

DESIGN AND CONSTRUCTION OF TUNNELS

PIETRO LUNARDI

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Analysis of controlled
deformation in rocks and soils
(ADECO-RS)

 Springer

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About the Author



Pietro Lunardi

A civil engineer in the field of transport, he is one of the greatest experts in world on the design and construction of underground works, the creator of highly innovative solutions: the cellular arch, developed for the construction of the Porta Venezia station on the Milan Railway Link Line for which he was nominated “Man of the Year in the construction field” by the United States journal “*Engineering News-Record*”; shells of improved ground using jet-grouting techniques; full face mechanical precutting, face reinforcement using fibre glass structural elements; he devised and developed the revolutionary new approach to design and construction, known by the acronym ADECO-RS, described in detail in this book, which for the first time has made it possible to construct tunnels even in the most difficult geological-geotechnical and stress strain conditions with reliable forecasting of construction times and costs.

A former university lecturer in “Soil and rock improvement” in the Faculty of Engineering of the University of Florence and in the “Defence and conservation of the soil” in the Faculty of Engineering of the University of Parma, he has filled many institutional roles including that of Minister of Infrastructures and Transport for five years in the second Berlusconi government (2001-2006).

The author of more than 130 publications he has held more than 40 national and international conferences on the subjects of tunnelling and geo-engineering.

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Preface

To those who believed...

Geological hazard and the lack of appropriate survey, design and construction instruments for tackling those terrains we call “difficult”, with good prospects of success, have always made the design and construction of underground works a risky affair, which could not therefore be faced with the same degree of accuracy as other civil engineering works. As a consequence they have always occupied a subordinate position with respect to similar surface constructions and in the past they were only resorted to when the latter seemed impractical or of little use.

However, decisive progress made in the field of geological surveys, the availability of powerful computers for making calculations and above all the introduction of excavation technologies that are effective in all types of ground have created the conditions for a qualitative quantum leap forward. The last formidable negative factor to be overcome to achieve that transparency in this field, which has until now been the prerogative of traditional surface works, remains the absence of a modern and universally valid design approach, capable, that is, of integrating and exploiting the new capabilities and of guiding the design engineer through the stages of design and construction. In fact even today the answer to the apparently obvious and banal question, “What does the design and construction of an underground work consist of?”, would find many design engineers in disagreement not only on the form but also on contents of design. And this is not surprising because this type of problem has always been addressed in a very indeterminate fashion. Until not very long ago the inadequacy of the available knowledge and means meant that the design of an underground construction had to be improvised during tunnel advance. As a consequence, the design of such a construction was merely a question of identifying the geometry of the route and some of the tunnel section types, while the means of excavation, intervention to stabilise the tunnel and which linings to use were largely decided during construction as the tunnel advanced.

The practice of “observing” the response of the ground to excavation in order to devise appropriate countermeasures to stabilise a tunnel in the short and the medium term has therefore always lain at the basis of underground construction. In the last century some engineers sought to develop design and construction “methods” around this practice and although they were based on incorrect scientific theory, they nevertheless constituted significant progress at the time. This brought them great success at first, and despite many clamorous failures, they have managed to survive and flourish, assisted by a lack of alternative ideas caused by an unexplainable, lazy, and far too common tendency to conform. These methods, led by the NATM, were not only found to be inadequate in really difficult geotechnical and geomechanical conditions, but they also appear very much behind the times, because they cannot, by their very nature, furnish solutions which will enable construction to be planned in any way, in terms of finance and schedules, an undoubtedly essential requirement for transparent and prudent management of resources in modern societies.

This is the context in which, a little more than ten years ago, the presentation of the approach based on the Analysis of Controlled Deformation in Rocks and Soils (ADECO-RS) was met with great general interest, mixed with a degree of scepticism. I and my research team had developed it over a long period of theoretical and experimental research conducted outside traditional lines. It finally recognised how important the three dimensional nature of statics and the dynamics of tunnel excavation was and by taking this to its ultimate consequences and by appropriately exploiting the new technologies, it seemed to hold the promise of that long awaited quantum leap forward. It would for the first time enable an underground work to be designed before construction commenced with all the consequent advantages in terms of planning, construction costs and schedules.

Since then the validity of the approach has been tested on the construction of more than 300 km of tunnel and at least 150 km of this was under very difficult stress-strain conditions. These have been fully discussed as the occasion arose in conferences and publications in which it has been demonstrated beyond any doubt that we know how to transform our promises into reality. The approach had in fact made it possible to predict times and costs for the construction of underground works with a fair degree of precision (proportional to the knowledge of the geology acquired beforehand), minimising unforeseen events and eliminating tunnel advance problems, which were previously encountered under the same ground and overburden conditions. It seemed to have become finally possible to make a reliable estimate of the cost benefit ratio for an underground project, a fundamental parameter in the decision making progress of selecting design alternatives.

We are therefore on the right track; however, I do feel that much investigation and study is still necessary. The purpose of this book is not just to illustrate the basic concepts of the approach as fully and exhaustively as possible and to show how, by following its principles, underground works can be designed and constructed with a reliability and accuracy never attained before. Its purpose is above all to furnish the scientific community with a useful reference text around which all may work together to improve the ADECO-RS approach or even to go beyond it.

Pietro Lunardi

A note to the reader

I was concerned in writing this book to make it as easy and pleasurable to read as possible, despite the very technical and highly specialised nature of the contents. I therefore drew on the experience I had acquired in past years as a university lecturer, trying throughout the book to imagine the curiosity and desire for greater explanation that might arise in my readers. It was by trying to respond to this curiosity, which sometimes even led me to touch on subjects apparently quite distant from those being dealt with, that I felt I was often able to make the explanation more straightforward and to stimulate the attention of my readers, even on the more complex concepts.

The outcome is a book with two sets of contents, one for odd numbered pages on which the central theme of the book unfolds and one for even pages, which can be read independently of the text. It is on these pages that I have sought to satisfy the reader's desire for greater explanation with observations and extra detail.

Thanks

To complete this book, which collects together experiences from forty years of working on numerous construction sites, in universities and other professional environments, I wish to sincerely thank those who have believed in me over these long years, teaching me and advising me. They include Angelo Palleschi from Capistrello, one of the many tunnel miners who have helped me during those long hours spent on tunnel construction sites, Angelo Farsura, an enlightened entrepreneur who gave me the chance in the 1960's and 1970's to follow the works on site for the Gran Sasso tunnel, one of the most complex and fascinating projects of the last fifty years and so many other people who I obviously cannot mention here, but to whom I am bound, through my memories, by gratitude and friendship.

Finally, I wish to say a special thank you to those who have worked most closely with me, Renzo Bindi, Giovanna Cassani and Alessandro Focaracci, who, with their shrewd engineering sense, have helped me to develop this new approach to the design and construction of underground works. It is an approach, which I hope will serve as a useful guide for young engineers who wish to study and implement these works, which differ from other civil engineering works because of the extreme and continuous variation in the geological, geotechnical and stress-strain conditions in which the design engineer is obliged to operate.

Pietro Lunardi