SECANT PILE

Introduction:

Over the last few decades construction of retaining walls in urban areas has grown significantly, as a result of territorial and economical development of the cities. In most cases, retaining walls are deep structures with the existence of groundwater level because urban areas are often at a few meters above sea level. Furthermore, construction of retaining walls in cities, introduce special problems as a result of being directly in touch with urban elements and citizens.

In situ pile retaining walls are very popular due to their availability and practicability. There are different types of pile walls contiguous (intermittent) bored pile construction, (spacing between the piles is greater that the diameter of piles)

In these conditions, for deep borings and with the existence of groundwater level, diaphragm walls and secant pile walls are the only feasible retaining walls in urban areas. Secant pile walls are usually used in hard ground, where it is not possible to install diaphragm walls, and in rocks, and it is technically possible to install secant pile walls in a extensive range of grounds.

Secant bored pile walls are formed by keeping spacing of piles less than diameter (S<D). It is a watertight wall and may be more economical compared to diaphragm wall in small to medium scale excavations due to cost of site operations and bentonite plant.

Construction:

The traditional construction techniques for cast-in-situ concrete retaining walls have included principally:

a) Contiguous bored pile walls
b) Secant bored pile walls
c) Diaphragm walls

In contrast to the open structure of a contiguous bored pile wall, in which individual piles are spaced at 1.1 to 2 pile diameters, the piles in a secant wall are spaced at 0.8 to 0.9 pile diameters. Primary piles are secanted by secondary piles thus providing a closed structure to act as a barrier in water bearing soils, and to prevent ingress of soil between the piles. In some soil conditions the gaps between the piles in contiguous bored pile walls are grouted after the piles are installed in an effort to achieve the same objective. [3]

While a diaphragm wall consists of a sequence of panels, typically 3m to 7m or more in length, which may be interlocked at panel joints. A secant pile wall consists of interlocking piles with diameters ranging from 410mm to 1500mm. Piles are usually of constant diameter but, occasionally, primary piles may be of a smaller diameter than secondary piles.

The secant pile method consists of boring and concreting primary piles at centres slightly less than twice the nominal pile diameter. Secondary piles are then bored at mid-distance between the primary piles, the boring equipment cutting a secant section from them. Secondary piles are bored through primary piles before the concrete has achieved its full strength should this operation be delayed, wear on the auger or the cutting edge to the casing is likely to be much increased. Concrete quality control is therefore important in this respect and deviations in maximum strength may be important as minimum strength deviation. In practice three types of secant piles are constructed:

- Hard-soft secant pile wall
- Hard-firm secant pile wall
- Hard-hard secant pile wall

"Hard-soft" secant pile walls are formed by a series of interlocking drilled shafts. Primary piles without reinforcement are cast first; these are constructed of a soft pile mix of cement and bentonite or cement, bentonite and sand. The mix has a weak characteristic strength of 1-3 N/mm^2. The primary piles are used as water retaining structure rather than a load bearing column. Soft piles can retain up to 8m head of groundwater. The unreinforced soft pile is not usually used as a permanent wall material. As the bentonite and cement mix dries, it will shrink and crack, losing its water-resisting properties. Some soft piles have been designed to retain their water-resisting properties for the life of the structure; often this necessitates the mix remaining hydrated throughout the life of the building. The gaps left by primary piles are filled by secondary reinforced piles, which overlap the primary ones. [1]

"Hard-firm" secant pile walls are similar to "Hard-soft" secant piles,but here the characteristic strength of primary pile lies in d range of 10-20N/mm^2 . During the construction, the strength of the pile is held low by adding a retarding agent to the concrete mix. Primary piles are usually designed to hit their target strength within 56days rather than the more typical 28 days. Obviously, such practice ensures that the construction of the secondary/hard pile is easier as the auger has to exert less force when secanting the soft pile. Piles usually overlap a minimum of 25mm.

