

Erection of Diaphragm Wall via Open Trench

Pusplata¹, Sonam Kumari²

¹M. Tech. Scholar, Department of Civil Engineering, Ganga Institute of Technology and Management, Jhajjar, Haryana, India

²Assistant Professor, Department of Civil Engineering, Ganga Institute of Technology and Management, Jhajjar, Haryana, India

Abstract: *The Construction of Elevated or Ground Structures are simple in comparison to the construction of Under Ground Structures like Basements, Tunnels, Under Ground Car Parking, Underground Metro Stations, Subway, etc. It becomes more risky when it has to construct near about huge ground structures without Deep Foundations. Due to this surrounding Structures Shoring arrangement of these areas became headache for Construction to the Every person involved in it. Therefore, the Construction of Diaphragm Wall became a boon for Civil Engineering to tackle the problems occurs during construction of Under Ground Structures. This Review paper addresses the brief introduction and over view of the Diaphragm Wall, Necessity, Applications, Machineries required, Safety and Quality Measures about the Diaphragm Wall for its efficiently construction. Difference between Diaphragm Wall And Retaining Wall are also discussed.*

Keywords: Diaphragm Wall, Safety and Quality Measures, Retaining Wall, etc

1. Introduction

The Diaphragm wall technique was first introduced during the excavation of Line 1 on the Underground Rapid Transit System of Milan, Italy by the company ICOS (Impresa Costruzioni Opere Specializzate) in 1948. This new technology became an important component of the top-down tunneling method also known as *Metodo Milano*

A **Diaphragm wall** is a civil engineering technique used to build reinforced concrete walls in areas of soft earth close to open water, or with a high groundwater table. This technique is typically used to build diaphragm (water-blocking) walls surrounding tunnels and open cuts, and to lay foundations.

While a trench is excavated to create a form for a wall, it is simultaneously filled with slurry (usually a mixture of bentonite and water). Nowadays Poly mud Slurry is instead of Bentonite Slurry, it is avoided due to its bad Environmental Effects and unsafe working conditions. The dense but liquid slurry prevents the trench from collapsing by providing outward pressure, which balances the inward hydraulic forces and also retards water flow into the trench.

In past years, Diaphragm walls are typically constructed by starting with a set of guide walls, typically 1 metre (3 ft 3 in) deep and 0.5 metres (1 ft 8 in) thick. The guide walls are constructed on the ground surface to outline the desired slurry trench and guide the excavation machinery. Excavation is done using a special clamshell-shaped digger or a hydromilltrenchcutter, suspended from a crane. The excavator digs down to design depth (or bedrock) for the first wall segment. The excavator is then lifted and moved along the trench guide walls to continue the trench with successive cuts as needed. Nowadays Hydraulic Grab machines are used for trenching work. The trench is at all times kept filled with slurry to prevent its collapse, but the liquid filling allows the excavation machinery and excavation spoil to be moved without hindrance.

Once a particular length of trench is reached, a reinforcement cage is lowered into the slurry-filled pit and the pit is filled with concrete from the bottom up using tremie pipes. The heavier concrete displaces the

bentonite or Poly mud slurry, which is pumped out and stored in tanks for use in the next wall segment, or recycled.

Diaphragm walls are successively extended to enclose an area, blocking water and softened earth from flowing into it. Once the concrete has hardened, excavation within the now concrete-wall-enclosed area can proceed. Stability of the trench is essential in trench cutting. Usage of Poly mud Slurry with precise density prevents collapse of trench walls.

Diaphragm Wall- its necessity & requirements

The Diaphragm Wall construction technique is an advanced Civil Engineering technique. Mainly its necessity for typical Underground structure construction.

It is a very advanced technique and costly also. Skilled persons are required to perform that activity. Therefore it is not required in ordinary cases. It became necessary in following conditions.

- Very unstable soil profiles below the water table.
- Limited construction time.
- Working below a highway without its stoppage.
- Where deeper than normal cantilever support may be required.
- Limited Construction space available.
- Top-Down Technique primary requirements.
- In case of High Ground Water Table.

Diaphragm (Structural) Wall Applications

- Earth retention walls for deep excavations, basements, and tunnels.
- High capacity vertical foundation elements.
- Retaining wall-foundations.
- Retaining wall-water control.
- Used in top-down construction method as permanent basement walls.

Machineries

The construction of Diaphragm Wall can't be think without the help of Machineries. Lots of Machineries required for

the construction of Diaphragm Wall. There are following machineries given below:

Grab Machine: -The machine required for Trenching Process. Casagrande started manufacturing equipment for diaphragm walls in 1963. Over the years, it has developed a complete range of machines in order to satisfy the contractor's requirements. Requests for a special machine to excavate efficiently in medium hard to soft soils led to the development of the KRC and grab type K combination. This equipment guarantees superior productivity and makes control of verticality easy in the excavation of diaphragm wall panels and barrettes. The KRC can get into tight corners; a turntable enables the Kelly and the grab to be rotated 45° or 180°, easy transportation without dismounting and quick assembly without service crane. Latest introduction is the hydraulic rope suspended grab system KG25.



