

REHABILITATING AND REPAIRING THE BUILDINGS AND BRIDGES OF THE AMERICAS

Hemispheric Workshop on Future Directions

CONFERENCE PROCEEDINGS

April 23–24, 2001
Mayagüez, Puerto Rico

EDITED BY
Daniel Wendichansky
Luis F. Pumarada-O'Neill

SPONSORED BY
National Science Foundation

CO-SPONSORED BY
The Chancellor's Office, The Department of Civil Engineering, and the Civil
Infrastructure Research Center of the University of Puerto Rico-Mayagüez

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ORGANIZED BY
Center of Hemispherical Cooperation
Civil Infrastructure Research Center

ASCE *American Society
of Civil Engineers*

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RESTON, VIRGINIA 20191-4400

Abstract: These proceedings, *Rehabilitating and Repairing the Buildings and Bridges of the Americas*, are from a hemispheric workshop on future research directions held in April 2001 in Mayagüez, Puerto Rico. Its purpose was to present current international knowledge about buildings and bridges, to suggest future research directions and enable international interactions leading to joint research projects for repair and rehabilitation. Covered topics included repair and rehabilitation strategies using fiber-reinforced polymers, structural assessment and nondestructive evaluation, and case studies, such as the analysis of the structural collapse of a 26-story building and the repair and rehabilitation of a pony truss span bridge during service time, plus other innovations.

Library of Congress Cataloging-in-Publication Data

Hemispheric Workshop on Future Directions (2001 : Mayagüez, P.R.)

Rehabilitating and repairing the buildings and bridges of the Americas : Hemispheric Workshop on Future Directions : conference proceedings, April 23-24, 2001, Mayagüez, Puerto Rico / edited by Daniel Wendichansky, Luis F. Pumarada-O'Neill ; sponsored by National Science Foundation, co-sponsored by ...

p. cm

Includes bibliographical references and index.

ISBN 0-7844-0613-8

1. Public works—America—Maintenance and repair—Congress 2.

Bridges—America—Maintenance and repair—Congresses. I. Wendichansky, Daniel A. II. Pumarada-O'Neill, Luis. III. National Science Foundation (U.S.) IV. Title

TA21 .H46 2001

352.77'0973—dc21

2002022572

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Library of Congress Catalog Card No: 2002022572

ISBN 0-7844-0613-8

Manufactured in the United States of America.

Foreword

The Problem

Deteriorating infrastructure is a major concern for national and local officials and the general public. Billions of dollars, countless technological efforts, and multiple resources are needed to alleviate this structural and materials problem. In most cases, buildings, bridges, highways, sewers, and so on, are not failing catastrophically but are slowly deteriorating. According to the U.S. Department of Transportation, in 1992 there were 564,000 bridges in the United States, of which approximately 105,500 were considered either structurally deficient or functionally obsolete. There is consensus between engineers and administrators that until the money, time, and manpower become available, the direction and purpose of efforts should be directed to extend the service life of existing structures. This problem is of particular importance in countries where the level of maintenance and investment in infrastructure are low.

Extending the service life of the existing structures should be accomplished through the following steps: (1) assessing the structure to determine the extent and type of damage, if any; (2) finding a suitable alternative, in terms of life-cycle cost and performance, to rehabilitate and repair the structure; (3) monitoring the structure; and (4) comparing for future uses the results obtained using the methodology adopted in Step 2 with other rehabilitation alternatives to find the one most suitable for each type of problem.

The most productive way to evaluate the current techniques ("the offer") and to direct future research efforts ("the demand") toward the most urgent needs within this critical field is to bring together top experts with different perspectives in the field. Experts should (1) discuss their views on the problem and on the state of practice and current research and (2) discuss priorities and joint future efforts. Experts should come from different sectors, such as the academic, research, industry, and government communities, and from different countries. This will enable suppliers to better understand demand and to bring new capabilities into the picture.

Although many investigations are under way to develop new alternatives to assess, repair, and monitor structures, it is not clear if these alternatives can be used for specific cases or will be suitable only for general applications. The problems that confront developing countries will challenge these investigations, providing extreme and realistic situations and experiences to the researchers and help answer the questions of what is well focused, what needs to be improved, and what needs to be investigated.

