ASCE Journal of Construction Engineering and Management: Review of the Years 1983–2000

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Abstract: This study considers the contents of the papers published by the ASCE Journal of Construction Engineering and Management which has witnessed a growth in terms of number and length of papers and breadth of participation, particularly of international origin, during the 1983–2000 period. The content is analyzed according to two main dimensions: the type of subject and its composing topics, and the institutional sources of the papers. The analysis shows the evolution of the construction engineering and management discipline as it is represented in the journal. Over the years traditional construction engineering topics have been complemented by an increasing interest in construction management topics, such as management of the firm, project delivery systems (Build–Operate–Transfer and Design/Build), project performance evaluation and project quality planning. This paper, in addition, identifies 30 institutional sources of the published papers and the extent of specialization of these institutions in terms of subjects relating the construction engineering and management discipline.

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Introduction

Construction engineering and management (CE&M) is still a relatively new discipline in the civil engineering realm. In the United States, it started with the development of pioneering master's programs approximately 45 years ago, followed by PhD programs 5 years later (Carr 1997). Today CE&M is an established academic and research area that builds upon a long series of publications of scholarly work and debate. In any discipline academic journals play a vital role because they are the primary context for communicating and exchanging research experience, shaping educational programs and assessing academic careers. The historical analysis of the content of these journals, in addition, shows patterns of evolution within a discipline, particularly as young as CE&M, by revealing its structure and the changes in its contents. This type of analysis is also useful in assessing the impact of academic contributions on construction practice. While the long-term approach of academic research may not meet the short-term needs of the construction industry, Harris has argued correctly that over the years concepts and techniques developed in academia have been adopted by the construction industry (Harris 1996). This study addresses the papers published by the ASCE *Journal of Construction Engineering and Management* (JCEM) during an 18-year period, from 1983 to 2000. The paper contains the initial results of an ongoing investigation aimed at assessing the past and possible future developments within the CE&M discipline. More simply, this contribution reflects the intellectual curiosity of one of the authors with more than 20 years of professional and academic experience in the construction industry and readership of JCEM.

The assessment of academic and scientific publications is not a new undertaking. In the past, bibliometric studies have been developed within the Institute for Scientific Information for exploitation of its Science Citation Index database. In the last 30 years bibliometric scalar indicators such as counts of papers, patents and citations have been used for evaluating science and technology performance, mapping temporal changes in these areas, and occasionally establishing new research policies or directions (Tijssen and Van Raan 1994). Mainstream academic journals have been analyzed for setting more rigorous research efforts, mapping existing areas of research and changes in a discipline, detecting emerging research topics and patterns of collaboration and, occasionally, establishing future editorial policies, among others. Typical examples can be found in logistics (Mentzer and Khan 1995), chemical engineering (Peters and Van Raan 1993a,b), environmental management (Shogren and Durden 1991) and artificial intelligence (Courtial and Law 1989). Journals in the field of construction-related research areas have been investigated also to provide a partial map of the discipline of construction management and project management (Betts and Lansley 1993, 1995). In this last regard, this paper addresses two objectives:

1. To assess the evolution of the JCEM's contents by identifying changes in its subjects and related topics over the 1983–2000 period; and
2. To identify the academic institutions that have been major contributors to the development of the JCEM's subjects and emerging topics over the period under examination.

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Table 1. Size of Journal over 1983–2000 Period

	1983–1985	1986–1988	1989–1991	1992–1994	1995–1997	1998–2000	1983–2000
Issues	12	12	12	12	12	18	78
Number of papers	107	143	138	162	163	178	892
Number of authors	183	261	267	364	344	400	1819
Percentage of international authors	0.26	0.14	0.21	0.25	0.30	0.36	0.25
Number of pages[a]	487	644	733	863	434	481	NA[c]
Average number of word equivalent/paper[b]	7137	7047	8278	8310	8866	10226	9973
Percentage of papers from sponsored research	0.13	0.26	0.33	0.33	0.37	0.27	0.29

[a]Includes papers and notes and related figures and tables, and discussions.

[b]Word equivalents are 520, 1,040 and 1,260 in 1983–1994, 1995–1996, and 1997–2000, respectively.

[c]Not available.

