戴 俊 编著

岩石动力学特性与爆破理论（第2版）

Dynamic Behaviors and Blasting Theory of Rock (The Second Edition)

冶 金 工 业 出 版 社
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内 容 简 介

本书介绍了岩石的基本力学性质、岩石中的应力波理论、岩石的动态实验技术、动载荷条件下的本构关系、断裂破坏机理和强度理论以及岩石爆破理论与技术，特别是岩石周边爆破技术的新进展，其中有些内容属于作者近年来的研究成果，包括光面爆破参数计算方法、岩石定向断裂爆破及工程应用。

本书可作为高等院校岩土工程、防灾减灾工程及防护工程、采矿工程、工程力学专业研究生的爆炸及岩石动态破碎等相关课程教材和教学参考书，也可供从事爆破工程、地震工程、防灾减灾及防护工程、采矿工程、国防工程、铁道及道路工程、水利水电工程等的高校教师、研究人员、研究生及工程技术人员参考。

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Abstract

In this literature, the theory on stress wave is introduced, as well as the constitutive relation of rock under dynamic loading, the mechanism on fracture and fragmentation by explosion load, and the recent advance in the theory and technology on rock blasting including author's research achievements published in recent years, including parameter calculation for smooth blasting, the directional split blasting of rock and its application in engineering.

The literature is suitable for graduate students majoring in geotechnic engineering, mining engineering, prevention and mitigation of disaster and protection engineering, mechanics in engineering and blasting engineering to use as textbook or teaching reference book. It can else be used as reference material by the teachers in college, the researchers, the graduate students, and technicians majoring in blasting engineering, earthquake and its defense engineering, mining engineering, national defense engineering, railroad and highway engineering, water conservancy and hydra-electric engineering etc.

第2版前言

《岩石动力学特性与爆破理论》一书自2002年首次出版以来，得到了众多读者的关爱，被多家高校选作研究生相关课程的教材，被国内同行广泛参阅和引用，并于2007年被陕西省教育厅授予科技成果三等奖。近年来，不断有读者来电向作者索要此书，均因此书已售完而无法给予满足。在2011年北京召开的全国岩石动力学大会期间，多位与会的岩石动力学专业委员会委员表达了希望能得到此书的愿望，进而岩石动力学专业委员会建议作者重印或再版《岩石动力学特性与爆破理论》一书，以满足当前研究生教学和参阅的需求。

经与原书出版社——冶金工业出版社联系，决定再版《岩石动力学特性与爆破理论》一书。决定再版一方面是为了保持原书的特色和知识结构体系的完整性；另一方面也为了能对原书做一些修正和完善，并增加一些对近年新成果的介绍。

此次再版，在充分保持原书知识结构体系的同时，对不同章节均做了不同的补充或完善，如：第1章增添了对莫尔库仑准则较深入讨论的内容和岩石流变与岩石断裂力学原理等内容；第2章增加了弹塑性应力波和一维应变波的内容；第3章增添了爆轰理论与爆轰参数计算的内容；第4章补充了岩石动态拉伸实验技术，以及岩石动力学实验加载手段的内容；第5章增加了爆破破碎块度的控制及考虑地应力效应的地下开挖崩落眼爆破参数计算等研究成果；第6章增添了岩石光面爆破参数计算与岩石定向断裂爆破原理、参数设计与工程应用方面的研究成果。此外，也利

用此次再版的机会对原书中的错误进行了修正。

经过这样的补充完善，第2版呈现出以下特点：对岩石力学性质的介绍更趋于完善，更有利于读者对后续章节内容的理解；应力波理论介绍更加深入，将为有关读者开展岩石爆破理论与技术的研究提供更多帮助；岩石动力学试验技术的补充将为开展岩石动态试验开拓思路；所作的补充将有助于读者更好地了解当前岩石爆破理论与技术发展动态，促进岩石爆破理论与技术，特别是岩石周边爆破技术研究的更加深入。

