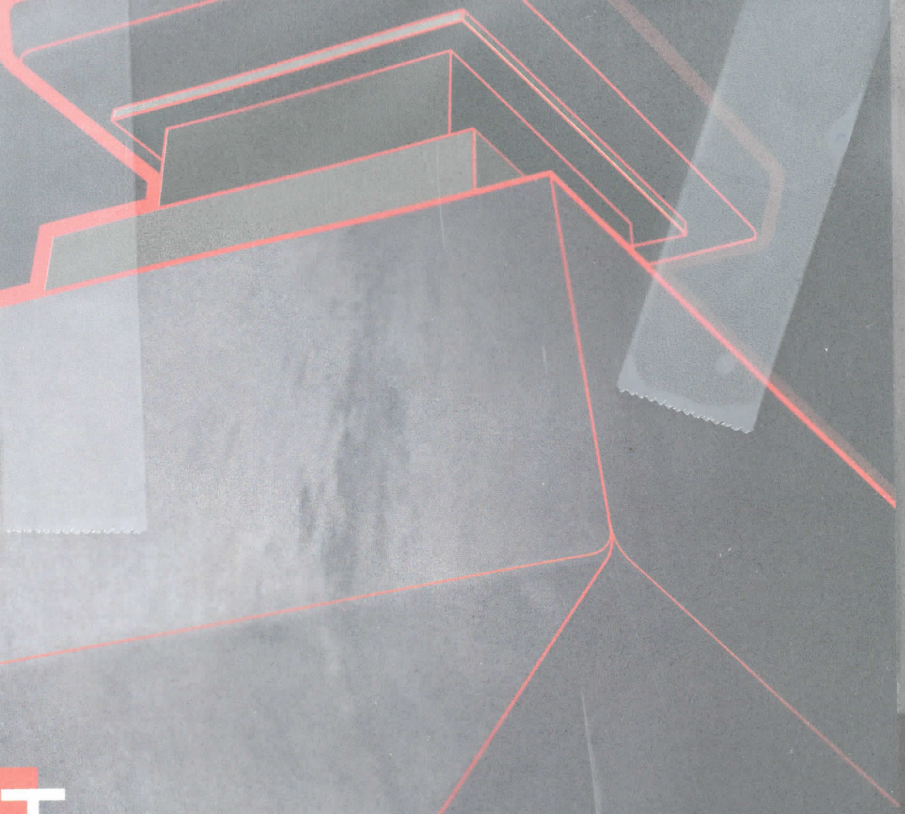