Journal: History, Objectives, and Statistical Data

The journal was first published with the title, *Journal of Construction Engineering and Management*, in March, 1983, namely in Volume 109 whose three digits show the continuation of a long publishing tradition of construction-related papers that dates back to the late 19th century. Before 1983 these papers had been published in journals with different titles; the last one before 1983, the *Journal of Construction Division*, began publication in 1957. Under the editorship of Robert Harris, the aim of JCEM was ''to advance the science of construction engineering, to harmonize construction practices with design theories and to further education and research in construction engineering and management.'' The focus on construction engineering reflected the civil engineering base of the contributors to the journal, whose original editorial objectives have remained the same over the years and contents have been enriched by a growing number of new topics. It should be noted that the ASCE *Journal of Management of Engineering*, established in 1985, publishes some subjects pertaining to CE&M as well. In the 1983–2000 period, 892 papers appeared in 78 issues of the JCEM with 1,819 writers and increasing international participation, as shown in Table 1, whose data are grouped according to a 3-year period. Over the years the number of writers, papers, and their average length (approximately 40% greater in 2000 than in 1983) have grown.

This pattern shows the progressive development of the journal and CE&M discipline in general. In the period under consideration, in addition, approximately 29% of the papers resulted from sponsored or funded research and this very positive trend in the 1990s reflects the increasing acceptability of the CE&M area for research by funding agencies.

Gathering of Journal Data and Classification Criteria

The Civil Engineering Database was the main source of information for the papers to be analyzed (Civil Engineering Database 2000). The current coverage includes all the ASCE journals published from 1973 to date. Several linked databases were developed to record the title of each paper, abstract, key words, writers, their affiliation and country of origin, and whether the paper reflected sponsored or funded research. This time consuming operation entailed the inputting of approximately 12,000 entries. An important task was the development of a classification framework to assess the content of each paper. In the construction industry there are several established information systems, but their focus is not on the CE&M discipline per se, to the best of the writers' knowledge. The intent of the study, in addition, was to develop a partial mapping of the discipline, as is reflected in the content of the journal, and not, more ambitiously, to develop its metaclassification. The main analytical thrust was to group the papers by main subject areas. In this regard, twelve subjects were identified:

1. Management of the firm;
2. Construction planning and control;
3. Site and equipment management;
4. Time scheduling;
5. Cost estimating and control;
6. Construction methods and materials;
7. Management of human resources (productivity, safety, and personnel issues);
8. Project management;
9. Project delivery systems;
10. Contractual issues;
11. Industry issues; and
12. Technology development issues.

The order of the above-listed subjects reflects three broad perspectives according to which the contents of the papers were interpreted: the first seven subjects focus on the general contractor's operations and business, the following three subjects focus on the project planning, organizing and controlling by a client (or his/her representative), while the last two subjects focus on issues related to the construction industry at large. A further differentiation of each subject yielded more than 100 topics. Appendix I shows the identified subjects and their related topics. The 892 papers were classified according to subjects and topics through a series of steps. Initially the writers undertook the classification of each paper independently by analyzing its title, abstract and key words. Paper contents were occasionally examined in cases of difficult attribution. The inevitable differences were progressively narrowed down through iterations until the level of agreement was virtually 100%.

Evolution of Journal Content

As stated earlier, one of the two objectives of the study was to assess the evolution of the journal's content and identify new developments and emerging topics. Table 2 shows the counts of the papers in percentage format according to two dimensions: subject and perspective. Their time profile shows sizeable changes in the examined 18 years of publication. The counts are grouped according to 3 year base and the first 9 years (1983–1991) are compared with the last 9 years (1992–2000) of observation. These two periods, roughly coinciding with the 1980s and 1990s, can be interpreted as the development and maturity phases

Table 2. Classification of the Journal's Papers by Subjects and Perspective

Subjects		1983–1985 (%)	1986–1988 (%)	1989–1991 (%)	1992–1994 (%)	1995–1997 (%)	1998–2000 (%)	1983–2000 (%)	1983–1991 (%)	1992–2000 (%)
1	Management of the firm	6.5	7.0	8.7	8.6	8.6	12.9	8.8	7.5	10.1
2	Construction planning and control	7.5	7.0	18.1	12.3	13.5	14.0	12.2	11.1	13.3
3	Site and equipment management	9.3	11.2	13.0	13.0	9.8	9.6	10.9	11.3	10.7
4	Time scheduling	6.5	4.9	5.1	5.6	5.5	6.7	5.8	5.4	6.0
5	Cost estimating and control	4.7	6.3	2.9	4.3	1.8	7.3	4.5	4.6	4.6
6	Construction methods and materials	16.8	11.9	13.0	12.3	8.0	6.7	10.7	13.7	8.9
7	Management of human resources	15.9	15.4	8.0	12.3	10.4	13.4	12.5	12.6	12.1
8	Project management	4.7	5.6	6.5	4.9	8.0	7.3	6.1	5.7	6.8
9	Project delivery systems	1.9	3.5	2.2	8.0	9.2	6.2	5.4	2.6	7.8
10	Contractual issues	7.5	9.8	8.0	7.4	8.6	5.6	7.7	8.5	7.2
11	Industry issues	10.3	10.5	7.2	4.9	11.7	7.3	9.3	9.3	8.0
12	Technology development issues	7.5	7.7	8.0	6.2	4.9	2.8	6.2	7.7	4.6
	Number of papers per period	107	143	138	162	163	179	892	388	504
	Perspectives									
	Firm	68.2	62.9	68.1	68.5	57.7	70.8	66.0	66.2	65.8
	Client	14.0	18.9	16.7	20.4	25.8	19.1	19.1	16.8	21.7
	Industry	17.8	18.2	15.2	11.1	16.6	10.1	14.8	17.0	12.5

