



**US Army Corps
of Engineers**

Construction Engineering
Research Laboratory

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A History of USA-CERL 1968-1986

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A HISTORY
of the
US ARMY
CONSTRUCTION ENGINEERING RESEARCH LABORATORY
(CERL)
1964-1985

by

Louis Torres

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FOREWORD

The U.S. Army Construction Engineering Research Laboratory is the youngest laboratory in the Corps of Engineers. In the 18 years of its existence, the Laboratory has contributed significantly to the Army's construction program in developing improved and unique systems of design, construction, and maintenance. These accomplishments have been enjoyed in a period when the national defense has looked to the space age and to a more sophisticated Army for the answers to its problems. While performing its mission, CERL has transferred several of its research findings and inventions to the public and private sectors where the general public has been the beneficiary. There is little doubt that this is what those enlightened individuals of the Office of the Chief of Engineers and the Building Research Advisory Board had in mind more than two decades ago when they first proposed a new laboratory.

CERL is still a young organization. Nevertheless, if this history succeeds in preserving some of the written records and experiences of that organization during its early years, it will have served its purpose.

NORMAN C. HINTZ, AIA, PE
Colonel, Corps of Engineers
Commander and Director

December 1987

PREFACE

This history of the U.S. Army Construction Engineering Research Laboratory attempts to show why such an organization was proposed and how the Laboratory was eventually established. It also attempts to provide some understanding of the problems and difficulties which confronted the young organization and how it ultimately succeeded in accomplishing its missions. The uniqueness of this Laboratory is in its relationship with the University of Illinois, and in this respect the history hopes to provide some lessons for the future. In no way does this history presume to be the final word. The organization is still too young. Only time will provide a more balanced historical perspective.

The author served as a government historian for 32 years; half of them with the Departments of the Army and Air Force, and the other half with the National Park Service. He is now retired from government service and works as a historical consultant. He is the author of books and articles on local history, and more recently the author of *"To the immortal name and memory of George Washington": The United States Army Corps of Engineers and the Construction of the Washington Monument*. His graduate work was completed at Columbia University.

The author is grateful to several individuals for making his research possible. Those people at CERL who unstintingly gave of their time to answer questions were Colonel Paul J. Theuer, Louis R. Shaffer, Edward A. Lotz, Ravinder K. Jain, Richard G. Donaghy, Gilbert R. Williamson, Ms. Shirlee Neathammer, William L. Assell, Victor G. Marty, and Ms. Kay E. Isaacs. John H. Hunt, Ms. Amy L. Jones, Ms. Martha Blake, and Ms. Bonnie Neukam were helpful in so many ways. A very special note of thanks goes to Ms. Diane P. Mann who handled the very many details so that the author was able to meet with key personnel and examine records. He also appreciates her editorial comments.

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RESEARCH: THE SINE QUA NON OF MILITARY CONSTRUCTION AND CIVIL WORKS

Who Accomplished Research

Although the Colonial governments used military engineers during the American Revolution, Congress did not establish the Corps of Engineers as part of the United States Military Academy at West Point, New York, until 1802. Congress intended to create an engineering capability for the country. The undeclared war with France during the 1790s and the constant friction between the United States and Great Britain, eventually leading to the War of 1812, convinced Congress that a body of military engineers was needed to construct the necessary fortifications along the coast, harbors, and inland waterways. As time passed and the country saw the growing need to protect its expanding trade, the Corps of Engineers became increasingly involved in civil works, constructing lighthouses, beacons, buoys, and public piers. It acquired considerable experience constructing navigational aids and improving harbors along the East Coast. As agents of the government, topographical engineers helped to map the unexplored areas of the West, eventually opening widespread territories to settlements and the railroads. These engineers recorded their observations of the territory, climate, topography, vegetation, and the habits of the Indians they encountered--very valuable information to the pioneers who were to follow them.

In 1874, Congress assigned to the Corps of Engineers the responsibility for planning and supervising improvements in the District of Columbia, maintaining essential city services, and overseeing the construction of Federal buildings. Flood control, especially along the Mississippi River Basin, and building the Panama Canal were other major duties assigned to the Corps in later years. More recently, the Corps has become deeply involved in environmental and energy problems.

With such an extensive and varied mission in matters extremely important to the growth and security of the country, it was inevitable that the Corps would become inextricably involved in some form of systematic investigation of construction problems. Developing unique solutions to problems would require a certain amount of research. The research often depended upon the initiative of the engineer in charge of a project. The research, however, was ad hoc; designed to apply to a specific problem where an immediate solution was necessary. It was applied research, and not pure or basic research. Evidence of this type of research is ample throughout the history of the Corps of Engineers.

Efforts during the Civil War showed that engineers in the Corps lacked the ability to practically apply the theory they had learned at West Point. The Engineer School of Application was established at Willets Point, New York, in 1866 to overcome this deficiency. Ironically, while the school was supposed to emphasize education in applied research, it also had the effect of promoting basic research. Major General Andrew P. Humphreys,

the Chief of Engineers who thought about starting the school, suggested that the school should be the special laboratory of the Corps where investigations requiring experimental research would be conducted. Studies in meteorology, field astronomy, tidal current measurements, military photography, a revised system of bridges, submarine mining, and coastal fortifications were some of the important projects that were eventually undertaken at the school. When it was reorganized and expanded in 1885, the school's mission was to "conduct researches in branches of science applicable to the duties of the Corps of Engineers, to instruct newly assigned officers in the profession, and train the enlisted men of the Battalion of Engineers to the highest possible degree of efficiency." By 1904, the school could boast of having a well-equipped electrical and torpedo laboratory, a photographic laboratory, and the "best" field astronomical laboratory.¹ While the Engineer School of Application promoted some basic research, applied research remained at the heart of the Corps' research program. This practice has continued to the present.

Occasionally, the Corps' applied research would trickle down to the general public, as in the case of Lieutenant Colonel Quincy Adams Gillmore's research. His experiments on various hydraulic cements were published. Colonel Gillmore also experimented on the compressive strength, specific gravity, and ratio absorption of natural building stones and artificial stone, observing the properties, relative merits, and the materials of which they were composed. "The subject [of these studies]," said one critic, "is one of special and growing interest and we commend the work, embodying as it does the matured opinions of an experienced engineer and expert."²

The Corps of Engineers was assigned the task of completing the Washington monument in the 1870s and 1880s. During this effort, the engineers tested the soil under the monument, the original foundation, and the properties of the stone that went into the monument itself--all involving a considerable amount of research.³

Although applied and ad hoc research was quite common throughout the Corps' history, the first formal research and development program was started in 1927 when the Waterways Experiment Station (WES) in Vicksburg, Mississippi was established. The first project was to help the Mississippi River Commission in flood control planning.⁴ For the first time in the history of the Corps of Engineers, research and development became a separately funded item. One thing was now clear--from its earliest days of mapping, exploring, cataloging wildlife, improving rivers and harbors, dredging waterways, and constructing navigational aids and fortifications, the Corps was maturing into a recognized indispensable part of the country's research and development team. The Waterways Experiment Station undertook a substantial part of the construction research program for the Corps of Engineers and the Army Material Command. It soon became involved in researching hydraulics, concrete, soil mechanics, mobility, environment, nuclear weapons effects, and flexible pavement design. Through both basic and applied research, mostly the latter, the Waterways Experiment Station helped to fulfill both the military construction and civil works missions of the Corps⁵

By the 1930s, the Corps of Engineers had established several Division laboratories. The number of division laboratories varied from time to time. Each laboratory was involved in specially assigned research; together they were charged with the mission of quality control and testing of concrete, asphalt, building materials, soils, water, wastewater, and rocks. The laboratories furnished testing and materials evaluation services in support of investigations, design, and construction for the Corps of Engineers' civil and military projects. They also provided technical supervision for testing that was done at commercial laboratories. When Corps Districts did not have the necessary skills or special equipment, the Division laboratories conducted the tests for them. Because of the highly specialized nature of the testing equipment available at Division laboratories, they also performed work for other Federal agencies, for local, state, and foreign governments, and in some cases, for private industry.

One of these Divisions was an exception to this general rule. The Ohio River Division Laboratory (ORDL) in Cincinnati, Ohio, had a dual function. One of these functions was similar to that undertaken at other Divisions; to test materials and construction engineering developed by the Districts to ensure quality control. The testing was primarily on concrete, soils, and foundations. The Division also provided technical advice to the District Engineers who were reviewing and preparing designs, reports, and plans. A responsibility recently assigned to this laboratory was to test cements and concrete produced in 26 states.⁶

The second major mission of the Ohio River Division Laboratory, which set it apart from other Divisions, was to conduct research and investigations into developing design criteria for construction and maintenance of engineering structures and applying new or unusual materials and techniques.

The Ohio River Division Laboratory was organized into three major components: the Concrete Laboratory, the Soils and Foundation Laboratory, and the Rigid Pavement Laboratory (later redesignated the Construction Engineering Laboratory [CEL]). In Fiscal Year 1966, ORDL distributed \$250,000 to the Concrete Laboratory, another \$250,000 to the Soils and Foundation Laboratory, and \$1.5 million to the Construction Engineering Laboratory.⁷

The research accomplished at WES and ORDL was to find solutions to existing problems in the Civil Works and Military Construction Programs. New materials being developed by private industry had to be tested by the Corps before being accepted for military construction. This process required both laboratory and field testing. After testing, the Corps published specifications for the article and a technique for its use. During this process, new testing techniques used to solve a specific problem were also evaluated. In short, the purpose of this research was to use available knowledge to find immediate solutions to problems in planning, design, construction, and maintenance of a particular structure. This research could best be described as applied research; it was conducted to solve a problem for a particular structure or for a specific requirement. However, it would be a mistake to conclude that WES and ORDL didn't conduct basic research. One had only to look at ORDL's involvement in lunar base, deep

underground communications systems, and nuclear weapons effects research to know that this was not true. Nevertheless, the bulk of all research undertaken by these laboratories was applied.⁸

Accomplishments of the Ohio River Division Laboratory

Over the years, the research conducted at the Ohio River Division Laboratory played a major role in the Corps' ability to provide engineering solutions to new problems and to accomplish its mission efficiently and economically. In World War II, one Corps mission was to design and construct airfields for the Army Air Force. This responsibility was assigned to the Rigid Pavement Laboratory of the Ohio River Division Laboratory. At the time of this new assignment, the B-17 and B-24 bombers were in production. These aircraft exhibited single wheel loadings of 37,000 pounds, a weight that was considerably higher than any aircraft or vehicle loading up to that time. In the meantime, automobile highways and commercial runways had developed different methods of construction because each one was based upon experiences with local traffic and materials. This situation provided the Corps with little uniform information on which to make comparisons for its particular use. Any method adopted by the Corps would have to be used worldwide to meet the needs of large bombers.

