Preface

This book addresses one of the most important material categories: Materials used for constructions. A large percentage of the gross national product of most countries goes into infrastructure and buildings. This statement is true not only for the present but for most other periods in history, and for most cultures. This explains why understanding the behavior of construction materials has always been the object of intense investigations. The construction industry consumes extreme volumes of material, and the growing demand for quality and safety require continuous improvement of materials and material compositions. A deep understanding of material behavior is essential to enable efficient construction: light-weight or heavily burdened structures ask for the development of innovative composites or new material compositions. Rapid economic growth and a dense and growing population require sensitive and sustainable use of resources. Finally efficient use of resources means extending the usage of existing structures, so non-destructive testing methods are needed to assess the safety and utility of these structures.

Civil Engineers and Material Scientists from all over the world are openly discussing ideas for new materials, and for structural health monitoring. Over the last decade many innovations have come to fruition, primarily in the field of composites but also for improving the design of existing material. This is especially true for concrete, perhaps the most used material in the world – broadening its range of applications and improving performance. Some of these developments include high-strength and high-performance concrete (HPC), self-compacting concrete (SCC), shotcrete, textile or fiber reinforced concrete (FRC), and chemical and mechanical additives. Performance can be further optimized by combining these improvements. Enhancement of material behavior and physical properties were also made for most other construction materials (e.g. wood, masonry, steel, polymers) as well.

This book contains descriptions of some of these developments giving a thorough overview about the state-of-the-art in construction material science. The book is subdivided in nine chapters addressing most of these aspects. Some of the leading experts in their particular research fields present their results – experts that are all more or less closely related to one impressive person: Prof. Dr.-Ing. Hans W. Reinhardt. The research in the field of construction materials was (and is) always influenced by dominant researchers, so many contributions in this book are dedicated to Reinhardt. Therefore, it is just consequent to start the book with a review about his scientific achievements up to his recent retirement.

The papers here presented were originally submitted to the conference on Advances in Construction Materials (ACM2007) which is held in July 2007 in Stuttgart which is also dedicated to Reinhardt’s work. This book addresses perhaps the
key element of Reinhardt’s contributions: Materials used for constructions as well as improvement and testing of structures.

The editor is grateful for the help of two hard workers who made this compilation possible. Mrs. Simone Stumpp has to be thanked first. She is always friendly, solid and maintained a high commitment to work. Her help was essential to all parts of the book production and conference preparation. Mrs. Anne Lehan was a very enthusiastic and dependable worker during the preparation and formatting of the manuscripts. This book would certainly not have been possible without both.

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Stuttgart, July 2007, Christian U. Grosse (Editor)
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Introduction

The contributions in this book are dedicated to the person and work of Hans-Wolf Reinhardt. Consequently, this paper describes stages of his scientific work, which is related to a variety of different fields in Civil Engineering such as construction materials, fracture mechanics and non-destructive testing. He investigated an amazing variety of different materials and material compositions including concrete (SFRC, HPC, SCC), wood and aluminum. His impressive vita comprises tenures at the University of Delft, the University of Darmstadt and the University of Stuttgart. The following chapters is an overview of the many contributions to our science that Prof. Reinhardt gave. The brief descriptions are certainly neither complete nor in the only possible order. The order chosen is merely based on the sequence of events during his scientific work at different institutions. One can imagine how he was influenced by the collaborators and scientific environment. However, many of the contributions in the following chapters of this book are directly related to his work summarized in this paper. It is also necessary to mention that he is still active with several scientific projects – he will continue to contribute with new research results.

Stuttgart: May 1964 – September 1969

Reinhardt finished his University Diploma in Civil Engineering at the University of Stuttgart in 1964 and got a PhD position by Prof. Gustav Weil. From the beginning Reinhardt was closely related to the Otto-Graf-Institute in Stuttgart. Gustav
Weil was one of the assistants of Otto Graf, who was head of the Institut für Bauforschung und Materialprüfung des Bauwesens (Institute of Building Materials and Materials Testing of Civil Engineering) from 1927 up to 1950. Friedrich Tölke was head of the institute between 1952 and 1969 and during his time the institute was renamed Amtliche Forschungs- und Materialprüfungsanstalt für das Bauwesen (FMPA-Bauwesen) (Official Research and Materials Testing Institute of Civil Engineering (FMPA-Civil Engineering). In honour of Prof. Otto Graf’s work the institute received the additional name “Otto-Graf-Institute”. Friedrich Tölke was than succeeded by Weil (1969 to 1972), who – like his successors – held the chair and lectured constructional science at the University of Stuttgart.