of the JCEM content. Overall, the counts of the subjects vary from a minimum of 5.4% (cost estimating and control) to a maximum of 12.4% (management of human resources) in the considered period. If the counts according to the ''perspective'' dimension are observed, the focus on the general contractor's operations shows stability over time (66% of all papers). The focus on industry issues, instead, shifts away toward the client's planning and control of a project (from 17% in 1983–1991 to 13% in 1992–2000, and from 17% in 1983–1991 to 22% in 1992–2000, respectively). As far as the ''subject'' dimension is concerned, the large share (49% of all papers pertaining to contractor's operations) of construction planning and control, site and equipment management and productivity issues (a topic of the subject, management of human resources) is to be noted. This emphasis is consistent with the mostly civil engineering base of the authors. The large share also suggests the image of a contracting firm that self performs a significant amount of civil engineering-related work and consequently is focused on the optimization of in-house human and equipment resources. These features could explain the low number of papers on specialized subcontractors and subcontracting issues, mainly on productivity and bidding practice topics.

The most significant changes between the two observed periods are the relative growth and decline of some subjects in terms of counts. As shown in Table 2, the growth in project delivery systems, management of the firm, construction planning and control, site and equipment management and project management (in order of magnitude) compares with the decline of technology development issues, construction methods and materials, and contractual issues. These changes are reflected in the counts of the topics that make up each subject and that are shown in Appendix I (where new topics in the 1990s are in italics). The following topics are the major sources of growth in the above-listed subjects:

- Delivery systems with private financing [i.e. build-operate-transfer (BOT)] and design//build (Subject 9);
- Bidding activities and strategies, business strategy, adoption of innovation, and bonding and insurance issues (Subject 1);
- Construction process simulation, evaluation of methods and technologies, and resource planning (Subject 2);
- Work area planning, equipment operations and performance, and environmental issues and management (Subject 3); and
- Project performance evaluation and feedback, and project quality planning and control (Subject 8).

The major sources of decline in the above-listed subjects, instead, are the following:

- Research and development issues (Subject 12);
- Material properties and admixtures, construction failures, and cases on specific facilities (Subject 6); and
- Responsibilities of contract parties (Subject 10).

Some changes reflect the pattern of sponsored or financially supported research work, as shown in Table 3. Over the years financial support has shifted from traditional sources such as National Science Foundation (or its foreign equivalent) to other government sources and public/private programs. In the 1990s research work in some subjects (seven out of 12) is based on an increased diversification of funding sources.

It should be noted that the increase of funding in Subject 6, construction methods, in the 1990s does not compare with the shrinking number of its related papers. From 1987 the topic of construction failure was no longer published, coinciding with the establishment of the ASCE *Journal of Performance of Constructed Facilities*. Within Subject 6, the growing interest in the topic of construction methods, mostly below grade construction operations and technologies is to be noted. The changes in the 12 subjects suggest a progressive evolution of the journal's content. The traditional emphasis on construction engineering has been complemented by management-oriented topics over time, as shown by the increased counts of project delivery systems, such as BOT and Design/Build, project performance evaluation and quality planning, and selection and evaluation of contractors. These topics consider the activities that compose the upstream phases of the construction process cycle and suggest a parallel evolution of the CE&M discipline, i.e., the emergence of the services by client representatives (being a professional or contractor or employee of the client's organization). The focus coincides