After a series of studies begun in Fiscal Year 1942, the Corps of Engineers developed and published pavement criteria that incorporated the requirements of new aircraft. This criteria was used by Divisions and Districts to design and construct rigid and overlay pavements. However, the ever-changing technology in military aircraft engineering altered these requirements constantly. Between 1942 and 1960, the B-36, B-47, and B-52 bombers were placed into operation. The Rigid Pavement Laboratory had to introduce new materials and techniques for runway paving that could handle these large and heavy aircraft. The laboratory undertook theoretical studies, static and repetitive load model studies, fullscale traffic testing, and field performance studies. Because of the ever-increasing weight of aircraft and their changing operational requirements, research undertaken by the Rigid Pavement Laboratory was continuous.

Rigid pavement design procedures developed by the laboratory were also used by the public for highways and commercial airfields. The American forces in Vietnam also used the results of these studies to solve pavement problems. Another benefit of the laboratory's work was the development of new materials and equipment that applied to the construction industry as a whole. Some of these developments were: epoxy resins for patching and bonding concrete, joint sealants and fillers, soil stabilizers, a borehole camera for geological logging of boreholes, nondestructive testing equipment for determining concrete strength, fibrous materials for concrete reinforcement, heat resistant surfacings, blast deflectors, flotation gear tests, exhaust effects, and other runway and pavement related problems.

With the introduction and advancement of space flight in the 1960s, the importance of conventional bombers tended to diminish. As a result, the Ohio River Division Laboratory's research in rigid pavement was almost

entirely discontinued. The Rigid Pavement Laboratory was redesignated the Construction Engineering Laboratory.⁹

Effectiveness of Research

No one could deny that the work of Corps' laboratories and Divisions, advanced construction engineering in the Army, other military and nonmilitary agencies, and the private sector. By the early 1960s, the Directorate of Military Construction, the Corps' office responsible for military construction, had the responsibility for spending about \$1.5 to \$2 billion a year for new construction for the Army. Large sums were also spent on construction for the Air Force, National Aeronautics and Space Administration, Defense Atomic Support Agency, Atomic Energy Commission, other Federal agencies, and foreign governments. Of the large sum spent for Army needs, less than 0.5 percent was for construction engineering research and investigations.¹⁰

As the Corps looked ahead toward the mid-Sixties, it predicted that more demands for a strong defense establishment would be made. The Corps knew that if research and development in construction was to remain funded and functioning at the same levels as it had always been, it would be unable to serve the Army and its other customers effectively and efficiently. A philosophy began to emerge within the Office of the Chief of Engineers, spearheaded by the Directorate of Military Construction, which held that the research program, as it was then understood, would not meet the responsibilities of the future. Many people inside and outside of the Corps seriously questioned the Corps' ability to face anticipated construction problems. This attitude was magnified by the fact that the engineering research program was to be vastly expanded and the fear that the relatively weak laboratory capability would be unable to handle it. These people saw serious flaws in the research and development program, stemming from factors within the Army, the Corps of Engineers, and the construction industry as a whole. When one added the growing national concerns of the environment and energy, the technological changes brought on by a space and nuclear age, and the problems of an ever-expanding Federal budget that demanded a maximum return for every dollar spent, there was a need for research with new and different approaches and methods.

Since the Army's reorganization in 1962, the proper role of the Corps in research and development had not been clearly understood. The distinction between the Corps' mission in this area and the role of the Army Materiel Command and the Army's Chief of Research and Development in the same area was not always clear. This point led Major General Robert G. MacDonnell, Deputy Chief of Engineers, to review the mission of each agency and to state that the Office of the Chief of Engineers "must not only perform these functions [i.e., research] but must also maintain and improve [its] capability to do so. [It] must, therefore, perform the necessary research, investigations, studies, development, engineering, test, and evaluation."¹¹

The problem however, was more than just a misunderstanding of responsibilities. The problem lay largely in the system which, because of

funding and scope, did not recognize the need for long-range and basic research oriented towards the total construction process as a system. Most basic and long-range research required 4 to 5 years or longer to produce useful and meaningful information, but funds were usually not available to cover such extended periods. Most of the research accomplished at the Waterways Experiment Station and the Ohio River Division Laboratory was responsive to problems and solutions of the moment. Thus, research was usually short-term. Such a program quite obviously did not provide the means to systematically address the long-term problems or projected requirements for improving capabilities in design and construction. Moreover, by handling unique problems on a crash basis, research was frequently repetitive. This approach was often inefficient, costly, and sometimes unsatisfactory.

The Civil Works Study Board, appointed by the Secretary of the Army in 1964 to study the Corps' Civil Works Program, outlined research weaknesses. Because the research applied largely to immediate needs and was accomplished on a "piece-by-piece" basis, the Board said that there was little overall planning or advanced coordination of research. Except for a few managerial personnel at these laboratories, no one had the full-time responsibility of coordinating and promoting Corpswide research. Research proposals were forwarded with recommendations through channels. A proposal for research to solve a particular problem was evaluated primarily by engineering sections at each level. The Board concluded that the Corps needed a "centralized responsibility for the development and management of a balanced and effective civil works research program. . . . Civil Works research could be strengthened by developing a corpswide, long range inclusive research program which would outline areas wherein research is needed and be used as a basis for approving research requests."¹²

After a visit to both the Waterways Experiment Station and the Ohio River Division Laboratory in 1966, the Assistant Secretary of the Army for Research and Development noted unhappily that most work at these laboratories was the "cookbook type" rather than scientific research. Dr. Gilford G. Quarles, Scientific Adviser in the Office of the Chief of Engineers, accompanied the Assistant Secretary and defended the laboratories by explaining that the existing research system was due in part to the project type funding within the Corps. The Assistant Secretary wondered why the Waterways Experiment Station was not conducting research in the field of agronomy when such research was relevant to the Army's needs for two reasons: using vegetation for erosion control was very important on many Army installations and civil works projects, and using vegetation for aesthetic purposes had been neglected. Much could be done to improve these areas.¹³

Little or no research had been done in other areas which were perhaps even more vital to construction. For example, very little research had been done in the areas of engineering management, material suitability, design, and construction techniques. Moreover, with the worldwide concern over environmental and energy problems, the absence of any research in these new areas did not speak well for the kind of major construction program anticipated for the future.

Many of the investigations carried on at the Ohio River Division Laboratory were horizontal; they dealt largely with soils and pavements. The Army and other Federal agencies needed vertical research; research on structures of all types and sizes.

In its indepth study of the scope and content of the Corps' construction research program, the Building Research Advisory Board (BRAB) of the National Academy of Sciences concluded that there was no organized research program in the Corps of Engineers. There was only a "collection of several projects which are not interrelated by a formal plan." It found that "orientation toward individual projects arises principally from procedures used to determine the content of, the manner of conducting, and the availability of funds for DMC [Directorate of Military Construction] research."¹⁴ The Board added that the manner of requesting and accomplishing research at Corps and Army laboratories did not stimulate or create new technological ideas and applications of potential interest. The BRAB study summed up the problems with the construction program in these words:

DMC, with a vital, almost catholic interest in construction, is supported by a research effort that is highly particular. Such a criticism is not in any way mitigated by the finding that the total DMC construction program is largely dependent on the utilization of products and technologies developed by other sectors of the construction industry.¹⁵

The construction industry was also partially to blame for the disorganized research situation. The industry had many long-time problems that contributed to inefficiency and waste and affected research within the Corps. The construction industry was perhaps the most backward of all industries when it came to technological progress. Because the industry was fragmented, few contractors had enough money to conduct research. And because the industry was very competitive, contractors were reluctant to reveal or publish information on successful techniques. The Building Research Advisory Board also found that the industry's research was primarily on existing materials, products, components, and techniques of construction. The construction research performed by academic institutions was not much better. It was research designed to find solutions to specific problems¹⁶ and was funded by government and the private sector.

The Building Research Advisory Board said that the construction industry was averse to change. The industry was not entirely to blame for this attitude. A significant barrier to change was the unwillingness of public agencies and private groups to accept innovations in the industry. The board observed that "The ability of a company to profit from a research investment is dependent upon ready access to the marketplace, and such access in the construction industry is most often controlled by those who set codes and standards for private and public construction."¹⁷ Faced with this opposition to change, contractors had little incentive to increase research.

While significant progress had been made in developing construction equipment and tools in the manufacturing industry, the same could not be

said for construction techniques. It was perhaps the most neglected of all areas within the industry; the one where the least amount of research had been done. A study undertaken by the Office of the Chief of Engineers concluded that research that could reduce the cost of construction, labor, and erection time (through repetitive assembly line operations) would be a significant contribution to the industry. The same study observed that research was needed to develop new materials, innovative designs, and more effective use of prefabricated elements, and to improve planning, scheduling, and management techniques in construction.¹⁸

The Building Research Advisory Board saw serious flaws in the Corps' total construction program, and said that the existing research, if it could be called that, was illusory. Only by providing "positive coupling" of the research program with other aspects of the construction program and strengthening the exchange of information with the private sector would Corps research produce the desired results.¹⁹

The Need for Expanding Research

With the dawn of the space age in the Sixties, there was an unprecedented demand for innovative and unique ideas in military construction to support the space program and new weapons systems. The Corps of Engineers needed to increase its ability to provide construction engineering solutions to meet the demands of the future. In the meantime, advances in technology and in material uses were taking place at a rapid pace in the private sector--advances that could apply to the military construction process. Many key members within the Corps of Engineers were convinced that unique and stringent requirements would be thrust upon them more frequently in the years ahead. Any delay in preparing to meet these future demands could mean that the only advances in military construction technology would be those which would rub off through routine association with the construction industry.

