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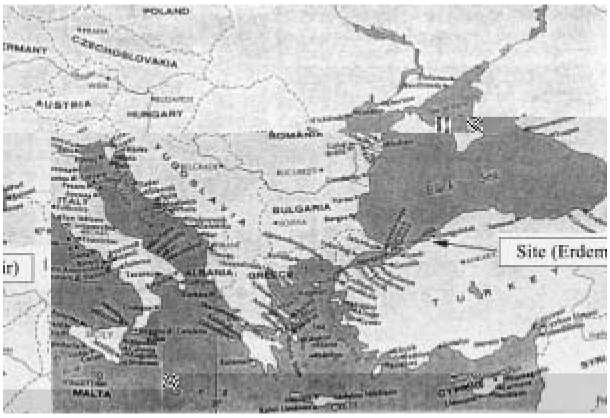
1. [illegible]

Erdemir Iron & Steel Works is the largest integrated iron & steel works in Turkey. The facility is located at the town of Eregli on the coast of the Black Sea at a distance of about 200 km East of Istanbul, as shown in [illegible]. 1. NKK has carried out construction at this facility continuously since the 1970's, including the installation of blast furnaces, engineering for the second-stage extension, and delivery of CAL equipment. Recently, following new construction of a series of cold mills, a facility extension was planned to increase the capacity of the existing cold mill. In June, 1997, NKK received orders for an electrolytic tinning line, a sheeting line, and an electrolytic cleaning line. This was a turn-key contract ranging from the design and procurement of equipment to earthwork & building work to the installation of equipment.

A major feature of the earthwork & building work in this project was the large-scale shoring required for looper pits, which are located in the entry and exit sections of the electrolytic tinning & chromium plating line within an existing building. This work was on the critical path for the whole project, so that any delay in this work would result in a delay in the delivery of the whole facility.



[illegible]. 1 [illegible]

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This report presents an outline of the work plan that was performed in a foreign country, where the freedom in selecting construction methods and materials is low, and that accommodated restrictions from working in an existing building. The description includes problems that occurred during the planning, design, and construction stages, countermeasures against these problems, and the resulting effects, primarily concerning the looper pit work.

2. [illegible]

Fig. 2 shows an outline of the earthwork & building work for the electrolytic tinning & chromium plating line that required the large-scale shoring work. Pay-off reels for uncoiling cold rolled coil and tension reels for coiling sheet were required in the entry and exit sections of the line, respectively. The process section, which lies between these reels, has a length of 71 m and is where the coil surface undergoes electrolytic tinning or chromium plating.

Loopers are installed at the front and rear of the process section to perform continuous coiling and uncoiling. The looper section is subject to a height restriction due to an overhead crane, as shown in Fig. 2. Therefore, the looper section requires a pit where the top of the bottom slab is as deep as FL –10 m. The top of the bottom slab of the process section must be FL –5 m for the same reason.

3. [illegible]

When the on-site work for this project was started, Erdemir had already completed the extension of the existing building containing the newly-built line. In this building, Erdemir had already driven steel pipe piles with a diameter of 324 mm and a length of 55 m for the foundations of the newly built line. These were installed in a lattice form with an interval of 2150 mm. The floor levels of the looper and process sections are FL –11.5 m and FL –6.1 m, respectively. The method for large-scale shoring work, which accounted for about half of the 4550 m^2 building area as shown in Fig. 3, had an influence upon the success or failure of this project.

