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Book Review
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Dams and Reservoirs

Book review

Earthquake engineering for dams and reservoirs

J. Hinks (ed.), ICE Publishing, HR Wallingford, UK, 2023, £95.

This is an excellent reference book for all with an involvement or interest in dam engineering, whether or not they have any knowledge of seismology, as it explains how earthquakes can affect dams and reservoirs, and how to understand and reduce the associated risks.

The book is edited by Jonathan Hinks, a distinguished member of the British Dam Society, who wrote several chapters himself, but also obtained contributions from many specialists around the world. A wide range of matters are covered, which engineers need to take into account when inspecting existing dams or planning new dams in areas that are prone to seismic activity. The numerous full colour illustrated examples throughout the book give the reader a 'reality check' on the topics covered, and a comprehensive list of references is included at the end of each chapter.

The book starts with an overview of earthquakes and the immense destruction they can cause. A description of the various tectonic plate movements around the earth shows how and where earthquakes are likely to occur. The magnitude of earthquakes, and how these are measured, are set out clearly, as are the terms used in seismic engineering, such as maximum credible earthquake (MCE), the earthquake with a return period of 10 000 years and the operating basis earthquake (OBE), which are essential parameters for the design of dams or the assessment of risk of failure of existing dams.

Knowledge of the magnitude of seismic forces that a dam could potentially experience can influence the type of dam that is most suitable for any given location. However, other factors must be taken into account, and the dam type finally chosen may not be the most appropriate to resist seismic loading. The book therefore includes chapters which examine the relative merits and risks of adopting each of a number of specific types of dam. These types include rockfill, earthfill and concrete dams, as well as dams with asphaltic membranes or cores, and ones with polyvinyl chloride membranes.

Earthfill dams in areas prone to seismic activity are at risk of failure due to liquefaction caused by earthquakes, which can cause the soil to lose its strength. This phenomenon, when stress is transferred from the soil to the pore water, is described in detail, along with the soil types that are the most susceptible to liquefaction, and the methods of analysis to determine that risk.

Statistics show that failures of tailings dams are high and increasing (possibly due to the increasing number of tailings dams). Some fundamental geotechnical concepts that are crucial in determining the stability of tailings dams under seismic loading are covered, with examples of numerous tailings dams that have failed due to liquefaction caused by earthquakes – but also several that suffered earthquakes with no damage. The form of construction of tailings dams is shown to play an important role in determining their susceptibility to earthquake damage.

The impact of seismic activity on the dam's structures and equipment, such as intake towers and spillway gates should not be underestimated, as damage to these can render a reservoir unable to perform its function – for example, irrigation or water supply – or unable to discharge floodwater, with the associated risks which that entails. Not only may gates become jammed, but their power supply and operating systems may be damaged. The book reviews a range of ancillary equipment such as gates and their auxiliary equipment and how design features can reduce the risk of earthquake damage to these essential components.

Moving from potential damage caused by earthquakes, the possibility of large reservoirs causing seismic activity, due to the increased stresses on the reservoir bed, is covered. As a rule of thumb 'large', in this context, is sometimes taken as a reservoir depth exceeding 100 m or a reservoir volume of more than 500 million cubic metres. A number of examples of earthquakes which were believed to have been triggered by large reservoirs are given, although it may be noted that reservoir-triggered earthquakes have not hitherto exceeded a moment magnitude of 6.3.

Earthquakes can also trigger landslides and rockfalls, and the book contains several examples where landslide dams have been formed, which are at risk of subsequently failing as they fill or overtop, potentially leading to a sudden release of floodwater. Rockfalls can destroy or damage reservoir infrastructure such as powerhouses and pipelines, but there are suggestions of how this risk may be mitigated. Earthquakes can also create large seiche waves, either directly, by movement of the ground, or from a large landslide displacing the water in a reservoir. Formulae are given to estimate the amplitude of such waves, for comparison with the available freeboard of a dam.

The book concludes with nine key points which dam engineers should take account of when working in areas of the world that are prone to seismic activity.

Perhaps inevitably, given the range of authors, there is some duplication across the chapters, usually relating to definitions and formulae. However, the book is laid out in a logical manner, and takes the reader from an understanding of what earthquakes are, through their direct effect on different types of dams, to the indirect effects of landslides, rockfalls and seiches.

Not only will this book be invaluable to dam engineers – whether carrying out feasibility studies or detailed designs – it will also be relevant to dam owners and managers to help with a understanding of seismic risk. In addition, many parts of this book are a fascinating read for those with an interest on earthquakes and their effects.

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