Deep-Buried Tunnel Thermal Hazard Cases and Thermal Hazard Effects Post-Print

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Abstract

The heat hazard problem in deep-buried tunnels has become a major challenge constraining their safe construction. This paper addresses the limitation of current tunnel heat hazard research that primarily focuses on addressing high rock temperature and high ambient temperature during the construction period while neglecting associated disasters such as high water temperature and harmful gases. By constructing a heat hazard case-response characteristic framework, it systematically summarizes the heat hazard effects in tunnels. First, based on thermal phenomena in geothermal anomaly zones and extensive engineering practices of heat hazards, the concept of tunnel heat hazard is redefined, incorporating high rock temperature, high water temperature, and harmful gas outbursts associated with geothermal anomaly zones into the scope of heat hazards. Then, through statistical analysis of 87 tunnel heat hazard cases both domestically and internationally, heat hazards induced by geothermal anomalies are categorized into five types: high rock temperature, harmful gases, high rock temperature + high water temperature, high rock temperature + harmful gases, and high rock temperature + harmful gases + high water temperature. It is found that tunnel heat hazards show strong correlation with surface thermal anomalies and stratigraphic lithology. Finally, the tunnel heat hazard effects are systematically reviewed, revealing that heat hazards lead to deterioration of the temperature-humidity environment inside tunnels, intensify deformation and failure of surrounding rock, induce cascading failure of support structures, and trigger a multi-dimensional gaseous disaster chain mechanism within the tunnel. The research in this paper provides a theoretical foundation for further investigation into the disaster-forming mechanisms and risk prevention and control of tunnel heat hazards.

Full Text

Preamble

Thermal Disaster Cases and Thermal Disaster Effects in Deep-Buried Tunnels

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Abstract

Thermal disaster issues in deep-buried tunnels have become a major challenge that constrains safe construction. This paper addresses the limitations of current tunnel thermal disaster research, which primarily focuses on addressing high rock temperature and high ambient temperature during construction while neglecting associated hazards such as high water temperature and harmful gases. By constructing a case-response characteristic framework, this study systematically summarizes tunnel thermal disaster effects. First, based on thermal phenomena in geothermal anomaly zones and extensive engineering practices, the paper redefines tunnel thermal disaster to incorporate high rock temperature, high water temperature, and harmful gas outbursts associated with geothermal anomaly zones within the scope of thermal disasters. Then, through statistical analysis of 87 domestic and international tunnel thermal disaster cases, thermal disasters induced by geothermal anomalies are classified into five types: high rock temperature only, harmful gases only, high rock temperature combined with high water temperature, high rock temperature combined with harmful gases, and high rock temperature combined with both harmful gases and high water temperature. The analysis reveals that tunnel thermal disasters show strong correlations with surface thermal anomalies and stratigraphic lithology. Finally, the paper systematically analyzes thermal disaster effects, revealing mechanisms through which thermal disasters deteriorate the temperature-humidity environment within tunnels, intensify surrounding rock deformation and failure, induce cascading failures of support structures, and trigger multi-dimensional gaseous disaster chains. This research provides a theoretical foundation for further investigation into the disaster formation mechanisms and risk prevention and control of tunnel thermal disasters.

Keywords: tunnel engineering; geothermal anomaly zones; thermal disaster cases; thermal disaster effects

Note: Figure translations are in progress. See original paper for figures.