

# **CONFERENCE SPONSORS**

THE INSTITUTION OF CIVIL ENGINEERS
THE INSTITUTION OF HIGHWAYS AND TRANSPORTATION
THE INSTITUTION OF WATER ENGINEERS AND SCIENTISTS
THE CHARTERED INSTITUTE OF BUILDING
THE BRITISH COMPUTER SOCIETY
THE FEDERATION OF CIVIL ENGINEERING CONTRACTORS
THE CONSTRUCTION INDUSTRY COMPUTING ASSOCIATION
'CONSTRUCTION COMPUTING'

## CONFERENCE ADVISORY BOARD

Professor H Adeli The Ohio State University U.S.A.

Dr R J Allwood University of Technology Loughborough, U.K.

Dr A K Azad University of Petroleum and Minerals Dhahran, Saudi Arabia

Dr Martin Barnes Martin Barnes Project Management Deloitte Haskins and Sells London, U.K.

P K Barton Sheffield City Polytechnic, U.K.

Dr A W Beeby Cement and Concrete Association Wexham Springs, U.K

W T Bell Contract Data Research Sheffield, U.K

Professor Y K Cheung University of Hong Kong

Professor J Christian Memorial University of Newfoundland St Johns, Canada Dr M A Crisfield Transport and Road Research Laboratory Crowthorne, U.K.

Professor S J Fenves Carnegie-Mellon University Pittsburgh, Pennsylvania U.S.A.

I Hamilton Construction Industry Computing Association Cambridge, U.K.

Professor H B Harrison The University of Sydney Sydney, Australia

Professor A Jennings
The Queen's University of
Belfast, U.K.

Professor P W Jowitt Heriot-Watt University Edinburgh, U.K.

Professor U Kirsch Technion, Israel

Professor H Liebowitz
The George Washington
University
Washington, D.C., U.S.A.

Professor K I Majid University College Cardiff, U.K. Dr M Papadrakakis National Technical University Athens, Greece

Professor Naruhito Shiraishi Kyoto Univeristy, Japan

Professor W R Spillers Rensselaer Polytechnic Insitute Troy, New York, U.S.A.

David Taffs
Ove Arup & Partners
London,
U.K.

Dr A B Templeman The University of Liverpool, U.K.

Dr B H V Topping University of Edinburgh, U.K.

Dr G J Turvey University of Lancaster, U.K.

Dr D. S. Wakefield Buro Happold Bath, U.K.

# THE APPLICATION OF ARTIFICIAL INTELLIGENCE TECHNIQUES TO CIVIL AND STRUCTURAL ENGINEERING

Edited by B. H. V. TOPPING

CIVIL-COMP PRESS

# published by

# CIVIL-COMP PRESS

10 Saxe-Coburg Place Edinburgh

© Civil-Comp Limited

# British Library Cataloguing in Publication Data

The application of artificial intelligence techniques to civil and structural engineering

- 1. Civil engineering Data processing
- 2. Artificial intelligence
- 1. Topping, B. H. V.

624′.028′563 TA345

ISBN 0-948749-06-7

# THE APPLICATION OF ARTIFICIAL INTELLIGENCE TECHNIQUES TO CIVIL AND STRUCTURAL ENGINEERING

|  |  | , |  |
|--|--|---|--|
|  |  |   |  |
|  |  |   |  |
|  |  |   |  |
|  |  |   |  |

