DEFINING A CONSTRUCTION EDUCATION RESEARCH AGENDA

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As the 20th Century draws nearer to a close, many are looking to the future of construction and, concurrently, to the future of construction education, in a concerted effort to determine how construction educators can best meet the requirements of the next century. How will university-level construction education programs in the United States respond to the importance of technology as an engine of change? Will developments such as object-oriented modeling or artificial intelligence impact construction education? The recent National Construction Industry Education Forum (NCIEF) addressed several issues, Construction Education in the 21st Century among them. Some of the issues are:

1. What will be the impact of the continuing globalization of construction? Will there be pressure to internationalize codes, standards, or contracting methods?

2. How will construction research be funded? The funds for applied research must be found. Is the construction industry prepared to begin funding research in a meaningful way? Today's students need to be prepared for work at the site.

3. High School graduates and University students are not generally motivated to enter the construction industry. Where are tomorrow's construction industry leaders going to come from if there is no increase in the level of effort to advertise and recruit students for the industry?

4. The construction industry needs to improve its image. Americans in general do not have a good impression of the integrity or quality of the construction industry.

5. There is a growing opportunity for international work. Graduates need to be more aware of other cultures, other societies, and the laws that govern construction practice in other countries.

6. The greatest changes in the industry may be in the technology of the contract delivery systems. Changes such as design-build and performance-based procurement have the potential to completely change construction procurement methods.

These six points reflect the opinions of leaders in the industry who attended NCIEF. They show that there is an effort to determine what the challenges of the future of construction education will be. Obviously, they may or may not be accurate. Of the six points above, five relate directly to the content of future university construction education programs. Those five points are:

- Globalization,
- Research funding sources,
- Preparing students for leadership roles,
- International construction opportunities, and
- Changing contract delivery systems.

In addition to the points discussed at NCIEF, there is one additional point that must be addressed to round out the area of construction education research:

- Teaching a larger number of people.

Issue Number 1. Globalization.

Tomorrow's construction graduates will do business in a global economy, even a global cyber economy. How can we best determine what curriculum changes will best suit their needs? The courses taught and the teaching methods used in construction programs need to be reviewed. Are the courses offered in today's accredited construction programs the courses that will be needed in the next century? What areas may not be needed, and what should be added? What will the effect of globalization of construction be?

Issue Number 2. Research Funding Sources.

The trend in research has historically been toward pure research. Construction graduates will operate in the field. They will earn their livings on construction sites or in offices that support construction sites. Construction research needs to be applied, directed toward field operations. Who will fund applied research in construction?

Issue Number 3. Preparing Students for Leadership Roles.

There is no question that the construction industry needs leaders. Its greatest need is leadership, and its greatest need in the 21st century will continue to be leadership.

Where are the leaders going to come from, if not from the university construction programs? How are the university construction programs of the future going to prepare students for leadership in the industry? Do today's education systems instill the leadership qualities that will be required in the future? How do we measure what ought to be done to prepare for future leadership?

Issue Number 4. International Construction Opportunities.

The internationalization of construction will continue. More companies will operate internationally. The construction curriculum must prepare students for international opportunities. This issue is related to globalization, but is not the same issue. This issue addresses the preparation of the individual for work in another country, in another culture, or in a firm from another country.

How should international influences, and their accompanying intermix of cultures, be addressed at the university level? How will universities respond to a need for increased international certification of construction managers? Should international codes and standards have a place in American construction education? What social and cultural courses will be needed?

Issue Number 5. Changing Contract Delivery Systems.

The only constant is change. During the Medieval Ages, when many of the great cathedrals of Europe were built, it took a hundred years to change construction methods. The Industrial

Revolution reduced the time to make changes to about ten years. Today's constructors make changes in a matter of minutes, even seconds.

The contract delivery systems are changing. Technology is forcing change. The trends are away from low bid selection processes. How long will it take construction education to change? How can construction education be as responsive to change as the industry itself? What is the role of accreditation bodies in effecting change?

Issue Number 6. Teaching a Larger Number of People.

