Methodology for Automated Monitoring of Induced Vibrations in Tailings Dams Built Upstream

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Abstract

Induced vibrations in tailings dams in Brazil became subject to studies after two major accidents in upstream-built structures. These ground vibrations may be responsible for liquefaction triggers and that motivated the development of this paper, which consists in the presentation of a methodology to perform homogeneous vibration monitoring tests along the entire embankment with an initial offline stage that later progressed to an automated process that represents the core object of the paper. Data collected from the initial monitoring enabled analyses of dam stability when correlating vibration levels in the embankment. As a consequence of such analyses, it was possible to parameterize control levels associated to safety criteria. Monitoring methodology, analysis techniques and gains resulting from the use of automated monitoring systems are presented herein. Parameterized control levels regarding the structure under study as well as their association to the stability condition, analysis of liquefaction trigger set for vibration values, advanced analysis of seismographic records and an automated operational vibration control system from monitoring using seismographic stations are shown. The implementation of the automated monitoring system associated to safety control levels allowed a robust diagnosis of eventual structural damages caused by vibrations in dams. That methodology was applied to a dam in operation and permitted evaluation of operation continuity concerning industrial plants and different operations with earthworks equipment on the embankment and its surrounding area.

Full Text

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Figures

Figure 1

Figure 2

Ground measurement sensors – Geophones.

Figure 3

Seismographic study in a dam – offline.

Figure 4

Main sources of vibration

<div> <div>ZC</div> <div> <div>ZC > 4Hz</div> <div>ZC < 4Hz</div> </div> <div> <div>Check PPV and PGA</div> <div>Check PGA and PGD</div> </div> </div>			
Component	PPV (mm/s)	PGA (g)	PGD (mm)
Longitudinal	Normal: $PPV \leq 1$	Normal: $PGA \leq 0.005$	Normal: $PGD \leq 0,1$
Transversal	Attention: $1\text{mm/s} < PPV \leq 3,5$	Attention: $0.005\text{g} < PGA \leq 0,015$	Attention: $0,1 < PGD \leq 0,5$
Vertical	Alert: $PPV > 3,5$	Alert: $PGA > 0,015$	Alert: $PGD > 0,5$

Figure 5

Safety limits for the pilot dam.

Figure 6

Seismographic assessment per section

Figure 7

Autonomous monitoring station for automated transmission

Figure 8

Automated seismographic data transmission system

Figure 9

Automated and homogeneous seismographic monitoring on the pilot dam

Figure 10

S waves encounter.

Figure 11

Signature of induced waves – sources operating equipment

Figure 12

Graphs with seismographic test records on the dam transverse channel

Figure 13

Graphs with seismographic test records on the dam vertical channel

Figure 14

Graphs with seismographic test records on the dam longitudinal channel

Figure 15

Automated and homogeneous seismographic monitoring with redundant communication on the pilot dam