INTERNATIONAL COLLABORATIVE ACTIVITIES IN STRUCTURAL CONTROL AND MONITORING

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Abstract

An overview is provided of the international collaborative activities in the broad field of Structural Control that the International Association for Structural Control (IASC) has been fostering since its inception in 1993. Specifically, the major accomplishments and future plans of the IASC Working Group on Control and the IASC Working Group on Monitoring are described. A general framework entitled "International Initiative for Intelligent Infrastructure Control (I4R) envisioned by the Structural Control community to conduct multi-disciplinary and multi-national collaborative research and development studies is described. Information is also provided about the goals and agenda of the forthcoming Fourth International Workshop on Structural Control (4IWSC) to be convened in the USA in 2004.

INTRODUCTION

The objectives of the International Association for Structural Control, which was established in 1993, are the advancement of the science and practice of structural control and monitoring of civil infrastructure systems, by means of education, research and application of knowledge. An important mission of IASC is to foster international collaboration and information dissemination through the activities of its Working Groups and through the convening of periodic Workshops and Conferences.

This summary report provides (1) an overview of a general framework envisioned by the Structural Control community operating under the umbrella of IASC to conduct multi-disciplinary, and multi-national collaborative research and development studies, (2) a brief report on the activities of the Working Groups of IASC, and (3) some information about the goals and agenda of the forthcoming Fourth International Workshop on Structural Control (4IWSC) to be convened in the USA in 2004.

INTERNATIONAL COOPERATION IN CIVIL ENGINEERING RESEARCH

The nature of cooperative research that will be of particular importance in the coming years includes: reduction of natural disasters of earthquake, wind, flood, landslide, tsunami, and wildfire. In addition, the retrofitting and upgrading of the civil infrastructure is of great importance in the United States and also in other countries. For example, countries in the Pan Pacific region have the same problems of natural disasters and also of building and retrofitting the civil infrastructure, so cooperative research

could be of great benefit to all these countries.

Cooperative research could be of several types:

1) Different aspects of the same problem could be studied in two or more countries in a coordinated program;
2) A large experimental project could be undertaken in one country and subsidiary projects by researchers from other countries could piggyback on the main project;
3) Researchers on related projects in two or more countries could meet annually in a workshop to exchange information and make recommendations for future projects.

In the past, one of the difficulties in establishing a coherent cooperative program has been the identification of the problem and bringing together appropriate researchers to cooperate. For example, the organization of the relevant public and private agencies in the United States, Japan, and China differ so greatly that it is difficult to arrange cooperative projects between appropriate researchers. This is unfortunate because the success of cooperative research depends mainly upon a good match of the interests and plans of the researchers involved.

Improvement in cooperative research programs could be achieved by coordination on a planning level in which a Planning Panel is established in each country whose function is to keep informed on the research projects underway and to identify such projects that would benefit from international cooperation. Representatives from each of the Panels would constitute an International Oversight Committee that would meet at intervals for the purpose of identifying, initiating, facilitating, and coordinating cooperative research projects. The members of the Oversight Committee would serve for a prescribed term of office, perhaps three years, and an orderly procedure established to retire existing members and bring in new members. In this way there would be continuity in the functioning of the Oversight Committee and, consequently, a continuity in the cooperative research program.

The Oversight Committee would not undertake research projects but would focus on strengthening the cooperative research program between the countries. The Oversight Committee would act as a standing Advisory Committee whose value would be enhanced by its continuity of service. The name International Initiative for Intelligent Infrastructure Research (I4R) has been proposed to identify the activity of the Oversight Committee.