Table 3. Percentage Distribution of Sponsored or Funded Research within Subjects

Subject		1983–1991						1992–2000					
		%[a]	1[b]	2[c]	3[d]	4[e]	5[f]	%[a]	1[b]	2[c]	3[d]	4[e]	5[f]
1	Management of the firm	6.2	0.67	0.33	—	—	—	9.9	0.38	0.19	0.25	0.06	0.13
2	Construction planning and control	13.4	0.54	0.15	0.23	—	0.08	16.8	0.37	0.26	0.11	0.19	0.07
3	Site and equipment management	13.4	0.31	0.15	0.38	0.08	0.08	10.6	0.47	0.12	0.12	0.29	—
4	Time scheduling	4.1	1.00	—	—	—	—	4.3	0.43	0.14	0.14	0.14	0.14
5	Cost estimating and control	3.1	0.33	0.33	0.33	—	—	3.7	0.33	0.67	0.00	—	—
6	Construction methods and materials	6.2	0.50	0.17	0.33	—	—	9.9	0.38	0.44	0.06	0.06	0.06
7	Management of human resources	16.5	0.25	0.06	0.69	—	—	11.8	0.37	0.16	0.47	—	—
8	Project management	3.1	—	0.67	0.33	—	—	8.1	0.08	0.15	0.54	0.15	0.08
9	Project delivery systems	2.1	1.00	0.00	0.00	—	—	7.5	0.08	0.08	0.75	0.08	—
10	Contractual issues	7.2	0.43	0.14	0.29	0.14	—	7.5	0.42	0.42	0.08	0.08	—
11	Industry issues	7.2	0.57	—	0.43	—	—	5.6	0.33	0.33	0.33	—	—
12	Technology development issues	17.5	0.71	—	0.24	—	0.06	4.3	0.29	0.29	0.43	—	—
	Breakdown of papers by sponsorship and funding (in %)	1	0.49	0.12	0.33	0.02	0.03	1	0.34	0.25	0.27	0.11	0.04
	Number of papers from sponsored or funded research	97	48	12	32	2	3	161	54	40	43	17	7

[a]% = Percentage distribution of research sponsorship and/or funding within each subject.

[b]1 = Research agencies, i.e., NSF and foreign equivalent.

[c]2 = Other government agencies, i.e., State DOTs.

[d]3 = Private sponsors, i.e., CII and Exxon.

[e]4 = Public/private sponsorship and/or funding.

[f]5 = Other sources, i.e., universities.

with a concurrent trend in the construction market in the 1990s, namely the growing demand for services capabilities, in addition to those relating to production, from construction firms. Another expected pattern is the growth of topics such as construction planning and cost estimating, with the application of simulation techniques, following the diffusion of computing capabilities in the 1990s. Future research should assess whether the suggested evolution is also reflected in the research and teaching activities of a large body of academicians or whether it results from individual but highly productive efforts.

Contribution of Academic Institutions

The second objective of the study encompassed the identification of the academic institutions where the papers had been written and the type of subject most frequently found in their publications. Table 4 shows that most of the journal's papers are authored by academicians, with a declining participation of practitioners and government agencies. The average number of writers per paper, in addition, has increased from 1.70 in 1983–1985 to 2.25 in 1998–2000. These values are slightly higher than those found in a study of two U.K. journals (Hughes 2000): *Construction Management and Economics* (from 1.43 in 1994 to 2.38 in 1999) and *Engineering Construction and Architectural Management* (from 1.89 in 1994 to 2.38 in 1999).

This pattern was interpreted as a result of increased collaboration, particularly in the same institution. As far as the JCEM is concerned, other possible reasons are the sizeable number of graduate students involved in the publications or, more simply, the academic pressures of U.S. universities. Given the preponderance of academic contributions, 184 different universities were active in the observed period with a production of approximately 693 weighted (paper divided by the number of writers) papers. Most of these contributions (69%) were from 30 universities, as shown in Table 5. These results were expected, considering the size of the faculty and graduate programs in these universities. The list includes six foreign institutions whose inclusion rate has increased considerably in the 1991–2000 period. Most have faculty with U.S. doctoral degrees and recurrent collaborative contacts with U.S. universities.

Finally, Table 6 shows the distribution by subject of the weighted papers published by the 30 universities under consideration. The table provides insights into the institutional structure of the CE&M discipline. The number counts and their distribution show the breadth of research interests at a given university and the possible extent of research concentration in a given subject among these universities. In terms of breadth, the Univ. of Michigan is the most represented institution (11 subjects), while Zagaziz Univ. and the Univ. of Singapore are the least represented (5 subjects) of the sample considered. The range of research concentration (in terms of subjects) goes from a minimum in cost esti-

Table 4. Breakdown of Journal's Contributions

	1983–1985	1986–1988	1989–1991	1992–1994	1995–1997	1998–2000	1983–2000	1983–1991	1992–2000
Education	0.69	0.75	0.79	0.77	0.83	0.90	0.79	0.74	0.84
Industry	0.24	0.21	0.16	0.18	0.12	0.07	0.16	0.20	0.13
Government agencies	0.07	0.04	0.06	0.05	0.04	0.02	0.05	0.06	0.04
Average writer/paper	1.70	1.82	1.93	2.25	2.12	2.25	2.01	1.82	2.20

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Table 5. Top 30 Publishing Universities by Weighted Papers

