Construction Technology 3
D39TA

Lecture 3: Basement construction

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Lecture Outline

1. Introduction
2. Issues to consider for basement construction
3. Approaches for basement construction
4. Waterproofing
Demand for space in cities often makes it essential to use space below buildings. The concept of deep basement technology has been employed since the middle of last century, but is becoming more popular as the pressure on urban space increases.

The structural solutions available for deep basement construction revolve around the need for creating as much usable space as possible and protecting the space from moisture penetration. The solution must also integrate with the overall structure of the building above and the transfer of loads to the foundations.
What can basements be used for?

* The use of these areas can vary from car park space, where little waterproofing is required through to store rooms or plant rooms where a high quality of waterproofing is required. Demand for space in cities often makes it essential to use space below buildings. Parking, storage, plant and even commercial accommodation can occupy floors below ground. The concept of deep basement technology has been employed since the middle of last century, but is becoming more popular as the pressure on urban space increases.
So, basements can provide additional space in a building and thereby enhancing the quality of life of occupants.
Basement Solutions for Shoe-Box Homes

The provision of basements would counter the strong criticism by the Royal Institute of Architects (RIA) that house builders are building "shameful shoe-box homes" which are too small for family life.

Research by the RIBA has found that the average floor area of the average new three-bedroomed home in the UK is a mere 89sq m. Not only is this some 89sq m short of the recommended space, it is also significantly less than the average 100sq m provided in most European new homes. RIBA's study was based on a sample of 3,418 houses across 71 sites in the UK and is based upon the recently introduced London Plan space standards. According to Harry Rich, RIBA chief executive: "Shameful shoe-box homes are being churned out all over the country, depleting households of the space they need to live comfortably and cohesively."

The answer, believes Guy Thompson, head of architecture and sustainability at The Concrete Centre, is below our feet: basements. "For a two-storey home, a basement can provide up to 50 per cent more living space". He explained: "Basements are no longer dark coal cellars but can provide light, airy space for study and games rooms, guest suites and utility areas as well as additional storage. Too often new homes have been too small and have not had enough off."

In addition, basements provide good sound insulation and improved energy efficiency. Research carried out by BRE found that given two houses of the same floor area and construction, the one with a basement would be 10 per cent more energy efficient. A further sustainability benefit is that basements provide larger homes with increased living space without requiring more land.

House builders argue that the provision of basements would make new homes too expensive. However this is not the case. Cost modelling research carried out by the Basement Information Centre found that the cost of constructing a house with a partially below-ground basement, divided into rooms and fully finished, adds only 1.9 per cent more to the construction cost. A house with a fully below-ground basement would cost an additional 5.9 per cent when compared with a house of the same total area.

"These are not huge additional costs and would offer the forward-thinking house builder a distinct competitive advantage over those shoe-box homes," says Thompson. "House buyers want more living space and basements provide an economic and sustainable solution."

What are the loads that act on a basement wall?

What are the main issues to be addressed for basement construction?

1. Getting the loads from the superstructure to the soil.
2. Providing an optimised open space for use.
3. Resisting lateral soil pressures.
4. Preventing the ingress of moisture

1. What are you going to find when you start excavating – hazardous materials, archaeological findings, or dead bodies! (of course you take borings to investigate the soil but you only take few and you really don’t know what you will find until you actually excavate!)

Falcon’s operatives were shocked to come across a wooden box which contained what was instantly recognised as human remains. Because the coffin had been located internally, it was relatively intact, but disintegrated during excavation due to the moist ground conditions.

2. Securing the structure in place (water and weight of the soil)
Approaches for basement construction

1. Temporary support to basement excavations

• Retaining wall construction helps in setting-out the basement layout and then excavation takes place to construct the basement.
• The main issues to be addressed in the construction of basement foundation systems are how the excavation will proceed and the methods that are used to support the walls of the excavation prior to the construction of the permanent basement structure.
Broad approaches to temporary soil support