Between Fiscal Years 1965 and 1968, the research program of the Construction Engineering Laboratory was expected to rise from \$937,700 to \$3,723,000. Table 1 reveals how this research money was to be distributed among 16 areas of research.²⁰ This increase in the research program was largely the result of a new Research, Development, Testing, and Evaluation (RDT&E) project for permanent construction materials and techniques initiated in Fiscal Year 1966. The project was designed to provide the essential long range research in broad areas of material use, environment, construction techniques, power plants, and testing techniques. Such an increase could only be realized by using contracts to expand the in-house capability of the Corps. It was also apparent that the Corps' existing laboratory capability would not be adequate to undertake its growing project-oriented engineering investigations while meeting the demands of an expanded construction research effort. Facilities at the Ohio River Division Laboratory were adequate for its quality control functions in support of Division and District offices, but its Construction Engineering Laboratory was incapable of handling a research program of the size contemplated. The Laboratory needed to be enlarged significantly, but facilities were not available at its location. The Division was situated within an industrial complex that precluded expansion. Meanwhile, the Waterways Experiment Station had a substantial amount of work for both

Table 1

Areas of Research, FY 1965 Through FY 1968

CATEGORY WORK		FUND SOURCE	M-ESTIMATED EXPENDITURES			
			FY-65	FY-66	FY-67	FY-68
1	Soils Structures, Materials Pavements	Army O & MA	321	365.5	375	375
2	Pavements	Air Force	245	250	250	250
3	Bearing Evaluation of Weak Rock	CWI	25	16	21	20
4	Miscellaneous Studies	CWI	--	--	--	130
5	Overseas Highway Study	Aid. State Dept	--	60	120	120
6	Soil Studies in Vacuum	Army Research Office	918	50	--	--
7	Lunar Base Research	Army RDTE	--	25	--	--
8	Exploratory Development	Army RDTE	0	30	100	500
9	Rock Mechanics Research, Rock Strengthening	DASA	123	155	317	463
10	DUCC	Army RDTE	--	685	997	650
11	Spall Resistant Concrete	DASA	50	50	50	80
		ASESB	35	40	40	20
12	Response of Buried Structures to Ground Shock	DASA	--	--	80	100
13	Mil Enging Applications of Nuclear Weapons Research	Army RDTE	--	120	150	150
14	Nike X Power	Army RDTE	--	850	650	650
15	Flame and Explosive Resistant Effects	NASA	158	280	245	215
16	Special Studies	Air Force	311	--	--	--
TOTAL			937.7	2976.5	3395.0	3723.0

the Corps and the Army Materiel Command, but its facility was poorly located for any major expansion.²¹

If the Ohio River Division Laboratory and the Waterways Experiment Station were unable to assume this added research and development, the answer had to be found elsewhere--in establishing a new laboratory at a new location; a facility that would concentrate on vertical construction engineering research. Appendixes 1 and 2 list research items which might be assigned to the new research facility.

II

A NEW LABORATORY

The Idea is Born

The idea of a new construction engineering research laboratory began in early 1964. The idea originated with several individuals in the Office of the Chief of Engineers, but perhaps one person more than any other nurtured it until it was fully developed. He was Harry B. Zackrison, a civilian who was Chief of the Engineering Division, Military Construction Directorate. It was Zackrison who thought about such a laboratory long before it became general knowledge within the Corps.

In February 1964, the Ohio River Division Laboratory asked the Office of the Chief of Engineers for more and better facilities.¹ The request, combined with the anticipated increase in the Corps' research program, prompted some people within the Office of the Chief of Engineers to examine the Corps' overall laboratory capabilities. Zackrison saw this as an excellent opportunity to promote his ideas. He requested that the Ohio River Division Laboratory study the impact of separating its testing functions from its Construction Engineering Laboratory. The study indicated that separation would adversely affect the Division's cost of operation and its technical capability.²

This negative response did not stop those in the Office of the Chief of Engineers from moving ahead with their plans. By January 1965, they pictured a new laboratory at a new location. The laboratory would be associated with a prestigious engineering institution and would have a research program encompassing all aspects of vertical construction. Personnel and equipment from the Ohio River Division Laboratory would form the nucleus of the new laboratory with temporary quarters at the Division until new facilities were constructed. The new facilities would be leased from the academic institution affiliated with the laboratory. Affiliation with an academic institution was considered unique for a Defense agency. Leasing facilities from the private sector, although not entirely new in the Armed Services, was not looked upon favorably.³

These concepts played a major role from the very beginning. Although other alternatives were considered, these ideas remained quite firm in the minds of those individuals who proposed them. In January 1965, Dr. Quarles observed that if the Corps associated itself with a university under a lease arrangement, "we have been assured orally the facility could be provided in 12-18 months." Quarles preferred to lease facilities from the university rather than use Military Construction Appropriation funding to build facilities. Others in the Office of the Chief of Engineers agreed with this approach. Quarles believed that the proposed laboratory would eventually need about 250 people to operate. Fifty would come from the Ohio River Division as a nucleus to maintain continuity of operations. The rest could be recruited when the new facility was constructed. Finally, he observed that the lease could be paid from overhead and would, therefore, be more or less prorated on the basis of research projects being accomplished at the laboratory.⁴

As new ideas for the proposed laboratory were being explored, one idea kept surfacing. Some hoped that this laboratory would eventually develop into the center of all Corps research or be a national research center. Perry F. Wendell, Chief of the Advanced Technology Branch, a staff element under Zackrison, proposed that instead of just a research laboratory, "establish an Engineering Center that would combine research with engineering development functions having Corpswide application." The center would be the focal point for engineering support of the Military Construction Program. Wendell was convinced that the idea of a center would be more "salable" than a laboratory per se.⁵

Even outsiders like John S. Foster, Director of Research and Engineering in the Department of Defense, suggested a similarly ambitious plan. He felt that the laboratory should be a national center. He believed it was feasible, without altering the basic concept, to develop the laboratory as a Department of Defense or national construction research center. Personnel from all elements of the Department of Defense could be integrated with the laboratory. Discussions with the U.S. Air Force, the Agency for International Development, State Department, and Department of Housing and Urban Development had indicated a favorable reception to such an idea.⁶

Up to this point, ideas about the proposed laboratory and its research were flourishing unabated in different quarters. By February 1965, actions were beginning to take the place of words. On 3 February, the Chief of Engineers, Lieutenant General Walter K. Wilson, Jr., called a meeting which was attended by his deputy and other key members of his staff. Two questions were posed: first, whether the Corps' capability to accomplish construction research should be expanded, and second, if so, who should do it and where? Members of the Directorate of Civil Works agreed that a continually growing research program demanded a greater research effort than was available within the Corps. However, they believed that it would be more logical and practical to have the Waterways Experiment Station accomplish additional research. The Waterways Experiment Station was the oldest of the laboratories, and had the personnel and other resources to handle an expanded research program.⁷

Zackrison, who attended the meeting on 3 February, viewed these expressions by the Directorate of Civil Works as outmoded. After reviewing the proposed expansion of the Ohio River Division Laboratory, he presented figures showing military construction research expenditures projected through 1969. These figures included an expanded program which could be undertaken at the Waterways Experiment Station, and funding for new projects and new research which could best be done at a new and separate facility. Zackrison believed the Corps' construction research laboratory should be separate from its water resource and hydraulic laboratory. Moreover, he suggested that such a facility should be near a university with an appreciable civil engineering research program. Zackrison concluded his presentation with four recommendations: approve a construction engineering and material laboratory without qualification as to location, expand the Ohio River Division Laboratory by leasing more office space, request the National Academy of Sciences through its Building Research Advisory Board to undertake a study to define a program of construction research which should be accomplished by the Corps in field

construction, and finally, establish a site selection board consisting of individuals from the academic and industrial sectors to advise the Chief of Engineers on the most desirable location for such a laboratory.⁸

General Wilson agreed it would be good to locate the laboratory near a university, but he also felt that the university should not be too big to give its fullest support to the laboratory. He suggested a university that was not in a major metropolitan area. Quarles agreed and added that the laboratory should be near, but not integrated with a university. Questions posed by General Wilson about how the laboratory was to be controlled and financed were not conclusively answered at this time, but the people at the meeting agreed that the laboratory would be a Corps facility and not a military construction or civil works facility like the Waterways Experiment Station and the Ohio River Division Laboratory.⁹

General Wilson concluded the meeting by making the following decisions:

1. He ordered planning to go forward to establish a separate construction research facility.
2. He appointed his deputy, Major General Robert G. MacDonnell, to organize a group to develop a plan within the next 2 weeks.
3. He approved Zackrison's suggestion, that the National Academy of Sciences appoint a committee of the Building Research Advisory Board to conduct a study about what should be done by the Corps in construction research.¹⁰

Within 2 weeks, Wendell reported to Zackrison that his office was assembling information on the proposed laboratory requirements. He offered some very important advice which may have laid the groundwork for future steps in making the new laboratory a reality.

Our position when presenting our proposed construction project to Congress a year from now would, for obvious reasons, be most favorable if we were seeking to improve an existing facility rather than to construct a new laboratory. Congress may well take the position that there are enough laboratories in DOD without building a new one. To accomplish this, our best approach would seem to be the ability to select and occupy a surplus installation as soon as possible... This approach requires that priority be given to the matter of site selection. Early appointment of a [Corps of Engineers] team to survey surplus sites is needed.

At about the same time that Wendell was expressing his views, Zackrison, Quarles, and others were meeting in response to Wilson's orders. They agreed that a construction research laboratory should be established to enable the Corps to maintain its leadership in the field of construction. They also agreed that a sizeable and comprehensive laboratory could be justified by research projects already programmed and by studies that could be proposed, depending upon the facilities and capabilities of the new laboratory and the Waterways Experiment Station.

Possible studies for civil works in similar fields were also considered part of the research program for the proposed laboratory.¹²

The group agreed that temporary facilities would have to be leased in Cincinnati by the Ohio River Division Laboratory. The group concluded that the use of a revolving fund (if it were legal) or Military Construction Appropriation funds was inadvisable, because in either instance it would take several years to build facilities. "A more probable and possible solution would be to select and occupy a surplus installation as soon as possible." Emergency construction funds could be used to make any necessary modifications to meet the minimum requirements. The group recommended that the Chief of Engineers establish a team immediately to survey surplus government installations.¹³

The group agreed that they should brief the Secretaries and Assistant Secretaries of the Army and Defense as soon as possible. Early support from these quarters was essential if the plan was to succeed. The Assistant Secretary of the Army for Installations and Logistics, Daniel M. Luevano, had already requested a briefing. After gaining the support of these individuals, it was necessary to brief representatives of the Bureau of the Budget to get the project included in the 1967 budget. Meanwhile, the group emphasized that a BRAB study dealing with the construction research needs of the Army and Department of Defense would do much to gain the approval of the Bureau of the Budget and Congress for the proposed laboratory. It concluded its meeting by recommending the following:

1. Establish a site selection team to review existing government installations, if possible within the next 3 months.
2. Authorize \$35,000 in construction maintenance money to develop a master plan.
3. Advise the Ohio River Division Laboratory that its construction research capabilities were to be removed and established at a new laboratory manned by a nucleus of its own staff.¹⁴

Quest for Approval

Briefing various officials in the Department of the Army and Department of Defense began as scheduled in May 1965. In almost every instance, the proposed laboratory was met with unusual enthusiasm. Assistant Secretary Luevano was especially interested in this unique organization after a briefing by Major General Frederick J. Clarke, Deputy Chief of Engineers, and Zackrison. He wrote to General Wilson saying that he was extremely interested in the proposed laboratory, especially in light of the magnitude of the Army's construction program. He said:

I share the concern that the current research effort in support of construction is small compared to our construction program and that there is insufficient incentive for private enterprise to meet our needs adequately. It is therefore encouraging to know that the Corps of Engineers is actively planning to broaden the scope and depth of

their present efforts in this area. Your plan to have a long range program reviewed by a select committee assembled by the...Building Research Advisory Board should help to insure an acceptable and sound approach.