Since Weil was collaborating with Otto Graf for a rather long time it is not surprising that road construction using concrete was one of the research subjects at that time. When Reinhardt took over a position under the supervision of Weil there were three road construction projects at the Otto-Graf-Institute (OGI) including the test track near Offenburg, the determination of shrinkage of embedded concrete plates and the examination of temperature distributions in such plates. The test track near Offenburg was part of the historical “HaFraBa” track that was in fact one of the first big highway projects in Germany connecting the Hanseatic cities with Frankfurt and Basel. Here, load cycle fatigue tests were conducted at joints and Reinhardt took over the task to file a summarizing report for the German Federal Ministry of Transportation. Realistic model specimen were concreted at an open site near the institute and used to investigate the shrinkage and temperature behaviour. All OGI assistants had to take over tasks to control the instruments and read the data in summer, winter, day and night. Reinhardt developed a method to calculate the stress distribution in multi-layered plates that was later applied to veneer plates.

Fig. 1. IBM 1130 mainframe computer Reinhardt used for his PhD thesis [by courtesy of Computer Museum of the University of Stuttgart]
The PhD thesis Reinhardt compiled during these years was dealing with photoelasticity of thermal stress. He was influenced by lectures given by Prof. Kuske, who demonstrated how stress can be visualised. In these days the three-dimensional stress distribution in construction materials was not understood and therefore Reinhardt used the composite-model technique based on interface layers using non-birefringent materials. It was a challenge to find such materials able to react chemically, being transparent and having similar mechanical and thermal properties. He finally succeeded using a mix of acrylic and polyester resins resolved in styrol and methylmethacrylate. The experiments using cylindrical specimens were analyzed using state-of-the-art computers. Reinhardt was one of the first OGI assistants being trained by IBM to use the IBM 1130 mainframe computer (Fig. 1) with 16 kByte RAM and a punch card interface. More details about the experiments and results can be found in the thesis itself [Reinhardt 1969].


A post-doc position was granted by the Max-Kade Foundation, New York, to H.-W. Reinhardt. He decided to go to the Illinois Institute of Technology (IIT) in Chicago, to work with Prof. James W. Dally. Dally was well-known for publications using dynamic photo-elasticity and was at these days evaluating wave propagation effects. In particular he investigated the behaviour of Rayleigh waves diffracted at a crack as well as the effect of explosives used for quarry blasting. The IIT was in the possession of a Cranz-Scharidin camera using spark discharges for high-speed recordings; up to 16 pictures could have been made in a few microseconds. Doing research in the field of wave propagation he needed to study the basic principles by following lectures at the IIT and reading books [Victorov 1967]. As it is not unusual at US Universities there were no technicians available to support his work and he needed to do all the experimental work on his own: miliecutting of specimen, adjusting the camera, preparation of specimen with explosives (lead acetate), conducting the experiments and developing the photographic film. [Reinhardt/Dally 1970]

Stuttgart: October 1970 – September 1975

Being back in Stuttgart, Reinhardt (now as Oberassistent and Akademischer Rat) proceeded with the work on road track concrete, but the work was interrupted by the sudden death of Prof. Weil caused by a traffic accident in Spring 1972. Reinhardt was asked to substitute Weil regarding teaching until a successor was found. This was Prof. Gallus Rehm, who started to work as a director of FMPA in Fall 1973 and was entrusted among other things with a research project called “Widespan Structures” („Weitgespannte Flächentragwerke“, Sonderforschungsbereichs 64). In this
frame Reinhardt was put in charge with a subproject dealing with the evaluation of the two-dimensional behaviour of coated textiles. He was able to use a biaxial test machine that was transferred from the Department of Mechanics to the OGI [Losch 1971]. This machine enabled for controlled biaxial stress-strain conditions during the experiments. The results [Reinhardt 1976] influenced the construction praxis in Germany and for example were used during the construction of a multi-purpose hall in Mannheim (Fig. 2) designed by Carlfried Mutschler, Joachim Langner and Frei Otto (http://de.wikipedia.org/wiki/Multihalle).