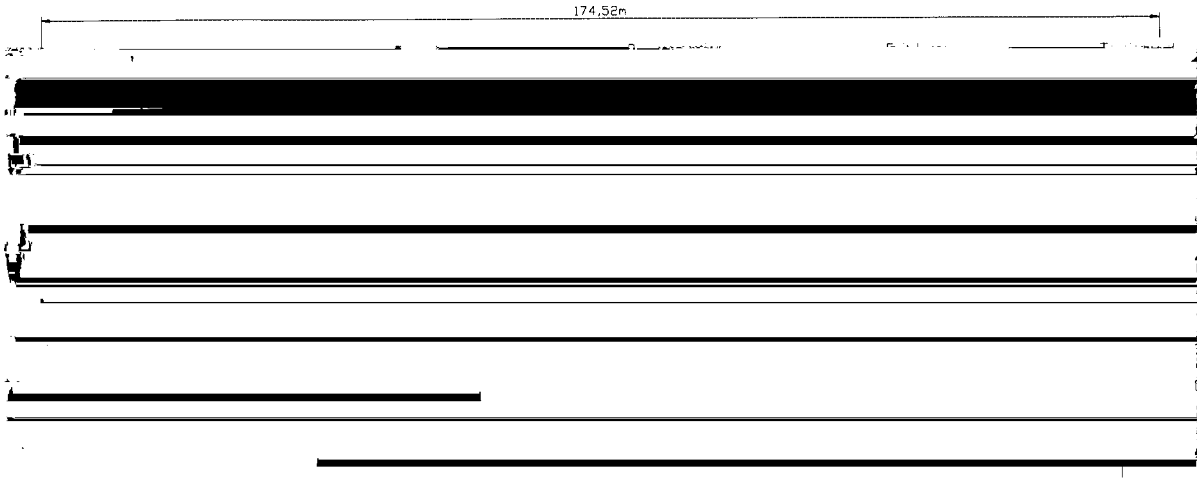


Fig. 2 [illegible]

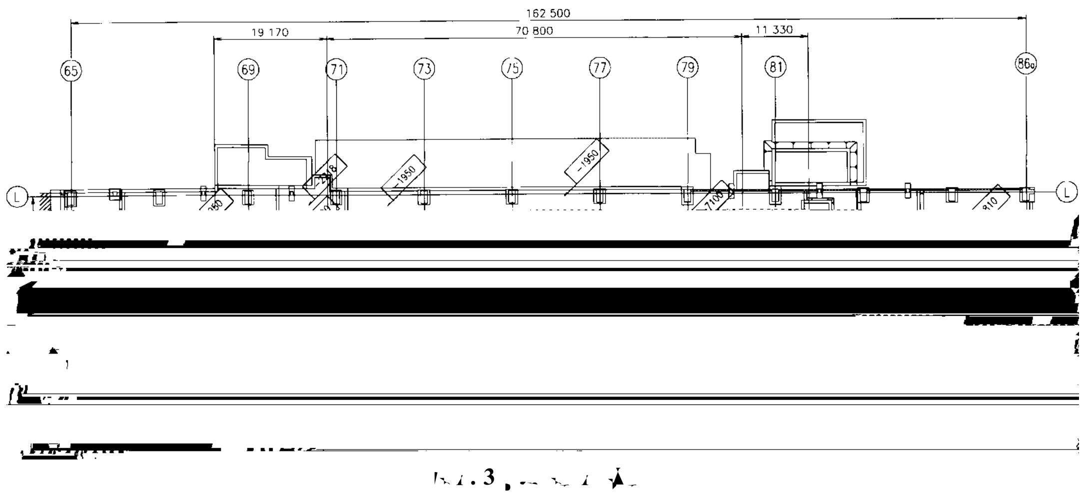


Fig. 3 [illegible]

3.1 [illegible]

The shoring work had to be performed in a limited space within the existing building while avoiding interference with the previously driven lattice piles. Therefore, the shoring method was selected considering the following points.

(1) Method can be used in the existing building

(2) Method has no adverse influence on the existing building foundations

(3) Method has no adverse influence on the operation of the nearby existing production facilities

(4) Local construction companies are familiar with the method

(5) Materials can be acquired on site

3.1.1 [illegible]

In Turkey, sheet pile installation methods that do not provide a specific joint efficiency are commonly used for shallow excavations, while the continuous bored pile wall method is generally applied to deep excavations.

As shown in **Fig. 4**, the foundations of the existing building are present on the back face of the earth retaining wall. The continuous bored pile wall method is suitable to prevent shifting of the building foundations during the excavation because the earth retaining wall has a higher stiffness than is provided by the sheet pile method. However, it was determined that the continuous bored pile wall method would be difficult to use because the lattice piles that were previously driven in the building may be inclined or deviated, and the construction equipment is subject to a

3.2

3.2.1

Erdemir Iron & Steel Works's in-house design criteria were used. This criteria extensively reflected NKK's design concept because NKK performed engineering for the second-stage extension. The design criteria for shoring is based on manuals published by the Japan Road Association.

