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Construction of diaphragm wall using grab system and sealing the executive joint by CWS method in Ahvaz Subway

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ABSTRACT

The plan of urban subway of Ahvaz as the biggest urban transport system in Khuzestan province include four lines with a length of approximately 70 km that was designed by Kayson using EPC engineering method. Construction is done by the purpose of building route of line 1 as the main line with the length of approximately 23 km that connect the Northeast part of the city to the Southwest by passing the central part of the city and Karoon River. This route includes 24 stations in which currently the executive operations of line one is on the process. One of the properties of Ahvaz city that causes dullness in building the station is the high groundwater level that reaches the water by two meters of excavation, in this situation of 18 or 19 meters deep excavation in addition to facing water the risk of water-bearing soil is also a plus. In this project, Kayson Company has increased the speed of performance trend by buying three hydraulic grab excavating machines that is one of the newest of the kind. This machine works in a way that first, the place of armature baskets are excavated with a specific depth and thickness and by applying the pre-knitted armature baskets the operation of concreting wall takes place that these concrete walls are the station's major walls that are sealed and prevent entering water into the station. By finishing the station's excavation, the operation of building station will start in a specific depth.

KEY WORDS: Hydrophers, CWS, grab, stopend mold

1. INTRODUCTION

Excavation takes place in the grounds that all or part of the building is built lower than the natural ground level that sometimes the excavation depth may reach to a few meters according to the ground's material. Excavation is done in two methods; excavation in unlimited grounds around which there is no building or in limited grounds around which there are some buildings [1]. To excavate urban subways' half deep and deep stations, the protection of hole's wall is done before or at the same time as excavating operation by using different methods such as wooden shield, metal shield (pile sheet), pre-made concrete shields, candle performance and diaphragm wall performance by attending to the region's condition, nature and the ground's material. Protecting the hole's wall in Ahvaz urban subway project with diaphragm wall method is done by using grab system. This will prevent causing extra cost for performing maintenance walls. In fact the structure that is performed by grab, are the major walls of the system. However, at the beginning of the project, to prevent delay in time table until the time of grab system delivery, the method of candle is used to protect the stations of gate hole, olive, oil and airport.

2.Diaphragm wall method

Diaphragm or slurry walls are the built armed and unarmed concrete walls under the ground level that are built in order to stabilize stations' walls. This wall as the external wall of station's region is mainly for preventing water leak and soil pour [2]. To built this wall hydrophers and grab system that is the most important excavating system in building diaphragm walls, is mainly used.

2.1. Excavation by using hydrophers

This system is for excavating the soils without adherence and hard stones. Hydrophers is an excavating system that works with three engines (lower hole) on the top of hydrophers frame, (guide frame) and by using the rotating system of excavating mud.

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Figure 1: Hydrophers system

2.2.Excavation by using grab system

Another method is building structural wall using grab system that in this method the built wall is the station's major wall. Its executive joints' sealing is done by different methods such as palate and tang, plastic candle, concrete pre-made bar and June pipe (Coffrage avec water stop) CWs.

In Ahvaz urban subway project by attending to the ground material, two types of grab were bought. Grab C800 for excavating in northern section and grab B250 for excavating in southern area that has looser soil; because this kind of machine has high depreciation in hard grounds. It is clear that grab C800 has the ability of excavation in southern section. In total three grab systems were bought; that two C800 hydraulic grab machines built by Kasagrande-Tak Company, that the digging section (BAYA-Clamshell) was made by TEC Company and the machine's body was built by Kasagrande Company and one B250 overview grab system made by Kasagrande Company. Figure (2) & (3)

Figure 2: two grab systems of Kasagrande-Tak Company

Figure 3: overview grab system B250

3.Performance operation of building diaphragm wall

In this paper, performance operations of building diaphragm wall such as digging, reinforcement, executive joints' sealing and concerting are mentioned that below schematic representation of diaphragm wall by using grab system is shown (figure 4).