Universities 1–15		1983–2000	1983–1991	1992–2000		Universities 16–30	1983–2000	1983–1991	1992–2000
1	Univ. of Michigan	46.08	21.75	24.33	16	Virginia Polytech. Inst.	12.33	6.17	6.17
2	Penn State Univ.	37.58	15.17	22.42	17	Univ. of Illinois	11.92	8.50	3.42
3	Stanford Univ.	36.00	20.17	15.83	18	Clemson Univ.	11.50	2.83	8.67
4	Univ. of Texas	28.22	16.50	11.72	19	Univ. of Florida	11.00	4.00	7.00
5	Purdue Univ.	27.37	12.17	15.20	20	Illinois Inst. of Tech.	10.75	4.75	6.00
6	Technion, Israel	22.50	7.67	14.83	21	Nanyang Tech. Inst., Singapore	10.47	1.00	9.47
7	Texas A&M Univ.	18.83	11.83	7.00	22	Arizona State Univ.	10.42	0.50	9.92
8	Iowa State Univ.	17.27	6.50	10.77	23	Zagazig Univ., Egypt	9.50	1.00	8.50
9	Univ. of Wisconsin	16.75	4.17	12.58	24	Northeastern Univ.	9.33	4.33	5.00
10	NC State Univ., Raleigh	15.92	6.83	9.08	25	Auburn Univ.	8.75	3.50	5.25
11	Univ. of Washington	15.83	6.33	9.50	26	Ohio State Univ.	8.50	2.00	6.50
12	Univ. of California, Berkeley	15.08	6.50	8.58	27	Univ. of Singapore	8.42	1.00	7.42
13	Univ. of Alberta, Canada	13.83	1.33	12.50	28	Hong Kong Polytech. Univ.	7.17	0.00	7.17
14	Georgia Inst. of Tech.	13.67	5.67	8.00	29	Univ. of Maryland	6.33	3.33	3.00
15	Univ. of Colorado	13.33	8.83	4.50	30	Carnegie-Mellon Univ.	6.17	5.00	1.17
						Total weighted papers/period	481	199	281
						Top 30/184 universities	0.69	0.70	0.69

Table 6. Distribution of Papers According to Subject and University

		Subjects												
University		1	2	3	4	5	6	7	8	9	10	11	12	Total
1	Univ. of Michigan	7.0	4.5	4.5	2.3	4.0	—	15.8	0.0	1.0	1.0	2.5	3.5	46.1
2	Penn State Univ.	1.5	3.7	3.3	1.5	—	1.0	13.6	0.7	2.7	7.7	—	2.0	37.6
3	Stanford Univ.	4.5	3.5	1.7	0.7	1.0	4.0	1.3	6.5	—	—	4.8	8.0	36.0
4	Univ. of Texas	—	6.9	6.3	—	—	1.0	3.5	2.8	0.5	1.8	3.8	1.5	28.2
5	Purdue Univ.	0.7	7.5	2.7	1.0	0.8	3.0	2.5	—	0.7	1.7	3.8	3.0	27.4
6	Technion, Israel	2.0	3.8	2.5	0.5	—	5.7	15	—	1.0	—	1.0	4.5	22.5
7	Texas A&M Univ.	1.0	2.2	2.3	0.5	0.3	2.3	2.8	—	—	5.5	1.3	0.5	18.8
8	Iowa State Univ.	1.0	2.0	2.8	0.5	2.0	1.0	1.3	1.1	1.3	1.0	2.6	0.6	17.3
9	Univ. of Wisconsin	1.0	1.5	0.3	—	—	2.7	3.1	4.2	2.0	1.0	0.3	0.8	16.8
10	NC State Univ., Raleigh	1.3	2.2	2.7	1.0	1.0	4.8	1.8	—	0.5	—	0.6	—	15.9
11	Univ. of Washington	1.0	—	3.0	—	—	1.0	4.8	1.5	—	2.0	2.5	—	15.8
12	Univ. of California, Berkeley	1.3	4.4	0.8	1.0	0.5	—	0.8	2.0	0.3	2.3	0.5	1.0	15.1
13	Univ. of Alberta, Canada	1.7	5.4	1.0	1.5	—	1.5	0.5	—	0.3	1.0	0.9	—	13.8
14	Georgia Inst. Of Tech.	3.2	0.5	—	1.0	0.3	1.3	—	0.5	0.5	1.3	3.5	1.5	13.7
15	Univ. of Colorado	0.5	—	—	—	1.5	0.5	0.3	0.5	1.8	4.2	2.5	1.5	13.3
16	Virginia Polytech. Inst.	0.3	1.0	3.9	1.5	—	—	0.3	—	—	1.7	1.3	2.3	12.3
17	Univ. of Illinois	2.2	0.5	0.8	2.0	—	—	—	1.8	—	3.2	—	1.5	11.9
18	Clemson Univ.	0.8	1.2	—	—	0.3	1.0	1.0	1.0	1.0	1.7	1.0	2.5	11.5
19	Univ. of Florida	0.5	1.5	1.0	—	2.5	—	1.8	—	2.7	—	1.0	—	11.0
20	Illinois Inst. Of Tech.	1.0	—	0.3	1.5	—	—	1.0	1.0	—	4.0	1.0	1.0	10.8
21	Nanyang Tech. Inst., Singapore	2.0	1.0	0.7	—	—	—	1.5	0.0	5.3	—	—	—	10.5
22	Arizona State Univ.	0.5	2.5	1.4	—	—	1.0	1.5	—	—	2.0	1.5	—	10.4
23	Zagazig Univ., Egypt	1.0	1.5	—	—	—	3.0	3.0	1.0	—	—	—	—	9.5
24	Northeastern Univ.	—	3.5	1.0	1.0	2.0	0.5	0.3	1.0	—	—	—	—	9.3
25	Auburn Univ.	2.5	0.7	2.0	—	—	—	1.5	—	1.0	—	0.6	0.5	8.8
26	Ohio State Univ.	—	2.0	—	3.0	1.0	1.5	0.5	—	0.5	—	—	—	8.5
27	Univ. of Singapore	2.5	1.5	—	—	1.0	—	—	1.4	2.0	—	—	—	8.4
29	Hong Kong Polytech. Univ.	1.3	1.5	0.7	—	0.5	1.0	0.5	—	0.7	—	1.0	—	7.2
28	Univ. of Maryland	—	2.5	1.0	0.5	—	—	0.5	—	0.5	0.5	0.8	—	6.3
30	Carnegie-Mellon Univ.	1.0	0.5	—	1.0	—	1.0	—	0.7	—	—	1.5	0.5	6.2
	Total top 30 universities	43.3	69.4	46.7	22.0	18.8	38.9	67.2	27.6	26.3	43.5	40.4	36.6	480.8
	182 universities	67.5	102.1	71.0	43.0	32.7	56.2	90.4	43.4	38.5	50.3	53.0	44.3	692.4
	Top 30/182 universities	0.64	0.68	0.66	0.51	0.58	0.69	0.74	0.64	0.68	0.86	0.76	0.83	0.69
	Top 5 (by subject)/182 universities	0.29	0.28	0.30	0.24	0.37	0.37	0.45	0.40	0.38	0.49	0.35	0.49	0.36