3.2.2

As shown in Fig. 5, the soil on the construction site consists of homogeneous clay with a cohesion strength of C=40–70 kN/m^2. Bedrock for the piles lies underground at –55 m, and the groundwater level is –2 m below ground.

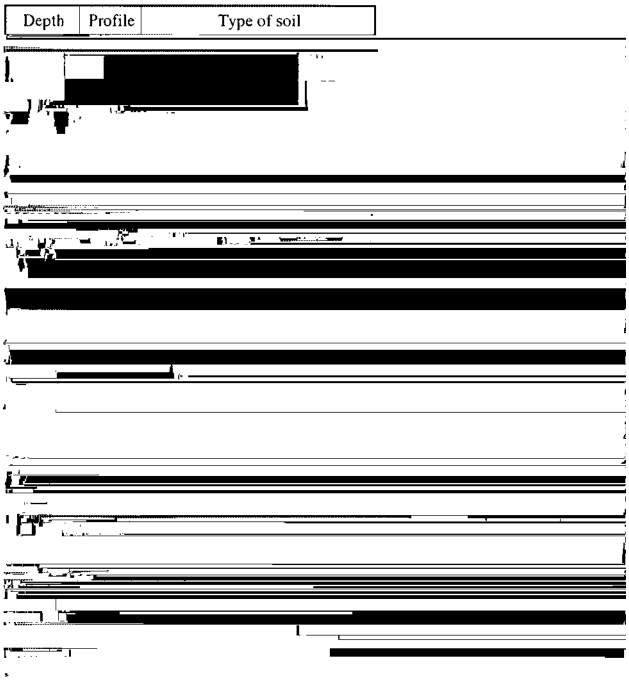


Fig. 5

3.2.3

(1) Looper pit section

Steel sheet piling & bracing method

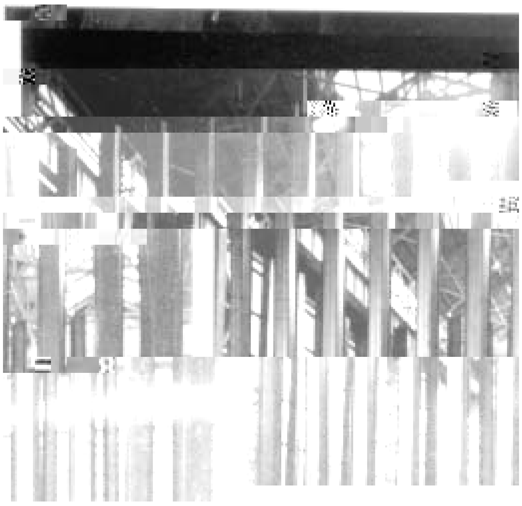
Steel sheet pile : 600 mm wide 20 m long

Wales and struts : 3 stages of bracing. Combined bracing was used because a single I–380 has insufficient section modulus.

King pile : Existing piles were left during excavation as well, and bracing was used as a king pile for intermediate support of the bracing.

