Design of Large-sized Accelerator Tunnel

Speaker

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Introduction

Accelerator Facilities / Civil Engineering

- Key points for the design of underground accelerator tunnel
- Overview of the structural analysis concerning with necessity of Expansion Joints

Based on the experience in J-PARC
2 key-points for the design of underground accelerator tunnels

① Transformation of the accelerator tunnel should be minimal

② Level of integrity and durability of the tunnel structure should be high

→ ◆stable operation of the accelerator

→ ◆very few cracks in the cover concrete
Transformation of the tunnel is controlled by following factors:

- Geological features, Situation of groundwater
- Change of live load to the tunnel
- Temperature change inside the tunnel, Influence from earthquake
- Structure of the tunnel itself (Foundation, Expansion joint, etc.)
② **Integrity and durability of the tunnel is controlled by following factors**

- To realize very few cracks in tunnel concrete
  - To use watertight mass concrete
  - To place indispensable quantity of reinforcement accurately in position
  - To perform proper waterproofing work
  - To take appropriate measures against shrinkage of concrete
- **Structure of the tunnel itself**
  - (Foundation, *Expansion joint*, etc.)
J-PARC 50GeV synchrotron tunnel

Bird's-eye view of J-PARC 50GeV

Complicated layer

Cross-section of J-PARC 50GeV tunnel
Expansion Joints

Analysis model

Without Expansion joint

If provided Expansion Joints
**Condition of structural analysis**

*(Temperature change of tunnel concrete)*

- Structural analysis was performed based on the assumption of safe side that the temperature of tunnel concrete change 12°C.
Axial force diagram in the case of concrete temperature 1°C rises

Software of structural analysis
3-dimensional ground and structure seismic response analysis system DINAS
Bending Moment diagram in the case of concrete temperature $1^\circ C$ rises

Table 1: Crack moment and Bending moment

<table>
<thead>
<tr>
<th>Moment (KN\cdot m)</th>
<th>Curve region</th>
<th>Straight region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crack Moment</td>
<td>6.16E+04</td>
<td>4.94E+05</td>
</tr>
<tr>
<td>Bending Moment</td>
<td>5.14E+03</td>
<td>1.46E+04</td>
</tr>
</tbody>
</table>

($12^\circ C$ changes)
Transformation diagram in the case of concrete temperature 1℃ rises

Maximum displacement to outside direction of the ring tunnel in a curved part is around 4mm

Average expansion and contraction rate \(1.6 \times 10^{-7} \, (1/\text{°C})\) < linear thermal expansion rate of concrete \(1.0 \times 10^{-5} \, (1/\text{°C})\)

Lap length of the ring tunnel increases around 3mm
Summary

- Key points for the design of the underground accelerator tunnel
  - Transformation should be minimal and level of integrity and durability of the tunnel structure should be high

- Structural analysis concerning with necessity of Expansion Joints
  - There will be no incidence of displacement and cracks in the tunnel concrete without expansion joints
Thank you very much for your attention