In civil engineering there is a huge interest to gain knowledge about the effect of stress inside a membrane-shaped structure and therefore a measuring device needed to be developed. Reinhardt developed together with colleagues from the department of steel structures a ring-shaped device able to aspirate at a membrane and to deform the structure. A measurement of the deflection enabled for the determination of the stress status inside warp and weft.

**Delft: October 1975 – August 1986**

In 1975 Reinhardt got a chair for Structural Engineering at the Department of Design and Construction of the Technical University of Delft, The Netherlands. At this time the new Stevin Lab was inaugurated and Reinhardt became director of
the concrete section of this laboratory. He was able to support the installation of the measurement equipment and machineries. His inaugural lecture (Fig. 3) was entitled “Demountable buildings using concrete?” that was a controversial subject but led to a research project funded by the “CUR commission” (a Dutch institution to support research and development of concrete structures). Demountable structures were designed as well as flexible joints of prefabricated concrete parts and experiments were conducted loading slabs horizontally. For practical applications several systems for school, clinical and office buildings were designed. In May 1985 a first international symposium entitled “Demountable concrete structures – A challenge for precast concrete” was held in Rotterdam.

Another subject he was intensively working on at TU Delft was the fracture mechanics of concrete. Based on shear experiments conducted at these times in Delft Reinhardt became interested in the problem of tension behaviour of concrete that is usually investigated using split tests. This class of experiments developed values for the tensile strength but provided no details about the stress-strain relationship. Measuring techniques dealing with axial tension in analogy to steel have not been fully developed at this time. With adhesives recently launched he was able to use plates attached to cylindrical specimen to load until failure, but a controlled axial deformation up to final separation could not have been established. With the help of the Stevin working group on measurement techniques a controlled deformation up to failure could be realized using fast feedback control. Additionally the geometry was optimized.

Dealing with the tensile behaviour of concrete led to an intensive preoccupation with fracture mechanical problems. Reinhardt, who was following courses earlier in Stuttgart on linear fracture mechanics of steel, transferred his ideas to concrete

Fig. 3. Reinhardt giving his inaugural lecture at TU Delft in 1976
cumulating in the article “Maßstabseinfluss bei Schubversuchen im Licht der Bruchmechanik” (“Size effect at shear experiments in the light of fracture mechanics”, [Reinhardt 1981]). About the same time, Arne Hillerborg introduced the “fictitious crack model” [Hillerborg et al. 1976], what resulted in the non-linear fracture mechanics. Zdenek P. Bazant derived the size effect law using linear theories in combination with the actual concrete behaviour [1976]. Reinhardt worked in this field together with Dutch colleagues at the Technical Universities Delft and Eindhoven, the TNO (Netherlands Organisation for Applied Scientific Research Building and Construction Research), RWS (Rijkswaterstaat) and CUR. At these days finite element techniques became more and more popular being applied to material problems in Civil Engineering. In this environment TU Delft was about to care for the material laws based on data of numerous experiments using regular, light-weight and fiber concrete and varying deformation velocities as well as the temperature. Additionally long term tests were conducted and the low cycle fatigue behaviour was examined. There was additionally a close cooperation with the Technical University in Darmstadt and different Universities in the US and Belgium.

Right at the beginning of his work in Delft it was discussed why precast piles got eventually damaged during driving. One possible explanation was that the pressure wave caused by driving converted at the end of the pile into a tension wave causing failure due to traction. His experiences with wave propagation effects during his visit in Chicago helped him to understand these phenomena including investigations of all parts of the system like pile drivers, the pile itself or an interface between both. An unknown parameter was the concrete and in particular the influence of the load velocity to its tensile strength, which was subject of a larger research project. After many experimental iterations the so-called “Split Hopkinson bar” was chosen for a test setup. This method is based on the propagation of longitudinal stress waves in elastic bars. When a striker, accelerated typically to a velocity of 2.5 to 40 m/s, hits the front end of the incident bar, a compressive stress wave is generated, which propagates in the bar until it reaches the interface of the incident bar with the specimen. At the interface, part of the stress wave is reflected back as a pulse of tension, while the remaining part is transmitted through the specimen to the transmitted bar. A vertical test setup of 11 m high was implemented where at one end a tensional wave was generated by a drop-weight. After passing the incident bar out of aluminium the wave hit the concrete specimen. The load velocity was controlled by the interface between the weight and the aluminium bar. With this unique device numerous experiments were conducted to test regular, light-weight and fiber concrete whereas the composition as well as the ambient humidity and temperature were varied again [Reinhardt 1982]. The temperatures chosen went to extremes, i. e. down to −160° C for example, to investigate conditions similar to liquefied gas tanks.