Lateral support arrangements used for sheet steel pile walls

Interlocking sheet steel piles used in a freestanding, cantilevered arrangement

Interlocking sheet steel piles Supported by flying shores

Interlocking sheet steel piles Supported by raking shores

Interlocking sheet steel piles Supported by ground anchors
Propping and shoring of temporary basement excavation walls requires detailed structural design. Where congestion inside excavation is to be avoided to speed construction of the permanent basement structure it is not appropriate to use conventional propping and shoring unless absolutely necessary. In such cases, the use of a system of ground anchors would be considered. There are constraints that limit the use of ground anchors. The installation of a ground anchor under a road or rail line or under an existing building can be classed as an act of trespass. Therefore, in such cases, permission must be sought from owners of adjoining property before the use of ground anchors can be considered. The ground anchor is a relatively simple device that can be thought of as pinning the piles back into the soil preventing them from collapse.
The anchor must be located far enough into the soil such that it is away from the critical soil zone in which failure may occur. The obvious advantage of using ground anchors is that the excavation area is clear and unobstructed meaning that the construction work can proceed in an uninterrupted fashion.

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Installing temporary support is expensive and slows down construction activity.

Therefore, to speed construction, modern techniques have been developed to allow the permanent basement walls to be instilled before the deep excavation work begins.

The pressure that has been placed upon contractors to produce buildings more quickly has meant that temporary methods of support for large basement excavations are not always appropriate.

This means that only a small amount of temporary support is necessary and the construction of the basement can proceed at a more rapid pace than would otherwise be the case.
2. Permanent basement wall construction prior to excavation

- Diaphragm walling
- Contiguous bored piling
- Secant wall piling

- Retaining wall construction helps in setting-out the basement layout and then excavation takes place to construct the basement.
- The main issues to be addressed in the construction of basement foundation systems are how the excavation will proceed and the methods that are used to support the walls of the excavation prior to the construction of the permanent basement structure.
In straightforward terminology a diaphragm wall is a reinforced concrete retaining wall that is cast in a very deep trench. The trench is excavated to the required depth in alternate sections of approximately 1.50m to 6.0m depending upon the soil type and the soil conditions.

Diaphragm walling refers to the in-situ construction of vertical walls by means of deep trench excavations. Stability of the excavation is maintained by the use of a drilling fluid, usually a bentonite suspension.

The walls are constructed in discrete panel lengths ranging typically between 2.5m and 7.0m using purpose built grabs or, in appropriate circumstances, milling machines (hydromills).
Excavation is typically carried out using either rope-suspended mechanical or hydraulically operated grabs. Standard grabs range in weight from 8-20 tonnes. The grabs are mounted on 80-120 tonne hydraulic base crane units providing stability and suitable line pull. **Diaphragm walls** provide rigid, cost effective solutions for permanent retaining walls and shafts, with less construction joints than bored pile walls. They are particularly suitable for large structures greater than 25m deep are required. The Diaphragm walling technique offers improved verticality tolerances to CFA and rotary bored piling, up to 1:400 for Hydrofraise, and delivers a smoother finish. Water tightness is normally delivered using a CWS water bar between the diaphragm wall panels.

**Bentonite Slurry**
Bentonite is an absorbent clay often used by utility contractors in the horizontal drilling and geotechnical engineering industry. Small quantities of bentonite suspended in water form a viscous, shear thinning material often referred to as bentonite slurry. At high enough concentrations bentonite suspensions begin to take on the characteristics of a gel. For these reasons it is a common component of drilling mud used to curtail drilling fluid invasion by its propensity for aiding in the formation of mud cake.

**Why is bentonite slurry commonly used in diaphragm wall construction?**
Bentonite slurry is one of the most common excavation fluid used in constructing diaphragm wall. 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.
Contiguous bored piling

Bored piles are installed in a line touching one another, or overlapping one another. The piles may be rotary augured or continuous flight augured. Because the piles are only close to one another or overlapping, the resulting wall is not generally watertight. Grout can be injected or a grout pile can be formed between the two closely spaced piles to improve this situation although the complete exclusion of groundwater remains difficult. The construction process is relatively straightforward; once the piles have been placed, excavation work may begin. However, a degree of propping will be necessary as the excavation proceeds. This can be achieved using raking shores, flying shores or ground anchors depending upon the site conditions and upon site constraints.
Secant wall piling
CFA (Continuous Flight Auger) piles are quick to install and offer an efficient, rapid solution for predominantly more lightly loaded structures. But, what to do if you have stronger soil and more obstruction in the ground?