Construction management education must be made available to a larger audience, including full- and part-time students, on- and off-campus students, and constructors who may not have direct access to a university campus. What are the best ways to use the internet, television, off-campus sites, and cable access to support construction education?

My Vision of Future Construction

What will the future construction industry be like? First, the industry will be basically the same as it is now. Engineers and architect will design projects, and contractors will build them; however, they will probably work for the same company. The projects will still be the same types - houses, utilities, commercial buildings, highways, bridges, airports, and all the other projects we see today. Second, it will be very different than it is today. The design process, contractor selection process, contract administration, materials, and contractual relationships will all be different.

a. **The Built Environment.** Greater use will be made of standardized structures, which will contain more computers and sensors. Tall buildings will be taller. More use will be made of areas now occupied by ocean, for purposes such as airports and cities. There will be construction in space.

b. **Design.** The design process will see great change. Most construction companies will employ architects, engineers, and constructors. The Internet will remove the necessity for the design team to be in the same locality. Design coordination by electronic means will lead to fewer design errors and omissions. No one will design an entire project before construction starts; instead some version of fast-track design will evolve into the normal design process. Some aspects of engineering and design will not change. For instance, engineers will always be needed to take borings for the foundation design.

c. **Contractor Selection.** The bid process will disappear. Even the government will find a better way. Contractors and designers will work together as part of the same company. Contractors will be selected based on performance, quality, safety, reliability, and other such factors defined by the owner.

d. **Construction Materials.** The processes involved in construction will change little. The materials will change greatly. 100,000 psi concrete will be common. Ceramics, composites, and fiber reinforced polymers will be in common use. Wood products will be entirely high performance, pre-assembled units. Structures will contain stress indicators. There will be increased use of new aluminum alloys. Construction materials will be 100% recyclable. The time to complete projects will be halved. The change in emphasis on

quality and safety will be profound. Technology, in forms not yet envisioned, will be common.

e. **Construction Contract Administration.** Work progress will be monitored automatically and instantaneous payments will be possible. There will still be performance and maintenance bonds; but there may not be bid bonds because there may not be bidding. Trust-based administration will become standard. Construction services will be more knowledge intensive.

f. **Labor.** The shortages of qualified labor will be severe. As a result, hourly wages will increase greatly. Labor unions and management will work together recruit and train qualified labor. Labor's main strength will come from its ability to provide highly qualified personnel.

g. **Price Structure.** The price of construction will be based on its value to the customer, and the quality of the work, rather than the cost to the builder and a mark-up.

h. **Global Influence.** In the global cyber economy of the future, construction companies will purchase materials and services from around the world.

i. **Infrastructure.** There will be less new construction, and more repair and rehabilitation of existing infrastructure.

Conclusion

I am the Associate Dean of Engineering and chair of the Construction Management program at a small university in New England, Roger Williams University. The future content of the Construction Management curriculum at this university, and others like it, is going to be decided by someone else. An ACCE committee will determine how many credits of each topic area must be included in the curriculum. That is not necessarily wrong; but it means that universities, especially small universities, will have a limited voice in determining what the changing educational requirements of the next century will be. That being the case, I am motivated to seek an opportunity to address the changes now, while there is a national forum to support the research effort.

I believe that the determination of future construction education requirements is a task for people with vision. It is a task that must involve most of the construction industry, and most of the construction education infrastructure. This should be a landmark research effort. I have nearly thirty years of industry experience, combined with fifteen years of construction education experience. I would like to have the opportunity to participate.

The Construction Education Research Agenda should address:

- the measures to be undertaken to prepare graduates for globalization,
- identification of applied construction research funding sources,
- preparing students for leadership roles in the construction industry,
- definition of the kinds of courses needed to prepare for international opportunities,
- meeting the challenges of the changing contract delivery systems, and
- methods to teach a larger number of people.

PERSONAL BACKGROUND OF RICHARD E. MAYO, PH.D., P.E.

Education:

Ph.D., Stevens Institute (Construction Management) 1992
MS, Rensselaer Polytechnic Institute (Management) 1970
MSCE, Purdue University 1966
BS, United States Military Academy, West Point 1962

Professional Engineer:

Arizona, 22110; Connecticut, 13797; Maine, 4827; Maryland, 16587; New Jersey, 29203; New York, 61055; Pennsylvania, 39363.