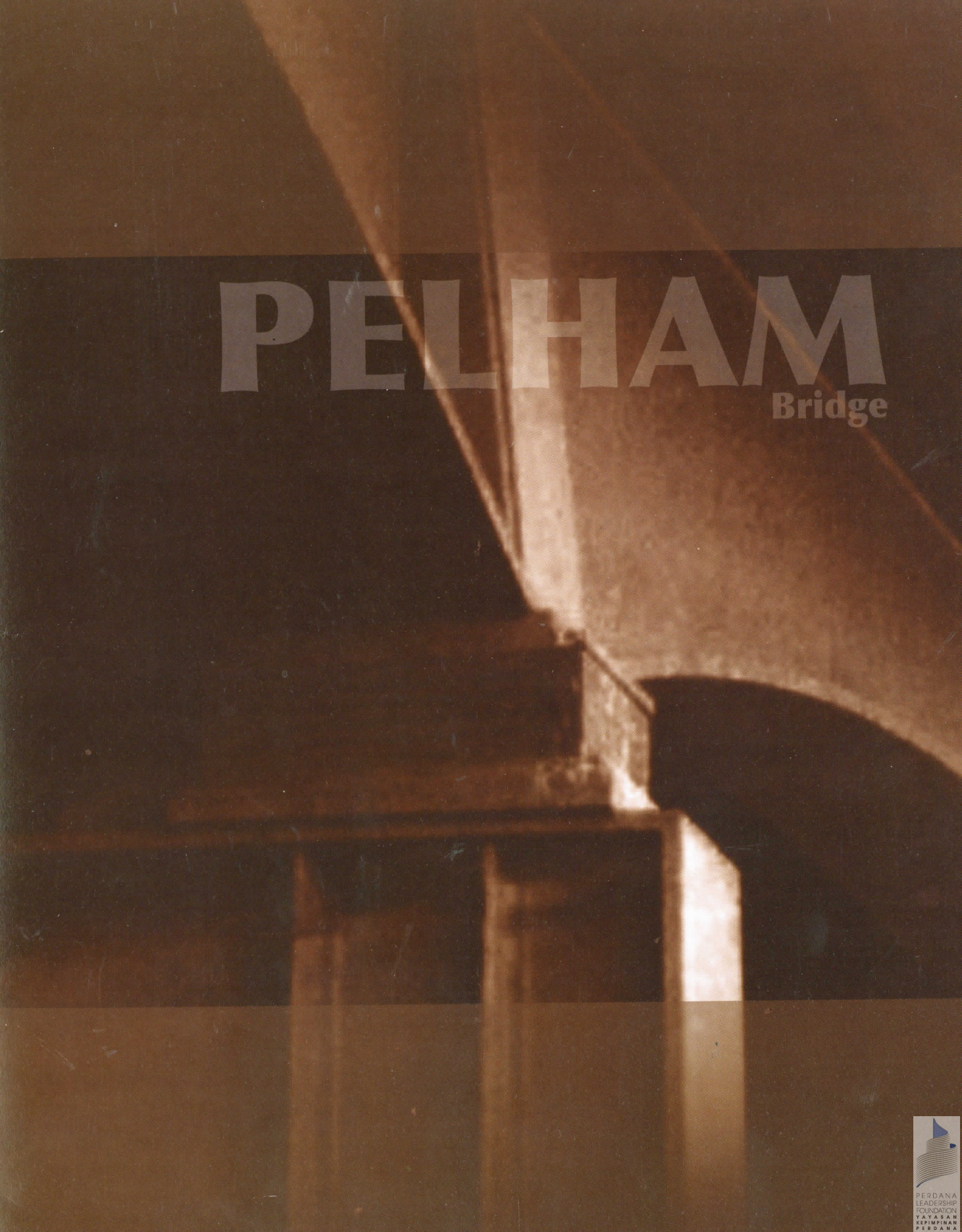
KAMARUDIN AB-MALEK & ALAN D ROBERTS