(2) Process section

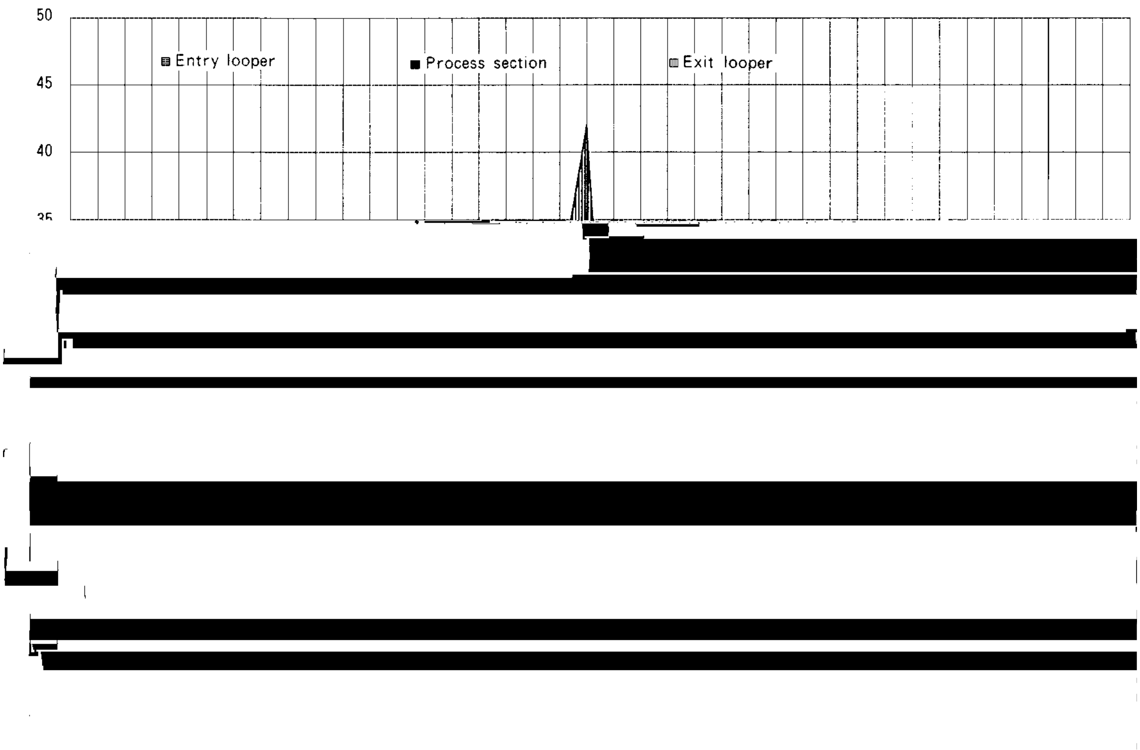
Method of steel sheet piling installation without bracing



[illegible] 2 [illegible]

T-shaped corner sheet piles were manufactured to fit the on-site conditions, and the steel sheet pile wall was closed completely, enclosing the entire area.

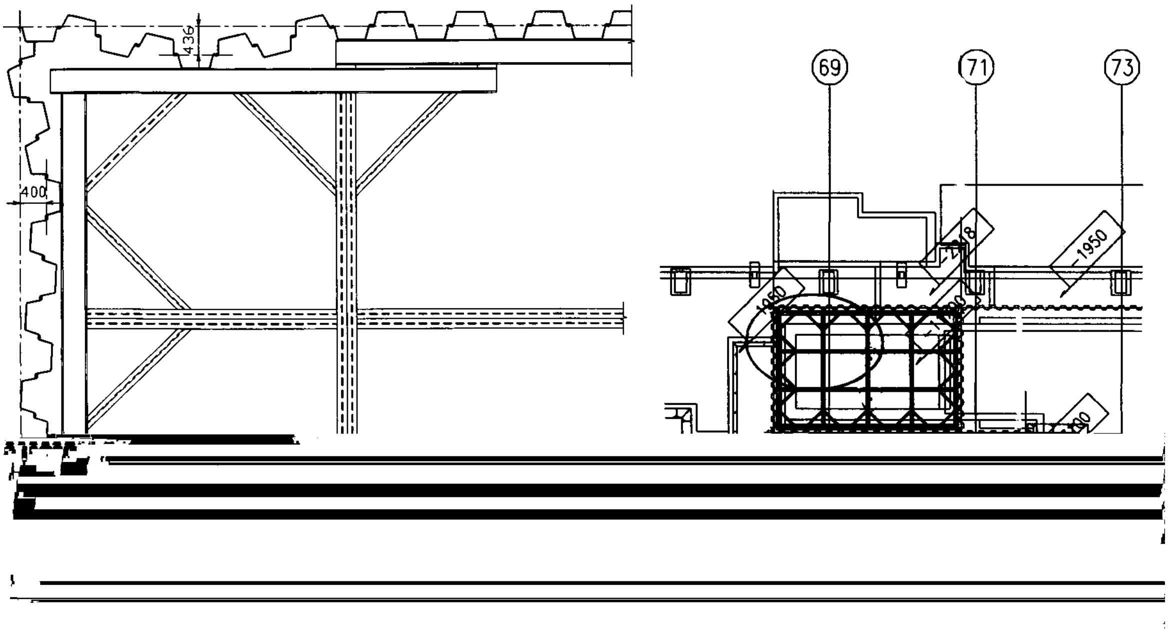
Soon after the start of shoring primary excavations in the entry looper section, abnormal deformations occurred at part of the steel sheet pile wall. This was presumed to be the result of removing the restraint to earth pressure by the excavation in front of the sheet pile and to the release of strains in the sheet pile accumulated during welding and driving of combined sheet piles. The result was that a kind of buckling phenomenon occurred on the steel sheet pile wall. Fortunately, it was judged that unless further deformation occurred on the steel sheet pile wall, the concrete structure could still be built as designed. As shown in [illegible], the wales and struts were modified based on the deformation of steel sheet pile wall, and excavation was continued while careful measurements were made. The result was that further abnormal deformation did not occur on the steel sheet pile wall, and the concrete structure was built with the designed location and dimensions.



