IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684, p-ISSN: 2320-334X
PP 45-50
www.iosrjournals.org

CONSTRUCTION OF COFFERDAM -A CASE STUDY

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ABSTRACT**:** *This paper presents an overview of the present state of construction of cofferdam techniques with special emphasis and a brief on other techniques developed world over for mitigating hydraulic forces on the temporary structures. A cofferdam is a temporary structure designed to keep water and soil out of the excavation in which a bridge pier or other structure is built. When construction must take place below the water level, a cofferdam is built to give workers a dry work environment. Sheet piling is driven around the work site, seal concrete is placed into the bottom to prevent water from seeping in from underneath the sheet piling, and the water is pumped out. There are different types of cofferdam, some are used to support excavation operation and some are enclosed type box placed in the water.* The present case study deals with step by step procedure adopted at Pipav Port, Rajula District, Gujarath. It depicts the intricacy of the management of the work at site and gives lot of insights to such similar works involving details of bentonite slurry, rock bund, planning and execution of interlocking sheet piles, reinforcement, concreting, plants and equipment, safety procedures to be adopted for the construction of cofferdam.

Keywords: *Anchors, Bentonite, Capping beam, Integrated piling ring, Sheet piles.*

I. INTRODUCTION

The word"cofferdam" comes from "coffer" meaning box, in other words a dam in the shape of a box.Cofferdams are temporary enclosures to keep out water and soil so as to permitdewatering and construction of the permanent structure in the dry.A cofferdam involves the interaction of the structure, soil, and water and the loads imposedinclude the hydrostatic forces of the water, as well as the dynamic forces due to currents and waves.In construction of cofferdams maintaining close tolerances is difficult since cofferdams are usually constructed offshore and sometimes under severe weather conditions [1].

1.1 Types of cofferdam

1. Braced:It is formed from a single wall of sheet piling which is driven into the ground toform a “box” around the excavation site. The box is then braced on the inside and theinterior is dewatered. It is primarily used for bridge piers in shallow water (30 - 35 ftdepth).

2. Earth-Type**:** It is the simplest type of cofferdam. It consists of an earth bank with a lay core or vertical sheet piling enclosing the excavation. It is used for low-level waters withlow velocity and easily scoured by water rising over the top.

3. Timber Crib: Constructed on land and floated into place. Lower portion of each cell ismatched with contour of river bed. It uses rock ballast and soil to decrease seepage andsink into place, also known as “Gravity Dam”. It usually consists of 12’x12’ cells and isused in rapid currents or on rocky river beds. It must be properly designed to resist lateralforces such as tipping / overturning and sliding.

4. Double-Walled Sheet Pile: They are double wall cofferdams comprising two parallelrows of sheet piles driven into the ground and connected together by a system of tie rodsat one or more levels. The space between the walls is generally filled with granularmaterial such as sand, gravel or broken rock.

5. Cellular: Cellular cofferdams are used only in those circumstances where the excavationsize precludes the use of cross-excavation bracing. In this case, the cofferdam must bestable by virtue of its own resistance to lateral forces [1].

1.2 Advantages of Cofferdam

Performing work over water has always been more difficult and costly than performing thesame work on land. And when the work is performed below water, the difficulties and costdifference can increase geometrically with the depth at which the work is performed. The keyto performing marine construction work efficiently is to minimize work over water, andperform as much of the work as possible on land [2].

Below some of the advantages ofcofferdams are listed:

- Allow excavation and construction of structures in otherwise poor environment
- Provides safe environment to work
- Contractors typically have design responsibility
- Steel sheet piles are easily installed and removed
- Materials can typically be reused on other projects

1.3 Cofferdam Components

- Inter locking sheet piles
- Capping beam
- Inclined Anchors

1.4 Bentonite slurry

Bentonite slurry is one of the most common excavation fluid used in constructing pile foundations. Bentonite clay (in powder form) and water are combined in a colloidal mixer and clay particles bond to each other and set to form a gel when left to stand for a period of time. When the bentonite is set in motion, it reverts back to the fluid state rapidly.

Bentonite slurry shores the trench to stabilize the excavation and forms a filter cake on the slurry trench walls that reduces the slurry wall's final soil permeability and to reduce ground water flow. The gel strength and viscosity properties of the bentonite clay allow for cutting suspension and removal [2].