The range of CFA piles is between 300mm and 1200mm in diameter and can be created up to 30 meters long.
Rotary Bored Piling

Bachy Soletanche defines piles in excess of 600mm diameter to be large diameter L.D.A. rigs tend to be higher power (torque) than CFA rigs are more able to overcome underground obstructions. Rotary piles have the ability to: quickly change coring or digging tools and auger type; have plunge columns installed into them; be under-reamed to facilitate higher base capacity. Bored rotary piles also have the advantage of having the reinforcement cage installed into the open bore, and so can accommodate full length reinforcement.

For larger diameter piles up to 3000mm rotary flight auger systems can be used, but these are not continuous flight and the soil has to be brought to the surface in sections.
This is a method that can be employed to further speed the construction process. In the top down method, the construction of the basement begins with the installation of the basement walls using one of the methods described in relation to using the permanent basement structure. At the same time, the internal columns within the basement area can be installed in one of two ways.

First, the columns can be installed as replacement piles which are designed to double as foundations and columns once the basement excavation is complete.

Second, if the superstructure is to be a steel frame, a piled foundation can be installed by rotary auguring. Rather than bringing the concrete pile up to ground level, the concrete replacement is stopped off at formation level. Steel columns can then be placed and secured using a concrete plug. Great accuracy is required to locate steel columns in this fashion to ensure that they are positioned correctly and that they are truly vertical.

Once the basement walls and internal columns are in place, the ground floor slab can be placed using the earth as formwork, however, suitable access holes must be left to allow excavation equipment to enter and conduct the basement excavation. At this point, since all the foundation systems are essentially in place, construction of the superstructure can begin even though the excavation of the basement is not complete. This can obviously speed the construction of a complete building significantly.

The ground floor slab provides the necessary lateral support to basement walls removing the need for temporary support systems such as shores or ground anchors. The basement excavation can now proceed to the level of the 1st basement floor. This can once more be constructed using the earth as formwork. Access must once more be left and the excavation can once more continue to the level of the 2nd basement floor. And so on until the basement floor is reached.

Once the level of the floor is reached, the excavation plant must be removed. Typically this is partially dismantled and then craned out through the access hole. Once this is done, the basement floor can be placed and the access holes replaced by permanent floor slabs depending on the design of the building. This process, although complex and requiring much planning, can significantly improve building delivery times.
What are the ICE Health and Safety specifications for piling and retaining walls work?
This specification has been written by practising engineers for practising engineers. The review panel has been drawn from consultants, specialist foundation contractors and client organisations.

**Workmanship**

The Contractor's or subcontractor's responsibilities for their workmanship in achieving compliance with the design, drawings and specification provided to them in addition to other relevant information accessible to them, should be stated in the contract or subcontract documents.

Proper supervision of piling and embedded walling works by experienced site personnel is essential. It is preferable that supervision is provided by both the Contractor and the Engineer. The Employer should facilitate supervision by the Engineer. Supervision by the Engineer should be by a competent person with appropriate qualifications and experience.
3. Waterproofing

[Diagram showing waterproofing concepts such as surface water, standing water, wet soil, and various types of soil conditions.]
Basements leak and flood in a number of ways, as detailed below. Water is heavy and it takes a large mass of water to produce the pressure it takes to push water through a seam of any kind. The little bit of water you see on your basement floor typically indicates a much larger amount of water. Water issues can advance quickly, causing existing cracks to expand. Erosion and soil movement can actually move your foundation wall and in time cause greater damage and flooding.
The image below shows various water penetration points. Nearly every one of these are present in the modern basement in some form or another.

Source: www.northernvirginia basementwaterproofing.com
What are the signs of water seepage through a basement?

1. DAMP SPOTS ON WALLS
2. CRACKED FLOORS
3. CRACKED WALLS
4. WARPED PANELING
5. PEELING PAINT
6. FUNGUS-RUST-MILDWE
7. TERMITES

THE RESULT: A Weakened Foundation!

Source: www.vulcanwaterproofing.com/residential.htm
Internal tanking

Tanking is applied to the inside face of the slab and walls.

Internal tanking

Tanking is applied from the inside. Here once the slab is complete the external wall is built. The tanking can then be applied to the inside face of the slab and walls. Finally the internal slab and wall are completed.

Integrity of tanking

It is important to remember that tanking, like all other forms of waterproofing, must be continuous and unbroken over the whole area where a moisture barrier is required. It is thus essential that all items that penetrate the tanking is carefully designed. This is especially the case where services have to pass through basement walls.
* The main procedures during the excavation for the construction of an externally tanked basement
Traditional asphalt tanked basement

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References

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