WHERE BEST IS LEAST

You remember the deacon’s “One-hoss Shay”: so carefully designed in all its parts that it ran for exactly 100 years without repairs until that last great day when it simply fell to pieces, “all at once, and nothing first”, everything worn out at the same dramatic moment!

In that fanciful story Oliver Wendell Holmes wrote a classic, 100 years before its time, about what engineers today call “optimisation”.

By optimisation, engineers mean in broad terms “most benefit for least cost”; in narrower terms they seek “least cost of construction” for a given duty, because their masters, the clients, demand it. And least first cost usually boils down to least quantity of materials.

Structures impose a special challenge here, since they can be composed in many different ways to accept their loads.

Along with engineers and engineering schools around the world, Dr. George Rozvany, reader in Monash’s department of civil engineering, has accepted that challenge—the designing of structures of least cost, in effect of least material, while meeting the required duty.

And not by the conventional processes of trial and error coupled with experience and intuition, but by seeking a general principle that goes straight to the optimum form of structure.

Though optimisation is now the “in” thing in engineering, the idea is not new. It began in 1638 with Galileo Galilei, who worked out the notion of a cantilever of diminishing cross-section to match the reducing bending moment from root to tip. Clerk Maxwell wrote to the Royal Society in 1869 on structures of least weight. In 1904 that ingenious Australian, A. G. M. Michell of thrust-bearing fame, wrote also to the Royal Society on the plane truss of least weight for a given duty.

Rozvany is in the modern forefront of that tradition, working first on the reinforcement of concrete slabs and on grillages—rows of beams under thin slabs—and extending it to long-span space frames supporting thin coverings.

In the conventional design of grillages and reinforced slabs, square or rectangular, the members (i.e., the beams in the grillages or the reinforcing rods in the slab) are laid parallel to one or both of the two rectangular sides. Within that convention any designer can arrive at an apparent least quantity of material.

Break with convention

But Rozvany and others have seen that practice was blocking the way to the real optimum: it was essential to break out of the convention.

It was the direction of the members in the grillage that Rozvany worked out, so as to arrive at the least volume of material and, by implication, least cost. In 1966 he was the first to solve the minimum volume of reinforcement for a square slab of concrete of given depth resting simply on its four edges.

That set off workers in many parts of the world (including Robert Melchers and Donald Charrett, his own research students) along comparable lines to seek solutions to other, presumably more difficult, problems. At least one worker suggested that some situations were beyond theoretical solution!

Soon, both Rozvany and Melchers (then working at Cambridge, England) independently solved for the square slab built-in on all four sides.

In the next five years, Rozvany himself found not only the solutions to the square grillage or slab supported in some 17 different ways, but the general method of solution for any shape of reinforced slab.
or for a grillage of beams of constant depth.

By excursions into unorthodox mathematics, and by methods too subtle to hint at here, he recognized that a transversely loaded grillage or slab (having least material) can be marked out into regions distinguished by the directions in which the moments in each region are distributed. (A loaded beam suffers "bending moments"—a product of force and distance—along its length; a slab suffers bending moments throughout its area.)

It followed that each region defines the direction in which the members should be placed in order to resist the bending moments most efficiently, and so to require least material.

It was the recognition of that, that enabled Rozvany, supported by his research students (including now Sai Adidam), to construct, precisely and indeed simply, the shapes of the several regions in a slab, and the preferred directions in those regions, that gave overall the least material.

When the members are placed in the directions indicated in Rozvany's incredible diagrams (page 1 and above) the amount of steel required—say, as reinforcement in a slab—can be dramatically reduced—in some situations to as low as one-sixth of the conventional quantity. In long-span space-frames, savings in cost of up to 30 per cent or so have been made notwithstanding the complications of cutting and placing the members in unconventional directions.

But, Rozvany points out, in structures used in space flight, it is the saving of every gram in weight that counts. Once the technique was established and formalised, Rozvany had no difficulty in extending it to flat slabs or grillages other than square: to rectangles (Fig. 1) and even to unusual shapes like that shown in color on page 1. And he has extended it beyond simple reinforcements and grillages to long-span three-dimensional trusses supporting thin coverings.

When looking up to a great roof supported on these zigzag arrays of members, one may wonder at the pattern of it all. Here, says Rozvany, the architects might find aesthetic excitement, as well as strict function.

Meanwhile, apart from writing his professional papers on this theme, Rozvany recently took his story to the 13th International Congress of Theoretical and Applied Mechanics in Moscow, September 1972, and to the Symposium on the Foundations of Plasticity, in Warsaw, 1972.

---

**COMPUTER TO ABACUS**

Monash's faculty of education has found it necessary to re-invent the abacus.

