

Methods of Pottery Research as it is Carried Out by the
Applied Science Center, University Museum, Pennsylvania

by

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Museum Applied Science Center for Archaeology
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Abstract

Current activities of the Museum Applied Science Center for Archaeology (MASCA) at the University Museum, University of Pennsylvania, were described briefly. They include radiocarbon dating of archaeological samples and of tree-ring-dated samples of known age for correcting the experimental results of radiocarbon dates in terms of absolute chronology, magnetometer surveys of archaeological sites, aerial photography and thermoluminescence dating of pottery.

Pottery research as it is carried out by MASCA is mainly concerned with the dating of objects by the thermoluminescence (TL) method. It is based on the fact that radiation from the traces of radioactive elements in pottery bombards the other constituents of the clay and raises electrons to metastable levels. When the pottery is heated, such as in firing, enough additional energy is supplied to enable each electron to fall back to its stable level and to emit a photon of light. On being reheated, the amount of TL observed is, therefore, representative of the number of metastable or excited electrons and hence of the time elapsed since the last firing of the pottery. The amount of metastable electron accumulation is also dependent upon the rate of radioactive bombardment and upon the susceptibility of the pottery to irradiation as determined by an artificial dose.

Eleven examples of Egyptian ceramics, which could be closely dated by context, from the University Museum collections were dated by TL. Of two decorated pots of the prehistoric period, one had an acceptable median TL date (3362 B.C. \pm 630), the other had no TL reading, being probably refired by a forger to fix added paint. A sherd from the tomb of King Djer, Abydos, had an acceptable TL date (3180 B.C. \pm 283) which strongly supported the "long" Egyptian chronology; another, although certainly of Dynasty I manufacture and from the same tomb, had a median TL date of late Dynasty XVIII (1416 B.C. \pm 240) and was probably refired during a historically documented renovation of Djer's tomb at that time. A jar from Bet Khallaf dating to King Sanakhte Nebka had an acceptable TL date (2926 B.C. \pm 350). Two First Intermediate Period jars, well dated by context, were respectively off the TL scale and datable to 1570 B.C. \pm 227; these results are inexplicable.

An Eighteenth Dynasty jar from a disturbed foundation deposit of Tuthmosis III (1504-1450 B.C.) at Coptos had TL date 300 B.C. \pm 111, apparently refired during a historically documented early Ptolemaic rebuilding of the temple. A saucer from a foundation deposit of Amenhotep II had an acceptable TL date of 1317 B.C. \pm 217. Two funerary cones of a well-known official, Montuemhat (689-609 B.C.) had TL dates of 1846 \pm 278, 1452 B.C. \pm 264, a result of incomplete original firing.

The above results show that TL dating has an obviously important application to the problems of prehistoric Egyptian chronology where it can supplement the currently insufficient C¹⁴ dates and the TL dates tend to support the "long" historic chronology, and, despite its \pm factor, TL dates proved unexpectedly valuable in interpreting certain historical period situations (e.g. renovation of Djer's tomb, Tuthmosis III foundation deposit).

As a follow-up, we propose to determine TL dates for more prehistoric Egyptian pottery, more sherds from Djer's tomb, more First Intermediate Period vessels, pots from undisturbed Tuthmosis III deposits at Coptos, and a jar from a Ptolemaic foundation deposit at the same temple.

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Fossil of the lower jaw of an adult of the genus *Homo* was dated by the potassium-argon method at between 3,350,000 and 3,750,000 years old. Mary Leakey and co-workers found the jaw and other remains of early man at Laetolil in Tanzania.