He noted that no other government agency was better suited to establish such a laboratory than the Corps of Engineers. He concluded his remarks by saying:

You can be assured of such support and cooperation from my office as may be appropriate to assist in furthering the establishment of a sound, long range program of research and exploratory development together with the in-house laboratory capabilities necessary for a well balanced Army program.¹⁵

Such an encouraging response so soon after initial planning was heartening. Responses from other sources were equally promising. The Assistant Secretary of the Army for Research and Development, Willis M. Hawkins, sanctioned the idea. In April 1966, John S. Foster, Jr., Director of Defense Research and Engineering in the Department of Defense followed suit with a laudatory letter in which he said:

We believe this concept is sound and deserves to be encouraged, not only by the Army, but by our office as well. We believe in the premise that this kind of center would do much to spur innovation in the construction industry and thereby aid in the very large military construction and Civil Works programs conducted by the Corps of Engineers. I would therefore urge you to proceed with the planning.

He suggested the possibility of beginning with an Army laboratory in a university setting and expanding it into a national center for construction research. "I certainly agree," said Foster, "that a strong university effort in related fields and in a nearby university would have a most beneficial effect toward ensuring success of this venture." Foster believed that government laboratories were often located in a "cultural desert," making it difficult to hire and keep professionals.¹⁶

Although support was favorable, some people misunderstood what the proposed laboratory was to accomplish. William Hooper, assistant to the Scientific Adviser to the President, expressed interest in the project, but he also feared that a controversy between the laboratory and the university could arise because of poor planning. He was concerned that the laboratory would get too involved in individual scientific research projects while neglecting the "blue sky, high risk, imaginative" feasibility studies, such as a radical new interurban transportation system and an experimental housing development.

Both Zackrisson and Quarles hastened to explain to Hooper that although this research was desirable, it would be financially impossible to expect such research during the initial period of the laboratory's existence. Quarles believed that Hooper did not understand the technical aspects of construction and its problems, nor the concept of a scientific or engineering laboratory. Hooper thought only in terms of broad planning-type studies and primarily in feasibility studies for radical new systems.¹⁷

Pushing Ahead

The actions General Wilson had sought in his meeting of 3 February were well underway. Such rapid progress could only have been possible because Zackrison, Quarles, Wendell, and others persistently pursued the idea of a construction research laboratory long before seeking general support. It was now time to handle the innumerable details to make it become a reality. The plan was set in motion, and there was no turning back.

On 1 March 1965, the Ohio River Division Laboratory was officially notified that it would lose its research capability to a new laboratory. The Chief of Engineers directed the Division Engineer to temporarily rent nearby space. The Division's request to lease about 27,000 square feet of space, was quickly granted by the Chief of Engineers.¹⁸

Initially, it was considered wise to survey surplus government facilities for the new laboratory as Wendell had suggested. However, it was clear that such facilities did not meet the Office of the Chief of Engineers' requirement to be near or in association with a prestigious engineering institution. Nevertheless, this approach did demonstrate to the Bureau of the Budget and to Congress that the Corps had investigated every avenue. In seeking government facilities, the Corps preferred existing laboratories, but large structures such as warehouses and aircraft hangars were also considered. Forty acres of land were needed with future expansion to 100 acres. In addition, a area of about 85 acres was needed to test blast effect simulation and other high-level-producing noises. The test area was not to be close to residential and industrial areas. Other factors were also considered: fire protection, access roads, utilities, proximity to scientific and technical resources, travel connections, character and conveniences of surrounding communities, and housing.¹⁹

The Chief of Engineers appointed a site evaluation team to review those available sites which conformed to the above criteria. On 6 April 1965, all Corps Division and District Offices were directed to survey their areas for surplus facilities on government-owned real estate. Twenty-eight installations were screened and evaluated. According to the site selection team's report, only four "most nearly fulfill the criteria." They were the Rocky Mountain Arsenal in Denver, Colorado, the Naval Ammunition Depot in Cohasset, Massachusetts, Lincoln Air Force Base in Lincoln, Nebraska, and the Nebraska Ordnance Plant in Mead, Nebraska. Although generally meeting the criteria, none was considered highly desirable as a site for a laboratory.²⁰ The idea of a government installation had been explored and was now abandoned.

On 9 March 1965, a contract was signed with the National Academy of Sciences, permitting the Building Research Advisory Board to conduct a study of the Corps' research program. The Board was to evaluate how much and what kind of construction research should be done by the Corps, determine how to accomplish the research program effectively, and determine the relationship of the program with other research programs conducted in the private and public sectors of the construction industry. The study was designed largely to convince both the Bureau of the Budget and Congress that the Corps was capable of conducting a construction

research program of the kind envisioned.²¹ The Board was to appoint a committee of distinguished representatives in the industrial and academic communities to carry out the study. Among the committee members was Louis R. Shaffer, Ph.D., a member of the faculty of the College of Engineering, University of Illinois, who later became Technical Director of the new laboratory. At its first meeting, the BRAB Committee was briefed by the Office of the Chief of Engineers. Zackrison reviewed the history of the proposed laboratory within the context of the Corps' broad missions. He stressed that the Committee was to help the Corps determine what research was needed, with emphasis on research that was not likely to be accomplished by other public or private institutions. The Committee's role was to help the Corps review its long range missions, the adequacy of existing technology in the construction industry to support these missions, the existing and planned research in government and industry, and the essential research for the Corps to pursue in order to accomplish its long range missions. The Corps noted that its current construction research was limited to finding solutions to immediate problems. The research that it now proposed, on the other hand, was designed to develop a long-range research program to meet the projected demands of its construction mission. The Committee was asked to judge whether the Corps should establish a new research laboratory and, if so, to recommend how it should be organized, the nature of investigations it should undertake, and if it should be located near an academic institution.²²

When the BRAB Committee report was published in June 1967, it strongly echoed the views of the Office of the Chief of Engineers. Research within the Corps, it concluded, had to concentrate on long-range solutions. Research had to take the systems approach and needed to be elevated to a level that would benefit both government and industry in the long run. The Committee approved the idea of associating the laboratory with an institution of higher learning because of the enormous benefits in such a relationship. In its conclusion, the Committee proposed:

that wide ranging inter-disciplinary groups both within [the Directorate of Military Construction] and without, be constituted to develop the program details initially, to review the program and its results continuously, and to evaluate the results of, and intercommunicate with research groups in other segments of the construction industry.²³

The composition of the new organization needed advance planning. The Ohio River Division Laboratory was the logical agency to provide the nucleus of personnel and equipment for the proposed laboratory. Even before this could be accomplished, the Office of the Chief of Engineers had to appoint a cadre of four (a number that was later increased to five--one officer and four civilians) to plan the details of organization, including personnel recruiting and equipment procurement. This task force worked closely with the Ohio River Division Laboratory in matters dealing with office space and administrative and clerical support. Initially, the cadre would be located in Washington in the Office of the Chief of Engineers, but after 6 to 9 months, it was to move to Cincinnati and merge with the newly established laboratory.²⁴ In the meantime, the Ohio River Division was furnished a list of about 60 to 65 percent of its positions which would be

surplus to its needs when the Construction Research Laboratory was deactivated. These positions (Appendix 3) would be transferred to the new laboratory.²⁵

The task force also considered equipment for the new laboratory. An estimated 20 percent of existing equipment, mostly laboratory items, at the Ohio River Division Laboratory would be transferred to the new laboratory when facilities became available. Another 30 percent of the Division's equipment would be duplicated for the new laboratory at a cost of \$600,000. The new laboratory would cost \$3.3 million in Fiscal Year 1968 for equipment, office supplies, salaries, rent, and miscellaneous expenses.²⁶

The Ohio River Division was responsible for crating and shipping equipment to the new facility. It was also responsible for assuring the continuity of research during the move and for fiscal planning during the transition period.²⁷

Since the nucleus of personnel and equipment for the new laboratory was to come from the Ohio River Division Laboratory, some people were concerned about ORDL's ability to fulfill its mission during the transition period. "Certainly we should carry out the transition involved in the impending separation of the Construction Engineering Laboratory in such a way as to retain high competency at ORDL," cautioned the Deputy Chief of Engineers, Major General Robert G. MacDonnell. "Although the separation may take some time," he added, "we must minimize duplication of personnel and equipment."²⁸

Military or Civilian Director

Selecting a director for the laboratory posed a problem. Some people preferred that an officer head the organization; others believed the position should be filled by a civilian. The advantages and disadvantages of both cases were thoroughly explored. Although having a civilian director would be a departure from tradition, there were obvious advantages. The new laboratory was expected to have close and continual contacts with the research and development community not only in government, but in the industrial and academic world. Proponents of a civilian director argued that in such an environment, a civilian director with recognized technical competence would be more acceptable to his civilian contemporaries and subordinates. A military officer, though not necessarily incompatible, was not generally associated with the scientific and academic communities, and a military demeanor was not appropriate for the research and academic environment. Moreover, there was usually a broader field from which to recruit a civilian director possessing the desired technical and administrative qualifications. If a military officer were to become director, there must still be a civilian technical director but, as an assistant, he would not be as influential in establishing the image and rapport desired.²⁹

Other reasons also weighed heavily in favor of a civilian director. The Director of Defense Research and Engineering of the Department of Defense had earlier suggested that the Chief of Engineers consider the national scope of activities possible through the proposed laboratory, and

he urged the Corps to consider a joint effort with other branches of the Armed Services and government agencies. If such a center should evolve, a civilian director would provide valuable continuity in any relationship. Another argument was that a civilian director would serve to strengthen the grade structure of the laboratory, allowing the Corps to obtain the services of more highly qualified engineers and scientists.³⁰

Brigadier General Andrew Rollins, Director of Military Construction, was in favor of a military director. Quarles did not agree. He believed that unless the military director was a general officer, it would be difficult to fill the position of technical director with a person of high caliber from outside the Army. He doubted that there was a civilian within the Army who was sufficiently qualified to be the technical director. The caliber of the technical director should not necessarily reflect the size of the operation, but the quality of work to be performed and the image to be projected to the scientific and academic communities. He believed that at the technical director's grade should be at least GS-16, and preferably a GS-17. Quarles felt that it would be difficult to attract such a person if he was subordinate to a military director below the rank of Brigadier General, and possibly even below a Major General. He was equally certain that from the military point of view, these ranks were not compatible with the relative size of the proposed laboratory.³¹