During the last two decades, the world has undergone deep transformations. Technological and political changes have modified the approaches to business and research. In the so-called "globalized world," the country that is able to provide efficient and low-cost solutions to the new emerging markets will be the leader in the new millennium. The only way to provide efficient solutions to these countries is to understand their needs.

National Science Foundation (NSF) actively supports the United States' participation in international conferences and research programs. Its disciplinary programs facilitate and encourage cooperative research projects, and often support attendance at meetings and other international events conducive to international cooperation. The Latin American component of its Science for Developing Countries (SDC) Program emphasizes mutual benefits and strengthens Latin America's ability to perform research and train scientists and engineers. However, top NSF officials have acknowledged that the current level of science and technology cooperation between the United States and the rest of the Americas is inadequate and has been declining overall in the past 15 years, contrary to the national interest (Bernthal, 1992; Bloch, 1991).

There is much to gain from hemispheric cooperation in tackling the problem of the deterioration of infrastructure. Many of the issues related to deterioration in the United States also exist in Canada, Latin America, and the Caribbean.

The more developed Latin American and Caribbean countries have competent and outstanding Ph.D.s in Materials and Civil Engineering, educated in the United States, Canada, Germany, France, or Great Britain who have accumulated diverse and enriching experiences upon returning to their countries. They can interact very fruitfully with U.S. experts in overviewing these problems and coming up with alternatives and research ideas that one side alone may not be able to produce.

There are many other ways in which joint hemispheric efforts may help all countries find solutions to the common problem of deterioration. Preventive programs that one country may be considering as a possible alternative may have already been tried somewhere else. The lower labor costs of some Latin American countries make them ideal partners for joint projects in which large-scale modeling is used. Some countries have extreme environmental conditions, natural or contaminated, and impossible or unwise to replicate, which may serve as an ideal experimental setting for model calibration, techniques, and materials being developed elsewhere. On the other hand, the identification of larger international markets for specific solutions may attract additional research and development funds from industry. Scientists and engineers from one country may come up with solutions that are not feasible under the labor, economic, or environmental conditions of his or her country, but which may be a good, competitive solution in another country with different conditions. U.S. industry will benefit from presenting their latest and coming products, the state of practice, to the top people in the field from Latin America and Canada.

But the above advantages of hemispheric collaboration cannot be realized unless effective personal contacts and exchanges of information are made in a conducive setting. Undoubtedly, the most effective way to increase international and intersectoral flow of information is to bring together scientists and engineers with industry and government agencies from across the hemisphere, the immediate users of the knowledge that they generate. The research needs and priorities set by such a group will benefit all.

The Event

The event, *Rehabilitating and Repairing the Buildings and Bridges of the Americas: Hemispheric Workshop on Future Directions* was held on April 23 and 24, 2001 in Mayagüez, Puerto Rico. It focused on the state-of-the-art, implementation problems, and future research priorities in the following topics: new methods, structural assessments, life-cycle evaluation for rehabilitated structures, fiber reinforced polymers, and sensors. This is the third workshop organized by the Center for Hemispherical Cooperation in Research and Education in Engineering and Applied Science (CoHemis) and NSF in a field that a hemispheric level requires billions of dollars and extensive technological efforts to prolong the life of structures. In 1994, University of Puerto Rico, Mayagüez (UPRM) hosted the conference/workshop *Repair and Rehabilitation of the Infrastructure of the Americas*, and in 1997 the University of Zulia hosted the conference/workshop *Repair and Rehabilitation of Reinforced Concrete Structures* in Maracaibo, Venezuela. The second conference was cosponsored by CoHemis and CYTED, Ibero America's Science and Technology for Development Program. It included a field trip to observe the rehabilitation work underway at the famous Maracaibo Bridge. CoHemis produced proceedings for both events, the second of which was an ASCE publication subtitled *The State-of-the-Art*.

For the 2001 workshop, the NSF granted \$49,900 to UPRM's Dr. Daniel Wendichansky and the CoHemis Center for staging this event. Twenty-nine participants presented written papers. The presentations and discussions were in English.

