



Rock Engineering

Course Number: GE-02-230

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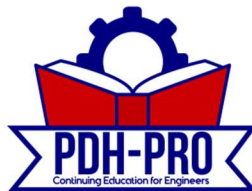
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The development of rock engineering

Introduction

We tend to think of rock engineering as a modern discipline and yet, as early as 1773, Coulomb included results of tests on rocks from Bordeaux in a paper read before the French Academy in Paris (Coulomb, 1776, Heyman, 1972). French engineers started construction of the Panama Canal in 1884 and this task was taken over by the US Army Corps of Engineers in 1908. In the half century between 1910 and 1964, 60 slides were recorded in cuts along the canal and, although these slides were not analysed in rock mechanics terms, recent work by the US Corps of Engineers (Lutton et al, 1979) shows that these slides were predominantly controlled by structural discontinuities and that modern rock mechanics concepts are fully applicable to the analysis of these failures. In discussing the Panama Canal slides in his Presidential Address to the first international conference on Soil Mechanics and Foundation Engineering in 1936, Karl Terzaghi (Terzaghi, 1936, Terzaghi and Voight, 1979) said ‘The catastrophic descent of the slopes of the deepest cut of the Panama Canal issued a warning that we were overstepping the limits of our ability to predict the consequences of our actions.

In 1920 Josef Stini started teaching ‘Technical Geology’ at the Vienna Technical University and before he died in 1958, he had published 333 papers and books (Müller, 1979). He founded the journal *Geologie und Bauwesen*, the forerunner of today’s journal *Rock Mechanics*, and was probably the first to emphasise the importance of structural discontinuities on the engineering behaviour of rock masses.

Other notable scientists and engineers from a variety of disciplines did some interesting work on rock behaviour during the early part of this century. von Karman (1911), King (1912), Griggs (1936), Ide (1936), and Terzaghi (1945) all worked on the failure of rock materials. In 1921 Griffith proposed his theory of brittle material failure and, in 1931 Bucky started using a centrifuge to study the failure of mine models under simulated gravity loading.

None of these persons would have classified themselves as rock engineers or rock mechanics engineers - the title had not been invented at that time - but all of them made significant contributions to the fundamental basis of the subject as we know it today. I have made no attempt to provide an exhaustive list of papers related to rock mechanics which were published before 1960 but the references given above will show that important developments in the subject were taking place well before that date.

The early 1960s were very important in the general development of rock engineering world-wide because a number of catastrophic failures occurred which clearly demonstrated that, in rock as well as in soil, ‘we were over-stepping the limits of our ability to predict the consequences of our actions’ (Terzaghi and Voight, 1979).

In December 1959 the foundation of the Malpasset concrete arch dam in France failed and the resulting flood killed about 450 people (Figure 1). In October 1963 about 2500 people in the Italian town of Longarone were killed as a result of a landslide generated wave which overtopped the Vajont dam (Figure 2). These two disasters had a major impact on rock mechanics in civil engineering and a large number of papers were written on the possible causes of the failures (Jaeger, 1972).



Figure 1: Remains of the Malpasset Dam as seen today. Photograph by Mark Diederichs, 2003.



Figure 2a: The Vajont dam during impounding of the reservoir. In the middle distance, in the centre of the picture, is Mount Toc with the unstable slope visible as a white scar on the mountain side above the waterline.



Figure 2b: During the filling of the Vajont reservoir the toe of the slope on Mount Toc was submerged and this precipitated a slide. The mound of debris from the slide is visible in the central part of the photograph. The very rapid descent of the slide material displaced the water in the reservoir causing a 100 m high wave to overtop the dam wall. The dam itself, visible in the foreground, was largely undamaged.



Figure 2c: The town of Longarone, located downstream of the Vajont dam, before the Mount Toc failure in October 1963.



Figure 2d: The remains of the town of Longarone after the flood caused by the overtopping of the Vajont dam as a result of the Mount Toc failure. More than 2000 persons were killed in this flood.



Figure 2e: The remains of the Vajont dam perched above the present town of Longarone. Photograph by Mark Diederichs, 2003.



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