truss structure by fixing the wall (meshing and shotcrete(3- Berlin Wall and boarding or meshing and shotcrete between columns 4- pilling		Sandy sediment	8-10

Table 6. The Guardian construction methods offer

Consideration	**Cost**	**Dig protection method**	**Deep of digging Meter**
Optimal quality	Low	1- stepped excavation and implementation of heels foundation 2- croocked reciprocal inhibition	**0-2**
Optimal quality	Low	1- stepped excavation and implementation of heels foundation 2- Reciprocal inhibition (Crooked or horizontal) structures in case of meeting the requirements 3- truss structures in case of meeting the requirements	**2-4**
Optimal quality	Low average	1- Reciprocal inhibition (Crooked or horizontal) 2- and shotcrete 3- truss structures and shotcrete	**4-6**
It must be applied by computing engineer idea	Low average	1- Reciprocal inhibition in case of meeting the requirements 2- and shotcrete 3- truss structures in case of meeting the requirements 4- and shotcrete 5- Nailing with two layers of shotcrete or performing Nile and anchor	**6-8**
It must be applied by computing engineer idea	Low average	1- Reciprocal inhibition in case of meeting the requirements 2- and shotcrete 3- Truss structures in case of meeting the requirement and shotcrete 4- Nile and anchor design 5- pill and inhabitation of 6- Berlin Wall and anchor	**8-10**

CONCLUSION

According to questions and hypotheses which were made initially for the researcher ,a lot of information in all fields and about research's questions and hypotheses collected and were assessed and were analyzed as well the obt5ained results summarized as below:

1-It's possible to find the type of the soil and its textures by speculations and getting the geotechnical information about various structures, including residential, commercial and service structures and as the researches showed, by identifying type of soil and underground water level amount different kind of deep protection can be applied.

2-Digging to a depth of 1 m for sand, 12/5 meter for clayey sand, 1/5 meter for clay and 2 meter for dense soil without safety pins, bumper and fender can be done in lands with natural moisture. In another cases, necessary safety precautions are taken according to some issues like soils type, digging depth and surrounded traffic condition.

3-Based on done studies and researches, deep protection systems are including: Shot Crete, Nailing, Reciprocal inhibition, truss structures, inhibition, Diaphragm wall, tai back and pilling which sometimes based on soil's type and its stagnation, the combination of it can be used as well.

4-Administrative and Management point of mentioned items is so important which is indicated recommendation, the construction manager's point of view such as time, cost, quality, speed of implementation , human Resource Management and equipment have been considered which has more significance from researcher's point of view and it means that in issue f guardian structures which is including safety and dig sustainability ,the quality must not be sacrificed for time and cost.

In continue, following proposed methods were recommended based on lack or loss of guardian structure's administrative and technical force and in special cases in which major difference has been considered with type of soil or in other depend condition ,so it must be revised and declare by expert.

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