FROM PELHAM TO PENANG

NATURAL RUBBER BEARINGS FOR CIVIL ENGINEERING



This book presents a summary of the various scientific and technological studies related to rubber-bonded steel laminate bearings and their engineering use in bridges and buildings. Contributors to this field are members of the scientific staff of the Malaysian Rubber Board (MRB), via its two laboratories of the Rubber Research Institute of Malaysia (RRIM) in Kuala Lumpur and the Tun Abdul Razak Research Centre (TARRC) in the UK. The chapters cover basic facts about rubber and its historical use in civil engineering, with a particular focus on structures that benefit from vibration isolation and earthquake protection. In the Second Penang Bridge High Damping Natural Rubber (HDNR) bearings are used to ensure that the bridge survives against any major earthquakes in its proximity. The book will be of value not only to scientists, technologists and engineers working in research institutes and in the rubber and construction industries, but also to a wider audience.



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FROM **PELHAM** TO **PENANG**
NATURAL RUBBER BEARINGS DEVELOPMENT
FOR CIVIL ENGINEERING

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FROM **PELHAM** TO **PENANG**
NATURAL RUBBER BEARINGS DEVELOPMENT FOR CIVIL ENGINEERING

by

Kamaruddin Ab Malek and **Alan D Roberts**

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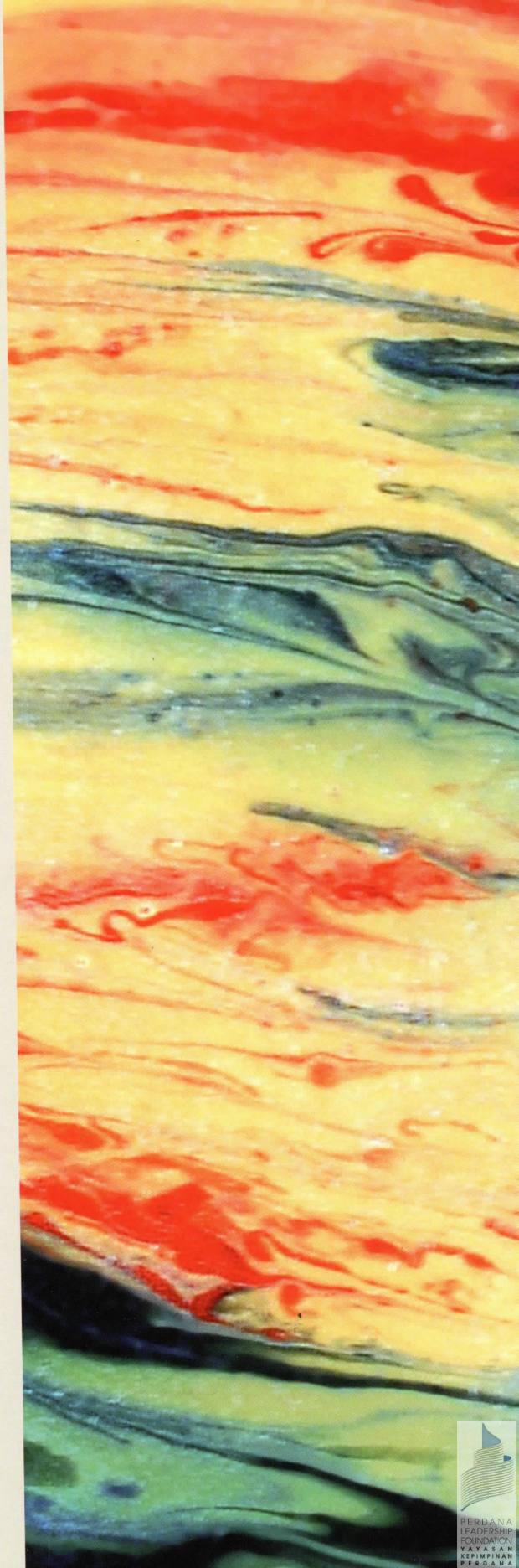