Figure 1 shows a sample organizational structure of I4R; Figure 2 shows the organizational structure of a sample I4R initiative, and Figure 3 shows the suggested organization of a specific I4R initiative on cracked steel joint problems

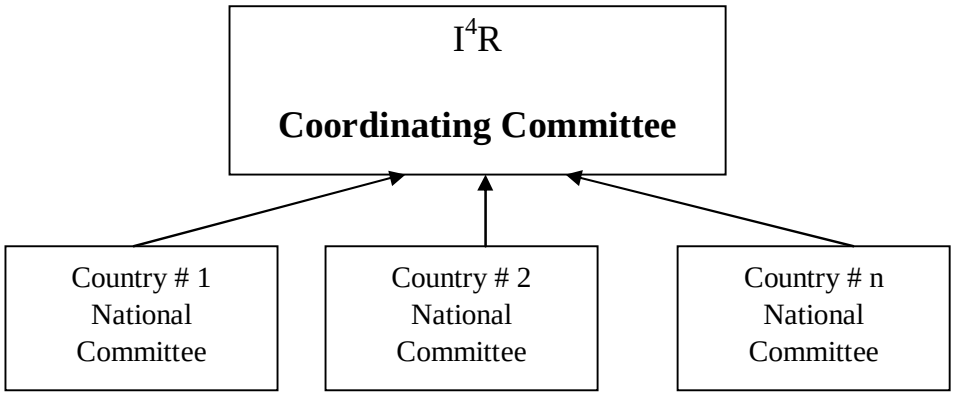

Figure 1: I4R Organizational Structure.

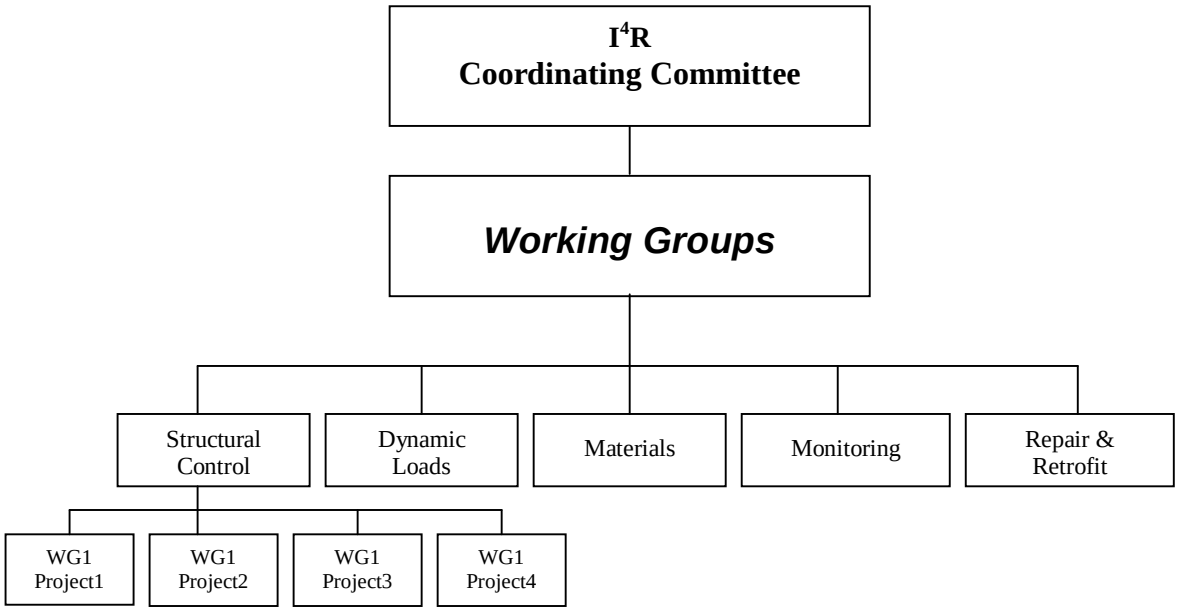

Fig 2: Sample I4R initiative.