In addition to these main research projects Reinhardt worked on the creep behaviour of regular and light-weight concrete in air and see water, on erosion of concrete in floating waters and shear load bearing behaviour of steel reinforced and prestressed concrete elements.
In 1986 Reinhardt got the offer to take over the chair of the Department of Construction Materials and Building Physics at the Technical University of Darmstadt and went back to Germany. At those days the German Federal Water Act (Wasserverhaltungsgesetz, WHG) was amended stipulating all chemical companies to proof that their plants do not pollute the groundwater. This included providing evidence of a secondary barrier system for storage systems protecting against water pollutants. To use retention basins out of concrete was common, but no one knew if this material being somehow porous was adequate. In cooperation with a large chemical company the penetration of fluids like gasoline, light and heavy fuel as well as ammonia was quantitatively evaluated. He took over two PhD students from his successor, Prof. Karl Weigler. One of the students was involved with partial area loading of concrete and the other just started to work on permeability of concrete. Reinhardt was interested primarily in the latter, because it dealt with the physical properties of concrete. This lead to a permeability prediction model subjected to
the pore radius being of help also for the prediction of penetration depths of organic fluids [Reinhardt & Gaber 1990]. Additionally, Reinhardt elaborated a concept to use computer based expert systems to assess near surface deteriorations of steel reinforced concrete structures. This resulted in the software REPCON being widely distributed but was suspended later, because the shell was not maintained anymore. SIFCON (Slurry Infiltrated Fiber Concrete) was a new highly ductile construction material developed in the United States but its other physical properties were generally speaking unknown. Reinhardt conducted tensile and shear load experiments. Coincidentally Antoine E. Naaman from the Michigan University, USA, was present as a visiting professor for several months in Darmstadt supporting him in his efforts. An extensive test series was conducted including the mechanical behaviour as well as the permeability in regards to organic fluids. 1990 was the year of the first workshop on "High performance fiber reinforced cement composites" (HPFRCC) in Mainz followed by four other workshops about this subject in later years either in Ann Arbor, Michigan, or Mainz. The next HPFRCC workshop (no. 5) is planned for July 2007 in Mainz and will be – of course – organized by Prof. Reinhardt.

Stuttgart: April 1990 – March 2006

In 1990 Reinhardt finally got a call back to his roots. He became full professor (Ordinarius) of the Department of Construction Materials of the University of
Stuttgart in association with the position of a director of the Forschungs- und Materialprüfungsanstalt Baden-Württemberg (Research and Material Testing Institute of the State of Baden-Württemberg). He followed Prof. Gallus Rehm (Fig. 5), who held these positions from 1973 to 1990 (see section Stuttgart: October 1970 – September 1975). Reinhardt was very active in these 16 years which requires a more detailed subdivision of this period.

Non-destructive Testing in Civil Engineering

1990 was also the year when the author met Reinhardt for the first time. Reinhardt had an interest to improve the methods of non-destructive testing (NDT) in Civil Engineering and initiated a new NDT working group (Fig. 6).

These efforts were supported by a new Collaborative Research Center (Sonderforschungsbereich 381) funded by the Deutsche Forschungsgemeinschaft (DFG) and dealing with Characterization of Damage Evolution in Fiber Reinforced Composites by NDT. Besides the investigations of the crack initiation and propagation in concrete the NDT working group evaluated methods to monitor the setting and hardening of concrete. Starting from scratch the group developed under Reinhardt’s supervision a method based on ultrasound to be applied for quality control of fresh cementitious materials. This technique was later patented for Germany and the US [Reinhardt et al. 2003]. In 2000 a RILEM technical committee „Advanced testing of cement based materials during setting and hardening” was founded with Reinhardt as chairman. The TC was working on NDT methods to investigate the hardening of concrete bringing experts from all over the world together. An international workshop in Stuttgart 2006 as well as a book including a state-of-the-art report [Reinhardt & Grosse 2006] were the results of this TC. Regarding the fracture techniques Reinhardt – together with PhD students – applied methods known from geophysical prospecting to problems dealing with much smaller specimens, e.g. out of fiber reinforced and steel reinforced concrete. The acoustic emission technique was enhanced by a more signal-based data processing enabling for the analysis of data in respect to a correct 3D localization of cracks and a fracture mechanical interpretation of acoustic events. The theory (e.g. moment tensor inversion techniques) was adjusted to problems in Civil Engineering.