Although Quarles' arguments seemed logical, the Chief of Engineers did not accept them. He decided initially to appoint a military head, while naming a civilian "acceptable to the academic community" as technical director. "Eventually," he said, "it may be desirable to place a qualified civilian in overall charge of this facility."³²

Partners in Research

The University of Illinois in Champaign-Urbana, had indicated an early interest in becoming associated with the proposed laboratory; an interest that was evident even while surveys were underway to locate adequate government facilities for the laboratory. In July 1965, W.L. Everitt, Dean of the College of Engineering, and Nathan M. Newmark, Head of the Department of Civil Engineering, visited the Office of the Chief of Engineers to discuss the possibilities of a site for the laboratory. After the visit, Everitt and Newmark wrote a letter to Zackrison containing a strong appeal to consider the university as a possible associate. "The University of Illinois and the community of Champaign-Urbana," began this letter, "are jointly greatly interested in having the proposed laboratory for Construction Research of the Corps of Engineers located near us." The letter described the many advantages, both from the standpoint of the academic community and the community as a whole.³³

It was more than a coincidence that the University was eventually successful. The Corps was familiar with the University's College of Engineering; the College had been involved in several Corps research projects in the past. It had helped the Army deal with earthquake landslides in Alaska, engineering geology in Nevada, and foundations for dams and locks on the Arkansas River. It had also been concerned with foundation research for the Waterways Experiment Station and airfield

pavements, radar towers, and lunar soil behavior for the Ohio River Division Laboratory. In fact, some people were concerned that the Corps was becoming too deeply involved with one school and excluding others.³⁴

Another reason which brought the University into close association with the Corps was the personal friendly relations that existed between the two over the years. Zackrison, who must be credited for much of the idea of a construction research laboratory, was a close friend of Newmark; a friend since their Army days.³⁵

The idea of a new laboratory associated with a university began long before the subject was officially broached within the Office of the Chief of Engineers. If the Corps had been serious about locating the laboratory on a government installation, the idea didn't succeed. The Office of the Chief of Engineers turned its attention to leasing facilities from a university.

In addition to discussions with representatives of the University of Illinois, the Corps also met with representatives of Purdue University, North Carolina State University, University of Colorado, and Texas A & M University. Owners of industrial research parks near these institutions expressed a strong desire to build the necessary facilities on a lease basis. Based upon these talks, the Office of the Chief of Engineers concluded that this approach offered the greatest promise for meeting the objectives within a reasonable period of time. The Corps was certain that a relationship such as this would benefit both the government and the university. The laboratory would be able to use university laboratory facilities and equipment and have access to consultant services and technical assistance from the faculty and graduate students. Corps employees could also undertake advanced studies while augmenting the university's teaching staff. Finally, the university could make its computers, technical library, and research results available to the Corps' laboratory.³⁶

In November 1965, the Office of the Chief of Engineers requested authorization from the Assistant Secretary of the Army for Installations and Logistics and the Assistant Secretary of the Army for Research and Development to obtain proposals from universities and industrial research parks interested in providing land and facilities on a lease basis. The rental was to form part of the laboratory's overhead costs; an expense paid by research projects on a proportionate basis. After receiving authorization, it was necessary to gain the consent of the House Armed Services Committee.³⁷

On 26 April 1966, the Office of the Chief of Engineers dispatched requests for proposals to 47 universities throughout the country. A site selection board was also appointed within the Office of Chief of Engineers. One member of the selection board was Melvin L. Martin, an employee in Zackrison's office. The board's responsibilities were to establish the criteria for selecting a university and to choose those which best fulfilled the criteria. Proposals from the most eligible schools would then be submitted to a committee appointed by the Building Research Advisory Board for final review and selection. Final approval of the

selection rested with the Assistant Secretary of the Army for Research and Development. Ultimate approval of the lease itself was in the hands of Congress.³⁸

The criteria that governed the selection of a university included a variety of factors. The total university-laboratory-community relationship was important. A large university with an equally large research program might appear to possess the desired capabilities, but it would not necessarily be as responsive to the needs of the proposed laboratory as a smaller school.

The laboratory would need about 28 acres of land for the buildings and parking area, and 100 acres for a test area. The test area should be located away from the laboratory, but still within a reasonable distance. A lease arrangement would be based upon an annual renewal that could be terminated upon a 60- or 90-day notice. The lease had to be renewed annually because the law precluded the Corps from obligating the United States for an expenditure of funds for which appropriation had not been made.

In considering the suitability of a location, the potential growth, attractiveness of site, proximity to other research institutions (including the university), and proximity to living areas were important factors. Other significant criteria were: the building and site improvements, the possibility of future expansion, access to airports, fire protection, computer facilities, local maintenance and supply services, hotels and motels in the vicinity, labor (clerical, technical, and nontechnical), and the cost of utilities.

The academic standing of the university was an extremely important factor. The institution's programs in engineering, architecture, basic sciences, and mathematics, as well as the size of its undergraduate and graduate schools, and the quality of the staff, the engineering research program, and the degrees offered were significant. Cooperative arrangements such as the use of libraries and computer systems, exchange of consultants and teacher services, student and staff privileges, and professional activities and contacts were still other factors. Finally, community features such as schools, housing, taxes, cost-of-living index, attractiveness of the community, social, cultural, religious, medical, and transportation conveniences were also important features of a proposal.³⁹

On 28 September 1966, the National Research Council submitted its committee's report on the site selected to the Chief of Engineers. Of the 47 institutions approached, 17 indicated they could not submit a proposal. Another 10, although interested, did not submit a proposal in the time allotted. Meanwhile, 20 schools submitted proposals; 7 were not responsive to the Corps criteria. Many who did not submit a proposal said they were unable to finance a project based on a 1-year lease renewal limitation. The selection committee reviewed only 13 responsive proposals. Based upon the criteria given to them, the committee was unanimous in recommending the University of Illinois as the site for the new laboratory. "We all agree," read the recommendation, "that their proposal comes closest to meeting all of your criteria." (Appendix 4 contains the University's proposal.) The

committee also believed that Purdue University, Cornell University, and the University of Cincinnati rated immediately behind the University of Illinois.⁴⁰

The Office of the Chief of Engineers, with the support of the Department of the Army, immediately approved the selection of the University of Illinois, and issued a press release announcing its choice.⁴¹ What remained were negotiations between the Corps and the University of Illinois to settle specifically the location, design of structures, rental, responsibilities of lessor and lessee, and a multitude of other details.

The initial plans contained three phases to acquire and occupy the site. The first phase was to acquire 5 to 10 acres with the construction of two buildings, consisting of about 100,000 square feet. This space, which was to be available in early 1968, was to provide work space for up to 100 persons. An alternate, more ambitious first phase was to acquire 12 to 20 acres with building space for 140 people. The second phase, proposed for 1970, was to construct an additional 64,000 square feet, including an administrative building, shops, and a warehouse. These added facilities were expected to bring the number of people at the laboratory to about 180. The third phase, scheduled for 1972, was to expand the property to 35 acres, with building space amounting to 280,380 square feet. This expansion would bring the number of people working at the laboratory to about 250, the projected full complement. In addition to the 35 acres for the laboratory proper, another 100 acres were needed for a proving ground.⁴²

The site that was finally selected was in Champaign, Illinois, approximately 8 miles from the University campus. It was in an area known as Interstate Research Park, a modern, privately developed research area zoned for light industrial use. The University proposed to lease the property from the Park, and sublease it to the Corps. The University was to construct the laboratory facilities in accordance with Army specifications. The proposed lease contained a provision giving the Corps the option to purchase the facilities, in which case the Corps would receive credit for a portion of the rental payments previously paid. Rental terms were to be established on the basis of a qualified appraisal. Based upon comparable rentals in the area, it was estimated that the rent would not exceed \$3.50 a square foot, excluding utilities and services. When the third phase was finally reached, it was estimated that the annual rent would be about \$911,260. The estimated rent for the proposed 100-acre proving ground would be about \$6,000 a year. The proposed lease was tentatively approved by the Assistant Secretary of Defense for Installations and Logistics.⁴³

The initial negotiations between the Corps and the University were held in mid-November 1966, although a signed contract would not be obtained before February 1967, because of the several approvals that were needed. This estimated goal would allow sufficient time to agree upon preliminary drawings and specifications from the architect. The final agreement for a design would take another 15 months. Thus, the Corps was hoping that the facilities would be ready for occupancy by 1 May 1968. The architect hired by the Interstate Research Park was Ralph Stoetzel of Chicago. The parties agreed on the alternate plan of the first phase, which

included building two structures, each consisting of about 48,000 square feet, plus a section of the central heating plant. The lease agreement included rental costs, taxes, insurance, and an amount for deferred maintenance of the facilities. The Corps was to make its own arrangements for utilities and janitorial and housekeeping services.⁴⁴

The terms of the lease provided adequate flexibility for government operations since provision was made for either the expansion of facilities or termination of the lease at the government's option. This provision also simplified matters if other government agencies wished to colocate with the laboratory in the future.⁴⁵

At the meeting, an official of the Illinois Power Company, owner of the land tentatively selected for the proving ground, assured Zackrison that there would be no problem in obtaining a tract at any location within its 1,800 acres.⁴⁶

Approval of Lease Despite Objections

Several other meetings between the two parties were held and negotiations continued. Because the Department of Defense and the House Armed Services Committee had not approved the lease, the architect, University, and Interstate Research Park were not able to move ahead with the plans. The Department of Defense was not totally convinced of the financial arrangements establishing the new facility. There were other reasons for its unwillingness to approve the lease. The Department questioned the essentiality of the proposed research program, and the desirability of leasing structures on privately owned land, noting the advantages to constructing facilities on government installations funded through the Military Construction Program. It was also concerned that the proposed research program might overlap or duplicate existing research programs. Finally, it explored the feasibility of developing a triservice engineering laboratory at a single location, absorbing similar programs currently being conducted separately by the three branches of the Service.⁴⁷

Fortunately, these objections were eventually overcome, and by July 1967, the Department finally granted its approval. Getting approval from the powerful House Armed Services Committee would be a problem.