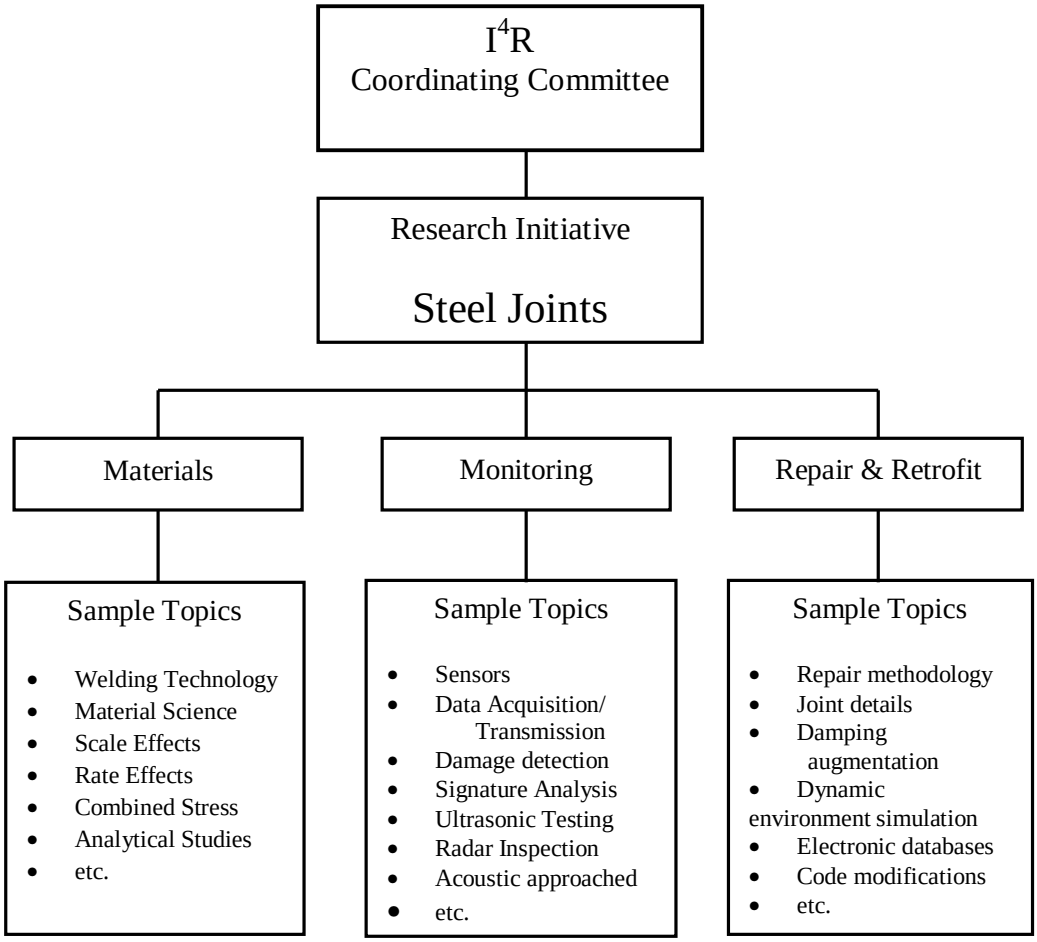

Figure 3: Specific I4R Initiative on cracked steel joint problem.

RESEARCH NEEDS IN STRUCTURAL CONTROL

As a result of recent earthquakes, the consensus of the Structural Control community, as reported in several recent IASC Workshop proceedings (Agbabian and Masri, 1988; Housner and Masri, 1990; Chen and Beck 1991; Housner et al, 1992; Kobori 1992; Housner and Masri, 1993; Housner et al 1994; Kobori 1994; Chen 1996; Kobori 1998; Bourquin 2000; Casciati 2002), is that certain areas of structural control especially require further study:

1. Use control to improve the seismic performance of existing structures, especially steel-frame buildings.
2. Develop more effective combinations of methods of control for design of new buildings.
3. Develop control methods for improving the seismic resistance of bridges.
4. Carry out experimental verification of integrated control and monitoring systems under realistic conditions.
5. Develop standardized benchmark tests for comparison purposes.
6. Carry out tests on full-scale buildings that have been provided with control systems.

7. Develop closer cooperation between research in structural control and research in smart materials and smart structures.
8. Study protective control of critical facilities such as emergency response centers, emergency communication systems, fire and police response systems, etc., which must continue to function during earthquakes.
9. Expand the studies of structural control to include protection of such items as large computer facilities, hospital facilities including large medical equipment, electrical generation and distribution systems, TV and radio facilities, and other items that are important for emergency earthquake response.
10. Improve the competence of practicing engineers by preparing explanatory documents, giving seminars and short courses, etc.