II. CONSTRUCTION PROCEDURE

The purpose of this method is to ensure that the project is understand and is used effectively for execution and also in providing status reports for managing, monitoring, and coordinating the work.

2.1 Fixing of alignment for cofferdam

Alignment of cofferdam shall be fixed on the ground with the help of total station as per the relevant drawing. Proper alignment of cofferdam shall be maintained by means of temporary steel pegs.

2.2 Construction of rock bund

Construction of rock bund with 4m top width and 1:1 side slopes. Rock bund will start by filling of boulders from the one end of diaphragm wall. Boulders will be transported from quarry to the cofferdam location by dumpers.

2.3 Temporary earth fill

Filling of temporary earth fillfor cofferdam and entrance gate will start parallel to the rock bund. Earth will be transported from barrow pit to the cofferdam location to by dumpers.The earth bund will be constructed in such a way that the top width of the bund should be 10m (5 m on both sides of the center line of pilling) wide with side slopes of 2H: 1V.Leveling and dressing will be carried out with the help of excavator if necessary.The earth filling will be carried out in the both ways to avoid the traffic congestions and to accelerate the work process.

2.4 Interlocking sheet piles

Driving of interlocking sheet piles will start from the east side the south dock with the help of crane with vibro hammer on completed portion of temporary bund. The driving of piles will start on approximately 70% completion of the temporary bund filling of avoid the traffic congestion during the pilling.

2.41 Driving of interlocking sheet piles: The crane with vibro hammer will continue the driving of interlocking sheet piles along the centerline of the cofferdam.

2.42 Boring: The integrated piling ring will start pile boring on driven sheet piles. Pile boring will be start in such a way that boring should not disturb the interlocking sheet pile driving or vice versa (give safe distance) [3].

2. 43 Placing of reinforcement steel: Reinforcement cage shall be fabricated near by the pile or in the fabrication yard. Cage shall be fabricated with binding wire and whenever required welding shall be done. The cage shall be lifted by two point lifting method and shall be placed in the bore. Care shall be taken to maintain position of cage and cover.

2.44 Flushing: After boring is completed, flushing can be done by using tremmie pipe of 200mm dia shall be lowered in the bore keeping a gap of 300mm to 500mm from bottom of bore. Bentonite shall be pumped through the tremmie pipe so as to clean the bottom of the bore. Bentonite level shall be maintained in bore by continuously pouring bentonite from the bentonite tank. Care shall be taken to avoid bentonite level going below bottom of guide wall. Flushing shall be continued unless bentonite density comes 1.15 gm/cc or below 1.15 gm/cc. for checking purpose the suitable bentonite sampler shall be used for collecting sample from the bottom of bore.

2.45 Concreting: Concreting for bottom plugging will be carried out by tremmie pipe method.Concrete to be used in pileshall be of M40 grade with slump of 150 mm to 190 mm. Pouring of concrete shall be continued till it accumulates in the vertical tremmie pipe up to top of funnel. The tremmie pipe shall be then raised so as to release the concrete in a single continuous flow. Care shall be taken so that bottom end of tremmie pipe remains immersed in concrete. The operation shall be continued till the good concrete reaches 200 mm above the cut-off level of diaphragm wall. The length of tremmie pipe shall be reduced by removal of tremmie segment stage by stage. Concrete shall be conveyed from mixing plant to placing location by means of transit mixer of suitable capacity. Sand filling by tremmie pipe will be carried out after setting of bottom plugging followed by top plugging. The procedure adopted will be continued for subsequent piles.

2.5 Capping beam

On completion of top plugging excavation along the interlocking piles will be carried out for construction of capping beam.Cutting and chipping of pile up to cutoff level will be carried out followed by fixing of reinforcement.Erection of shutters will be carried out.

Concreting will be carried out of the capping beam in stretches. After final set, de-shuttering for capping beam will be carried out.

2.6 Anchoring works

The main application of geotechnical ground anchors is to prevent horizontal movement and ensure stability of retaining structures including sheet pile, bored concrete pile and steel tubular pile walls. In addition anchors maybe used to prevent additional movement or stabilize existing retaining walls and bridge abutments.

