THE ROYAL SOCIETY

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ROYAL SOCIETY INDUSTRY FELLOWSHIPS

(BBSRC, EPSRC, PPARC and Rolls Royce plc)

COLLIMATE - Collaborative Solutions for Membrane Structures

The project, **COLLIMATE**, is proposed to facilitate the exchange, development and enhancement of the activities of both participating organisations in the analysis and design of membrane structures. In this context the following aims are identified:

1. To transfer research expertise developed at Newcastle University to Ove Arup & Partners such as to enhance the latter's international commercial competitiveness.
2. To receive from Ove Arups & Partners engineering expertise and experience to enable the continued development of highly informed and relevant research.
3. To **COLLIMATE** research and engineering development for the mutual benefit of both organisations and, ultimately, the UK's international standing and competitiveness.

At the University of Newcastle-upon-Tyne, Dr. Gosling has continued to develop a strong research theme in the field of the numerical modelling of structural membranes. Most notably, the papers Lewis & Gosling (1993), Gosling & Lewis (1996a), Gosling & Lewis (1996b), Gosling (1996e) and Gosling (1997d) have contributed significantly to this area of research. An additional valuable extension into pneumatic structures' research has also been made (Riches & Gosling (1998c), Riches & Gosling (1998d), Gosling (1998e)). Outcomes have concentrated predominantly upon finite element formulations, solution algorithms (in particular the Dynamic Relaxation Algorithm) and numerical studies. A limited number of physical investigations have been undertaken at the Institute of Lightweight Structures at the University of Stuttgart, Germany, using minimal surfaces developed from scale models and surface tension effects. Given the topic of research, little opportunity has existed for its practical realisation, impact assessment and demonstration of contributions outside the academic environment.

Ove Arup & Partners (''Arups'') designed its first major lightweight roof for the Hotel and Conference Centre at Mecca in 1968. Realising the architectural and commercial potential, Arups invested in the development of numerical methods applicable to this type of structure. Most significantly, the Dynamic Relaxation Algorithm as devised by Day [1] was developed further and applied at Arups to solve mechanics problems exhibiting strong geometric nonlinearity (as in the case of structural membranes). This algorithm continues to be used as the solution method for the analysis of Arups' membrane structures. Some thirty years after the completion of its first example, an impressive portfolio of internationally renowned membrane structures constructed worldwide now includes, for example: the Schlumberger Research Centre, Cambridge, UK [2]; San Nicola Stadium, Bari, Italy [3]; Glynborne Opera House, Lewes, UK [4], amongst several others. In addition, the Dynamic Earth Project, Edinburgh, serves as a good example of an Arup membrane structure most recently completed.

COLLIMATE is extremely timely. In the 4th February 1999 issue of *New Civil Engineer* a special feature appeared under the title ''Creative tension - wiring into tented structures''. The main article, written in the context of the Millennium Dome construction, opened with the following - **''Are giant tents domed? Tensile fabric structures are among the most spectacular of the 20th**

century - and the most controversial” . This statement was made with reference to the collapse of the new fabric roof over Montreal’s Olympic Stadium early this year (*NCE* 28th January 1999). The actual cause of the failure is yet to be published. This event, which is not unique, does, however, reflect the need for further research in all aspects of membrane structure design, not least in the refurbishment of fabric roofs now approaching their design life (30 years). It is in this environment that the proposed project is set.

Two primary activities will be undertaken. One will be the enhancement of existing Arups software and the development and implementation of new numerical formulations and capabilities. The needs in this area will be past and present project informed. The transfer of academic research to Arups, the host organisation, will be facilitated by this activity. The other primary activity will be the integration and involvement of Dr. Gosling into an in the engineering of commissioned membrane structure projects, from conceptual design to final adoption by the client. Practical engineering concepts, constraints and opportunities will be transferred to inform academic research.

References

1. Day, A.S., 1965, An Introduction to Dynamic Relaxation, The Engineer, 218-221.
2. Hopkins, M., 1992, Technology comes to town, RSA Journal, **140**(29), 395-404.
3. Prete, G., 1994, The covering structure of the St. Nichola Stadium of Bari (Italy), Int. J. Space Structures, **9**(4), 201-209.
4. RIBA Awards 1994, RIBA Journal, **101**(12), 36-55.