FOREWORD

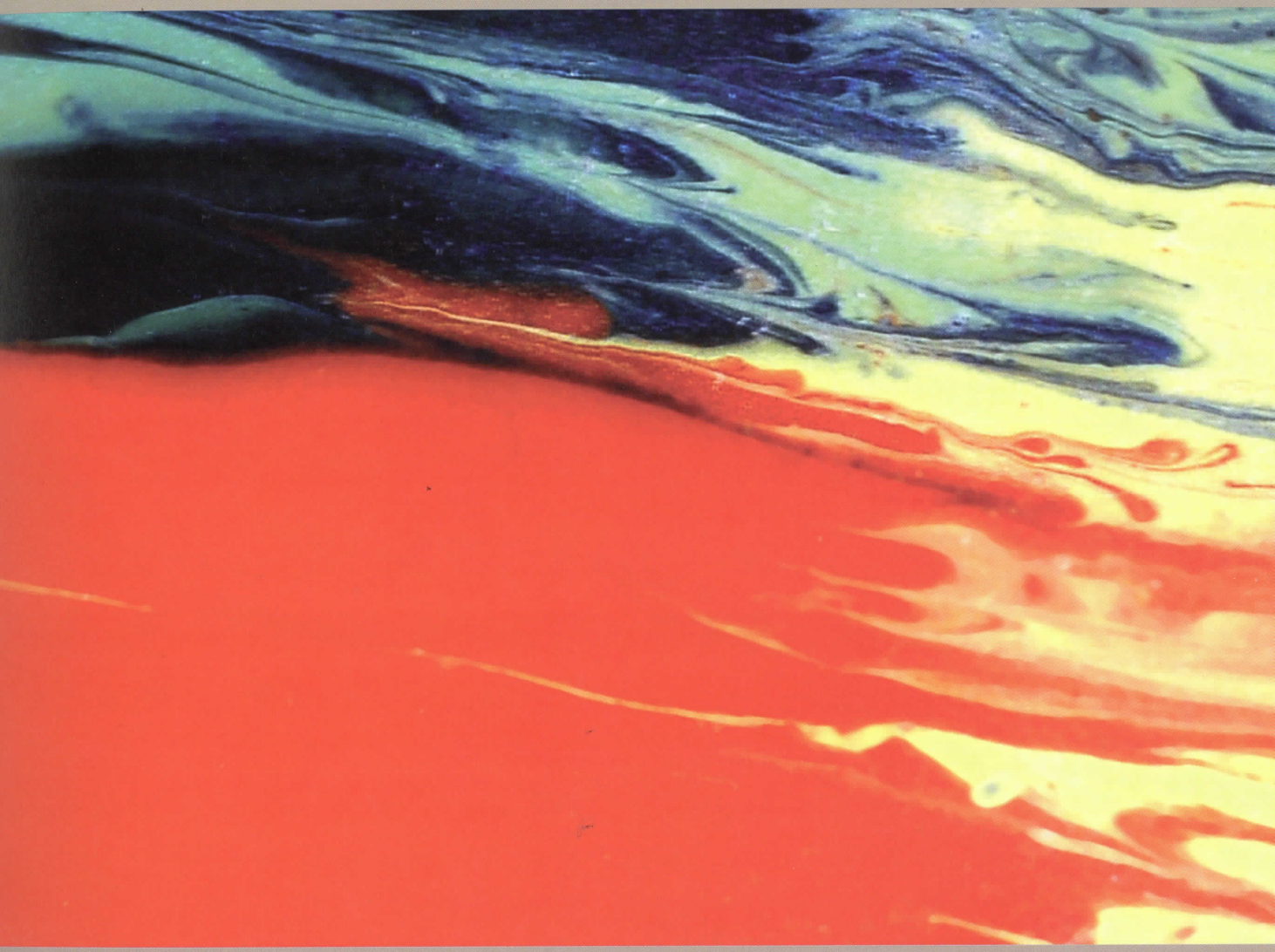
This book has been produced to mark the opening of the Second Penang Bridge spanning from the Malaysian mainland at Batu Kawan westward to Batu Maung on Penang Island. Being 24km long it is the world's largest structure on High Damping Natural Rubber bearings (HDNR). The use of such bearings will ensure that it is fully protected in the event of any major earthquake in the area. The HDNR bearings are a product of Malaysian research and manufacture, an indicator of advancing technological prowess.

Construction of the Second Penang Bridge began in 2008 and was completed five years later on budget and on time. It serves a rapidly growing industrial development and thriving communities on either side.

This book traces the scientific and technological pedigree of the bridge's bearings going back 55 years to the inception of rubber-steel laminated support bearings for bridges. The description given outlines how problems, both technical and conceptual, were overcome to arrive at a new type of natural rubber bearing suitable for the earthquake protection of structures. Such a bearing has been referred to as 'semi-intelligent'. This book relates our experience of a long journey from simple rubber supports for a railway viaduct a hundred years ago to sophisticated rubber-steel laminates for the first seismic protected Malaysian bridge.

The Second Penang Bridge is scheduled to be opened in late 2013. With the construction of this bridge it is anticipated that more bridges in the world's earthquake –prone countries will use this technology.

DATUK DR SALMIAH AHMAD
Chairman of Tun Abdul Razak Research Centre,
and Director General of the Malaysian Rubber Board