The reviewers could also have pointed out that the success of the Vicos and Comilla projects was assured not alone because they realized the values of the downtrodden but because men in political power supported those same values and actively promoted their cause. Clearly the Vicos Project was rescued from certain destruction by local landlords because its organizers had formed linkages with persons of great leverage in national politics. The Comilla situation is more complex. Initially the project was ignored by the most powerful landlords; thus in its earliest years it was spared a power confrontation. In addition, the poorest peasants in what was then East Pakistan were Bengalis, but the economic and political power structure was almost entirely controlled by West Pakistanis. When Bangladesh became independent in 1971, significant portions of the old power elite were replaced by Bengalis sympathetic to their downtrodden brethren, for whom Comilla had been one of the few bright spots.

Richard N. Adams pioneered among anthropologists in arguing that the key to development is the control of power on a national, not simply a community, basis. He made this clear in his case study of Guatemala, *Crucifixion by Power: Essays on Guatemalan National Social Structure, 1944-1966* (1970), and an important purpose of his *Energy and Structure: A Theory of Social Power* (1975) is "the construction of concepts and a series of related theoretical propositions" for the study of social power. Adams also contributed an essay to *Rethinking Modernization* (1974), edited by John J. Poggie, Jr., and Robert N. Lynch, which reconsiders the nature of development and the anthropological contribution to it. The book reports a symposium held at the University of Rhode Island in 1971 which may suggest a shift on the part of an-

thropologists to a much broader canvas. As the editors conclude:

Almost all the cases of modernization that made up the focus of our discussion in the symposium involved some kind of major economic and social transactions. In fact, practically all problems of modernization, because of the extreme delocalization and worldwide articulation that has now developed, involve complex interdependencies in different sectors of economic market systems, as well as interactions among different political institutions among nation states.

State of the discipline. The production of increasing numbers of anthropologists, together with a downward shift in birthrates, was resulting in a severe limitation of academic job opportunities. A thoughtful article on the topic by R. G. D'Andrade, E. A. Hammel, D. L. Adkins, and C. K. McDaniel in the December 1975 issue of the *American Anthropologist* concludes that "from 1977 onward the number of academic positions for anthropology Ph.D.s will decrease yearly until it reaches a 'worse than zero' situation in 1987 and 1988." Whereas only about 5% of all anthropologists with Ph.D.s were working outside academia in 1976, projections indicated that after 1982 over two-thirds would be doing so.

The activities of the American Anthropological Association were permeated with concern about the projected job crisis. The executive committee opened a placement service for nonacademic positions for 1975-76 and urged departments of anthropology to offer work experience in a variety of public service areas. It was decided to include in future meetings a panel on public issues and to set up a task force to identify research possibilities "of both practical relevance and theoretical interest in the contemporary world."

—Raymond Lee Owens

Archaeology

Two issues concerning archaeological research became increasingly prominent during the year. One had to do with the relevance of such research in a period of accelerating economic, social, and political crises, and the other with the scale and elaboration of archaeological excavations in a period when economic development, deep plowing, construction, and trade in antiquities were destroying many more important archaeological sites than were being excavated systematically.