Cranes: - These are required for Lifting of Reinforcement Cage and other accessories.



Backhoe Loader: - This requires for lots of work at site, without this work at site not possible, because its requires in lots of activities. Like Disposal of Excavated Soil, Levelling of Ground for machineries Movement.

Compressor: - An air compressor is a device that converts power (using an electric motor, diesel or gasoline engine, etc.) into potential energy stored in pressurized air (i.e., compressed air). By one of several methods, an air compressor forces more and more air into a storage tank, increasing the pressure. When tank pressure reaches its engineered upper limit the air compressor shuts off. The compressed air, then, is held in the tank until called into use. The energy contained in the compressed air used for mixing of Bentonite or Polymud Slurry, utilizing the kinetic energy of the air as it is released and the tank depressurizes. When tank pressure reaches its lower limit, the air compressor turns on again and re-pressurizes the tank.

KODEN machine: - Recent progress and development in foundation engineering has resulted in great strides in excavation techniques. By using artificial slurry of high density and specific gravity, deeper excavation has been made possible. The DM602R/604R series Drilling Monitor system has been developed in compliance with the user's needs arisen from the recent construction environment to accurately measure and record the shape of a drilled hole of greater depth. It can be easily positioned and set up for measurement to provide quick and accurate recordings of excavations. The DM602R/604R series Drilling Monitor provides the following advantages. Helps improve the quality of a drilled hole through judging the verticality of hole and reduces working time and cost. Provides onsite records of the perpendicularity of drilled holes and the shape of cross sections in high accuracy. There are following Features of the Machines are given below.

- The DM-602R/604R supplies clear records of a drilled hole even in slurry, heavily contaminated with dirt and sand.
- The DM-602R/604R supplies clear and precise records thanks to its unique signal processing technique that discriminates wall echoes from the noise.
- The DM-602R/604R has the facility to cancel the oscillation line echo that often prevents very close echo recordings.
- The sensor device is automatically controlled to stop at the casing and at the bottom of the hole. An emergency return function is also included.
- Depth range mark, depth mark, drilled hole mark, date, time, etc. can be printed on the recording paper.
- Limit switches are provided to avoid possible wire breakage or entanglement of the wire and cable.
- The recorded result can be output to an external PC via a built-in RS 232C output port.
- A non-fuse circuit breaker is used for circuit protection, eliminating the need for cumbersome fuse replacement at the construction site.



Difference between Diaphragm Wall & Retaining Wall

The Purpose of Both Diaphragm Wall & Retaining Wall are almost same to retain the Lateral pressure of Earth surrounding it. But there is lots of difference in their construction technic and working. Retaining Walls required more construction Time. A Length of around 5m is constructed in a single time from top to bottom. Diaphragm wall is an advanced and typical method. There are some following differences given below.

Table: Difference between Diaphragm Wall & Retaining Wall

S.no.	Diaphragm wall	Retaining wall
1.	Constructed via Open Trench	Constructed after full excavation
2.	Required Polymud slurry for excavation	Required Support for excavation
3.	Reinforcement cage is to be lift & Lowered inside the trench	Reinforcement are fixed at casting Place.
4.	Using Surrounding Earth as Shuttering	Requires Shuttering and Supporting.
5.	Excavation should be straight.	Excavation Requires Slope.
6.	Casting through Hopper & tremie arrangement with crane	Casting is Simple for placing of Concrete, can be manually or Static Pump and piping or Boom Placer

2. Analysis of Site Conditions

Before proceeding to any work analysis of site conditions are very necessary for efficiently construction of Diaphragm wall. Load intensities of surrounding structures their foundations detail, utilities, Geotechnical investigation, underground water quality measures to be verified.

Safety Measures

To Control accidents and hazards at Site, We have to set to Safety Measures a site before proceeding to any Work. The work has been to be carried out by workers and followed Engineers or Supervisors. Therefore, they have to be thorough knowledge about Safety measures to be followed.

To Control accidents or hazards at site following safety measures to be follow:

- Daily Tool Talk Box Meeting (activity wise).
- Risk assessment to be prepared by Safety Engineer before proceeding to any work.
- Safety precaution to be followed at site

Quality Measures

Different types of material are used in the construction of Diaphragm Wall. Therefore, quality measures to be set according to materials consumed during the activities.