### **CONTENTS**

|                                                                                                                                                                                                                                                                                                                                                                                                           | pag      |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| I – EXPERT SYSTEM SHELLS, INTERFACES AND KNOWLEDGE<br>ELICITATION                                                                                                                                                                                                                                                                                                                                         |          |
| *SOME EXPERIENCES FROM EVALUATING EXPERT SYSTEM SHELL PROGRAMS AND SOME POTENTIAL APPLICATIONS R J Allwood, BSc, PhD, CEng, MICE, D J Stewart, BSc, CEng, MICE, and Professor E G Trimble, BSc, CEng, MICE, MIStructE, MIMechE, Department of Civil Engineering, University of Technology, Loughborough                                                                                                   | 7        |
| ENVIRONMENT B Kumar*, P W H Chung† and B H V Topping*, *Department of Civil Engineering, † Artificial Intelligence Applications Institute, University of Edinburgh, Scotland KNOWLEDGE ELICITATION METHODS: A CASE-STUDY IN STRUCTURAL DESIGN Paul Wai Hing Chung* and Bimal Kumar†, *Artificial Intelligence Applications Institute, †Department of Civil Engineering, University of Edinburgh, Scotland | 15<br>21 |
| II – CONSTRUCTION PLANNING, MANAGEMENT AND CONTROL                                                                                                                                                                                                                                                                                                                                                        |          |
| *CAN EXPERT SYSTEMS HELP THE CONSTRUCTION INDUSTRY? Denis M Wager, BSc, MCIOB, FFB, Management Consultant with the Construction Industry Computing Association, Cambridge, England                                                                                                                                                                                                                        | 27       |
| *THE INTEGRATION OF AN EXPERT SYSTEM INTO THE CONSTRUCTION PLANNING PROCESS D W Wijesundera and Dr F C Harris, Department of Civil Engineering, University of Technology, Loughborough                                                                                                                                                                                                                    | 31       |
| AN EXPERT SYSTEM FOR CLAIM ANALYSIS Sabah Al-Kass, BSc, MSc, MCIOB, MIED, MASCE, and Frank Harris, BSc, MSc, PhD, CEng, MICE, MCIOB, Department of Civil Engineering, University of Technology, Loughborough                                                                                                                                                                                              | 39       |
| CRANES – A RULE-BASED ASSISTANT WITH GRAPHICS FOR CONSTRUCTION PLANNING ENGINEERS C N Cooper, Department of Civil Engineering, University of Technology, Loughborough                                                                                                                                                                                                                                     | 47       |
| THE DEVELOPMENT OF A KNOWLEDGE BASED EXPERT SYSTEM FOR THE SELECTION OF EARTHMOVING EQUIPMENT John Christian, BEng, PhD, FICE, MCSCE, CEng, PEng, and Havindra Caldera, BSc(Eng), MASME, MIE, CEng, Faculty of Engineering and Applied Science, Memorial University of Newfoundland, St John's, Newfoundland, Canada                                                                                      | 55       |
| THE DEVELOPMENT OF A KNOWLEDGE BASED COMPUTER SYSTEM FOR DECISION MAKING ON CONSTRUCTION METHODS A Manesero BSc, K P Chapman MSc, DMS, MCIOB and K A Sinclair, Department of Civil Engineering and Building, Coventry Polytechnic, England                                                                                                                                                                | 61       |
| THE USE OF EXPERT SYSTEMS AND SENSITIVITY ANALYSES IN FORMWORK PRODUCTIVITY AND DESIGN John Christian, BEng, PhD, FICE, MCSCE, CEng, PEng and Saif U Mir, BSc(Eng), MEng, Faculty of Engineering and Applied Science, Memorial University of Newfoundland St John's, Newfoundland, Canada                                                                                                                 | 67       |
| III – STRUCTURAL ANALYSIS AND DESIGN                                                                                                                                                                                                                                                                                                                                                                      |          |
| *KNOWLEDGE-BASED SYSTEMS IN STRUCTURAL ENGINEERING Professor H Adeli, Department of Civil Engineering, The Ohio State University, U.S.A.  A KNOWLEDGE-BASED APPROACH TO STRUCTURAL DESIGN B Kumar*, P W H                                                                                                                                                                                                 | 71       |
| Chung†, R H Rae† and B H V Topping*, *Department of Civil Engineering, †Artificial Intelligence Applications Institute, University of Edinburgh, Scotland                                                                                                                                                                                                                                                 | 79       |
| A KNOWLEDGE-BASED EXPERT SYSTEM FOR COMPUTER AUTOMATED STRUCTURAL DESIGN Professor Donald E Grierson and Gordon E Cameron, Department of Civil Engineering, Solid Mechanics Division, University of Waterloo, Canada                                                                                                                                                                                      | 93       |
| APPLICATION OF AI PROGRAMMING TECHNIQUES TO THE ANALYSIS OF STRUCTURES R Fruchter and Professor J Gluck, Department of Civil Engineering, and Y I Gold, Department of Computer Science, Technion – Israel Institute of Technology, Haifa, Israel                                                                                                                                                          | gq       |

