Research on the development of improved bent bolt segment		
Period	1997.4～ 1999.6	97P～102P

(Purpose)

The various examinations for reduction of construction cost of sewage works have been carried out at present. The bending bolted joint which there were considerably results in past, and can be rapid installed without rotating for fastening bolt was focused on in this study.

The bending bolted joint has been a technology since the past, in Japan almost has not been adopted owing to the problem of the low accuracy of assembly (roundness) for that the rigidity is so small that the crack is easily generated and deformation are large, on the merit that the rational design was more possible than metal fitting style straight bolted segment which becomes the mainstream at present, as well as has excellent workability. Then, the improved bending bolt segment which can solve these problems are to be developed, and it intends to attempt total cost reduction of shield tunneling by the reduction of production cost and the rationalization of design and construction of segment.

(Result)

(1) Development to the rational design.

Based on the result of elemental test in preceding fiscal year, the beam-spring ring analysis was carried out to confirm the effects of the improved bending bolt segment. As the result, the improved bending bolt segment was compared with the metal fitting style straight bolt segment, and in case of the identical gird height,

- The maximum bending moment is reduced for about 6%.
- The maximum deformation of ring is reduced for about 30%.
- The maximum shearing force is reduced for about 15%.

From above, the reduction of amount of steel reinforcement was possible for the improved bending bolt segment, and it was proven that it might be able to reduce shield outer diameter according to the design conditions.

When the high-rigid joint was adopted, it can be considered that the cost reduction becomes further by the beam- spring ring analysis than by common using calculation method on segment design.

(2) Demonstrative construction.

It undertook trial construction on the improved bending bolt segment in 20 rings of the middle of Kamiya trunk line 2-2 works of Bureau Sewerage Tokyo Metropolitan Gov..

1) Assembly performance test

With installed segments of 2 rings in the level on first ring which was deformed about 20mm, the rings deformation, apertures, irregularity, etc., was measured and as the result, the deformation tended to decrease and gradually approach the perfect circle with the rise of stage.

2) Measurement

In the trial construction, the items of assembly speed of the segment, tunnel inner convergence quantity, aperture quantity between each pieces, strain of reinforcing bar and the bending bolt were measured.

- The assembly speed of segment were average about 32 minutes per ring, and there was not especially large difference over 20 rings.
- The level inner convergence quantity coincided almost with design calculation value (3.72mm) at average 3.7mm.
- The change of the aperture quantity was very slight 1mm or less.
- The stress of the reinforcing bar satisfied the allowed stress capacity.

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