mating and control (15 universities) to a maximum in construction planning and control (27 universities). Some subjects tend to concentrate on few universities. In this regard, two groups of five universities published 49% of the papers with a focus on contractual and technology development issues, respectively. These observations are not conclusive. Extent of research breadth and concentration is also related to the individual researcher who, over the years, may have moved from university to university.

Conclusions

The JCEM has grown in terms of content, variety of considered topics, number and length of papers with an increasing participation, particularly of international origin, over the observed period. Construction engineering and management, as is reflected in the journal, is an established discipline that has evolved and expanded over the years. In this regard the study has provided some insights into the institutional structure of the discipline by identifying the most frequently publishing institutions and the extent of their specialization with the CE&M discipline. A significant share of papers (69%) is published by a group of 30 institutions. Some subjects such as contractual and technology development issues tend to be published by an even smaller set of institutions. In the 1990s a set of mostly international institutions has emerged. This fact and the growing number of contributors, without doubt, reflect past educational efforts in the discipline and the emergence of a new generation of better-trained and motivated researchers. Overall, the journal's content builds upon a civil engineering base, with emphasis on the operations of contractors mainly involved in civil work. It would be beneficial for the CE&M discipline to complement this focus with further consideration of the operations by specialty subcontractors. These firms represent a very large segment of construction industry structure and practice. The study has shown sizable changes in the subjects and topics discussed in the papers. The JCEM's traditional emphasis on construction engineering topics has been complemented by an increasing number of construction management related topics. The papers of the 1990s, in fact, have shown a growing interest in addressing management topics, such as management of the firm, project delivery systems (BOT and Design/Build), project performance evaluation, and project quality planning. As stated earlier, these interests reflect an overall evolution of CE&M practice with a combination of services and production oriented capabilities.

Directions of Future Research

Future research should address the impact of the presented subjects and topics, and their evolution, on research and educational activities. A study of the references in the journal's papers could address the issue of such an impact. Citation analysis, although complicated and sometimes controversial for the cases of biased citations, would provide valuable insights into the way new concepts and techniques are substantiated through the work of other colleagues and the criteria according to which a new topic is established and refined. Future research, in addition, could investigate the maturation extent of the CE&M discipline by addressing the research efforts that have produced the papers published in the journal. Paper contents would be classified according to three dimensions: research output, research methods, and mapping the research process. The first dimension refers to the type of contribution of the paper, such as engineering solutions, construction management techniques, theoretical and systemic models, methodological constructs, and case studies. The second dimension encompasses the methods used in the research work, such as surveys and data analysis techniques, case and archival studies, modeling and simulation techniques, engineering science applications, and systems analysis, to name a few. The third dimension entails the modeling of engineering and scientific method processes, as they apply to the CE&M realm, and mapping the paper contents according to the logical steps of these models. This classification of papers according to these three dimensions is an ambitious undertaking, but its rewards would be valuable for a better understanding of the research process in the CE&M discipline and improving the development of new techniques and theories, including their testing and application.