i

| IV – WATER ENGINEERING                                                                                                                                                                                                                                                                                                                           |     |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| <b>ENGINEERING CASE STUDY</b> K Ahmad, BSc(Hons), MSc, PhD and A J Langdon, BSc(Hons), MSc Computing Unit, University of Surrey, W D Moss, BSc(Hons), MA, PhD, MICE, MIWES, Department of Civil Engineering, University of Surrey, R K Price, BA(Hons), MA, PhD, AFIMA, MIAHR, Computing Unit, University of Surrey and Hydraulics Research Ltd. | 105 |
| EXPERT SYSTEMS AS A PRELIMINARY DESIGN TOOL FOR DRINKING WATER SUPPLIES IN DEVELOPING COUNTRIES G R Kelsey, BSc, MSc, Civil Engineering Department, University of Newcastle upon Tyne, England                                                                                                                                                   | 113 |
| V – GEOTECHNICAL DESIGN                                                                                                                                                                                                                                                                                                                          |     |
| A KNOWLEDGE-BASED APPROACH FOR THE DESIGN OF SPEAD FOOTINGS Nabil A B Yehia, Structural Engineering Department, Cairo University, Egypt formerly Assistant Professor, University of Pittsburgh, Pittsburgh, U.S.A. and Ahmad H El-Hajj, formerly graduate student, Civil Engineering Department, University of Pittsburgh, Pittsburgh, U.S.A.    | 119 |
| VI - MATERIALS ENGINEERING                                                                                                                                                                                                                                                                                                                       |     |
| COMPUTER ASSISTANCE FOR CONCRETE CONSTRUCTION Kenneth C Hover, PE, PhD, Associate Professor of Structural Engineering, Cornell University, Ithaca, New York, U.S.A.                                                                                                                                                                              | 125 |
| VII – PAVEMENT DESIGN                                                                                                                                                                                                                                                                                                                            |     |
| PERFORMANCE OF CONCRETE PAVEMENTS USING "PAVEMENT EXPERT"  J G Cabrera and M Al-Shawi, Department of Civil Engineering, University of Leeds, England                                                                                                                                                                                             | 131 |
| VIII – EDUCATION                                                                                                                                                                                                                                                                                                                                 |     |
| A KNOWLEDGE-BASED EXPERT SYSTEM FOR TUTORING IN STRUCTURAL ENGINEERING David J Gunaratnam, BSc, PhD, CEng, MICE, Department of Civil Engineering University of the West Indies, St. Augustine, Trinidad                                                                                                                                          | 137 |
| PANDORA'S BOX: AN AUTOMATIC GENERATOR OF STRUCTURES R L Sack, BS, MSCE, PhD, FASCE, and R D Schroeder, BSCE, MSCE, Department of Civil Engineering, University of Idaho, Moscow, Idaho, U.S.A.                                                                                                                                                   | 145 |

<sup>\*</sup>Papers presented at CIVIL-COMP 85, The Second International Conference on Civil and Structural Engineering Computing, 3rd — 5th December, 1985, The Institution of Civil Engineers, London. All other papers presented at CIVIL-COMP 87, The Third International Conference on Civil and Structural Engineering Computing, 22nd — 24th September, 1987, The Institution of Civil Engineers, London.