

**Guideline for Selection of Seismic Countermeasures
for Existing Mountain Tunnels in Poor Geological Conditions**

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There are various seismic countermeasures for existing mountain tunnels such as backfill grouting to voids behind tunnel linings, installing of rock bolts to the roadbed, pasting of reinforcing materials to outside surface of linings and construction of an additional invert. In this study, the authors performed model tests and numerical analyses to clarify quantitative effect of these seismic countermeasures in poor geological conditions such as the fractured zone. According to the results of the studies, it has been apparent that inner reinforcement can control the initiation of the cracks and prevent spalling; backfill grouting can improve deformation performance of the tunnel and control the compressive failure at the arch crown; and rock bolts can control heaving of the roadbed. Moreover, there are a lot of restrictions on constructing an invert in the existing tunnel; however it has been apparent that the invert is a fundamental countermeasure to control the deformation of the tunnel and heaving of the roadbed.