The problem was to select the applicant students, and to organise the classes for the course in B.Ed. (B.Ed. is a one-year degree course for graduates, not for new matriculants.)

On the one hand, the faculty offers a range of 60 subjects, six to be done, either in one year of full-time study, or over two or three years by part-time study.

On the other hand, while about 20 students might enter for the full-time course, about 500 would do it part-time while working as full-time teachers in schools around Melbourne.

The restrictions were, for the faculty, a limit of 30 in any subject or class, and of course a scheduled weekly time table; and, for the part-timers, only on few occasions in the week would they be free of school duties to attend university classes.

Add to those the further refinement that students would be selected for a particular class on the quality of their earlier degrees.

All of this was no matter for the formal computer; as Mr. Richard Osborn, secretary of the faculty, said, such material would be "unprogrammable".

So he invented his own computer, BEDSAC 1800. (Every computer must have a name and a number—the name usually a more or less euphonious acronym of initial letters; the number, meaningful or not, must be large and important.)

**BEDSAC stands for Bachelor of Education Selection Assistance Calculator; 1800 truly represents its initial capacity for 1800 B.Ed. subject entries.**

*Made at a cost of just $10 for materials, including the 1800 coloured plastic beads for counters, BEDSAC is essentially a king-sized abacus.*

Instead of wires, we have grooves (60 of them) in a plastic ripple-board or wash-board, each groove representing a particular subject in the course. Each bead means a subject-entry when dropped into the appropriate subject groove. The different colours represent such different categories of students as full-time, part-time, new applicant, a continuing student, a master's degree student.

Simple, says Osborn (pictured above) . . . it works!
SPECIAL EDUCATION

Monash, unique among Australian universities, has a department within its education complex working on the special education of the handicapped.

Professor Marie Neale, the head of this section, takes as her theme Goethe’s statement:

“If you treat an individual as he is, he will stay as he is, but if you treat him as if he were what he ought to be, he will become what he ought to be and could be.”

She reminds us that, judge as you will—by height, weight, native abilities, intelligence—most members of a population fall near the mean; but that some, in increasing numbers, fall further and further below and others further and further above the population’s mean.

While most children, lumped around the mean, manage to cope with the hardships of being brought up into a given society or community (including its initiations, schools and pre-schools), Marie Neale is concerned with the exceptional children, those further and further above and below the mean—in particular, those who do not cope with growing up into their arbitrary cultural environment.

Neale points out that mental retardation is essentially a cultural problem: on the one hand, the individual’s inability, at the appropriate stage, to do the things that the culture expects of him (including walking or talking at the expected ages); on the other, his being rejected by the culture for his failure.

Neale believes that the handicapped child can be stimulated by the activities of his normal peers on the playground or in the class room into imitating and learning the language and social behaviour demanded by his local culture.

Though that belief is not new, what is new is the work at the Child Study Centre is the intervention of the specialist so as to combine clinical tuition with specified periods of interaction with the subject’s peers. To give this special educational program a name, she calls it the “intervention-integration” approach to learning.

Neale points out that Monash’s child-study centre is a regular kindergarten, with children from the staff on campus and from the precincts in Clayton. The subjects or patients may be referred to the centre by a medico or a teacher or, in certain circumstances, by the parents.

In this, Neale and her team—Mr. Merrill Jackson, interested in learning disorders, and Mr. Fred Perry, a specialist in teaching the deaf, and a whole team of kindergarten teachers and therapists, voluntary and professional—have had encouraging results.

Albert, who had been badly injured in a car crash when 10 weeks old, and was diagnosed “severely mentally retarded”, was withdrawn from a group of other handicapped children, and came to the clinic when three years old, neither walking nor talking. Within a month he began to walk, and joined in the movement-music lessons, and began to build things in the same way as other three-year-olds. After four months he was well advanced in competence and “socialisation”. His problems now lie not so much in mental retardation as in sensory handicap.

Jenny, aged four, with cerebral palsy, has progressed so well that she has been accepted into the local primary school.

Robert, who totally lacked self control over his behaviour at home, has now acquired socially acceptable behaviour that has opened the doors of regular school to him.
But what about the culture's rejection of the retarded, the ostracism, the parental and social attitudes?

Neale agrees that we must modify social attitudes, so that the handicapped child is quickly recognised and provided with remedial treatment. And, we must sensitise the community to new levels of acceptance of the handicapped, so as to admit them to the regular opportunities of becoming socialised and of gaining employment.

While on social rejection of the handicapped, one may ask why the normal kindergarten children don't also reject the "different" child. Neale points out that in free play they might reject the child, but in the Centre the program employs individual and creative teaching that puts no emphasis on competition. The group therefore sees the special child as just one of them.