An alternate way of describing the future of structural control research is to state recommended goals. These can be divided into short range goals and long range goals:

Short-Range Goals:
(a) Expanded application of passive control devices,
(b) development of active control methods for moderate oscillations,
(c) cost-effective control of existing structures,
(d) health monitoring of civil infrastructure systems, and
(e) experimental verification of large scale, if not full-scale, control applications.

Long-Range Goals:
(a) Cost-effective methods of integrated control,
(b) control systems for very large earthquakes and very strong winds,
(c) post-earthquake damage detection,
(d) development of appropriate design codes for structural control, and
(e) collaborative international research.

IASC WORKING GROUPS

The US Panel on Structural Control Research has established three Working Groups in collaboration with the ASCE Engineering Mechanics Dynamics Committee in 1999

- Task Group on Benchmark Control Studies
- Task Group on Structural Health Monitoring
- Task Group on Codes for Structural Control

These Working Groups are cooperating with parallel task groups in other regions.

The *Working Group on Structural Control* is coordinating a number of benchmark control studies in various stages of development: wind and seismic, building and bridge, etc. Benchmark problems provide common structure and common evaluation methodologies, making direct comparison of control strategies feasible

Past and current benchmark problems include:

- nonlinear seismic building benchmark (1999-2003)
- wind-excited building benchmark (1999-2003)

- seismically-excited cable-stayed bridge benchmark (phase I and phase II) (2000-2004)
- controllable base isolated building benchmark (2003-?)
- asymmetric wind building benchmark
- typical highway bridge benchmark

Further details about the research activities of this Working Group are available in the 1998 Special Issue of the *Journal of Earthquake Engineering and Structural Dynamics*, Volume 27, Number 11, which was fully devoted to papers reporting on the activities of this Working Group.

The *Working Group on Health Monitoring* is coordinating a number of benchmark Structural Health Monitoring (SHM) studies in various stages of development. Benchmark studies, coordinated by the Working Group, provide mechanisms for comparing SHM strategies on a common problem.

Several phases of a benchmark study in SHM have been defined by the task group:

- phase 1 simulated data (12DOF identification model; different excitation models; known vs. unknown excitation; Six damage patterns generated by eliminating or reducing stiffness in one or more braces)
- phase 2 simulated data; Same structure, but add more realism (improved modeling error; modest damage with simple spatial distribution; brace and connection damage); Results presented at 3IWSC (Paris, 2002)
- phase 2 experimental data; Same structure, but actual experiment; data taken in numerous configurations at University of British Columbia; Damage simulated by removing bracing or loosening bolts; Full data sets and video describing the methodology is on the Task Group web site http://wusceel.cive.wustl.edu/asce.shm/experim_phase_2.htm

Several possible benchmarks are under investigation: typical highway overpass bridge; long-span bridge (cable-stayed or suspension). Further details about the research activities of this Working Group are available in the work of Johnson et al, 2004).

FOURTH INTERNATIONAL WORKSHOP ON STRUCTURAL CONTROL (4IWSC)

The *U.S. Panel on Structural Control Research* and the *International Association for Structural Control* (IASC), in collaboration with the Organizing Committee at Columbia University in New York City, are planning to convene the *Fourth International Workshop on Structural Control*. The purpose of this meeting is to review progress, promote research cooperation, and make recommendations for further research in the general field of active/hybrid vibration control and monitoring of civil infrastructure systems under the actions of earthquakes, wind, and extreme loads. The Workshop will focus on topics related to building structures, adaptive structures, intelligent/smart materials and systems, health monitoring and damage detection, actuators, sensors, and hybrid vibration control of civil infrastructure components under the action of dynamic loads. Among the specific topics to be addressed by the Workshop Working Groups are: (1) Building and Bridge Control, (2) Structural Health Monitoring, (3) Research Needs in Structural Control (involving adaptive materials, innovative sensing hardware, wireless technology, and novel actuators), and (4) International Collaboration involving recent national and multinational collaborative initiatives in North America, Asia and Europe.