The event began with a plenary session on the state-of-the-art on each topic, establishing a common framework for subsequent discussions. It was followed by concurrent topical workshop discussions. Each workshop intended to identify and evaluate existing problems and create lists of urgent, specific research needs that effectively and efficiently improve the quality, durability, and efficiency of future rehabilitation and repair (R&R) work on bridges and buildings. A final plenary session reviewed and integrated the workshop conclusions.

The participants were researchers from related fields, such as structures, imbedded and remote sensors, materials, artificial intelligence, and signal processing; engineers from government agencies or private practice that face or attack structural problems requiring R&R who presented their needs for data, technologies, instrumentation or analytical models; and manufacturers and vendors of R&R products who may have wanted to exhibit and discuss their information and technology needs and other problems. The participants came from different countries of the Americas and raised issues and pointed out particular dissatisfactions, which they developed into a set of research topics that are the most relevant for the needs of the different countries of the Americas.

The grant, which provided funds for inviting some of the researchers and professionals, came from the Building Systems Program, directed at that time by Dr. Jack Scalzi, from NSF's Engineering Division. UPRM's Civil Infrastructure Research Center collaborated in the organization and co-sponsored. ISIS-Canada, UPRM's Civil Infrastructure Research Center, West Virginia University's Constructed Facilities Center, the Johns Hopkins University's Center for Non-Destructive Evaluation, and the Panamerican Institute of Highways were the event's cosponsors. The Constructed Facilities Laboratory at North Carolina State University and the Puerto Rico Engineers and Surveyors Association also collaborated in different ways.

Dr. Daniel Wendichansky
Principal Investigator

Dr. Luis F. Pumarada
Co Principal Investigator

THE COHEMIS CENTER

HISTORY AND LONG TERM GOAL

The Center for Hemispherical Cooperation in Research and Education in Engineering and Applied Science (CoHemis) was founded in November, 1991 in a conference sponsored by the National Science Foundation (NSF) and the University of Puerto Rico at Mayagüez. It had the participation of delegates from national science and technology organizations from the U.S., Canada, and twelve countries from Latin America and the Caribbean. The assembly produced a unanimous declaration creating the CoHemis Center, naming an advisory council to help mold its organization, and endorsing the Mayagüez Campus of the University of Puerto Rico as its site. Since then, other countries have joined the declaration, and their national councils of science and technology have named delegates to the Center.

According to the founding delegates, CoHemis should eventually become a world-class multinational center for applied research of about 100 investigators and 200 graduate students supported by sponsored research. It will carry out projects of hemispheric interest, conducted mainly by visiting researchers from other countries and institutions, who will return home upon the completion of their projects. Resident investigators from the Mayagüez Campus will provide continuity to the research efforts and be responsible for the students' academic and research progress.

The Center would be open to all the countries of the Americas and will serve member nations and the regional industry, as well as agencies that sponsor research. It will complement research activities by funding graduate students, facilitating joint research and technology assessments, and organizing workshops and conferences.

As it carries on with its daily activities, CoHemis strives for excellence, networking and demonstration to merit the funding required for its original goal.

MISSION AND OBJECTIVES

The CoHemis Center's mission is to promote, facilitate, and coordinate collaborative applied research, technology assessment, and human resources development and exchange programs to serve the needs of the Americas with the participation of engineers and scientists from the different countries of the hemisphere.

Its priority subjects are:

- energy
- environment
- infrastructure
- natural resources
- process and manufacturing technologies
- technology assessment and forecasting

CoHemis currently receives its basic funding from the University of Puerto Rico. It receives funding for specific projects from government agencies from the U.S. and Puerto Rico, and from the private sector. It also benefits from collaborative efforts with Consortium members, international agencies, and entities from other countries of the hemisphere.

The Center publishes *CoHemis... update*, a quarterly bulletin, free of charge, in both English and Spanish, and distributes it to persons and institutions interested in scientific and technological cooperation between the Americas. It has also published the proceedings of activities funded by the National Science Foundation, and three reports of the Center's activities, among other publications.

Objectives:

- ~ Increase the industrial competitiveness of the Western Hemisphere.
- ~ Enhance the science and technology capabilities of the Americas and the Caribbean.
- ~ Stimulate the protection of the hemisphere's resources and environment.
- ~ Increase knowledge of regional problems of high priority among researchers in the Americas.
- ~ Increase the number and quality of Hispanic Ph.Ds. in engineering and science in the U.S.

