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Excavation of Ankara Metro Shaft by Using Inclined Piles

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Abstract
Underground structures are the most challenging construction part of metro projects. Basically there exist two types of underground structure in a metro line: Stations and tunnels. These structures can be built by either cut-and-cover or tunnelling methods. In a cut and cover method, temporary supporting of the excavated sections of the ground is a major problem especially if ground conditions are unfavourable and if the excavations are too deep and to be executed under water table. In this paper the excavation method of the metro shaft structure incorporating 20 degree inclined concrete piles which was used for the first time in Turkey is explained.

Keywords
Metro shaft, Inclined pile, Excavation

1. Introduction

The part of the Ankara metro project which the subject of this paper is the line between Kızılay and Çayyolu. Kızılay station is under operation within the line of Kızılay-Batıkent. New project is extension of the existing line and two tunnels are connecting the Kızılay station to the Necatibey Station which is to be newly constructed under the same project. On the new line, very close to the Kızılay station a crossover switch has to be built. Since the dimensions of the crossover switch is larger than the tunnel dimensions a seperate structure became a necessity.

In the methodology, first the excavation is done by employing temporary support structue and than permanent concrete structure is built and the excavated area is backfilled. For temporary support structure usually vertical concrete piles are used. But in the subject case the geometrical restrictions due to the client's request made it impossible to employ a conventional vertical pile supporting structure. In the following paragraphs the problem and its solution is explained.

2. Restrictions

Since the excavated area is to be used as launcing shaft of the tunnel boring machine, a large working area is required at the bottom level due to the operation length of the boring machine, and the excavated area is to be kept as it is untill the tunnelling operations are completed, which means normally closing of the one lane of traffic on the main road for extended durations approximately one year.

There were also old trees on the construction area cutting of which means a big problem for the municipality as per environmental aspects.

The excavation area is at the center of the capital city of Turkey and over the structure there exist very heavy vehicle and pedestrian traffic.

The client has put two strict restrictions: no tree shall be cut and no traffic shall be disturbed. But, there was not enough space at ground level in order to be able to satisfy these conditions. The width of the structure at the bottom level of excavation has to be 24.3 m. But it was impossible to find a working area at ground level with these dimensions if conventional excavation support methods are employed and the conditions put by the client were satisfied at the same time.

3. Geotechnical Conditions and Shaft Support Structure

The ground is artificial fill and alluvial for about 8 meters depth and the rest is specific Ankara clay. The underground water table is 3 meters.

Since the shaft dimensions are greater at the bottom level than at the ground level it was decided to construct a shaft having a asymmetrical trapezoidal cross section as shown in Figure 1 by using secant piles at the walls.

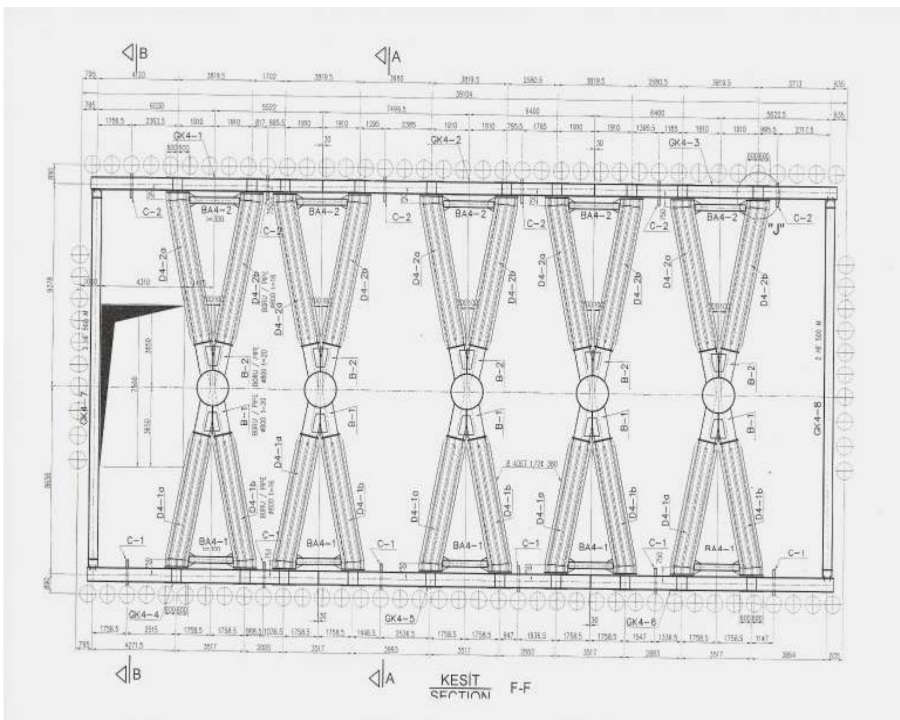

Figure 1: Plan View of the Shaft

For this purpose a composite structure of inclined concrete piles (20 degree at one side and 12 degree at the other side) and steel support beams were decided to be used

Concrete piles were having 0.8 m diameter and 30 m length. Excavation width was 11.9 m at ground level and 24.3 m at bottom level. Concrete piles were to be supported by steel beams at four levels approximnateley 6 m intervals until the upper level of tunnel boring machine is reached and below that level anchor bolts were used. At the mid sectin 5 concrete piles having steel portions have driven for the purpose of tranferring lateral loads to the ground.