[illegible]

4.1.2 [illegible]

Considering that, at –2 m from the surface, the groundwater level is relatively high, great attention was paid to the cutoff of water in the steel sheet pile joint for the entry looper pit section, for which shoring work was done first. Especially in the four corner sections, Little inflow of ground water was observed while shoring the entry looper section. Thus, in shoring of the exit looper section, two of the four corners were released to prevent strains from accumulating. As a result, shoring work could be carried on in the exit looper section without the occurrence of abnormal deformation.



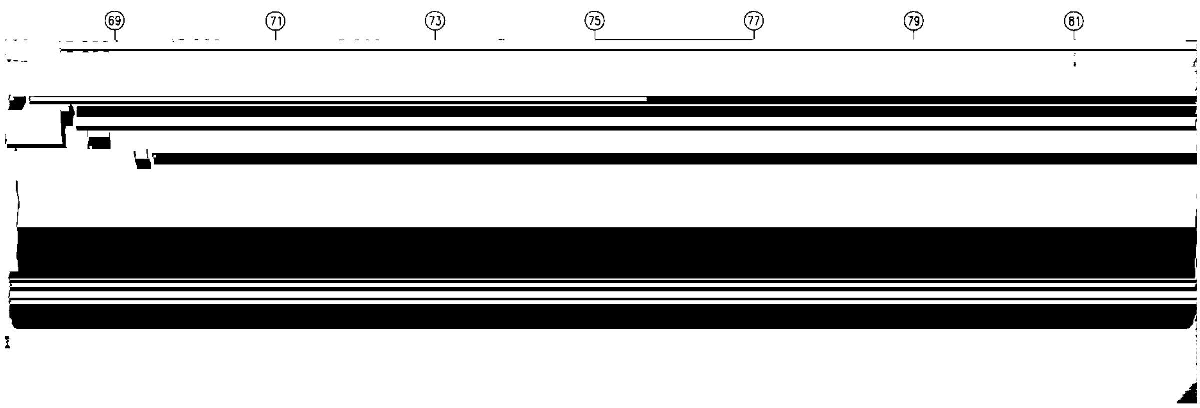
[illegible]

4.2 [illegible]

Excavation of the process section was accomplished by dividing the section into eight blocks, as shown in [illegible]. In the first block, where excavation was started, a tendency for the nearby building foundations to shift was observed as the excavation proceeded within the unbraced, steel sheet pile area. In the first block, the countermeasures that had been evaluated in advance, as described in **3.1.2** (1)–(4), were taken successively. [illegible] shows measurements of the shifting of the foundations of the existing building that occurred during the excavation of the first block.

The measurements taken for the first block suggested that the existing building foundations could shift in other blocks as well. A local support beam was installed as shown in [illegible] **3** before the start of evacuation, and work was carried out by using the local support beam for the previous block in the next block. As shown in [illegible], the second block was also affected by the first block, and a shift in the foundations of the existing building was found. However, the effect of the installation of local support beams became evident in the third and subsequent blocks.