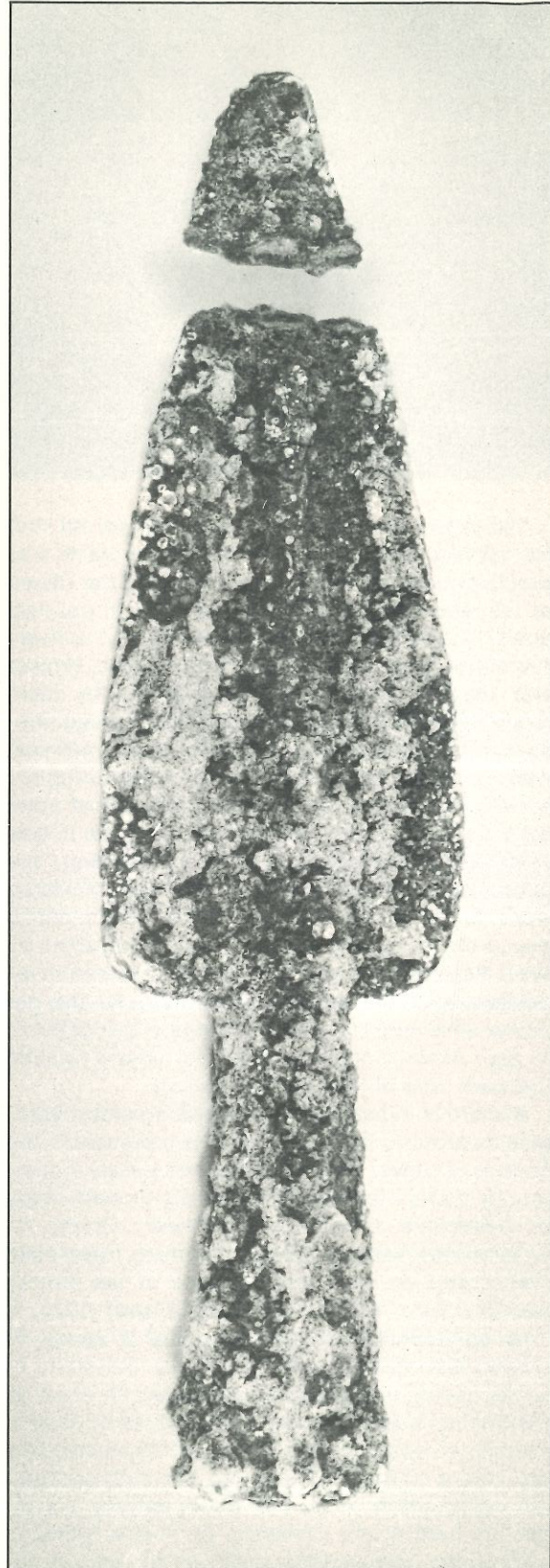
The significance of ancient history to an understanding of human affairs always has been a concern of archaeological writers, but the current upheaval in political affairs, the struggle for food and other resources, and the shift in centers of wealth and influence gave added urgency to the search for an explanation of the present in a study of the past. Thus, Loren Eiseley, a writer and archaeologist, took a searching look at our times in mass media publications; Barry Cunliffe worked with the British Broadcasting Corporation in producing a documentary on the rise and decline of the Roman Empire; and Ivor Noël Hume raised the whole issue in an address to the annual meeting of the Societies for Historical and Underwater Archaeology in Philadelphia. It seemed inevitable that this trend would accelerate.

Increasingly meticulous methods of excavation and specialized systems of interpretation, requiring more time not only for excavations in the field but for publication of results, appeared to be coming into conflict with the need to save significant archaeological sites before they are destroyed. Many archaeologists believed there was no point in excavating at all if it was not done properly, while others pointed to the irrevocable loss of knowledge about the past taking place everywhere while money, time, and manpower were concentrated on relatively few systematic excavations. As yet there appeared to be no obvious compromise in such a conflict of values.

Asia. Theodore Wertime of the Smithsonian Institution, Washington, D.C., writing in the *Washington Post*, described the site of Ban Chiang in northeast Thailand as "now possibly the most exciting and controversial arena of archaeology anywhere in the world." The second season of excavation there by the Thai Department of Fine Arts and the University Museum, University of Pennsylvania, under the direction of Pisit Charoenwongsa and Chester Gorman, was completed in the fall of

Bronze spearhead was found in a grave at the lowest levels at Ban Chiang in northeast Thailand. Bronze objects at these levels date from about 3600 B.C.

Courtesy, The University Museum, University of Pennsylvania



1975, and the collections (21 tons) were being studied at the University Museum.

The crucial issue remained the age of the bronzes found at the lowest levels at the site and not yet dated by radiocarbon and thermoluminescence (TL). There were, however, adequate charcoal and skeletons from the lowest levels, and these were to be dated by the University Museum's Applied Science Center for Archaeology (MASCA), an operation financed by the National Science Foundation. The oldest carbon-14 dates so far established at Ban Chiang for bronze were on the order of 3600 B.C., but TL dates on pottery of unknown level extended to about 4600 B.C. William Schauffler, a member of the team, and Pisit Charoenwongsa also made soundings in other sites in the area, and it appeared certain that they were all part of a major cultural complex.