At a meeting held on 12 August 1967, at which Zackrison and Quarles presented the Corps' plan, the Committee strongly objected to the new laboratory. Certain members questioned the need for another laboratory and the feasibility of leasing facilities rather than building them using Military Construction Appropriation funds. One member went so far as to accuse the Office of the Chief of Engineers of circumventing the Committee by employing a lease arrangement. Some members of the Committee wondered why the University of Illinois had been selected. Questions were raised when Representative Porter Hardy, Jr. "seemed convinced that somebody--if not us personally--," said Quarles, "had deliberately solicited proposals from universities while we were searching for surplus Government property." At the end of the meeting Quarles said, "He sort of pinned us to the wall and made us state in actual words that we,

of course, did not personally know that nobody [sic] had done this. [Hardy] suggested that possibly somebody in the Corps of Engineers or somebody in DOD had."⁴⁸

Before it would grant approval, the Committee insisted on further evidence to support the need for a laboratory, including a statement of technical achievement of the Ohio River Division Laboratory, further economic justification for employing a lease, and the criteria used in selecting the University of Illinois.⁴⁹

Soon after this meeting, General Clarke, who was then Acting Chief of Engineers, wrote to Representative L. Mendel Rivers, Chairman of the House Armed Services Committee, repeating much of what had been previously stated by the Corps to justify the laboratory. He summarized all the successful attempts made by the Corps in the design and construction of airfields and materials that were being used in Vietnam, thereby lending support to the achievements of the Ohio River Division Laboratory. He stressed that Army laboratories had not kept pace with the increase in technology or with demands for facilities which were critical to the effective performance of new space and weapons systems. He quoted the recent BRAB study which emphasized the need for a coordinated, long-range military construction research program that was oriented towards the whole construction process as a system. The proposed research program, said General Clarke, was directed towards this concept.⁵⁰

General Clarke stressed the economic advantages of a lease. He said that facility costs would be low, since arrangements were being handled without profit to the University. Operating costs would be realistic because there were no hidden costs. After the initial expense of transferring personnel and equipment, for which funds were to be separately programmed, all other expenses would be paid by project funding. Lease arrangements provided a means of recouping the cost of facilities on an equitable basis from all project sponsors. Finally, he observed that the plan provided maximum flexibility since under the terms of the lease, the Corps could abandon the facility without penalty, or, if it preferred, it could assume title with full credit for previous payments on the principal.⁵¹

In its plea before the House Armed Services Committee, the Corps now received strong support from the Department of Defense. The Assistant Secretary of Defense for Installations and Logistics, Paul R. Ignatius, wrote a similar letter to Representative Rivers, stating why the lease was so important.⁵² On 24 August 1967, the Real Estate Subcommittee of the House Armed Services Committee conducted further hearings on the lease and, after listening to a convincing argument from General Clarke on the need for the laboratory, recommended approval.⁵³ On 5 October 1967, Representative Rivers notified Secretary of the Army, Stanley R. Resor, that the Committee had no objections to the new laboratory.⁵⁴

During the hearings, negotiations with the University of Illinois continued. Disagreements over the annual cost of the lease almost halted further negotiations, but on 6 November 1967, both parties signed the lease for 15.175 acres of the south tract. The Corps was to pay an annual rent of

\$319,590 at the rate of \$26,632.50 a month. The annual rent was based on the cost of constructing the buildings and related facilities. The annual rent included \$50,250, which was to be used by the University to create a reserve for repairs and maintenance. The fund was to be used to replace items such as boilers, roofs, and other fast-deteriorating equipment. The fund was to become the source of some dissatisfaction later, because the Corps was convinced that much of this reserve was not being used for repairs and maintenance. The University also agreed to reserve for a period of three years, beginning 1 April 1969, not less than 15.175 additional acres of the north tract adjacent to the premises for the purpose of expansion. The Interstate Research Park was not fully occupied when the lease was signed. There was only one tenant. The Laboratory's annual rent included the cost of sewage, access roads, and other utilities. A condition of the lease provided for a \$2,000 annual decrease in the rent as new tenants were established at the industrial park. This provision was terminated in later years as the park filled up.⁵⁵

Final Preparations

Although the most important phase of this project was finally settled, many details surrounding the actual establishment of the laboratory needed to be worked out. Scheduling had been going on since 1965 when the laboratory was first officially proposed, but these schedules were largely concerned with promoting the laboratory and included briefing the various heads of departments, contacting the National Academy of Science, and selecting a site. Many of these actions were general and tentative in nature. Now that approvals had been granted, a site selected, and a lease signed, it was necessary to resolve personnel and equipment matters, create a Table of Organization for the laboratory, and prepare for the transition. Planning became more concrete and specific, but even at this point, plans were constantly revised and dates rescheduled simply because there were too many variable factors.

The facilities at Champaign were not expected to be completed before early 1969, at which time the Corps was to take possession. The laboratory was expected to be in operation by June 1969.⁵⁶ A General Order and mission statement were drafted by July 1967, but they both awaited the appointment of a director before they could be published. The Construction Engineering Laboratory of the Ohio River Division Laboratory was to be redesignated the "U.S. Army Construction Engineering Research Laboratory," a separate Class activity under the direct command of the Chief of Engineers with temporary headquarters at the Ohio River Division. Sixty-nine civilian spaces were to be transferred to the new laboratory upon its establishment. This did not mean 69 people; the eventual transfer of personnel was to be much less. Personnel projections for the first 6 years of the new agency were established (Table 2).

Table 2

Personnel Projections FY 1968 Through 1973

Fiscal Year	Spaces
1968	85
1969	130
1970	170
1971	190
1972	210
1973	260

Although an organizational chart was established, it was recognized that the organization would probably change by 1973. The organizational structure provided some flexibility in the use of personnel and contained a "dual ladder" wherein the researcher would be recognized for technical competence without supervisory duties.

The five cadre positions (one officer and four civilians) were to be filled from departmental spaces allocated to the Directorate of Military Construction, Office of the Chief of Engineers.⁵⁷

In October 1967, Lieutenant Colonel Rodney E. Cox (Fig. 1) was appointed Director of the new laboratory. He commanded the four civilian cadre. Colonel Cox was responsible for coordinating matters between the Office of the Chief of Engineers, Ohio River Division Laboratory, and Ohio River Division concerning staffing (Appendix 5), equipment, and facilities. He needed to prepare the Table of Distribution and Allowances, job descriptions, and resolve the allocation of personnel and equipment removed from the Ohio River Division Laboratory for the proposed laboratory. Cox had to establish the criteria for selecting, procuring, and installing equipment based on the available resources and projected program planning. He needed to establish a relationship, then unknown, between the University and the new laboratory. He also had to establish priorities and procedures for moving personnel to the new facility and to keep those who were to move advised of their status. Finally, Cox had to arrange for support from the various staffs in the Office of the Chief of Engineers in matters pertaining to personnel, supplies, payroll, transportation, utility contracts, fiscal, and a multitude of other details.⁵⁹

In January 1968, final plans were placed in motion to make the new laboratory a reality. The Table of Distribution and Allowances called for a minimum strength of 129 civilians and 1 military to begin operations at Champaign during the first quarter of Fiscal Year 1970. These civilian spaces included the 34 that were to be gained from the deactivation of the old Construction Engineering Laboratory in Cincinnati. An additional 35 spaces were to be made available to the new laboratory while it was still in Cincinnati. The balance of the 130 spaces would be made available between the anticipated date of activation, 1 February 1968, and the operational date in Champaign, 1 July 1969. The Table of Distribution was to look like Table 3.



Fig. 1
Lt. Col. Rodney E. Cox
Director
1968 to 1969

Colonel Cox graduated from Virginia Polytechnic Institute in 1952, with a Bachelor of Science Degree in Civil Engineering. He received a Master's Degree in Highway Engineering and a Ph.D. in Transportation Engineering from Iowa State University. Cox attended the Army Command and General Staff College and the Army War College. He served in Korea, Germany, and Vietnam. He was also Director of Construction Projects at the Omaha District Office. Before coming to the new laboratory, he was in the Office of the Deputy Chief of Staff for Logistics.⁵⁸

Table 3

Table of Distribution, 1968 and 1969

	1968	1969
Officers	1	1
Graded Civilians	34	115
Wage Board Civilians	0	14
Totals	35	130

When plans were formulated in January 1968, the general offices of the laboratory were to consist of the following: Executive Office, Programs Office, Research Support Office, Management Support Office, Engineering Development Division, and Laboratories Division. The Construction Systems Laboratory, Materials Laboratory, Test and Evaluation Laboratory, and Power Laboratory were under the Laboratories Division. The Building Research Advisory Board had also recommended establishing a Data Analysis Branch, Special Projects Branch, and Project Systems Branch under the Engineering Development Division in the future.⁶⁰

III

ESTABLISHMENT

In September 1968, a General Order established the Construction Engineering Research Laboratory (CERL), effective 1 May 1968, with temporary headquarters at the Ohio River Division (Appendix 6). The new organization was authorized 1 officer and 34 civilians, and was structured to expand to 129 civilians. The 34 civilian spaces were transferred from the defunct Construction Engineering Laboratory of the Ohio River Division Laboratory. The Ohio River Division was to provide administrative and logistical support to the new organization through a service agreement until the Laboratory moved to its permanent location in Champaign.¹

Broadly speaking, the new Laboratory's mission was to undertake research and development to support Army programs devoted to constructing facilities in the United States and overseas. The Laboratory was to advance and disseminate knowledge in new and improved construction materials and techniques in the interest of national defense and the conservation of national resources. It was to investigate the rapidly changing fields of science and engineering to discover new applications in construction for the Army, Air Force, and other government agencies when requested. The Laboratory's research was to supplement the existing technology in the industrial community.²

CERL was to conduct applied research to determine the effects of nuclear explosion upon building materials, conduct research to support extraterrestrial construction, and conduct limited engineering and research investigations in support of Civil Works construction not normally assigned to the Waterways Experiment Station or the Coastal Engineering Research Center. The Laboratory was to establish and maintain a data center for collecting, storing, analyzing, and disseminating data on facility design, construction, operation, and maintenance. The laboratory was also to maintain a test and evaluation center for developing and field-testing prototype, model, and operational facilities; undertake feasibility studies in project development; and prepare and execute symposia and educational training programs in facility planning, design, construction, maintenance, and operation. These activities were to be performed in conjunction with the University of Illinois. Some existing projects were absorbed from the old Construction Engineering Laboratory, thus assuring continuity.³

On 23 May 1969, Louis R. Shaffer, Ph.D. (Fig. 2) was appointed Assistant Director of the new Laboratory following a nationwide search. Shaffer had served as a member of the Building Research Advisory Board Committee to study the Corps' research capability. At the time of his appointment, he was a Professor of Civil Engineering at the University of Illinois and an authority on applying the systems engineering approach to construction. This factor weighed heavily in favor of his appointment. He had been on the faculty of the University for 15 years. Since 1961, he had been in charge of the academic program in construction engineering and management in the Department of Civil Engineering. The program, which was founded solely on the systems approach, was recognized as one of the most outstanding of its kind in the country. Shaffer was the author of more



Fig. 2

**Louis R. Shaffer, Ph.D.
Technical Director/Deputy Director
1969 to Present**

Doctor Shaffer has a Masters Degree and Ph.D. in Civil Engineering from the University of Illinois at Urbana-Champaign where he taught from 1957 until he was appointed to the laboratory. He has written many articles, papers, and texts on construction engineering and management.

than 50 articles, papers, and texts on applying the systems approach, operations research, and the digital computer to solving problems in the construction industry. These publications documented the academic program as well as part of a \$600,000 research program for which he was principal investigator during the 6 years prior to his Corps appointment.⁴

Colonel Cox's tenure as the first Director of the new Laboratory was brief, but in this capacity he bore all the difficulties common to an infant organization. On 28 May 1969, he was reassigned, and it was not until 1 July that Colonel Edwin S. Townsley (Fig. 3) succeeded him as the Director.