Latex Painting by Ahmad Suhaime Nordin of MRB

MESSAGE

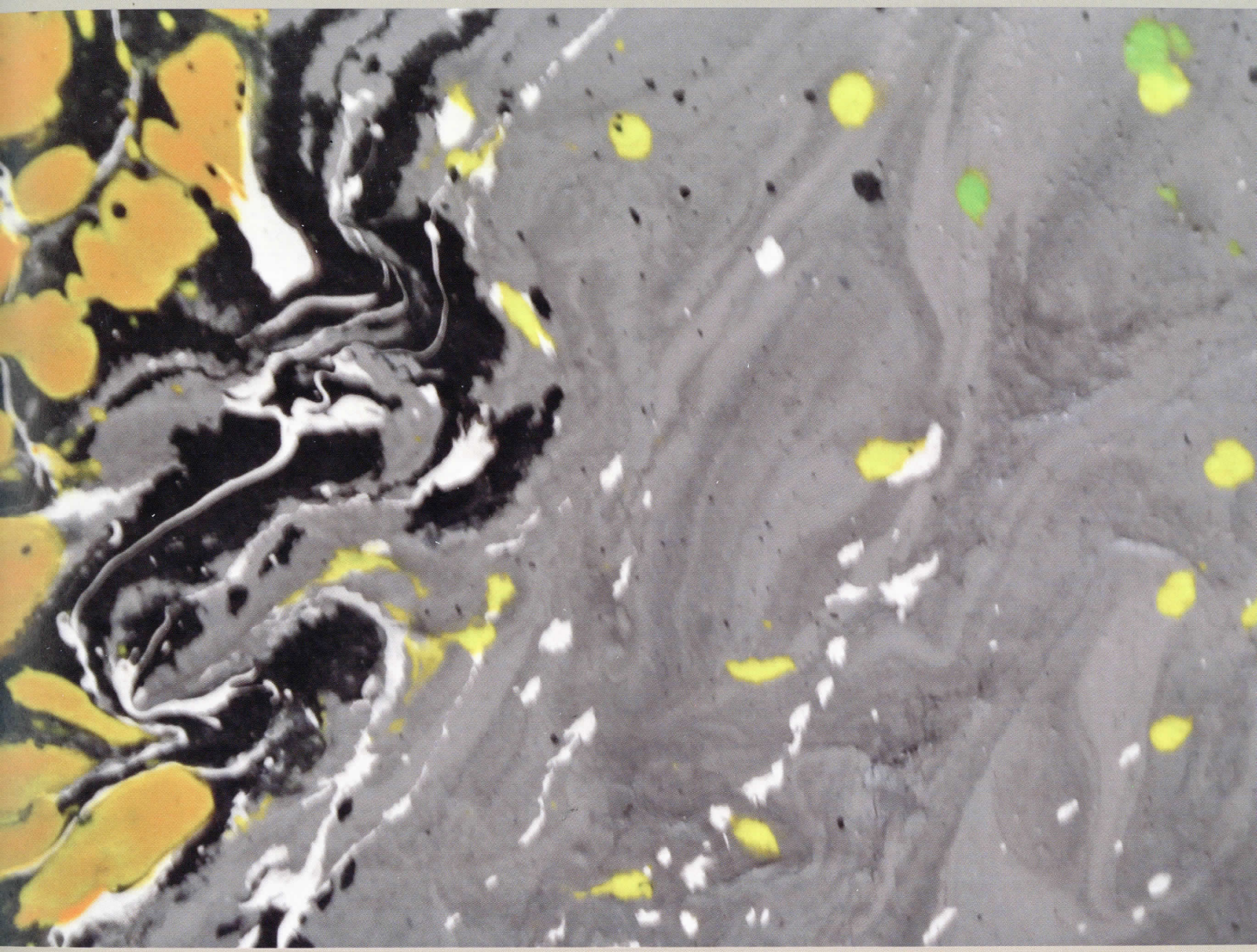
Jambatan Kedua Sdn Bhd is proud to present to the world the longest bridge that is protected against major far field earthquakes using a seismic isolation technique. The High Damping Natural Rubber (HDNR) seismic bearings used in the project are the result of pioneering research at the Malaysian Rubber Board's Tun Abdul Razak Research Centre (TARRC) in Hertford, UK. The HDNR bearings were designed by TARRC and their manufacture and testing was carried out at the Doshin Rubber factory in Klang under the supervision of the Rubber Technology Centre (RTC), the Malaysian Rubber Board's research centre in Sungai Buloh, Malaysia. The design of the bearings and their quality control procedures comply with the European seismic standard EN 1998 Eurocode 8.

The Government of Malaysia has recognised that the construction of the Second Penang Bridge forms an essential part of an infrastructure programme required for the continuous economic and social development of the northern part of mainland Malaysia.

During the course of the project close collaboration between the Malaysian structural engineers and the Malaysian Rubber Board (MRB) research staff provided an opportunity for transfer of base isolation technology, so that Malaysian bridge engineers can offer this expertise to other seismic areas of the world.