[illegible] **3** [illegible]



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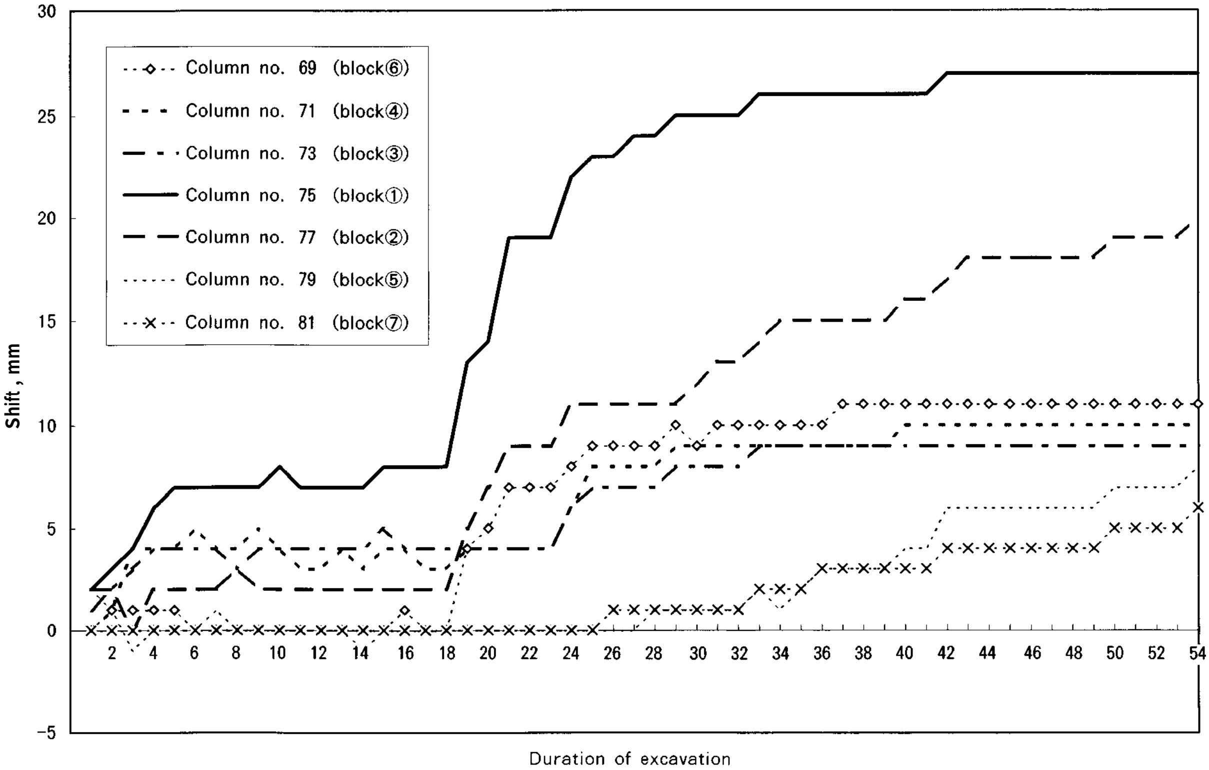

[illegible]

As a result, shifting of the foundations of the existing building was restrained even though the cost reduction and high workability permitted by installing steel sheet piling without bracing were maintained, and deformation of superstructure was kept within the allowable value.

5. [illegible]

Although problems that were not predictable in advance occurred during the on-site work, delivery of the foundation to the erection work group was made at the scheduled delivery time. We believe that the main reason for the smooth execution of work was that we investigated materials that were available on the construction site and gathered on-site information about methods familiar to local construction companies and other information at the initial stage of the project, and that this data was then incorporated into the work planning and design. By using local construction companies and by incorporating materials available at the construction site into the design, we could contribute relevant technology.

The facility started commercial operation in October, 1999. Although Erdemir Iron & Steel Works is less than 100 km from the seismic centers of two great Turkish earthquakes occurring in August and November of 1999, the facilities related to this project were not damaged and still operate smoothly.

[illegible]

1) Edited by Japan Road Association. Manual for Road Bridge. Japan Road Association(1996).
2) Edited by Architectural Institute of Japan. Design Manual for Building Foundations. Architectural Institute of Japan(1988).