Fig. 6. The NDT group in 2004
taking certain wave propagation effects into account. Later on a DFG Research Group (netzgestütze Forschergruppe 384) was established by the DFG bringing together scientists from different German Research Institutions to work on the *Non-destructive evaluation of concrete structures using acoustic and electro-magnetic echo-methods*. Again Reinhardt was the chairman (Sprecher) of this group and Stuttgart’s NDT team developed a modified Impact-Echo technique to be applied to hardened and hardening concrete elements. Impact-Echo became one of the first modern NDT techniques in Germany to be included in a quality assurance standard (here: detection of a reduced thickness of concrete tunnel walls).

In addition to concrete Reinhardt was interested more and more in wood as a construction material. Already during his second Stuttgart period he published a paper about creep of wood. And it was natural that he got involved in the years following 1990 in the Collaborative Research Center 230 “Natürliche Konstruktionen” (Natural Structures) responsible for a project about fracture mechanics of wood. During the SFB381 (see above) wood became again an important issue concerning the fiber matrix interaction and NDT. Some work was done regarding the anisotropic behaviour of wood, the size effect law and the behaviour under humidity and temperature variation. Finally, the shear behaviour of glulam girders with openings was investigated.

**Textile Reinforced Concrete**

Another subject Reinhardt was working on was textile reinforced concrete. This material is still en vogue and Reinhardt was at the research forefront at that time again. Besides of large research projects at the Universities in Aachen and Dresden he succeeded to seize a niche: Prestressed textile reinforced concrete. The advantage of prestressed elements is that fabrics can be stretched first of all in weft direction and will not be elongated too much at the first sight of cracks. The experimental work was supported by know-how collected during the membrane experiments earlier as well as by a load device similar to the one earlier mentioned by Losch, but larger.

**Civil Engineering in the Environment**

To work with environmental issues in a broad sense was also one of his foci. This included investigations dealing again with the penetration of organic fluids into concrete, where Reinhardt was involved with the standardization of test methods, the expansion of the theory, penetration through cracked concrete and the modelling of the sequential penetration of two different fluids. In the frame of the RILEM organization a successful international collaboration led to the book “Permeation and permeability of concrete – Barriers to organic and contaminating liquids” [1997].

Another one of his topics dealing with the environment was the collaborative project *Baustoffkreislauf im Massivbau* (BIM) (Recycling of Construction Mater-
mials), where he was involved with the recycling of light-weight concrete. In addition a data base was created to collect the data of all collaborators. The software-based information system “B-I-M online” was established still available in the internet (http://www.b-i-m.de/, in German only).

In a third environmental topic he made enquiries on sustainable constructions using concrete. After compiling a state-of-the-art report another data base was established in a cooperative development, which is the basis of a new and ongoing project.

Finally, Reinhardt was involved with the problem of underground storage tanks for warm water. He was interested in the use of high performance concrete and its permeability for hot water and steam of up to 80° C. Experimental work was done including the design of a suitable measuring device as well as theoretical work to enhance the theory of temperature dependent transport of water and steam.

Special Concrete and its Properties

Despite of the earlier mentioned concrete research programs Reinhardt conducted on steel reinforced, fiber reinforced and textile reinforced concrete he was involved with hybrid concrete and self compacting concrete (SCC). Hybrid concrete consists of a larger part of normal aggregates and in addition a smaller part of light-weight aggregates. The water-saturated light-weight aggregates can take care of the internal hydration of concrete if highly dense concrete is used where a normal hydration process is difficult to be enforced from outside. Instead of light-weight aggregates super absorbing polymers (SAP) can be used. After preliminary results these investigations are ongoing. Compiling a guideline for the use of SCC it became evident that issues regarding heat treatment, fire resistivity and rheology are not fully covered. All three issues were investigated in Stuttgart with the effect that the SCC guideline is now better confirmed and the public use of SCC is safer.