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Appendix I. Classification Method by Subject and Topic

1. Management of the Firm

- Accounting and financial management
- Adoption of innovation
- Bidding activities and strategies, practices
- Bonding and insurance issues
- Business planning and strategy (firm performance, competitive factors)
- Interfirm relationships (joint ventures, subcontracting)
- Marketing
- MIS and IT applications (firm level)
- Risk evaluation and management (project selection and risks)

2. Construction Planning and Control

- Constructability analysis and improvement
- Construction performance and control (performance criteria, evaluation, project information, quality programs)
- Construction process models (representation models)
- Construction process simulation
- Evaluation of methods and technologies (project level)
- Modularization and prefabrication (approaches to)
- Planning of the construction process (phasing, WBS, selection of procedures, factors affecting planning)
- Resource planning and allocation

3. Site and Equipment Management

- Conditions assessment (site and existing structures)
- Demolition and decommissioning
- Environmental issues and management (waste disposal, noise and pollution control)
- Equipment maintenance and replacement

Equipment operations and performance (logistics, optimization, fleet management)
Equipment, costing
Equipment, selection
Material and component management (bar coding, data collection and management)
Preservation of historic sites and buildings
Production plants (aggregates)
Work area planning (site preparation, space use)

4. Time Scheduling

Cost/time scheduling optimization
Critical Path method
LOB, linear and vertical scheduling
Network planning and analysis
Other deterministic time scheduling techniques
Other nondeterministic time scheduling techniques
Pert and Gert
Time duration estimate, variability

5. Cost Estimating and Control

Cost control, project cash flow
Cost modeling, cost data
Deterministic estimating techniques
Life cycle costing
Nondeterministic estimating techniques
Time/cost considerations

6. Construction Methods and Materials

Applied construction automation and robotics
Bridges
Buildings
Construction failures
Construction methods and technologies
Formwork, shoring and temporary structures
Foundations, retention walls and excavation
Marine related facilities
Materials, properties and admixtures (design, concrete placement, rebars)
Other facilities
Tunnels

7. Management of Human Resources

Craftforce characteristics and recruitment issues
Factors influencing productivity (motivation, teamwork, learning, training, leadership)
Injury analysis and cost
Injury data
Management of human-machines interfaces
Management of personnel (communication, incentives, evaluation)
Organized labor related issues
Productivity analysis
Productivity improvement
Safety performance, indicators
Safety planning and programs

8. Project Management

Cooperation and negotiation (partnering, leadership)
Design management (value engineering, predesign and design estimating)
Project MIS and IT applications (project level)
Project performance evaluation and feedback
Project planning, organization and scoping
Project quality planning and control
Project risk analysis

9. Project Delivery Systems and Contracts

Analysis and selection criteria (delivery systems and contracts)
Design/Build
Evaluation of capital investments
Financial evaluation of contractors, failures
Project delivery systems with owner financing
Project delivery systems with private financing (BOT)
Selection and evaluation of bids and proposals
Selection and evaluation of contractors

10. Contractual Issues

Claims and disputes (negotiation and resolution)
Contract and contingency management
Contractual clauses (risk allocation, incentives and disincentives, insurance requirements)
Plans and specifications (QA/QC, performance based specifications)
Responsibilities of contract parties
Staffing for contract administration (inspection and testing)

11. Industry Issues

Classification and information systems
Codes, standards and laws
Data about business failures
Domestic construction issues and practices
Domestic industry structure and performance (economic indicators)
Education and professional development
Environmental issues in the industry (energy issues)
Foreign construction issues and practices
Industrial relations, union, and nonunion construction
Roles and cooperation in the industry (owners, professionals, contractors and subcontractors)

12. Technology Development Issues

Construction automation and robotics, trends
Evaluation of new technology (industry level)
Foreign research and development (R&D) practices (other than R&D)
Innovation and technology transfer, analysis and mechanisms
IT based integration and communication
New material and component technologies, trends
Research and development issues, research needs

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Appendix II. Classification of Journal's Papers by Topic