Among the innumerable problems facing Cox and Townsley, those associated with the new facilities were unquestionably the most serious. The Director had to be sure that the structures were being built to specifications and that the finished product was acceptable to the Corps. He also had to be certain that there would be no delays in meeting schedules. Differences of opinion between the Corps and the University over specific costs in construction, which affected the annual rent, had delayed construction.⁶ With some of these questions settled, at least temporarily, construction finally got underway in March 1968.

When the lease was signed in November 1967, both parties had envisioned that the construction would be complete and the buildings would be occupied by 1 April 1969. This didn't happen. However, the lease contained a provision which, in effect, permitted the Corps to occupy the buildings before completion in order to install fixtures, machinery, and other essential equipment needed to begin operations. Colonel Cox took advantage of this provision, and in April 1969 he directed a few of his people to report to Champaign where they were to uncrate, install, and store incoming equipment. The University did not object to this action, provided that it did not interfere with construction.

In a meeting held at the University on 10 April 1969, Colonel Cox expressed interest in occupying the unfinished structures by 1 June on a limited basis only. He needed office space for himself and for his administrative officer so they could coordinate a multitude of actions that were better accomplished from Champaign rather than Cincinnati. Storage space was also needed to house machinery and equipment that were arriving almost daily at the new location. The people at this meeting understood that the dedication ceremony was to be held on 25 July 1969, and that by August, the structures would be completed. To meet the 1 June deadline for initial occupancy, it was agreed that a rent would have to be paid by the Corps to cover the interim period of 1 June through 31 July 1969.⁷

Later, in referring to this meeting, Sidney M. Stafford, the University Architect, noted that facilities would be "substantially" completed by 1 June 1969, the date suggested for partial occupation of the facilities. He also observed that by 1 August, "hopefully" the facilities would be "fully" completed. He believed that it was necessary to arrive at a mutually agreeable rental rate to cover the interim period. The University concluded that since the structures would be substantially completed by 1 June, the temporary rent should be set at a monthly rate of \$27,302.50. The rent would be recomputed when the buildings were completed.⁸



Fig. 3

**Col. Edwin S. Townsley
Director
1969-1972**

Colonel Townsley was a graduate of the U.S. Military Academy. Much of his graduate work had been done at the University of Illinois where he received a Master's Degree and a Ph.D. in Civil Engineering. He also earned a Master's Degree in Economics and Government from Harvard University and attended the Army Command and General Staff College. He served as Research and Development Officer at the Pentagon and was stationed at the Waterways Experiment Station for some time. Townsley served in Germany and Vietnam.⁵

Zackrison objected to this proposal, maintaining that the lease agreement did not provide for any rental during the initial period of occupancy since the structures were not completed. He insisted that while the lease was being negotiated, the Corps had made it clearly understood that it would incur no liability for any rent until the facilities were completed and declared acceptable. The Corps had also pointed out that prior to completion, it would have to install fixtures, machinery, and equipment, and possibly accomplish other actions to prepare for occupancy. Zackrison said the concept of prorating rents based on "substantial" completion of facilities was never discussed during negotiations. In quoting from the lease itself, he observed that "prior to assuming possession, the Government shall be permitted to install fixtures, machinery, and equipment, and to perform such other acts as may be necessary to prepare the premises for the conduct of its business." Zackrison stressed the point that the Corps existing activity at the facility (then May 1969) was confined to installing equipment and preparing the premises for occupancy. Zackrison evidently believed that such limited use of facilities as Colonel Cox desired fell under this provision, and any limited occupancy should not be subject to an interim rent.

When 1 June arrived, the facilities were far from complete. The Corps decided it could not wait any longer, and by 1 July, operations began at the new facility (Fig. 4). The Laboratory was dedicated on 25 July. The dedication was an occasion during which distinguished members of the national, state, and local governments, as well as the Armed Forces paid tribute to the Corps, the University, and the new organization. Meanwhile, the lease was modified in a supplemental agreement permitting the Corps to pay an interim rent of \$20,000 a month until the facilities were completed. The agreement was to be in effect during the period 1 September through 31 December 1969 unless the facilities were completed and fully occupied earlier.¹⁰

When the Laboratory was established in Cincinnati, 34 civilians were transferred into it from the old Construction Engineering Laboratory. This was about 50 percent of the civilians in research and development at the Ohio River Division Laboratory.¹¹ After the Construction Engineering Research Laboratory moved to Champaign, the number of civilians immediately jumped to 62. Most of the additional personnel were recruited in Champaign and Cincinnati. The rest were transferred from the Office of the Chief of Engineers, other Corps activities, and government agencies. In the following months, the Laboratory continued to grow. Between December 1968 and December 1969, appointments were made to head the various offices and laboratories. Several civilians who were transferred from the Ohio River Division Laboratory were appointed to these positions. Appointments were also made to newly established committees and boards.

Cooperation with the University in operational matters began even before the Laboratory was established at its permanent home. Colonel Cox and W. E. Fisher, Ph.D., worked out a graduate assistantship program with the University. They concluded that the Laboratory would offer five graduate research assistantships, starting with the 1969-1970 academic year. More assistantships would be offered as the program gained experience. The program was designed to offer highly qualified graduate

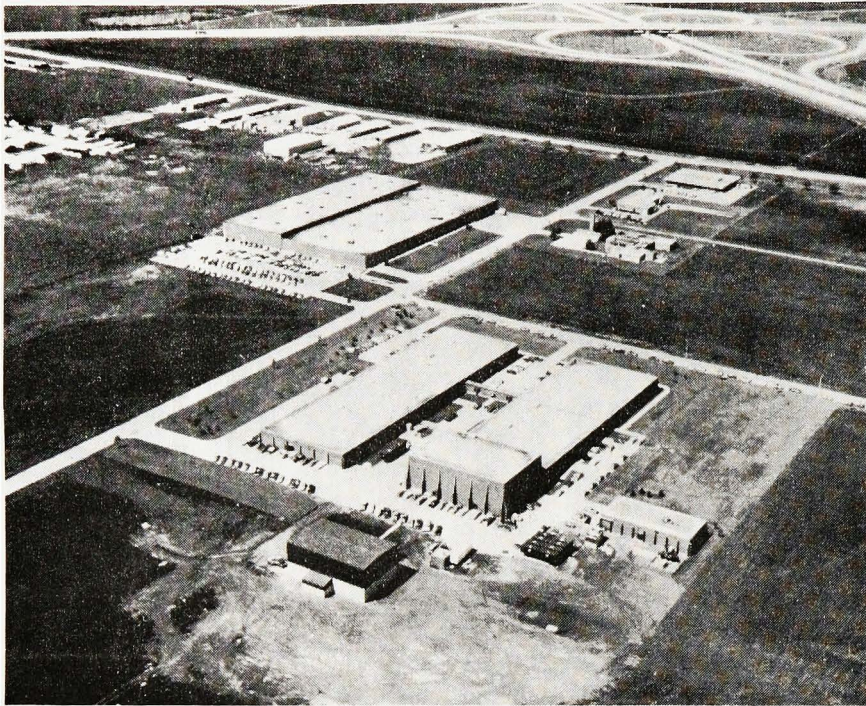


Fig. 4

**Aerial View of CERL facilities
c. 1973**

students the opportunity to complement their academic studies with research in their desired field of specialization. The Laboratory provided an environment in which individuals could judge their aptitude for a research career within a government laboratory. The assistantships would be permanent, full-time federal career positions, having all the privileges associated with federal service. The assistants would devote 50 percent of their time to academic studies and the rest of the time to laboratory research during the normal academic year. During summer months, they would work full-time on laboratory projects. The University was extremely pleased with this program, and immediately gave its support to candidate selection.¹²

Many of the items of equipment and machinery that came from the Ohio River Division Laboratory were not the right kind for the new type of research that was to be accomplished at the Laboratory. Many of the individual laboratories had no equipment to work with, as was the case in metallurgy research. Equipment such as the universal compression and tension testing machine was ordered in 1968 and 1969, but the availability of funds, which were often meager, governed the purchase of these expensive items. Acquiring the necessary equipment and machinery to begin research was a slow process requiring considerable patience.¹³

As noted earlier, a handful of civilian employees were in Champaign as early as April 1969. They were not there to begin operations but to sort

and install equipment that was arriving daily. Personnel from Cincinnati would be transferred to Champaign to start operations on 1 July 1969 with the official transfer of the Laboratory (Appendix 7). On that day, the Ohio River Division was relieved of its responsibility to provide administrative and logistic support to the Laboratory. The Division Engineer of the North Central Division assumed this responsibility.¹⁴

By 1 July, the Laboratory had 62 employees. During these early days, confusion reigned. With inadequate facilities and insufficient equipment, it was difficult for people to settle down to normal, routine work. Two of the first employees to arrive from Cincinnati, set up shop in the rear of the warehouse with only one desk and a telephone. Although equipment was arriving, few items could be uncrated. Another employee recalls the first few months in Champaign:

The building was not completed, and the contractors continued working until about November. There was no air conditioning, however, Col. Cox... had told the Cincinnati people that administrative leave would be authorized for extra hot days that summer [However, none was granted.].

Everybody brought their own fans, recalled a fourth employee, and because of the heat, they worked from 7 a.m. to 3:30 p.m. to avoid being in the building during the hottest hours. Still another employee remembered the confusion that existed in July. Furniture was moved from room to room to make way for the contractors to complete their work. Meanwhile, the buildings had other occupants besides the Corps: birds nested in large open spaces, and at least one cat lived inside.