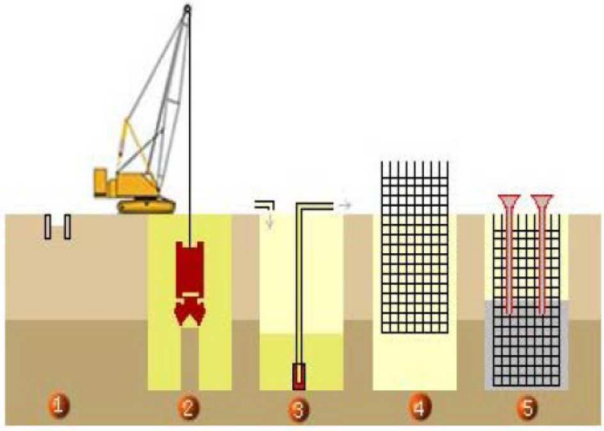


Figure 4: Schematic view of the implementation of diaphragm wall using grab

(1- Implementation of Help walls 2-Excavation by grab 3-Cleaned in place of bentonite 4-Reinforcement 5- concreting)

3.1. Drilling operations

To start digging operations, after leveling and removing the level's opponents, the loose and plant soil in guide wall's performance limit is taken and after identifying and equipment deviation and underground complications, nested with wall attempts to perform guide wall in a suitable bed. The purpose of making the guide wall is the possibility of an exact performance of diaphragm wall in the considered place and its vertical performance in the basic place of digging and continuing it and also preventing the wall pour at the time of digging operation performance and concreting. Then in order to have an easier performance of diaphragm wall, this wall is divided into smaller parts named panel. The dimensions and figure of the panels are designed and performed in different shapes such as L, U, T, I,… according to the condition of the region's ground, the depth of performing wall, the situation of performing panel in structure and the kind of digging equipments.

Digging in small panels is done in the form of one step and in higher panels it is done up to three steps. This way for digging each panel, it is divided into smaller pieces called Bart, the number of Barts depends on the length and grabs Clamshell's dimensions, the size of each Bart at most equals to the length of digging Clamshell length. In Ahvaz urban subway stations each panel is usually divided into three Barts. The Bart digging in its two bottoms equals to the Clamshell length (270 cm for C800 grab and 250 cm for B250 grab) and one middle Bart has a length less than Clamshell length.

The method of digging operation is that after digging and concreting performance, the panel guide wall that is seven meter high, is divided into three parts as figure 5. First, the grab system is placed in the first Bart place, leveled and starts digging, and then the machine is transferred to the second and third Bart. This way a panel is drilled. Then the machine digs the next panel. At the same time as digging each Bart, to prevent hole pour and stabilizing the Bart's walls while digging, Bentonite solution is frequently lead into the hole. The main role of digging mud, is saving the stability of drilled trenching against lateral pressures resulted from underground water, soil and the overhead on the platform that this action is done by forming a Bentonitecake[3].

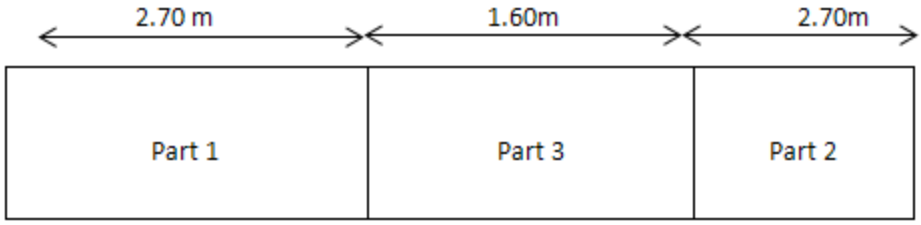


Figure (5), the schematic figure of a 7 meter length panel

3.1.1. In general drilling the diaphragm wall's panels is done in two methods that are as follow;
3.1.1.1. Performing panels as interlaced: in this method at first the initial panels of the two heads of performance joint are drilled and concreted with determined gaps (interlaced) and then the secondary panels are performed in the space between them (figure 6).
3.1.1.2. Performing panels neighboring each other: in this method, firstly the panel is drilled and concreted. Then next panel is drilled and concreted next to that. In park and cross over station, the airport station of panel drilling is done next to each other. In figure (7) the schematic representation of panel performance is shown linearly.