Topic	1983–1991	1992–2000	1983–2000
1. Management of the Firm			
Accounting and financial management	6	2	8
Adoption of innovation	2	8	10
Bidding activities and strategies	11	17	28
Bonding and insurance issues	0	5	5
Business strategy	2	9	11
Interfirm relationships	1	4	5
MIS and IT applications (firm level)	3	2	5
Risk evaluation and management	2	3	5
Other topics	0	1	1
Total	27	51	78
2. Construction Planning and Control			
Constructibility	8	11	19
Construction process models	1	2	3
Construction process simulation	7	20	27
Construction progress control	5	8	13
Evaluation of methods and technologies	0	5	5
Modularization and prefabrication	2	1	3
Planning of the construction process	6	5	11
Resource planning	9	14	23
Other topics	4	1	5
Total	42	67	109
3. Site and Equipment Management			
Conditions assessment	5	4	9
Demolition and decommisioning	2	4	6
Environmental issues and management	3	6	9
Equipment costing	3	2	5
Equipment maintenance and replacement	5	2	7
Equipment operations and performance	9	14	23
Equipment selection	3	4	7
Material and component management	9	6	15
Production plants	0	2	2
Work area planning	1	9	10
Other topics	3	1	4
Total	43	54	97
4. Time Scheduling			
Cost/time scheduling optimization	1	5	6
Critical Path method	4	4	8
LOB, linear and vertical scheduling	6	2	8
Network planning and analysis	1	3	4
Other deterministic time scheduling techniques	1	7	8
Other nondeterministic time scheduling technique	3	4	7
Pert and Gert	1	2	3
Time duration estimate, variability	4	3	7
Other topics	1	0	1
Total	22	30	52

Topic	1983–1991	1992–2000	1983–2000
5. Cost Estimating and Control			
Cost control, project cash flow	3	3	6
Cost modeling, cost data	2	4	6
Deterministic estimating techniques	9	4	13
Life cycle costing	1	2	3
Nondeterministic estimating techniques	1	7	8
Time/cost considerations	1	3	4
Other topics	0	0	0
Total	17	23	40
6. Construction Methods and Materials			
Applied construction automation and robotics	3	3	6
Bridges	5	7	12
Buildings	4	1	5
Construction failures	5	0	5
Construction methods	1	10	11
Form work, shoring and temporary structures	4	7	11
Foundations, retention walls and excavation	5	6	11
Marine related facilities	4	1	5
Materials, properties and admixtures	11	5	16
Other facilities	2	3	5
Tunnels	5	1	6
Other topics	1	1	2
Total	50	45	95
7. Management of Human Resources			
Craftforce characteristics and recruitment issues	0	2	
Factors in fluencing productivity	11	15	
Injury analysis and cost	2	3	
Injury data	0	5	
Labor related issues	4	1	
Management of personnel	5	8	
Productivity analysis	16	10	
Productivity improvement	8	5	
Safety performance, indicators	2	7	
Safety planning and programs	2	4	
Other topics	0	1	
Total	50	61	
8. Project Management			
Cooperation and negotiation	0	2	
Design management	8	5	
Project MIS and IT applications (project level)	2	5	
Project performance and feedback	1	9	
Project planning, organization and scoping	7	5	
Project quality planning and control	1	7	
Project risk analysis	1	0	
Other topics	0	1	
Total	20	34	

Topic	1983–1991	1992–2000	1983–2000
9. Project Delivery Systems and Contracts			
Analysis and selection criteria	2	3	
Design/Build	0	7	
Evaluation of capital investments	1	3	
Financial evaluation of contractors	0	3	
Project delivery systems with owner financing	2	4	
Project delivery systems with private financing	0	11	
Selection and evaluation of bids and proposals	2	3	
Selection and evaluation of contractors	2	5	
Other topics	0	0	
Total	9	39	
10. Contractual Issues			
Claims and disputes	10	15	
Contract and contingency management	1	3	
Contractual clauses	7	6	
Plans and specifications	9	7	
Responsibilities of contract parties	5	1	
Staffing for contract administration	1	4	
Other topics	0	0	
Total	33	36	
11. Industry Issues			
Classification and information systems	4	4	
Codes, standards and laws	4	7	
Domestic construction issues and practices	2	4	
Domestic industry structure and performance	1	4	
Education and professional development	12	4	
Foreign construction issues and practices	7	6	
Industrial relations, union and nonunion construction	3	2	
Roles and cooperation in the industry	8	7	
Other topics	2	2	
Total	43	40	
12. Technology Development Issues			
Construction automation and robotics, trends	6	4	
Evaluation of new technology (industry level)	1	2	
Foreign R&D practices	1	3	
Innovation and technology transfer, analysis, and mechanics	8	6	
IT based integration and communication	4	6	
Research and development issues, research needs	9	2	
Other topics	3	0	
Total	32	23	

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