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### Study on Earthquake Damage Characteristic on Mountain Tunnel and Analysis

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
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**Abstract** This paper collects earthquake damage data and research on tunnel in recent years(Wenchuan earthquake, Ms 8.0; Yushu earthquake, Ms 7.1, Chi-Chi Earthquake, Ms 7.6 and so on). Damage patterns and characteristics of mountain tunnels in severe earthquake region are classified: Slope failure near tunnel portal; Spalling and collapse of tunnel portal and end wall; Lining collapse; Longitudinal and transverse cracks of lining; Slant and transverse fracture of lining; Sheared off lining in fault region; Steel frame damage of primary support; pavement or bottom cracks. The damage mechanisms are analyzed and some proposals are put forward for tunnel rehabilitation and new tunnel construction: It is suggested that in strong earthquake areas, a comprehensive aseismic design should be conducted considering tunnel portal structure and slope. Line selection should avoid or reduce passing through active faults and avoid placing tunnels too close to slope faces when planning future tunnels. The paper provides a reference for seismic design and construction procedures of tunnel.

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## Study on earthquake damage characteristic on mountain tunnel and analysis

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**Keywords:** earthquake damage, seismic design, mountain tunnel, active fault.

**Abstract.** This paper collects earthquake damage data and research on tunnel in recent years (Wenchuan earthquake, Ms 8.0; Yushu earthquake, Ms 7.1, Chi-Chi Earthquake, Ms 7.6 and so on). Damage patterns and characteristics of mountain tunnels in severe earthquake region are classified: Slope failure near tunnel portal; Spalling and collapse of tunnel portal and end wall; Lining collapse; Longitudinal and transverse cracks of lining; Slant and transverse fracture of lining; Sheared off lining in fault region; Steel frame damage of primary support; pavement or bottom cracks. The damage mechanisms are analyzed and some proposals are put forward for tunnel rehabilitation and new tunnel construction: It is suggested that in strong earthquake areas, a comprehensive aseismic design should be conducted considering tunnel portal structure and slope. Line selection should avoid or reduce passing through active faults and avoid placing tunnels too close to slope faces when planning future tunnels. The paper provides a reference for seismic design and construction procedures of tunnel.

### Introduction

Mountain tunnels built in areas subject to earthquake activity must withstand both seismic and static loading. Being situated deep within rock layers, mountain tunnels have generally been assumed to be sustainable against damage from earthquakes. Historically, tunnel have experienced a lower rate of damage than surface structures. Nevertheless, some tunnels have experienced significant damage in recent large earthquakes, including the 1999 Chi-Chi, Taiwan earthquake and the 2008 Wenchuan, China earthquake. On May 12, 2008, at 2:28 pm (local time), a strong earthquake with a magnitude of 8.0 (Ms) struck Wen-chuan town, in the eastern Sichuan area of west China (N31.0, E103.4), at a depth of approximately 19 km. It was officially named as Wenchuan earthquake. According to the statistics by the Chinese government, as of June 16 9016 deaths had been confirmed, 368565 people had been injured, and many more had lost their homes. This paper outlines the findings of this investigation on the earthquake disaster to mountain tunnels and geotechnical engineering. It is hoped that the information shared herein could enhance the outstanding of seismic behavior of mountain tunnels and improve seismic design and construction procedures. Previous studies have found earthquake damage in tunnels to be localized at sections with two important characteristics: those running through displaced faults, which were damaged by shear forces that developed during the earthquake, and those near surface slopes which were damaged owing to slope failures.

### Research of mountain tunnels during seismic events

Several studies have documented earthquake damage to mountain tunnels. ITA took open session 1984, Caracas: Seismic Effects on Underground Works and Originally published in the Journal "Advances in Tunnelling Technology and Subsurface Use". In 1987 and 2001 ITA gave two reports of Aseismic Design of Underground Structures & Seismic design and analysis of underground structures. W.L.Wang made investigations of mountain tunnels after the Chi-Chi Earthquake in central Taiwan revealing that many tunnels suffered significant damage to various extents. It was found that among the 57 tunnels investigated 49 of them were damaged.