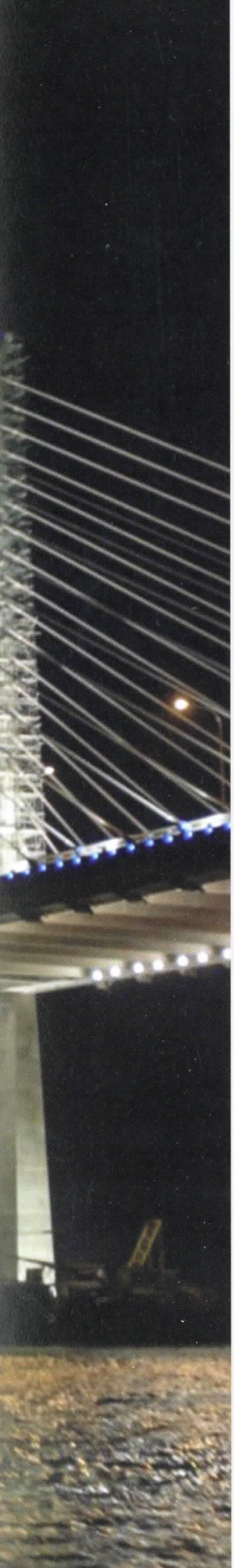
I am therefore delighted to offer my support for the publication of this book aimed at raising the awareness of the public especially in Malaysia to this novel technique developed at Malaysia's Tun Abdul Razak Research Centre in the United Kingdom.

DATUK IR DR. ISMAIL MOHAMED TAIB
Managing Director of Jambatan Kedua Sdn. Bhd,
Bukit Damansara, 50490 Kuala Lumpur



Latex Painting by Ahmad Suhaime Nordin of MRB

Second Penang Bridge, Malaysia (Courtesy of JKSB)



PREFACE

This book, written to mark the opening of the Second Penang Bridge, describes the various scientific and technological studies related to rubber-bonded steel laminate bearings and their engineering use in bridges and buildings that have been carried out over the last fifty years by the Malaysian Rubber Board (MRB), via its two laboratories of the Rubber Research Institute of Malaysia (RRIM) in Kuala Lumpur and the Tun Abdul Razak Research Centre (TARRC) in the UK. Contributors to such sustained effort have been members of the scientific staff of the two institutes. The chapters cover basic facts about rubber and its historical use in civil engineering, with a particular focus on structures that benefit from vibration isolation and earthquake protection.

The elastic properties of rubber make it ideal as a 'spring' in particular components such as suspension devices for ground vehicles and noise isolators in buildings. Its initial use in bridges was to allow expansion and contraction of the decking with changes in ambient temperature without imposing large horizontal forces on the piers. In the foundations of buildings the rubber-steel laminate spring was introduced to isolate the building from ground borne vibrations in metropolitan city centres.

Rubber is classified as a viscoelastic material, meaning it has elastic and damping properties to control motion. By special compounding, the damping properties of rubber can be increased and this finds particular use in protecting structures from horizontal ground movement as experienced in earthquakes. In the Second Penang Bridge High Damping Natural Rubber (HDNR) bearings are used both to accommodate thermal expansion of the deck and to protect the bridge against earthquake tremors.

The multi-disciplinary approach most necessary to understand rubber properties has been clearly facilitated by the philosophy of the two institutes. An example has been the co-ordinated application of physics, engineering and dry rubber compounding to find a way of producing HDNR bearings and related accessories for the Second Penang Bridge. This bringing together of a range of resources to bear upon conceiving the best possible bearing for the bridge has resulted in a unique design fit for the 21st Century.

The authors owe much to the board members of the Malaysian Rubber Board for their encouragement and advice. We thank members of staff of the laboratories for countless exchanges of ideas and support. In particular, we thank Kevin P Jones for preparing the Index, Hamid R Ahmadi, Keith N G Fuller and Judith K Picken for their helpful suggestions and proof reading. We are grateful to Fauziah Ab Rahman and Ahmad Suhaime Nordin for helping in the publishing process.

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KAM / ADR

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