Conversely, to keep handicapped children together, as in many institutions, cuts off stimulation from their peers: the children are committed not only to the institution but to confirmed retardation.

As to a more sympathetic and more sensible response from the culture, Neale reports much recent enlightenment, especially in the USA, where in 1962 President John Kennedy set in train what was to become the President's Committee on Retardation. Marie Neale addressed that committee in Hawaii recently.

Another stimulus has come from the recent US federal legislation on civil rights, under which the citizen's rights cannot be abridged—for example, by excluding a child from regular school on the ground of his being declared "retarded," while at the same time failing to provide a special place for him.

On the one hand, the legality of labeling someone as retarded, and thereby abridging his educational rights, has been questioned and successfully tested in the US courts. On the other, some are now proud to say they are handicapped because of right—"they can enjoy special services that are better in some places than those available to the normal population.

Neale, just returned from the Fifth International Congress on mental retardation in Montreal, has been appointed the only non-departmental member of the ministerial committee of inquiry into special education in Victoria.

She is optimistic about the outcome of that committee because, after years of uncertain and fragmented approaches to special education, the climate of opinion and the improved technology are now highly favourable.

--

**KNOWLEDGE RETRIEVAL**

A university library is more than a mere collection of books, it is an active part of the learning tapestry.

According to Mrs. Jacqueline Baillie, librarian of Monash's biomedical library, scientific libraries should be thought of not so much as a repository of inviolate knowledge in the established text books, but as a record of change in the scientific papers.

Today, in all fields, especially in science and technology, the number of journals is vast and increasing. On the main campus and at the teaching hospitals, Monash's biomedical library subscribes to some 2000 journals. These are current working journals, not archives; though the *Lancet* runs back to 1860.

The increasing number of journals and the tapes makes them increasingly difficult to cope with. If you know the identification of a paper you are looking for—at least the author or title, which journal, what date—you can find it in the shelves: that is the easy part of it.

But if, for example, you want to find the papers on a given topic, to search the journals one by one, vol. by vol., is a daunting task; a stackful of journals by themselves is virtually inaccessible.

To know how to keep up with information when you want it, is to know how to use the modern indexes, with their elaborate cross-references—each paper entered by three or more key-words, as well as by author.

The biomedical library subscribes, for example, to *Science Citation Index* from USA at $3000 a year, and *Biological Abstracts* at $600 a year.

*Index Medicus* is a computerised affair, printed out monthly and recompiled annually. The tapes from which it is compiled also record other information which it is not practicable—through mere size—to print out in the Index. Yet *Index Medicus* covers only 2400 (repeat 2400) of the 30 or 40 thousand current periodicals in all fields.

The tapes form the database of the Medical Literature Analysis and Retrieval System (MEDLARS). A copy of these tapes is held at the National Library, Canberra, to which Monash library has access. Through it, it is possible to search a file of some 600,000 citations, which is being added to at the rate of 100,000 a year.

The great question in the learning process in medicine and in the biological sciences, is how to introduce the students, the future practitioners, to come to terms with information that is both vital to their professions (and to their patients), and that changes so quickly—so soon superseded, rendered already out of date by the time each new work is published.

So the biomedical library is to the medical faculty one of the laboratories, taken in second year, with tutorials and bibliographic assignments that send the students searching through the indexes, and from the indexes to the journals, and in the journals to the papers themselves and their references to preceding works.

A valuable "key" paper, turned up in such a search, may be used as the basis of further search in *Science Citation Index*, to find out who has cited that particular paper in the years following its publication.

For example, in 1941 N. M. Gregg, a Sydney medic, published a paper in *Transactions* of the Ophthalmological Society of Australia, which for the first time linked congenital cataract in an infant with the fact that the mother had suffered German measles during the pregnancy.

Thirty years later, that epoch-making paper is still being quoted by other authors. The extract from *Science Citation Index* reproduced here identifies 28 papers written in 1971 that cited Gregg (1941) as a reference.

Jacqueline Baillie points out that good supporting back runs of the major journals are needed, not for the sake of archives, but because each new technical advance calls for a re-examination of past work that could go back into last century.

Nor, with its 60 thousand books, is the library a collector of rare editions—it is happy to do with reprints. The library of medical history is the special interest of the University of Melbourne.

Mrs. Baillie, in 1969, attended the international conference of medical librarians at Amsterdam, with 1000 delegates: in the course of her tour she visited 80 scientific and medical libraries. Another member of the biomedical library staff, the hospital librarian, Mrs. Fay Baker at the Alfred Hospital, has been seconded to the World Health Organisation to advise on a library for the department of health in the Philippines, and on setting up the medical library at the University of the South Pacific, in Fiji.