Career Summary:

1997 – Present. Associate Dean of Engineering and Professor of Construction Management, Roger Williams University, Bristol, Rhode Island.

1991 – 1997. Associate Professor and Director of Graduate Studies, Del E. Webb School of Construction, Arizona State University, Tempe, AZ.

1984 – 1991. Director of Construction Services, Senior Vice-President, Board of Directors, The RBA Group, Morristown, NJ.

1984 – 1991. Adjunct Professor of Construction, Stevens Institute, Hoboken, NJ.

1962 – 1984. Commissioned Officer in the U. S. Army Corps of Engineers.

Industry Experience

1984 - 1991. Director of Construction Services, Senior Vice-President, Member Board of Directors; The RBA Group, Morristown, New Jersey. The RBA Group is a 350 person engineering firm specializing in highway and bridge design, site planning and development, and construction services. Developed the Construction Management Division into an organization of more than 100 employees, which accomplished more than 25% of the firm's work. Managed highway and bridge projects in the $1- to $15-million range. Example projects: New Jersey Turnpike Widening (11 contracts), Garden State Parkway Bridge Repair and Rehabiitation (9 contracts), Garden State Parkway Realignment and Paving (4 contracts). New York Department of Transportation: Sunrise Highway Extension and Cross Bronx Expressway Rehabilitation.

1981 - 1984. Deputy District Engineer, New York District, Army Corps of Engineers. Army and Air Force projects in New England, navigability projects in the New York Harbor, beach erosion control in New Jersey and Long Island. The District Designed and built projects worth about $120 million annually.

1979 - 1981. Director, Construction Division, Installation Support Group, US Army Europe. Managed NATO funded construction program in Germany, Turkey, and Greece. Annual workload exceeded $500 million.

1972 - 1977. Assistant District Engineer, Fort Worth District, Army Corps of Engineers. Army and Air Force projects in Texas, Louisiana, Arkansas, Oklahoma, and New Mexico. Construction value exceeded $200 million per year. The Fort Worth District has approximately 1200 employees.

1962 - 1984. Platoon Leader, Company Commander and Staff assignments in the Army Corps of Engineers in Korea, Viet Nam, Cambodia, Germany and the United States.

Academic Experience

August 1997 – Present. Professor of Construction Management and Associate Dean of Engineering, Roger Williams University, Bristol, RI.

August 1991- July 1997. Associate Professor and Director of Graduate Studies, Del E. Webb School of Construction, College of Engineering and Applied Sciences, Arizona State University, Tempe, AZ.

1984 -1990. Adjunct Professor, Department of Civil, Environmental and Coastal Engineering, Stevens Institute, Hoboken, New Jersey.

Sponsored Research Projects

Mayo, Richard E., "Plan Review and Technical Services Staffing Study," City of Tempe. 1996. $7700.

Mayo, Richard E. "Salt River Project Compatible Units Manhour and Cost Estimating System Study." Salt River Project. Nr. 97-0118. 1996. $8000.

Mayo, Richard E. with Gorur, Ravi of the Electrical Engineering Department, M. Lisa Urias, and Gary Barras from SRP. "Salt River Project / Mexico Energy Trade Study." Project Nr. 94-0105. 1994. $48,300.

Mayo, Richard E. Research of Construction Methods and Contract Requirements for the Demolition and Removal of three 775 foot tall Chimneys at Navajo Generating Station. SRP. Project Nr. 94-1252. 1994. $15,191.

Mayo, Richard E. and Bashford, Howard H., "Inspector Productivity Analysis." City of Tempe, 1993. $7600.

Consulting Assignments

"Leadership and Management." Presentation for Construction Financial Management Association (CFMA) National Conference. Chicago, 1997

Partnering Facilitator. Val Vista Water Treatment Plant, 80 MGD Expansion. $50 million, 1995.

Injury Accident Expert Witness. Modification of Ute Dam, Quay County, New Mexico, 1995.