Polymud Slurry play a great role in the construction of Diaphragm wall. This slurry act as shoring to prevent collapse by hydraulic pressure and thyrrotrophic Property. Therefore it's to be measured time to time very carefully. Its Quality Measures are:

Parameters	Fresh Mix	Reused Slurry	Before Concrete Pour
Viscosity (sec.)	65-140	65-140	50-140
Density (kg/m ³)	1.00-1.04	≤1.08	≤1.04
Sand Content	-	≤2%	≤2%
Ph value	11-12	11-12	9-12

Cement is a binder, a substance used for construction that sets, hardens and adheres to other materials, binding them together. Cement is Main content of Concrete. The different Tests on Cement are:

- Color test
- Presence of lumps
- Adulteration test
- Temperature test
- Float tests
- Strength test
- Setting test

Sand is a granular material composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. The different test on Sand are:

- **Organic impurities test** – this test is conducted at the field, for every 20 cum or part thereof.
- **Silt content test** – this is also a field test and to be conducted for every 20 cum.
- **Particle size distribution** – this test can be conducted at site or in laboratory for every 40 cum of sand.
- **Bulking of sand** – this test is conducted at site for every 20 cum of sand. Based on bulking of sand, suitable water cement ratio is calculated for concrete at site.

Table: Gradation Sand

IS Sieve	Percentage passing for			
	Grading Zone I	Grading Zone II	Grading Zone III	Grading Zone IV
10mm	100	100	100	100
4.75mm	90 – 100	90 – 100	90 – 100	90 – 100
2.36mm	60 – 95	75 – 100	85 – 100	95 – 100
1.18 mm	30 – 70	55 – 90	75 – 100	90 – 100
600 micron	15 – 34	35 – 59	60 – 79	80 – 100
300 microns	5 – 20	8 – 30	12 – 40	15 – 50
150 microns	0 – 10	0 – 10	0 – 10	0 – 15

Table 4.3.2: below gives the relation between moisture content and percentage of bulking for guidance only.

Moisture content (%)	Bulking percentage (by volume)
2	15
3	20
4	25
5	30

Coarse Aggregate particle size vary from 4.75mm to 75 mm. These occupy at least three quarters of volume of concrete. Quality is especially important. The different test on coarse aggregate are:

- Impact Value test
- Los Angeles abrasion Test
- Specific Gravity Test
- Water absorption test
- Deleterious Substance in aggregate
- Soundness of aggregate
- Fineness Modulus
- Gradation

Admixtures have become an important part of everyday concrete production. Thanks to admixtures we are able to alter the performance of concrete in ways that previously were not possible. There are several types of admixtures such as:

- **Water Reducing Admixtures** (low range, mid-range and high range) that allow you to reduce water in concrete, therefore increasing the strength of the concrete
- **Retarding and Accelerating Admixtures** allow you vary the setting time of the concrete
- **Shrinkage-Reducing Admixtures** are used to minimize shrinkage in concrete and subsequently the tendency of cracking
- **Alkali-Silica (ASR) Suppressing Admixtures** help mitigate or suppress ASR
- **Air Entraining Admixtures** which allow the concrete producer to control the amount of air in a concrete mix. The air content in concrete often determines how well it will withstand freezing and thawing.

Concrete, usually Portland cement concrete is a composite material composed of fine and coarse aggregate bonded together with fluid cement (cement paste) that hardens over time. The different tests on concrete are:

- Workability
- Setting time
- Rapid chloride permeability test
- Compressive Strength
- Permeability Test

Steel Reinforcement bars are used in reinforced concrete and are one of the main parts of R.C.C. structure. For that reason, quality of plain and deformed bars should be checked specially for yield, ultimate strength and elongation (ductility). The different tests on concrete are:

- Tensile Test
- Bend Test
- Quantitative Chemical Analysis

Alfa bond

The cross-linking characteristic of Alfa-Bond/reg; provides the industry's first 'intrinsic-binding' polymer system. In addition, Alfa-Bond/reg; polymers instantaneously bind to soil particles and reinforce the overall stability of the excavation.

Micro bond

Micro-Bond is the newest component of the 'G3' System. This liquid polymer promotes 'micro-bonding' of the Poly-Mud and Alfa-Bond polymer molecules, to generate a unique 'three dimensional framework' of polymer stability. Micro-Bond is primarily used when difficult or unpredictable soil conditions are encountered. Intrinsic data shows improvements in slurry performance and characteristics when Micro-Bond is incorporated into the 'G3' System.

3. Conclusion

- The Construction of Diaphragm Wall became a boon in construction of Under Ground Structure.
- It is costly in comparison to construction of Retaining Wall, but overall efficient due fast & secure construction technique.

- It's emerging a Top- Down construction technique, which does not require Shuttering and supporting.
- It's mandatory to follow its Safety & Quality Measures for safe, secure & efficient construction.

References

- [1] M. S. Shetty, "Concrete Technology: Theory and Practice", S. Chand Publications, 1982.
- [2] S. Unnikrishna Pillai, Devdas Menon, "Reinforced Concrete Design", Tata Macgraw- Hill publications, 2009.
- [3] Petros P. Xanthakos, "Slurry Wall As Structural System", Tata Macgraw- Hill publications, 1993.