当今，科学技术发展日新月异，大量新知识、新观点不断涌现，爆破技术也不例外，加之岩石爆破理论与技术的复杂性，给原书的再版增添了不少困难，在新知识、新成果的介绍方面难于做到全面和精准，再加之作者的知识水平和时间所限，本书中不足和差错在所难免，期望读者在继续关注本书的同时，提出宝贵意见，给予指正。

最后，作者真诚感谢为本书再版提供过帮助的机构和个人。

作　者

2012年10月于西安

Forward of the Second Edition

The book, dynamic behaviors and blasting theory of rock, has been adored by a great number of readers, with some part of the book cited in their publications, since it was published in the year of 2002. Because of the book, the author was conferred a third-rate scientific and technical achievement award in 2007 by Shaanxi provincial education office. Nowadays, the book is selected as the textbook for graduator teaching by some universities over the country. In the recent years, so many persons wrote to me to expect to get the book, but it was in vain as the book was sold out. When the national rock dynamics conference was held in Beijing in 2011, some members of the special interest committee of rock dynamics under China rock mechanics learning society, the conference attendees, told the author that they want to get the book for their graduate teaching, so the committee expressed their suggestion that book be reprinted or republished.

In this case, the author decides that the book is republished by the original publisher, metallurgical industry press. Such decision was made for the reason that on the one hand, the original feature and the integrality in knowledge structure system can be reserved in the republished book; on the other hand, some revision can be done and some new contributions can be introduced in new book.

In the new book, the different revision and addition is done for the different chapters when the knowledge structure system of original book is kept down. For instance, the further discussion to Mohr Coulomb

criterion, and rock rheology, and the principles on rock fracture mechanics are added in the first chapter; the elastic and plastic wave and one-dimensional strain wave are added in the second chapter; the detonation theory and calculation of detonation parameters are added in the third chapter; the dynamic tensile test technique and loading equipments for rock dynamics test are added in the fourth chapter; the control of the fragment size from blasting and parameter calculation for tunneling breast blasting with geo-stress effect being considered are added in the fifth chapter; and the achievements from the author in the field of parameter calculation for smooth blasting and the principle, parameter design, and use in engineering etc. are added in the sixth chapter. Also, by means of the republication opportunity, the mistakes in the original edition book have been revised.

Through the addition and revision, the following characteristic features will be shown in the new book. The rock mechanics property is introduced all around, which will makes readers easily understand the subsequent chapters; the stress wave theory is introduced deeply, which will help readers to research the blasting theory and technique of rock; the additive introduction to rock dynamics will help to exploit the approaches to finish the rock dynamics tests. The new book will be helpful for readers to know well the trend that the blasting theory and technique of rock develops toward, accelerate the blasting theory and technique of rock to be researched further.

Nowadays, the science and technology develop very quickly with a great amount of new knowledge, new viewpoint coming forth constantly. There is not an exception in blasting technique development. Also, the blasting theory and technique are complicated. For this reason,

the republication of the original book is faced a lot of difficulties in accurate and all – around introduction of new knowledge and achievements. In addition, some mistakes or shortage may exist in the new book due to the author limited knowledge and pressing time, so the author expects honestly readers' attention as well as valuable suggestion. Please favor me with your instructions.

Finally, the author expresses his genuine appreciation to all the institutes and persons who have given their help to him for the book being republished.

Author

In Xi'an, October 2012

第1版前言

爆破是目前岩石开挖的主要方法。工程中，实施岩石爆破时，一方面使开挖部分的岩石达到合理有效的破碎；另一方面尽可能减少爆破对开挖边界以外的岩石损伤或破坏，有效保护爆后保留岩石的稳定性，这是广大爆破专业技术人员追求的目标。然而，由于岩石性质和岩石爆破过程的复杂性，目前仍有许多问题亟待解决。急需介绍岩石爆破理论与技术的基础理论、学科前沿与最新研究成果的著作。

岩石爆破是一个复杂的动力学过程。对这一过程进行研究需要用到岩石力学和固体中的应力波理论等多学科知识。目前，尚缺少介绍这两方面知识及其在岩石爆破理论与技术研究中应用的专著，不便于年轻研究人员及研究生尽快熟悉掌握必备知识，掌握学科的前沿与发展方向。本书正是作者根据多年从事研究生教学的经验，在有关研究成果的基础上，为了解决这个问题而完成的。