The significance of Ban Chiang was its relevance to a growing controversy about the origin of the techniques basic to civilization. Current evidence indicated that there were at least three centers of origin, in Southeast Asia, the Near East, and Central and South America, where the basic requirement for civilization, agriculture, developed at a very early period. Metallurgy, presumably another basic element in civilized living, was known in all three regions, but scholars had long assumed that it originated in the Near East. One of the major puzzles about the newly discovered center for agriculture and metallurgy in Southeast Asia was the lack of evidence of the flowering of fully developed civilization in the region until quite recent times. Many years of research would be required to understand what appeared to be a process of change that was quite different from that in western Asia.

The worldwide sale of painted pottery from northeast Thailand (described by William Honan in the *New York Times Magazine*) reached such proportions that members of the Ban Chiang expedition reported more than a score of sites totally destroyed by pot hunters, even during the two seasons of work there, and it was questionable whether the prehistory of the region could be recovered before the sites were gone. Once again, this pointed up one of the major problems of contemporary archaeology: with limited time, funds, and trained personnel, how does the archaeologist decide between meticulous excavation standards and the loss of knowledge? The age and the nature of all these sites is unknown, and there was no assurance that systematic sampling of a few sites could result in more than a distorted historic record.

Further dramatic discoveries were reported from China. At Sian, capital of China during the Chou, Ch'in, Han, Sui, and T'ang dynasties (11th century B.C. to 10th century A.D.), an immense structure (700 by 200 ft) buried 15 to 20 ft underground was discovered by well diggers 3,500 ft east of the outer walls of the old city. Excavation during 1975 exposed a fantastic army of some 6,000 terra-cotta warriors with their horses and the remains of wooden chariots. Horses and men are life-size, startlingly lifelike, and arranged in a phalanx in 11 symmetrically balanced corridors. The men are armed with real swords, spears, and crossbows and were in a standing position as if in the order of attack. No two warriors look alike. Chinese archaeologists said the figures were related to the tomb of the emperor who ruled from 221 to 210 B.C., although the tomb itself is in the inner part of the old city and not yet excavated.

Life-size terra-cotta figures of warriors and horses were excavated from a burial pit at Sian in northwest China, near the tomb of an emperor who ruled from 221 to 210 B.C.



UPI Compix



Jug of 23-carat gold, part of the Thracian Treasures from Bulgaria Exhibit shown at the British Museum in London. It is believed to date from 300 B.C.

Another outstanding discovery was a very well-preserved body, like the woman in the now famous Han period tomb discovered a few years earlier. This is a man buried in 167 B.C. (a date given on a bamboo tablet found in the tomb) in a red preservative fluid in the inner of a series of three coffins. The find was made in the town of Chinancheng in Hupeh Province, central China. The tomb contained 500 burial objects, including lacquer and bronze utensils, copper pins, clothes, headgear, and shoes. Excavations at the site of ancient Panlung near Wuhan, also in Hupeh Province, uncovered the foundations of another Shang dynasty palace, dating from 3,400 years ago. The find demonstrated that during its early stages the Shang dynasty had spread its control southward from the Yellow River to the Yangtze.

In Burma the earthquake of July 8, 1975, badly damaged many of the pagodas and monasteries at Pagan, famed royal capital in the period from the 11th to the 13th century. More than half of the 500

major temples were partially destroyed, with severe damage to sculpture and frescoes. These must be shored up in order to prevent further disintegration.

