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青藏铁路多年冻土隧道围岩季节活动层温度及响应的试验研究

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摘要　高原多年冻土区隧道的修建，将不可避免地影响到隧道背后多年冻结围岩的热稳定性，并形成季节融化与冻结的活动层。结合青藏铁路二期工程格尔木—拉萨段风火山隧道修建，选取11个断面对多年冻土隧道开挖直到贯通引起隧道冻结围岩体的热学响应规律进行深入的现场试验研究。现场试验结果表明：(1) 隧道背后围岩地温随时间及深度呈线性变化趋势。(2) 施工期间，因受人为热源影响，围岩冻融范围超过该地区天然冻土上限值。有些断面隧道背后围岩融化深度超过5 m，远远超过该地区天然冻土上限值(1.36～2.11 m)。分析结果表明，其围岩融化范围与多年冻土上限的比值，随着洞内温度与洞外温度比值呈现线性变化。(3) 贯通后，良好的保温措施使得围岩冻融圈范围小于天然冻土上限，且其围岩融化范围与多年冻土上限的比值，随着围岩表面温度与隧道洞外温度比值也呈现线性变化。

关键词　隧道工程；多年冻土；风火山隧道；活动层；冻融；温度监测

分类号

EXPERIMENTAL STUDY ON TEMPERATURE AND RESPONSE OF SEASONAL ACTIVE LAYER OF TUNNEL¢S SURROUNDING ROCK IN PERMAFROST REGION ON QINGHAI—TIBET PLATEAU

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Abstract

The excavation of tunnel will affect the thermal stability of surrounding rock in permafrost region. Accordingly，an active layer close to the supporting system of tunnel is formed in the surrounding rock under seasonal thawing and freezing. Based on the excavation of Fenghuoshan Tunnel of Qinghai—Tibet Railway，a detailed experimental investigation is conducted. Some useful conclusions of the active layer¢s thermal regularity are achieved. First，an important fact of in-situ experiment is that temperature of frozen rock behind the liner varies with time and space linearly. Second，another interesting phenomenon is that thawing depth of surrounding rock surpasses the natural thawing depth of this region during construction period. For instance，some areas¢ thawing depths are found below 5 m，while the natural value of this region is only 1.36–2.11 m. Analytical result indicates that the temporary heat produced during excavation causes the additional thawing of frozen rock/soil behind liner，such as chamber blasting，machine operating，construction illuminating，and so on. According to the in-

situ data，regression analysis shows that the ratio of thawing depth value during construction and its natural thawing value of this region vary with the ratio of atmospheric temperature inside to outside of the tunnel linearly. Finally，the achieved data illustrate that thawing depth is less than that of the region¢s natural value after tunnel excavation，which is deemed as a vital fact：the special insulating layer which is set between the primary support and the liner structure. Similarly，regression analysis shows that the ratio of thawing depth after excavation to its natural value changes with the ratio of atmospheric temperature inside to outside of the tunnel linearly，i.e. the atmospheric temperature in the tunnel refers to surface temperature of surrounding rock，where temperature monitoring units are installed on the surface of the primary support behind insulating layer.

Key words tunnelling engineering；permafrost；Fenghuoshan Tunnel；active layer；thawing and freezing；temperature monitoring

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