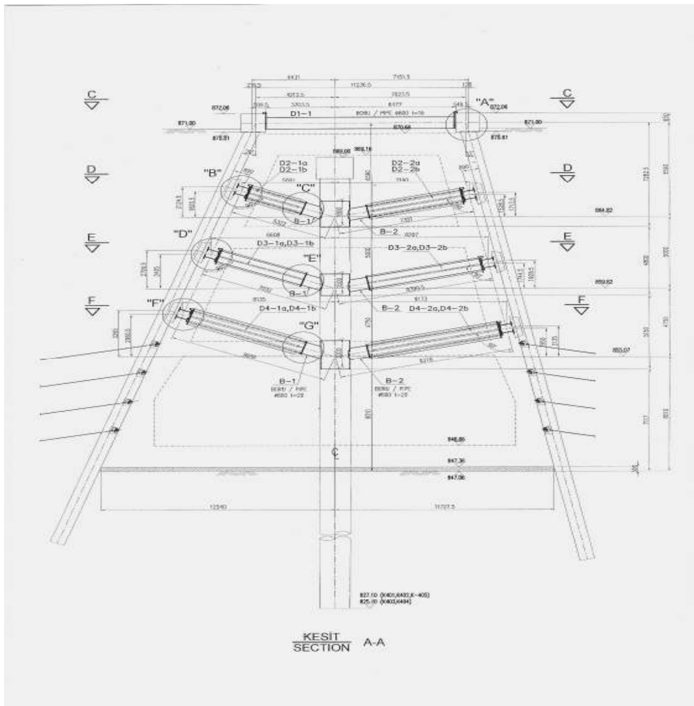

Figure 2: Cross Section of the Shaft Structure

4. Excavation

Excavation was compeleted at 5 stages as parallel to the supporting steel beams levels.

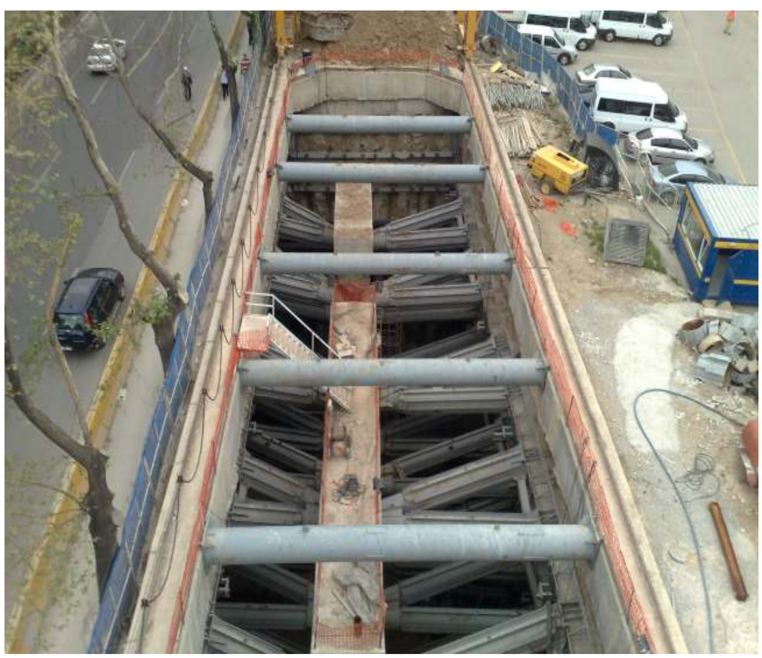

Figure 3: Excavation Area at Ground Level

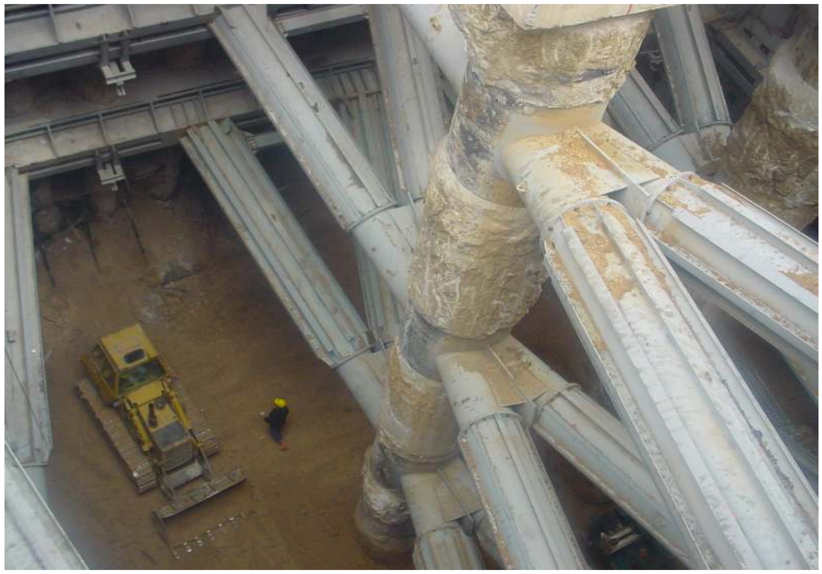

Figure 4: Support Beams at Intermediate Levels

Critical points of the steel beams carrying maximum loads were determined and strain gages were installed at those points. During all the excavation period, the loads measured by the gages were compared with the theoretical values given by the calculaions by using a software on 24 hours real-time basis.

Figure 5: Excavation at Bottom Level

5. Conclusion

Excavation was completed without any problem. Neither damage nor disturbance were given to the surroundings. Traffic was not effected by the construction.

The most critical factor of piling was the linearity tolerance of the inclined piles. If the deviation becomes more than tolared there may be a risk of water leakage problem. At the end of excavation it was detected that deviations were within expected limits and no water leakage problem happened.

All the loads measured by strain gages were in compliance with the theoretical calculations. They were never reached more than 90% of theoretical values.

The method proved itself as a reliable technique under limited space conditions.