Ground anchors can be temporary or permanent depending on application; can either be "passive" or pre-stressed to 110% of working load post installation; and can be installed inclined or vertical.

Anchor capacities generally range from 100kN to over 3000kN depending upon the ground conditions over the grouted anchor length and the tendon material used [4,5].

2.70 Time Cycle for Piling

Sr. No	Description	Qty		Rate of production		Crane	Pilling	From	To
1	Survey, Shifting Positioning	14	Meters	5	Meters/hour	1	1	0	1
2	Boring of pile (+5.0m to -9.0m)	6	Meters	2	Meters/hour		3	1	4
3	Boring of pile (-9.0m to -15.0m)						3	4	7
4	Cage lowering, Tremmie lowering, and Flushing					3		7	10
5	Checking					2		10	12
6	Concreting of pile	16	cum	10	Cum/hour	1.5		12	13.5
	Total					7.5	7		
	Add 10%of idle/Misc.					0.75	0.7		1.35
	Total time taken for 1 pile(Hours)					8.25	7.7		14.85
Therefore it is understood that, 2 piles per day can be done per Rig.									

III. PLANTS AND EQUIPMENTS

Sr. No.	Plant /Equipment Description	Unit	Remarks
1	Concrete Batching Plant(60 cum per hr)	02Nos	Concrete works
2	14x10: Concrete Mixer	02Nos	For concrete transportation
3	Integrated Piling Rig	02Nos	For boring works
4	Bentonite Mixing Plants	02sets	For Bentonite Supply to Location

5	Vibro Hammer	01 Nos	For Liner driving
6	F-35 D/D Winch with 4 YDA Engine	02 Nos	For chiseling
7	Wagon Driller/C-6 Drilling Rig	04 Nos	For Drilling Rig
8	Crawler Crane Hind Marine 101 -SPD	02 Nos	For lifting
9	HM 101 Crane	01 Nos	Muck Removal
10	Dead weight roller	01 Nos	For compaction
11	Tractor	01 Nos	Muck Removal
12	Welding Machine	01 Nos	Chisel Maintenance
13	Vertical Pump	02 Nos	Chisel Repairing
14	Venture	01 Nos	Bentonite Mixing
15	Tremmie Pipes 8/10 Inches	01 Set	Flushing
16	Lifting Head	01 Nos	Flushing
17	Tremmie Head	01 Nos	Flushing
18	Flushing Head	01 Nos	Flushing
19	Bentonite Powder	MT	Bentonite Mixing
20	Chisel 580 mm (3.5 Ton)	01 Nos	For Breaking of Rock
21	DG set (125KV/75KV)	RMT	For Lighting and Vertical Pump

IV. SAFETY PRECAUTION

In cofferdam construction, safety is a paramount concern, since workers will be exposedto the hazard of flooding and collapse.Safety requires that every cofferdam and every part thereof shall be of suitable design, construction, sound material, sufficient strength and capacity for thepurpose for which it is used. Cofferdam should haveprovision for adequate access, light and ventilation, and attention to safe practices on thepart of all workers and supervisors, and shall be properly maintained. Fig. 1 shows the bored pile covered with iron mesh.

V. CONCLUSION

In this project Cofferdam is constructed across the dock to install Entrance Gate with approximately 100 interlocking sheet piles. It is a temporary enclosure constructed to allow the enclosed area to be pumped out, creating a dry work environment for the major work to proceed. Enclosed coffers are commonly used for construction and repair of oil platforms, bridge piers and other support structures built within or over water. These cofferdams are usually welded steel structures, with components consisting of sheet pilesand braces. Such structures are typically dismantled after the ultimate work is completed.The sheet piles used in the project were found to be very useful in reducing the effort of dewatering by about 35% and adding stability and reliability of thecofferdams by cutting down the chances of piping in a very conducive environment. Cofferdams offers economical and practical alternative to propping and all anchorages are post-tensioned to 110% working load.

This project was a good example of AFCONS Infrastructuresltd., ability to coordinate the various ongoing activities of a major project via efficient planning, good teamwork and site management. High standards of safety and quality were also maintained throughout the project for the delivery of a high quality building foundation.

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