"Hard-hard" secant piles, here both primary n secondary piles re cast with full strength concrete and both are fully reinforced. The female piles are cast first and a high torque cutting casing is used to drill through the primary pile. The reinforcement in the primary pile is positioned so that the rig does not cut through it when boring the secondary pile. The depth of overlap is usually about 25mm; considerable care is required to ensure that this is maintained along the full length of the pile. I-section beams can also be added to the pile to further increase the lateral strength of the wall.

The "hard-soft" concrete secant wall offers similar soil and water retention properties compared to the "hard-hard" concrete secant wall [3]. The "hard-soft" wall is cheaper than the "hard-hard" wall, primarily due to the lower strength of the primary piles and hence avoidance of secanting into structural concrete. Since "hard-soft" secant walls are weaker, they are used for shallow excavations or to where high bending stresses within the wall can be avoided.

Standard pile drilling rigs are used for construction.

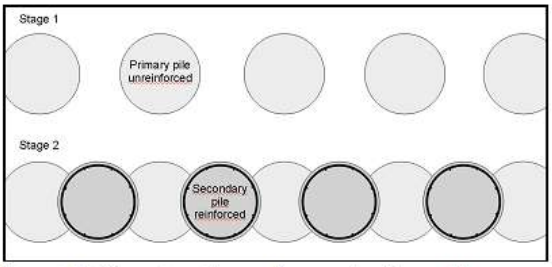

Figure 1: Construction of secant pile walls.

Figure 2: Secant pile wall with flaw at a power plant construction site in France.

Figure 3: Secant pile wall under construction at a river lock in northern Germany.

Uses:

Most secant pile walls are used as retaining walls or hydraulic barriers. In view of the structural and serviceability limitations associated with the open structure of a contiguous bored pile wall, and the practical limitations associated with conventional diaphragm walls, secant bored pile walls have enjoyed an unprecedented revival during the surge of inner city redevelopment.

Advantages:

The redevelopment of inner city sites in recent years has highlighted many environmental, design and site restrictions. The ability of secant pile construction techniques to overcome these constraints has led to an increased use of secant pile walls to form basements and other underground structures.

- Noise: comparatively secant piles methods are more adaptable.
- Wall plan geometry: As site values increase, the pressure to use all available space within basements has become intense. Sites are often sandwiched between existing buildings, and walls are placed in close proximity to adjacent structures or roads.
- Can be built in industrial complexes where access, headroom and restriction on vibration may make other methods such as steel sheet piling or diaphragm walling less suitable.
- Suited for all types of soil but penetration through boulders may be difficult and costly.
- Length can be varied to suit ground conditions.
- Large diameters are possible.
- Inclined walls can be constructed.
- Increased wall stiffness compared to sheet piles.

Disadvantages:

The main disadvantages of secant pile walls are:

- Verticality tolerances may be hard to achieve for deep piles.
- Total waterproofing is very difficult to obtain in joints.
- Increased cost compared to sheet pile walls.

Conclusion:

For temporary works, a hard-soft secant constitutes a perfectly satisfactory structure. For permanent structures the suitability of the technique demands critical evaluation in the particular site circumstances and structural requirements.

Cased secant construction methods provide a high degree of security when working in granular soils adjacent to heavily loaded foundations or adjacent structures.

In suitable conditions the watertightness of a hard-hard concrete secant wall can approach that of a diaphragm wall. However, as secant walls get deeper the risk of non intersection of adjacent piles increases creating possible leakage paths.

For walls greater than 25m deep cased secants with high torque rigs and diaphragm walls are the only suitable method.

Diaphragm wall methods involve much larger reinforcement cages compared to piles. Hence more site space is therefore required.

Hydraulic diaphragm wall cutters are high production machines and require a large site, both to work efficiently and for their related service plant and back up facilities.

Reference:

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2. "Deep excavations", M. Ufuk Ergun.
3. "Recent developments in secant bored pile wall construction", *D. E. Sherwood, C. N. Harnan & M. G. Beyer.*
4.