

# Special Session on Rigidity

at the Syracuse Meeting of the American Mathematical Society

## Research Note

Questions concerning the rigidity of structures have interested a number of mathematicians in recent years. In the Fall of 1978, Len Asimov, on leave from the University of Wyoming, organised a special section of the regional meeting of the American Mathematical Society held at Syracuse University, Syracuse, New York, on the subject of rigidity of structures. Kee Dewdney, from the University of Western Ontario, was on hand with his camera, and took a group photograph, which he kindly offered to the Bulletin.

On the left of the photo we find Robert Connelly of Cornell University, who constructed the first example of a concave (but properly embedded) spherical polyhedron having a full finite motion (that is, being a mechanism). This work was reported in the *Seminaire Bourbaki* and by Connelly in an address to the International Congress of Mathematicians in Helsinki (August 1978).

Third from the left stands Ben Roth, from the University of Wyoming, who collaborated with Len Asimov to analyse the concept of general position (generic) structures. They found that generic structures form an open and dense subset of configuration space, and proceeded to characterize topologically those structures which are generically isostatic in the plane. Roth is presently on leave from his post in Wyoming, on a visit to Branko Grunbaum in Seattle.

In the centre we find Ethan Bolker, from the University of Massachusetts in Boston, who collaborated with Henry Crapo to solve the bracing problem for a one-story building over a grid of squares (the braces being cross-braces in wall and in ceiling panels). He has also extended these results to deal with "taller" grids of cubes, that is to buildings with more than one floor.

Third from the right stands Branko Grunbaum, of the University of Washington, a member of the advisory board of the Bulletin, and an authority on polyhedra and convex polytopes. He has recently completed, in collaboration with Geoffrey Shephard, a compendium of results on tessellations of the plane. His paper "Lectures on Lost Mathematics", concerning both structural rigidity and tessellations, was the



subject of a talk he presented to the workshop on Structural Topology at the University of Montreal in 1976, and an updated version was distributed for the present meeting.

Four members of the Structural Topology Research Group drove in from Montreal. Henry Crapo (second from the left), Ivo Rosenberg (second from the right), Walter Whiteley (on the extreme right, holding two examples of critical forms of woven rod structures), and a fourth, Rachad Antonius, who was not available for the photograph. All four have worked with Janos Baracs on and off since 1974, mainly on the subject of static rigidity.

Henry Crapo organised the first conference on "structural geometry" at the University of Waterloo in 1974, and collaborated with Walter Whiteley to confirm the Baracs conjecture concerning critical forms for bar and joint structures in the plane. He worked with Ethan Bolker on the bracing of grids of squares and with Tiong Seng Tay on dependent bar and joint structures in space. On leave from the Memorial University of Newfoundland, he is visiting the Centre de recherche en mathématiques appliquées and the Ecole d'architecture at the University of Montreal.

Ivo Rosenberg, a member of the Centre de recherche en mathématiques appliquées, has studied special positions of spatial structures, from the aspect of static rigidity.

Walter Whiteley, from Champlain Regional College in St. Lambert, Quebec, has studied the rigidity of various types of structures: bar and joint, hinged panel, sheet polyhedral, woven rod, and cabled frameworks. He has written introductory papers on the statics and mechanics of structures, has advanced the theory of the correspondence between stressed bar and joint structures and infinitesimally movable polyhedra (panel structures), and has extended the work of Cauchy and Alexandrov on statically rigid panel structures.

Rachad Antonius, a doctoral student working with Ivo Rosenberg and Walter Whiteley, has studied the rigidity of grids of parallelograms, braces with ca-

bles, and the dependencies occurring in spatial structures which are projections of 4-polytopes.

The intellectual fare for the special session was as follows:

"Exotic Rigidity", by Robert Connelly.

"Rigidity of polyhedra, frameworks and cabled frameworks", by Branko Grunbaum, and by Geoffrey Shephard of the University of East Anglia, Norwich, England.

"Cabling Grids", by Ethan Bolker.

"Dependent plane frameworks and projected polyhedra", by Walter Whiteley.

"The projective invariance of infinitesimal properties of frameworks", by Ben Roth.

"Dependent Spatial Frameworks", by Henry Crapo.

"On the rigidity of cabled grids of parallelograms", by Rachad Antonius, of Champlain Regional College in St. Lambert, Quebec.

"Characteristic function for infinitesimal rigidity", by Ivo Rosenberg.

"Counting types of P L frameworks", by Peter Kahn of Cornell University.

Toward the close of the session, François Gabriel, architect and professor at the School of Architecture, Syracuse University, joined us, and showed us some of his interesting work on spatial frameworks, which are the subject of an article entitled "Vers la cité transparente", in **Architecture Concept**, mars-avril 1977.