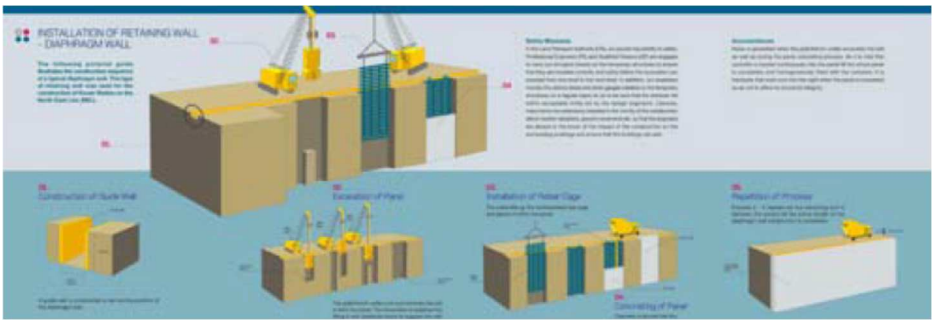


Figure (6) the schematic representation of panel performance as interlaced

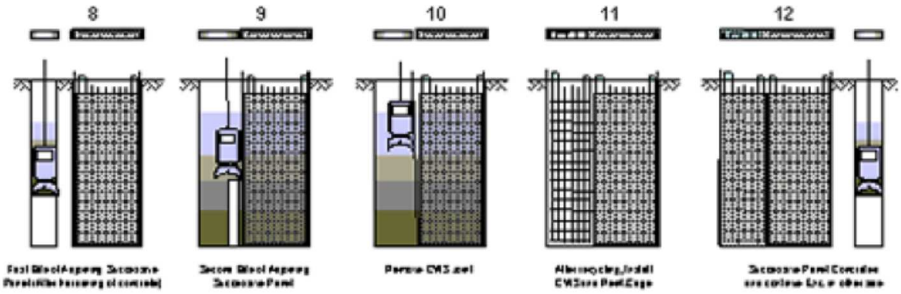


Figure (7) the schematic representation of panel linear performance

3.2.Reinforcement

The reinforcement baskets are designed based on cranes' capacity, performance observations and panels' length. Two or three individual baskets may be found based on the relevant plans and be used in panel.

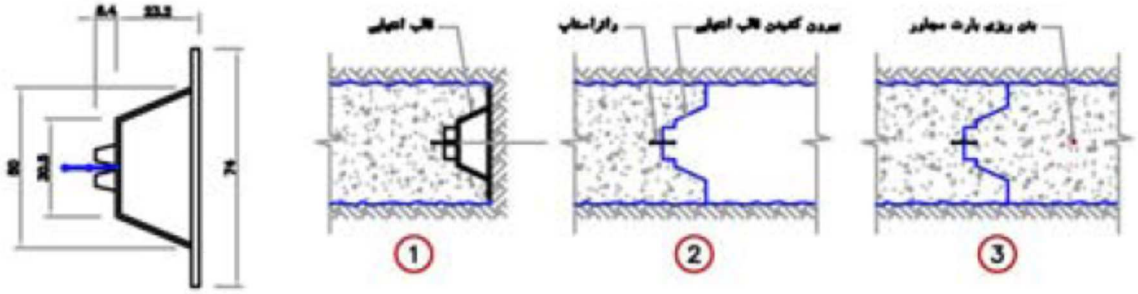
In addition, due to the impossibility of placing the expecting fitting with required length on diaphragm wall's basket, the common method of fitting patch can not be used, so for connecting foundation armatures and the floors' ceiling to the diaphragm wall of around station in Ahvaz urban subway project, mechanical connections will be used (figure 8).


Figure (8) reinforcement baskets accompanied by mechanical joints

3.3. Executive joint sealing

By attending to the high level of underground water in Ahvaz (almost 1-2 meter from ground level); sealing the executive joints has a great importance. For sealing joints between panels, different methods such as using June pipe, plastic concrete, pre-made bar (either concrete or metal) and CWS method are used. In Ahvaz urban subway project, CWS method (that is a modern and updated method in the world and it is performed by Kayson Company for the first time in Iran) is used. In this method, after drilling panel, the two sides of Stop end that surrounds water stop, is placed on two sides of the panel in a way that the Stop end is installed at the bottom of drilling and then concreting takes place. Figure (9), (10) and (11)

Figure (9) installing water stop inside the Stop end



Figure(10) steps of water stop installation at the end of the panel

Figure(11) installation of stop end

3.4. Concreting

After installing the Stop end of the two sides of panel and locating armature baskets, the concreting operations start. Since concreting is done in submerged depth, a periodic pipe is needed to protect concreting and decreasing its quality. At the time of concreting and for preventing Bentonite grout penetration in the concrete poured in the panel, the depth of periodic pipe penetrationin concrete must be regulated in a way that at least two meter always remain in the concrete. Concreting must continue up to the balance on guide wall or the height of diaphragm wall in order for the dirty concrete that is contaminated, to be located in higher level and destroyed later to connect the armatures of the first ceiling[4]. Figure (12) and (13)

Figure (12) concreting of diaphragm wall by shoot and two tremie pipes

Figure (13) diaphragm wall of park station after excavation

4.The performance problems of diaphragm wall

4.1. According to the design results, based on the required height (up to 60 meters), some stations will have some problems for digging, locating basket and concreting to perform diaphragm wall with the sickness of 80 cm.

