Developing a modern infrastructure
Offshore foundation in concrete – Cost reduction by serial production

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1 INTRODUCTION

Independent from the technical concept of the foundation type concrete and steel are used as the predominant construction material. Lighter foundations like pile foundations can be built as a steel structure utilizing the logistical advantages during construction. Gravity foundations – built from concrete – are less expensive from their construction costs but more complicated and costly as regards to the logistics involved.

2 GRAVITY FOUNDATION TYPES, GENERAL VIEW

2.1 Geometry

Loads on foundations act from all directions, therefore axi-symmetric structures are ideal. To economize on the weight of the foundation for transportation, shell design based structures are preferable. Designs with integrated uplift chambers enable floating of the concrete structures to its final locations.

2.2 Gravity foundations

Gravity foundations are manufactured out of concrete and are suitable for areas where seabed conditions can stand the soil pressure at the edges the foundation due to overturning moments.

Furthermore gravity foundations have to be protected against scour by using protective skirts or other applicable measures like gravel embankments. Since the weight of the concrete under water is reduced by 1t per m³ additional measures for adding ballast are required. This can be achieved by adding additional sand, high density gravel or ore. Provision of this ballast needs to be incorporated in the design.

2.3 Overview on concepts for gravity foundations

2.3.1 Standard types
2.3.2 Special foundation structures

3 ERECTION COSTS OF OFFSHORE GRAVITY FOUNDATIONS CONSISTS OF

- Production
- Transportation
- Seabed preparation
- Lowering (placing)
- Removing

All this works depend on each other and influence therefore the total costs. Especially production, transport and lowering must be seen as an unit. Especially for serial production this has to be considered.
4 PRODUCTION METHODS OF GRAVITY-STRUCTURES AT A GLANCE

- Dry-dock
- Floating docks
- Production on piers
- Production on pontoons (barges)
- Submerge able barge system
- Floating production

4.1 *Ad dry-dock*

For this method marine dry-docks in dockyards or harbours or a temporary made dry dock are normally used. The gravity foundations are produced according available space, and then transported by floating cranes to the location.

A basically advantage of dry-docks is that the weight of submerged structure is reduced.
4.2 Ad floating docks

The production of foundations on floating docks is easy unless the dock is used a transport vehicle as well. On one side the working times for the lifting cranage can be reduced on the other side the working times for the floating docks increase.

4.3 Ad production on piers

Concerning work flow the production on piers is the best possibility, and with the appropriate length of the pier ideal for the serial production. But the produced foundations have to be moved and placed by heavy lifting vessels which are at present very expensive and rare.

If the pier is not long enough for a serial production you have to produce the foundations in a way so that they can be pulled to the edge of the pier with heavy-duty rollers.

4.4 Ad production on pontoons/barges

The production on pontoons is excellent for the serial production. As the pontoons can be moved easily (like in an industrial plant) according to the construction progress. The infrastructure for the civil works can be optimised and concentrated at the best places in the harbour area.

An adequate lifting vessel is necessary to place the foundations down from the pontoons.

4.5 submerge able barge systems

The gravity foundation is constructed in a dry dock or a floating dock.

After putting the foundation under water a special submerge able u-shaped barge picks the concrete structure up from the top, lifts it up and will be towed to the desired place. There the barge is flooded again and leaves the foundation on the prepared seabed.

4.6 Floating production

The floating production combines the shipping of the foundations to the site and the corresponding lowering.

After a partial production on land, the lower part of the floating foundation is lowered or slipped to the water and floats.

The use of street bounded lifting cranes which are cheaper and easier available is a big advantage. As the floating substructures can be transported to every production place a serial production is easily possible.

Also the placing on site is easy, the lowering requires a lifting vessel for stabilisation. The condition of floating have to be considered.

5 PONTOON PRODUCTION “LILLGRUND”

After analysing different production methods the joint venture Hochtief/Pihl decided for the pontoon production.

On each of the flat barges (with ballast chambers) 4 to 5 foundations were produced. Thereby floor panels, ballast-chambers, tower part and the ice-cone were constructed in a pulsing procedure on different work places. Because of that the site logistics could be optimised and the cranes were optimal in use.
This production process was similar to production lines in the automotive industry in which the components are brought to the according production place, but not based on the principle of an assembly line but rather on principle of the optimal availability.

On the “Lillgrund” Project 49 foundation were produced with this method in less than 8 months. The advantage of this production technique is that because of additional pontoons the production time can be decreased as the pontoons are also an interim storage facility.

6 SUMMARY AND FUTURE PROSPECTS

Concrete gravity foundations are ideal for serial production. The other aspects as transport, lifting and lowering has to be considered seriously, too.

By a growing number of foundations also the necessary marine equipments (vessels, swimming cranes etc.) will be available more easily.

The future belongs to the serial gravity foundation.