This meeting is planned to be a genuine workshop and not a mini-conference with presentations only; meaning that the emphasis is on maximizing the amount of interaction by the attendees and the various Working Groups so as to discuss research progress, exchange technical information, and work collaboratively within the existing IASC Working Groups to advance the state-of-the art of the broad field of Structural Control by continuing to advance the planning and implementation of large scale collaborative projects involving physical benchmark problems, as envisioned by the concept of the International Initiative for Intelligent Infrastructure Research (I4R), which was presented by Professor Housner at the First International Workshop on Structural Control, held in Hawaii in1993

A brief outline of the Workshop is provided in the Appendix. Further details regarding the 4IWSC program, registration, housing information and paper format can be obtained from:
http://www.civil.columbia.edu/4IWSC

CONCLUSIONS

The International Association for Structural Control is coordinating several collaborative international activities through the operation of its Working Groups on Control and Monitoring. A framework proposed by IASC for conducting multi-disciplinary, multi-national collaborative research in the broad field of structural control and monitoring is presented. Improvement in cooperative research programs could be achieved by coordination on a planning level in which a Planning Panel is established in each country whose function is to keep informed on the research projects underway and to identify such projects that would benefit from international cooperation.

ACKNOWLEDGEMENTS

The support of the US National Science Foundation to the US Panel on Structural Control Research is appreciated.

APPENDIX: Program for Fourth International Workshop on Structural Control

International Association for Structural Control (IASC)

First Announcement for

4th International Workshop on Structural Control (4IWSC)

Columbia University
New York, NY, USA
Thursday-Friday, 10-11 June 2004

Thursday 10 June 2004

7:00-8:00 Breakfast
8:00-8:30 Registration
8:30-8:45 Welcoming remarks (Columbia U people, IASC President, NSF person)
8:45-12:00 about 2.5 hours [150 min] net (with 30 min break) for presentations
• Panel technical reports from USA
• Panel technical reports from Japan
• Panel technical reports from Europe
• Panel technical reports from China
• Panel technical reports from Korea
• USA NEES and International Collaborative Efforts
• Japan Miki Shaker Collaborative Efforts
• European Testing Facilities Collaborative Efforts

12:00-1:30 lunch

1:30-5:00 [3 hours net including 30 min break] break participants into Working Groups
• WG1 Benchmark Problems in Control [buildings, bridges]
• WG2 Benchmark Problems in Monitoring [sensors, methodologies, models]
• WG3 International Collaboration Involving NEES, Miki shaker, Europe, etc

NOTE: brief (15 min) summary papers can be accommodated within WG meetings

6:30-10:00 dinner boat-cruise around Manhattan

Friday 11 June 2004

8:00-10:30 Special Session on "Distributed Sensing for Structural Systems in the USA"
- Overview of State-of-the-Art in "Sensor Nets"
- State-of-the-Art in Wireless Sensing
- NEES Nodes Sensor Capabilities and NEESgrid Capabilities
- High-Accuracy GPS-based Relative Position Dynamic Sensing
- Overview of State-of-the-Art in Model-Based Simulation & the Interface with Sensing Data

10:30-11:00 coffee break

10:45-12:00 Research Needs in Structural Control and Monitoring Areas (smart materials, innovative sensing hardware, wireless technology, semi-active actuators, simulation, etc)

12:00-1:30 Lunch

1:30-2:15 WG summary reports (each about 15 min with discussion)

2:15 - 3:00 pm General discussion

3:00 pm Adjourn

The proceedings, including the presentations, highlights of the group discussions, and recommendations, will be published in the form of a book. In addition to presentations by invited Plenary Session speakers, there will be an opportunity for participants to present brief overview papers during the Working Group sessions. Contributed papers slated for publication in the 4IWSC Proceedings should not exceed 6 pages total.

Further details regarding the 4IWSC program, registration, housing information and paper format can be obtained from: http://www.civil.columbia.edu/4IWSC.

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