Near East. The archaeological mission of the University of Rome reported the discovery of 15,000 clay tablets at Tell-Mardikh in Syria which, when deciphered, will have a profound effect upon knowledge of the 3rd millennium B.C. in Syria and Mesopotamia and will aid in the study of the Sumerian language. The texts are written in syllabic cuneiform, but in two different languages; one is Sumerian and the other an unknown Semitic tongue. Some are diplomatic documents and literary texts, which are relatively rare in collections of clay tablets but extremely important in terms of historic details. There are also grammatical texts and students' workbooks annotated by their teachers. One of the religious texts contains the oldest known version of the famous Gilgamesh poem. The bulk of the tablets were inscribed about 2300 B.C. and were found in a room off the great royal audience hall of what was at that time the city of Ebla.

Europe. In September 1975 Greek archaeologists announced the discovery of the oldest known shipwreck in the world. It was found by Peter Throckmorton off the island of Hydra and was dated by the pottery found in the remains as Early Bronze Age II (about 2500 B.C.). Presumably it was a Cycladic ship since all the pottery brought up by divers was characteristic Cycladic ware. It was not known whether enough of the ship remained to allow a reasonable reconstruction of its design. All that is known of Early Bronze Age Cycladic ships comes from sketches found on pottery, and the design of any ship of this age would be of great concern to nautical history in general.

In Yugoslavia construction of a dam exposed the remains of a city extending about two miles along the Tisza River near Senta, close to the borders with Romania and Hungary. Excavations, under the direction of Laszia Szekeres, exposed walls, pit dwellings, granaries, and other structures. Pieces of burial urns and other objects convinced Szekeres that the city was occupied during the 1st century A.D. by Sarmatians, one of the nomadic hordes who, like the Huns, plagued the Romans on their frontiers in Europe. The great settlement clearly shows that the Sarmatians were not purely nomadic. Remains of burials suggested to the archaeologists a remote possibility of discovering the famed burial of Attila, king of the Huns.

In October 1975 Soviet archaeologists reported the accidental discovery, by construction workers, of rich burial chambers near Anapa on the Black Sea coast. Two stone-roofed chambers containing

sarcophagi were mentioned; some had been plundered but at least two yielded treasures including golden crowns, silver vessels, and a huge iron sword with a gold-encrusted handle. Frescoes, with the colors still fresh, represent everyday scenes of the period and also Greek legends and mythical heroes. The tombs are dated to the 2nd century A.D. and may be associated with the so-called Bosphorus State.

The "Thracian Treasures from Bulgaria" exhibit, which opened at the British Museum in January 1976, focused worldwide attention on archaeological research in Bulgaria. The most complete prehistoric chronological scale in Europe was worked out at Varna, and a recent excavation in one of the mounds near Varna uncovered a Chalcolithic necropolis, dating to the 4th millennium B.C., which should drastically alter our conception of this period in Europe.

America. The age and the place of origin for the domestication of corn (maize) was again in question as the result of a discovery in Ecuador. Donald Lathrap, University of Illinois, excavating a site near Real Alto, found evidence that corn was grown there about 3000 B.C. It was generally believed that corn was first domesticated in Mexico about 3000–4000 B.C., but if corn was grown in Ecuador, several thousand miles to the south, at roughly the same time, real questions arose as to the age and the place of origin. The site contains