4-1-1. Drilling and trench stability

Increasing the wall's depth creates major problems in drilling possibility and saving trench stability. Table 6 the use case in Ahvaz project is observed. Based on this, the most possible drilling depth with these TEC specifications of grab machine is 50 meters. Therefore, drilling walls with the depth of more than 50 meters by the existing machines are impossible [5]. Moreover, by increasing the drilling depth, the pressures made of underground water and soil on trench will increase and for preventing its wall's hole pour, the used Bentonite grout must have an acceptable quality. By attending to the major part of drilling inclay and silt layers, the possibility of drilling mud's pollution is

resulted from the high entrance of clay and silt fine. In addition to that due to the big height of drilling the time of Bentonite mud's stay in trench increases that this case may surge the thickness of Bentonite cake and as a result grow the possibility of wall pour.

Table 1: specification of grab TEC

Possibiliotesd'excavation	Excavation Possibilites		
Profondeur maximum	Maximum depth	164ft (230ft,option)	50m(70m, option)
Epaisseurs en 2700mm	Thickness in 106.3 in	19.7 to 59 in	500 a 1500mm
Epaisseurs en 3200mm	Thickness in 126 in	23.6 to 59 in	600 a 1200mm
Epaisseurs en 3600mm	Thickness in 141.7 in	23.6 to 59 in	600 a 1200mm
Epaisseurs en 4200mm	Thickness in 165.4 in	23.6 to 47.2 in	600 a 1200mm
Synchronisationdesgodets	Bucket synchronization	Yes	Oui
Trepan incropore	Incorporated chisel	Yes	Oui
Benne hydraulique	Hydraulic grab		
Capactitedesverins	Hydraulic jack capacity	187000Lb	82000daN
Force en bout de dent	Force at the end of the teeth	125000Lb	55000daN
Positionnement pan joint toumant	Positioning with turning joint	Yes	Oui
Possibilites de depart	Departure Possibilites	0 to 90"	0 a 90"
Demi – tour automatique	Automatic half turn	0 to 180"	0 a 180"

Furthermore, in case of likely hitting of drilling with hard or stone layers, in a way that drilling with grab made possible, drilling hammer or trepan is used. In this case the hard layer is fined by trepan and then the crushed materials are exited by grab.

4.1.2. Placing basket

By attending to the considerable amount of made moments in wall level (190 body meter in width unit), the needed amount of armature for each Bart will be considerable that will increase the armature network's weight and cost. Also, due to the big depth of wall, the armature cage must be made in 4 or 5 network that performing these networks and their connection is so time consuming.

4.1.3. Concreting

Each 6 meter panel will have almost 255 M^3 of concrete that based on the predicting 40 M^3 concreting in an hour, concreting each panel will be almost 6 and a half hours.

4.2.In low quantitiesthe performing cost is very high but in high quantities the total cost of performing the work can be less than simple methods.

4.3.In this method the relevant drilling machines need a large amount of working environment and if there is a limitation in the two sides of wall, the work performance is impossible or it will be done very hard.

4.4.In this method special drilling machines are needed.

4.5.Using this method in deep holes (more than 10 meters) without using horizontal tools is impossible.

4.6.Using this method in fine soil is very difficult.

RESULT

By attending to the executive trend of diaphragm wall with the help of drilling machines, this kind of wall for urban areas that replacing wall's back is very important for the neighbor structure of the hole, is a pleasant option. Additionally, due to causing less noise and more limited shake comparing to the other options such as intersecting candle, it is preferred. The diaphragm wall is sealed and will ease drilling hole at the presence of underground water. The speed and security of the performance method are also high. Creating an impermeable level around trench or hole and also minimizing the soil replacement at the back of the wall are the other advantages of this method.

Diaphragm wall is suitable for drilling and holes with big length. Additionally, this wall will work as a structure of hole or trench guard and also at the time of benefiting from it, the wall is used as a porter wall. So in this method the workforce with high specialty for working with the mentioned machines and other cases is needed.

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