"Excellence in Leadership and Management," Seminar. Markham Contracting Company, Phoenix, AZ, 1994.

"Scope Definition and Control," Construction Industry Institute (CII) Seminar, Tempe, AZ, 1994.

Partnering Facilitator. Casa Grande Water Treatment Plant. $10 million, 1994.

Partnering Facilitator. Gilbert Water Treatment Plant. $15 million, 1994.

Investigation of Fatal Accident. Yuma Proving Grounds, 1994.

Management Seminar. Bay Pacific Construction Company, Kauai, Hawaii, 1994.

City of Phoenix, Standardization of Energy Management Temperature Control Systems (EMTCS), 1993.

Intel Corporation, Internal Partnering, 1993.

Areas of Teaching and Research

Project Management, Construction Labor Management, Partnering, Construction Contract Administration, Construction Equipment, Cost Control, Computer Applications, Tall Chimneys, Electric Power Distribution.

Refereed Archival Journal Papers

Walker, Kenneth K.; Schexnayder, Cliff; Mayo, Richard E.; and Walsh, Kenneth D.; "Methods and Procedural Considerations in Demolishing Tall Concrete Chimneys," *American Society of Civil Engineers Journal of Construction Engineering and Management.* Vol. 122, No. 3. September 1996, pp. 223 - 230.

Mayo, Richard E. and Williams, Burt E., "Standards and Methods for Minimizing Underground Utility Conflicts," *Journal of Infrastructure,* J. B. Wiley. Volume 1, Nr. 2, June 1996, pp. 34 - 41.

Barras, Gary and Mayo, Richard E., "Minidirectional Drilling for Installation of Underground Electrical Conduit," *American Society of Civil Engineers Journal of Construction Engineering and Management.* December 1995. Vol. 121. No. 4. pp. 364 - 369.

Biedermann, Rob; Bashford, Howard; Mayo, Richard; Weber, Sandra; "Development of an Expert System for Military Horizontal Construction", *American Society of Civil Engineers Construction Congress '95*, October 1995.

Mayo, Richard E.; Badger, William W.; and Bashford, Howard H.; "Public Agency Cost Savings from Standardizing Energy Management Temperature Control Systems," *Cost Engineering, The International Journal of Cost Estimation, Cost/Schedule Control and Project Management.* American Association of Cost Engineers, Vol. 37, No. 4. April 1995. pp. 30 - 33.

Mayo, Richard E. and Liu, Gong, "Reform Agenda of The Chinese Construction Industry", *ASCE Journal of Construction Engineering and Management*, Vol. 121, No. 1, March 1995, pp. 80 - 85.

Zumbehl, Richard K. and Mayo, Richard E. "Customer Focused Quality for the Maintenance and Repair of Air Force Facilities", *Project Management Journal,* Vol. XXV, No. 4, December 1994. pp. 32 - 36.

Carter, John P. II and Mayo, Richard E. "Prediction of Repair Parts Budget Requirements," *Cost Engineering*, The American Association of Cost Engineers. Vol. 36. No. 4, April 1994, pp. 15 - 22.

National Conference Proceedings

Badger, William W. and Mayo, Richard E., "Development and Application of the Information Transfer Model", *Associated Schools of Construction, Proceedings of the 31st Annual Conference,* April 6 - 8, 1995, Arizona State University, pp. 189 - 196.

Mayo, Richard E., "Group Learning in Engineer and Construction Courses", *Proceedings of the 1994 Centennial Meeting Gulf-Southwest Section of ASEE,* March 24 - 25, 1994. Vol. II, pp. 508 - 513.

Mayo, Richard E., "Group Dynamics - Using the Game 'Gray Matters,'" *American Society of Engineering Education Annual Conference Proceedings,* 1993, Vol. 2, pp. 1562 - 1564.

Professional Committee Service

American Society of Civil Engineers
Construction Research Council
American Council for Construction Education Guidance Committee 1996 – Present
Accreditation Committee 1999 –
Society of American Military Engineers
Fort Worth, Texas, Post President
Heidelberg, Germany, Post Vice-President