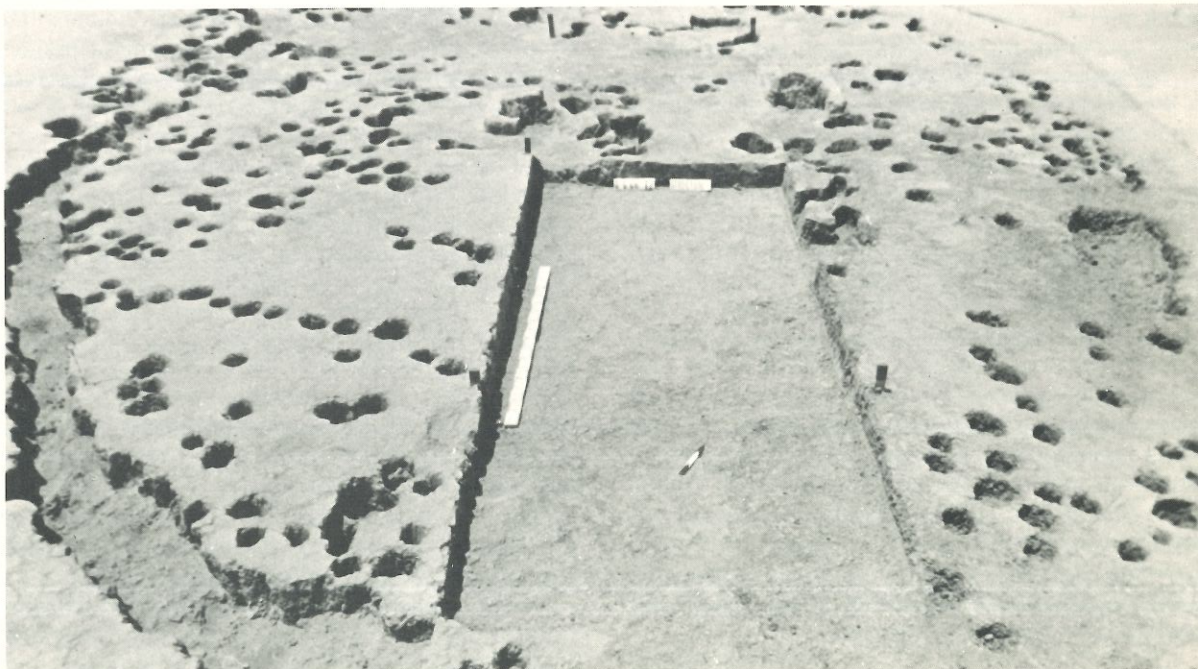
grinding stones, corn beer mugs, pottery decorated with corn-kernel impressions and teeth badly worn down by the grit from the grinding stones. Significantly, 80–90% of the animal bones in the refuse are of Virginia white-tailed deer, a species known to thrive where there are Indian cornfields.

Mexican, U.S., and Canadian archaeologists, using computer analysis, concluded that Teotihuacán in the Valley of Mexico was a great urban center, not only a ceremonial center as originally thought, and the focus of a far-flung empire stretching from the plains of Mexico to the mountains of Guatemala during the period from A.D. 400 to 700. Windowless one-story apartment compounds housed about 100 persons each, with no particular separation of classes. Similar conclusions were developing in the study of the great Maya city of Tikal, although in this case there was a significant class system.

In both cases researchers were asking why the cities died. René Millon of the University of Rochester speculated that Teotihuacán's inhabitants may have abandoned the city because it had become "a clumsy giant—too unwieldy to change with the times." Others believed that the people desecrated the temples and abandoned the city in a rage against the gods for permitting a famine.

A somewhat different look at the decline of Mayan civilization was emerging in a study of the

Remains of a 5,000-year-old oval house, about 25 by 35 feet, were found in Ecuador. Holes are from poles used for room divisions and hammocks, and rectangular area is from an earlier excavation.



Courtesy, Donald W. Lathrap, University of Illinois

island of Cozumel off the coast of Yucatán, where Jeremy Sabloff and William Rathje were documenting the development of a new kind of trading empire based on the island by a group of Chontal-Maya-speaking people known as the Putun. By A.D. 1224 Chichén Itzá had been abandoned, and Toltec power was gone from Yucatán. The Putun on Cozumel were in a unique position to develop a coastal sea trade in cocoa beans, salt, cotton cloth, and many other raw materials. Columbus, on his fourth voyage in 1502, met what probably was a Putun trader in a dugout, eight feet wide and as long as a galley, propelled by 20 paddlers. The accepted theory is that by the 12th century classic Mayan civilization had long been in a state of decay, and this was looked upon as a general social decline. It was now proposed that, after the decline of centralization and the elite class, the commoners' standard of living rose.