近年来，在国内外学者的共同努力下，岩石爆破理论的研究取得了许多重要的研究成果，大大促进了岩石爆破新技术的广泛应用。本书首先介绍了研究岩石爆破理论所必需的静载下岩石的变形与强度特性与固体中的应力波理论等知识，而后介绍了岩石中应力波传播特征与岩石动力学性能实验方法及近年来在这方面已有的研究成果，并重点介绍了岩石爆破作用理论及其计算模型的研究进展及最新的研究成果，最后介绍了作者近几年在岩石周边控制爆破理论研究领域中所取得的研究成果。

本书全面总结了目前较成熟的岩石爆破理论知识与最新研究成果。有助于研究生及相关研究人员把握学科前沿与发展动态。因此，本书不仅适合于岩石爆破工程领域的研究生、高校教师及相关研究人员阅读，而且也适合于岩土工程、结构工程专业的研究生、高校教师及相关研究人员阅读，还可供从事地震与防护、采矿、国防、道路、水利水电等工程的相关教师、研究生及工程技术人员参考。

我的两位导师，王树仁教授和杨永琦教授对本书的写作完成始终给予了大力支持和热情帮助，在此表示衷心感谢。此外，在本书的写作过程中，参考了国内外同行公开发表的众多研究成果，在此一并对他们表示感谢。

由于作者水平所限，加之时间仓促，不当之处在所难免，敬请各位读者批评指正，并予赐教。

作　者

2002年1月10日于西安

Forward of the First Edition

Nowadays, blasting is the main rock-excavating method. In engineering, it is required that blasting, on the one hand, make the rock to be excavated be fragmented suitably and effectively, on the other hand, minimize the damage or fracture from blasting in the rock beyond excavation to keep the national stability of the remaining rock. Both of them are the goal the blasting technicians make great efforts for. But, there exist still many problems to be resolved because of the complexity in rock property and blasting process of rock. As a result, one literature is needed that discusses the essential theory and technology on rock blasting, and its development trends and newest research achievements.

Blasting rock is a complicated dynamic process. To research it, many subjects of knowledge, such as rock mechanics and theory of stress wave in solid, etc, will be used. But there exists no book containing such knowledge and its application in the research of the blasting and technology of rock. As a result, It is not convenient for young researchers and graduate students to learn and know well the essential information and the development front line and development direction of these subjects. It is for all of these that the literature is written based on the experience in author's teaching graduate students for many years and correlative achievements.

In recent years, many important achievements in theory on rock blasting have been obtained because of the efforts made by

domestic and oversea scholars, and the achievements obtained accelerate the broad application of new blasting technique. First of all, the literature will discuss the information needed for researching the theory of rock blasting, such as deformation and strength characteristic feature of rock under static load and theory of stress wave in solid. Next, introduces the research results obtained in recent years in such aspects as propagation characteristic of stress wave in rock and test methods for dynamic property of rock. And then, introduce especially blasting action principle and its calculation model and the newest research achievement and the latest advancement in them. Lastly, introduce the author's achievement obtained in recent years in the research of theory on controlled perimeter blasting of rock.

The book sums up comprehensively the existing blasting theory of rock and its newest achievement from research. It is helpful for graduate students and correlative persons to know well the front line and development trend of the subject. So the book is befitting not only for graduate students, teachers in college, and correlative researchers majoring in the subject, but also for those majoring in geotechnic engineering and structural engineering. The book can else be used as reference material by graduate students, teachers in college, and engineering technicians in the fields, such as earthquake and its defense, mining, national defense, highway water conservation and hydra-electric engineering.

Here, I will give my devout thanks to Professor Wang Shu-ren and Professor Yang Yong-qi, my doctor tutors, for their passional supporting and great help from beginning to end. Furthermore, I

will thank domestic and oversea craft brothers for some of their publications being consulted during author's writing.

Maybe, there are some mistakes in this book because author's limit knowledge and hurried time. So the pointing out the mistakes and criticizing and grant instruction are warmly welcome.

Author

In Xi'an, 2002. 1. 10

目　录