Creep and shrinkage of concrete are well-known effects, but during experiments on high-performance concrete and SCC an additional effect was found called stress-induced shrinkage: The shrinkage effect of concrete is more evident if the material is subjected to stress.

Memberships and Distinctions

This compilation is giving certainly a poor overview if one does not mention the committee work Prof. Reinhardt did over the years in many national and international committees. Prof. Reinhardt is a member of numerous organizations including – among others – the International Union of Laboratories and Experts in Construction Materials, Systems and Structures (RILEM), the American Concrete Institute (ACI), the American Society for Testing and Materials (ASTM), Deutscher Ausschuss für Stahlbeton (DAfStb), Deutscher Beton- und Bautechnikver- ein (DBV), International Federation for Structural Concrete (FIB), Internationale
Since several TCs were already mentioned in the text above where Reinhardt served as a chairman it would extent this article outmost to include a full list – this list would also not be complete since he is still very active in committees.

He was given many distinctions including the RILEM Fellowship (09/2000), the ACI Fellowship (04/2005). Since 2006 he is one of fourteen RILEM Honorary Members worldwide. In 2000, he was Visiting Professor at Southeast University, Nanjing, China, 2002 he got a Honorary Professorship from Dalian University, Dalian, China and in 2004 he received an Honorary Doctor from University of Technology, Braunschweig, Germany.

Conclusions

The results of Reinhardt’s research were obtained in most cases by the support of colleagues, Diploma and PhD students, assistants or other coworkers. However, some of his probably most characteristic qualifications were the ability to bring people with different scientific background together, to work on new solutions and to push the developments to the most successful direction. Moreover, his quiet and deliberated character was the basis for much collaboration. It might be also the main reason that he was a demanded consultant of projects.

This book brings together not only papers of some of his collaborators who will come together during the ACM2007 symposium. It will demonstrate also in which directions his ideas were developed.
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The author dedicates this article to Prof. Hans-Wolf Reinhardt recognizing his fundamental work in particular in the field of non-destructive testing and to honor his advice and cooperation throughout the years.

References

Towards a better visibility of outstanding research

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Abstract

After a brief introduction of the mission of RILEM, this paper describes the facilities offered by the new RILEM web site, for having the contributions from scientists and engineers more visible, and freely available to the international scientific community.

The optional free download option – implemented in October 2006 – proposed to the visitors of the RILEM website with the financial support of institutes and companies, is a completely new economic model, which will result very quickly in a much wider dissemination of the scientific articles available at www.rilem.net.

A practical example is given for RILEM Report 31 [1] produced by RILEM TC 185-ATC “Advanced testing of cement based materials during setting and hardening”, published online in September 2005, which electronic edition is available for free to each researcher or engineer in the world.

1. The mission of RILEM

The International Union of Laboratories and Experts in Construction Materials, Systems and Structures (RILEM, from the name in French) was founded in June 1947, with the aim to promote scientific cooperation in the area of construction materials and structures.

Today, the new meaning of the acronym RILEM (Réunion Internationale des Laboratoires et Experts des Matériaux, systèmes de construction et ouvrages) emphasizes its dominant focus on people as well as its worldwide activities, covering 70 countries.
The mission of the association is to advance scientific knowledge related to construction materials, systems and structures and to encourage transfer and application of this knowledge world-wide.

This mission is achieved through collaboration of leading experts in construction practice and science including academics, researchers, testing laboratories and authorities.

The three main goals of RILEM are:

- to promote sustainable and safe construction, and improved performance and cost benefit for society,
- to stimulate new directions of research and its applications, promoting excellence in construction,
- to favor and promote cooperation at international scale by general access to advanced knowledge.

Our worldwide goals are:

- to promote environmental friendly, safe and sustainable construction
- to improve performance and cost benefit for users and general public
- to engage top experts of construction practice and in science as well as promising young scientists and engineers
- to involve a broad range of players including academics, researchers, testing laboratories, suppliers, contractors, owners and authorities
- to ensure networking
- to promote education and training
- to encourage the formation of active regional groups
- to provide a platform of experts in interdisciplinary terms
- to stimulate new orientations of research and application
- to promote and maintain excellence in research and technology
- to prepare and widely disseminate outstanding RILEM products such as guides to good practice, recommendations (and if required also pre-standards), proceedings of symposia and workshops, state of the art reports, data basis, and International Journals.