Africa. The most recent in the series of discoveries of fossil bones of men and manlike creatures made in Tanzania, Kenya, and Ethiopia during the past few years was announced by Mary Leakey in October 1975, when radioactive dating gave an age of 3,750,000 to 3,350,000 years for fossil bone deposits excavated in an arid region 25 mi S of Olduvai Gorge. The deposits included the jaws and teeth of at least 11 individuals who appear to be of the genus *Homo*. Like earlier finds made in Kenya by Richard Leakey and in Ethiopia by Donald Johanson and Maurice Taieb, these differ markedly from *Australopithecus*. Mary Leakey believed they confirm the opinion that this "ape-man" was an offshoot of the hominid line, a contemporary of early man who died out. No stone tools were found with the bones, but the search for them continued.

Techniques. MASCA was planning to announce a breakthrough in the search for ways to preserve ancient mud brick and stone monuments. Darrel Butterbaugh of MASCA had developed two chemical compounds, one to preserve brick and adobe structures, and the other stone monuments and buildings. Both are inexpensive and simple to apply. Field tests were made at Chaco Canyon in the southwestern U.S., at Hasanlu in Iran, and in Philadelphia. At Hasanlu experiments were also being conducted in the production of mud bricks and mud plaster in which the chemical compound had been mixed. It appeared that such material can be used commercially in areas where mud brick or adobe is still a major building material. Unlike other chemicals used in previous experiments, which formed a thin crust that peeled off in time, the new compounds deeply penetrate adobe and stone. An additional advantage is that they do not change the color of the structure.

—Froelich Rainey

Architecture and civil engineering

To promote "appreciation of the aesthetics of steel bridges and to honor the architectural excellence of modern bridge design," a national competition is held each year by the American Institute of Steel Construction to select beautiful new bridges. Because there are many types of steel bridges, the 1975 awards were given in seven categories: long span (bridges with a span over 400 ft in length), Daniel Webster Hoan Memorial Bridge, Milwaukee, Wis., designed by Howard Needles Tammen & Bergendoff; medium span, high clearance (bridges with a vertical clearance of 35 ft or more and a span between 125 and 400 ft in length), Kentucky Highway 312 Bridge over Laurel River Lake, designed by the U.S. Army Corps of Engineers, Nashville District; medium span, low clearance (bridges with a vertical clearance of less than 35 ft and a span between 125 and 400 ft in length), South Fork Flathead River Bridge, Montana, designed by Morrison-Maierle; short span (bridges having no span more than 125 ft in length), Laceyville Bridge, Laceyville, Pa., designed by Gannett Fleming Corddry and Carpenter; highway grade separation bridges, South Weber Interchange, Davis County, Utah, designed by the Utah Department of Highways; movable span bridges, Burlington Northern Bridge No. 117.35, Beardstown, Ill., designed by Howard Needles Tammen & Bergendoff; and special purpose bridges, Pedestrian Bridge over U.S. 27 at Pine Knot, McCreary County, Kentucky, designed by the Kentucky Bureau of Highways, Division of Bridges.

The Daniel Webster Hoan Memorial Bridge is a vivid expression of structural form. The type of structure, a tied arch, was selected primarily because of the necessity to eliminate an external horizontal thrust that could not be sustained by the poor lateral resistance of the site's underlying foundation materials. The center section of the stiffened tie girder is suspended from the primary arch by bridge strand hangers, and the end sections are supported above the arch rib by box posts. The primary arch, the rectangular vierendeel bracing (an open-web truss with vertical members but no diagonals), and the tie girder are all made of welded steel box girders, brightly painted to differentiate the arch (gold) and the tie (blue). The excellence of the design comes from the elegant geometry of the structural form and from the aesthetic of welded steel sculpture.

Clearly, it is not size that makes the Hoan Bridge notable; its 600-ft span is not comparable to the world's longest arch bridges, the 1,652-ft Bayonne