COHEMIS CONSORTIUM

The CoHemis Consortium consists of universities and research centers in the Americas which share CoHemis' objectives and are looking to expand their participation in collaborative activities for mutual benefit, such as joint research exchanges of faculty and students, short courses, participation in and co-sponsoring CoHemis activities, and sharing research facilities. Currently, the members are:

Colorado State University
CONACYT (Bolivia)
CONCYTEC (Perú)
Georgia Institute of Technology
Escola Politécnica da Universidade de Sao Paulo
Escuela Colombiana de Ingeniería
IGAC (Colombia)
INIDEP (Argentina)
INTEC (Dominican Republic)
Lehigh University
Los Alamos National Laboratory
Oak Ridge National Laboratory
Pontificia Universidade Católica do Rio de Janeiro
Sandia National Laboratories
Universidad Autónoma del Caribe (Colombia)

Universidad de Chile
Universidad de Costa Rica
Universidad de Guadalajara (México)
Universidad de Piura (Perú)
Universidad de Puerto Rico
Universidad del Zulia (Venezuela)
Universidad de la República (Uruguay)
Universidad de los Andes (Colombia)
Universidad Mayor de San Simón (Bolivia)
Universidad Nacional Autónoma de México (UNAM)
Universidad Nacional de Córdoba (Argentina)
Universidad Nacional de Río Cuarto (Argentina)
Universidad Rafael Landívar (Guatemala)
Universidad Simón Bolívar (Venezuela)
Université Quisqueya (Haiti)
University of Florida
University of Guyana
University of the West Indies (Trinidad & Tobago)

Activities:

The members of the Consortium have: promoted faculty exchanges, organized short courses with other members' resources, participated in the Center's activities, co-sponsored the Center's activities, and prepared joint proposals.

CHRONOLOGY: PRINCIPAL ACTIVITIES

1994

Meeting of Consortium Universities
 Panel on Science and Technology Policies for Economic Development
 Technical Assistance for Environmentally Conscious Manufacturing
 Hemispheric Workshops and Conferences:
 -Rehabilitation of the Infrastructure of the Americas
 -Geo-environmental Issues Facing the Americas

1995

Caterpillar seminars (6 Latin American countries)
 Hemispheric Workshops and Conferences:
 -Raytheon Hemispheric Conference on Remote Sensing
 -Transportation Research for the Americas

1996

Vital Issues Panels for Sandia N.L.: P. R. Water Safety
Caterpillar seminars (4 Latin American countries)

1997

Hemispheric Workshop on Repair and Rehabilitation of Concrete Structures
(Maracaibo, Venezuela)
Caterpillar seminars (5 Latin American countries)
Conference-Workshop on the Caribbean Countries and the Inter-American Institute for
Global Change
Patent Law & Trademarks: Seminar

1998

IAI Caribbean Core Group Meeting (Dominican Republic)
Workshops: Learning Factory; and Creativity and Innovation (Guadalajara)
Workshop: Learning Factory (Rio de Janeiro)
Exchange between UPRM and CETEM, Brazil
Vital Issues Panels: Comprehensive Management Plan for the Mayagüez Bay
Watershed
Template for a Feasibility Study in the Caribbean for Solar Air Conditioning
Retreat on Ethics for Engineering, Science and Business

1999

12th Annual Technical Conference (Trinidad)
GIS Spring Seminar for Caribbean Islands
Vital Issues Panels for the Parismina River (Costa Rica) and a Michigan River (USA)

2000

Short Course on the Impacts of Trace Elements and Toxic Metals
6th International Symposium on Metal Ions in Biology & Medicine

2001

Workshop: Repair and Rehabilitation of Buildings and Bridges of the Americas - Future
Directions
Conference: *Government and Business in Research and Development: the Chilean
Experience*
Two-day Seminar on Foresight
Microsoft Workshop on ABET 2000 – “Learning Factory” (Brazil, Chile, Argentina and
Mexico).
Short Course on the Impacts of Trace Elements and Toxic Metals (Venezuela)

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