2. The three steps of information

RILEM is dedicated to contribute to the progress in the construction sciences, techniques and industries, essentially by means of facilitating communication between research and practice. RILEM dissemination of knowledge can be considered as a 3-phase process:

Meeting together: RILEM members meet together in many circumstances, and in particular:
• during international RILEM events: workshops, seminars, conferences
• through meetings of the best international experts working together and sharing their expertise and knowledge in RILEM Technical Committees (TCs)

Producing the information: if meeting together is a starting point, then the TC is responsible, under the leadership of the chairperson, for preparing working documents which are discussed during the lifetime of a TC, resulting in

• testing methods concerning a specific characteristic of a building material
• a state-of-the-art report on the subject treated by the TC.

Spreading the information: Producing the information is of major importance for those scientists and engineers actively contributing to the TC work. The final resulting products also have to be widely disseminated through appropriate access to RILEM members (even those not directly involved in the TC work), and in a second step through general access to the public.

The final products of a TC work These final products, combined with the proceedings of workshops and conferences organised by the TCs, follow other immediate reports on on-going activities, which are mentioned in our annual report and presented in more details in our scientific journal, Materials and Structures, combined with the proceedings of workshops and conferences organized by the TCs, follow other immediate reports on on-going activities, which are published in our scientific journal, Materials and Structures.

3. Increased visibility of RILEM publications

3.1 The different types of publications

During the recent 5 past years, RILEM considered different options for an enhanced dissemination of outstanding research. This is in fact a permanent concern, for which different actions are decided when appropriate. But first let us come back quickly to the production of RILEM.

RILEM Technical Recommendations

Over 200 RILEM Technical Recommendations have been produced by RILEM Technical Committees. Many of these recommendations have been adopted in research and practice, and are used by international standardization bodies, as a basis for their work.

State of the Art Reports

These reports constitute a critical appraisal of current knowledge on a specific research subject. They often identify gaps in knowledge, thereby contributing to the development of strategies and scenarios for future research.
RILEM Journals

The RILEM flagship publication is “Materials and Structures / Matériaux et Constructions” (M&S). Since 2006, M&S is published by Springer, for a wider visibility. With 10 issues a year, it is a leading international journal, publishing results of current research on the properties and performance of building and structural materials, standardization of test methods and the application of research results. Another scientific journal has been created by RILEM in 1999, Concrete Science & Engineering (CSE), for creating a bridge between research and practice [2]. During the period 1999-2002, CSE published outstanding articles and special issues on different topics, thanks to the personal endeavor of the Board of Editors (Suru Shah, Hans Reinhardt, Francis Young and Jacques Marchand) and of the Editorial Advisory Committee. Any of these published articles is now available online at www.rilem.net. For a wider audience and exposure, CSE has been merged with M&S (in Fall 2002), with special thematic issues of CSE still published quarterly in M&S between 2003 and 2005.

Symposia and Workshops

RILEM has been organizing symposia and workshops since its foundation, with more than 100 proceedings published. A quick glance at our online catalogue shows the diversity, importance and international scope of the topics, which can be classified in 5 different clusters (as it is the case for the different active RILEM Technical Committees):

- Mechanical Performance and Fracture
- Materials Characterization, Properties Evaluation and Processing
- Design and Service Life
- Performance and Deterioration Mechanisms
- Special Construction Materials and Components.

3.2 RILEM online publications and DOI

In April 2004, RILEM Publications joined PILA, a non-profit making Association created in 2001 by international large publishers for cross-reference linking of their publications. The spirit of the DOI (digital object identifier) is to assign a permanent identification code to any article published online, which results in a permanent linking to this article, even in case the URL for reaching this article can be changed. This use of DOIs by RILEM has been implemented for both our journals, and for our online reports and proceedings. As regards our scientific journal Materials and Structures, the use of a DOI for each original article published online resulted in a major increase of the impact factor of the journal between 2004 and 2005 (IP multiplied by 2.26 between 2003 and 2005).