Improvising was very common in those early months, and both laborers and professionals pitched in to uncrate, move, and install equipment and furniture. One of these employees told an amusing story that occurred on Dedication Day:

Almost none of the doors had labels on them before the dedication, so it was decided to at least identify the bathrooms. The print shop was located next door to the women's restroom in Building 2, and as you walked by, the doors at that part of the corridor were marked, in order, 'Men,' 'Women,' 'Reproduction.'¹⁵

IV

GROWING PAINS: THE FIRST FIVE YEARS

The Resources

Personnel. At the time of its dedication, the Laboratory had 1 officer and 62 civilian employees assigned. By June 1972, there were 3 officers and 145 civilians.¹ If there were any personnel problems during this period, it was because the Laboratory was still young and its research program had yet to mature. The organization could not be certain exactly what expertise was needed and in what numbers. Very early, Colonel Townsley complained of the high number of administrative personnel in relation to the number of research personnel. This proportion was inevitable at a time when many activities of the Laboratory consisted of processing newly appointed employees, unpacking and installing equipment, and dealing with general administrative matters common to a new organization.²

As the staff settled into its new quarters and the research program began to mature, additional research personnel were hired so that the ratio between research and administrative employees rose from 1.7 in Fiscal Year 1970 to 2.4 by April 1973. By then, 49 administrative and maintenance people supported 114 research personnel.³

While the ratio between administrative and research personnel was being slowly adjusted, the proper mix of disciplines among the research staff could not be determined until the research program took definite shape. Some of the problems seemed to stem from an unclear picture of what kinds of research projects were to be handled by the Laboratory. There were also instances of duplicate research in concrete at the Laboratory and the Waterways Experiment Station. Some believed that the Laboratory was doing research that more properly belonged to the Waterways Experiment Station. One observer in the Office of the Chief of Engineers believed that an early decision should be made as to which of the two laboratories was to accomplish concrete pavement research. Decisions of this nature might free personnel and spaces for the more critical and innovative building research systems which had been envisioned for the new Laboratory.⁴

As more funds became available and the Laboratory gained greater recognition, additional spaces were authorized and more personnel were assigned. In Fiscal Year 1973, 168 civilian spaces were authorized, but there was a projected need for at least 200 spaces, mostly in research.⁵

The Laboratory was fortunate in being able to attract a highly competent staff with expertise in the major disciplines of the building industry. By January 1973, it could boast of an engineering, scientific, and architectural staff of 104 people, 40 of whom had Ph.D.s. These experts represented 22 disciplines, including health sciences, physiology, and civil engineering. Thus, while there was no depth in a particular discipline, there was obviously a sizeable spread. The research staff included people with academic and research experience in planning, design, construction,

and in the operation of buildings, pavements, and utilities. Table 4 illustrates the diversity in the architectural, engineering, and scientific disciplines and the cumulative man-years of laboratory experience of the research staff. The typical member of the research staff was 36.1 years of age, had achieved a Master's Degree, and had 4.4 years of experience in laboratory research and 3.2 years of experience in design and construction. This distribution of expertise among the disciplines provided the basis for forming interdisciplinary teams to attack the problems inherent in each of the major research program segments. Perhaps the Laboratory's Director said it best when he observed that "Our strength of expertise has never been in depth but in coverage and mix. This we intend to retain."⁶

When Colonel Robert W. Reisacher became Director on 27 July 1972 (Fig. 5), relieving Colonel Townsley, he had other plans for improving the personnel picture.⁷ He was especially interested in assigning military

Table 4
Education and Experience Summary
CERL Research Staff

Engineering Discipline	EDUCATION			EXPERIENCE (Total Man Years)			
	B.S.	M.S.	Ph.D.	Teaching	Research	Design	Construction
Architecture	5	4	1	16	9	36	1
Biology			1	8	1		
Botany			1	7	1		
Chemistry	3		1		68		
Chemical Engineering	1	2			13	17	3
Civil Engineering	6	11	12	51	124	61	42
Computer Science	1	2	1	7	16	6	
Economics		1			1		
Electrical Engineering	3	3	2	9	56	53	10
Engineering Mechanics			3	9	23	8	4
Environmental Engineering		4	2	5	11	4	
Forestry		1		1	1		
Geography		1	1	2	8	2	
Geology		1		2	7		
Industrial Engineering	1	4	1	2	11	9	33
Mathematics	1		2	14	15	7	
Mechanical Engineering	4	4	2		36	18	8
Metallurgy		1	3	5	21		
Nuclear Engineering			1		3		
Physics	1				1		
Structural Engineering			2	5	34	5	
Urban Planning			1	3			
TOTALS	26	39	37 (102)	146	450	226	103 (925)



Fig. 5

Col. Robert W. Reisacher
Director
1972 to 1973

Reisacher came directly from the Saudi Arabia District where he served as District Engineer. Besides this position, he held a variety of assignments, including research and development with the Army Aviation Test Board, in the Mediterranean area, and in Alaska. He taught for a time at the U.S. Military Academy; served with aviation and air-mobile commanders in the Far East; and was military assistant to the Under Secretary of the Army. Reisacher received a Bachelor of Architecture Degree from the Carnegie Institute of Technology, a Master of Fine Arts Degree from Princeton University, and a Master of Science Degree from George Washington University. He was also a graduate of the Command and General Staff College, Armed Forces Staff College, and the U.S. Army War College.

personnel to the Laboratory to participate in the growing environmental research program. Before 1972, there were only three officers on the Laboratory staff; all three, including the Director, were administrative personnel. Reisacher believed that military personnel with backgrounds in sanitation, acoustics, and computers would strengthen the Army's contribution in environmental research. He was convinced that they would provide military visibility in this very important area. He also welcomed the exchange of Army officers with the Air Force and Navy on a permanent assignment basis. However, his plan did not go very far. Colonel Reisacher believed the Office of the Chief of Engineers may have objected to assigning officers to a research organization for fear it would reduce their chances for reassignment.⁸

During these early years, professionals of the Laboratory received national honors. Between June 1969 and December 1973, they completed 121 technical reports and studies. Table 5 reveals how these studies were distributed among the several divisions and offices.

During the same period, this group also published 14 articles in professional journals, delivered 19 papers at professional conferences and meetings,¹⁰ and received nine awards and major honors. Professionals also participated as chairmen and committee members of several national and international organizations.¹¹

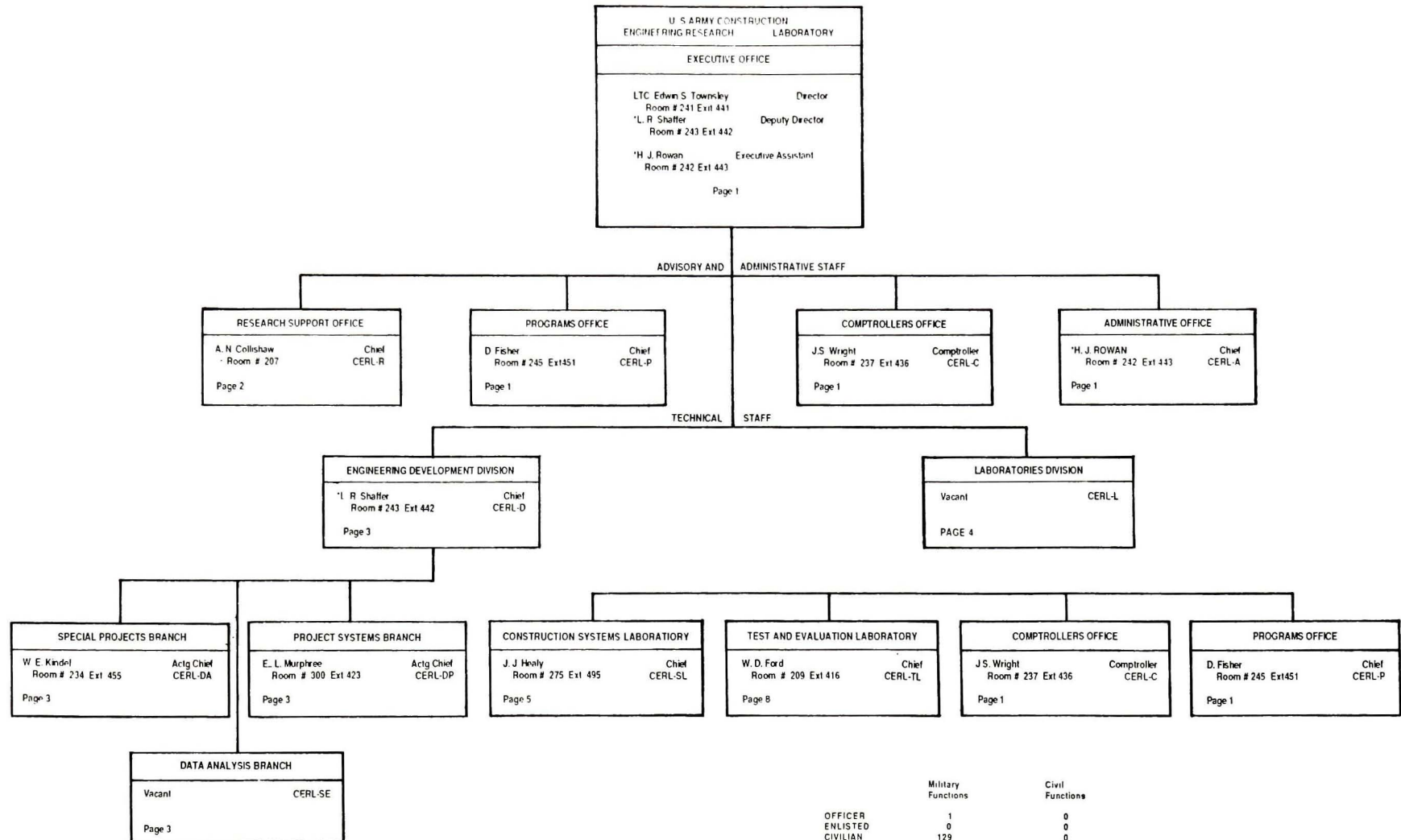
Organization. In 1969, the Laboratory's operational offices were organized as branches and laboratories under two coordinating divisions (Table 6). The Engineering Development Division contained the Special Projects Branch, Project Systems Branch, and Data Analysis Branch. The Laboratories Division contained the Construction Systems Laboratory, Materials Laboratory, Power Laboratory, and Test and Evaluation Laboratory. Although there was a Power Laboratory, energy research was minuscule. The research in this area dealt largely with an effort to provide the Army and Air Force with hardened power systems. There was no concentrated effort in research to minimize waste or to develop alternative energy sources as yet. Research in this area was so limited that Richard G. Donaghy, then Chief of the Power Laboratory, started in 1969 as a one-man operation working with electric power.¹²

Table 5
Technical Reports and Studies⁹

Divisions and Offices	No. of Reports
Materials Systems and Science Division	52
Environmental and Energy Systems Division	25
Facilities Engineering and Construction Division	20
Facilities Habitability and Planning Division	8
Facilities Operations and Maintenance Division	14
Support Office	<u>2</u>
Total	121

Table 6

Organizational Plan, 1969



Environmental research was another area where a paucity of projects affected the organizational makeup of the Laboratory. In 1969, the organizational chart did not identify any major staff element dedicated solely to environmental research. By 1971, there were only three or four professionals working in this area, and they were scattered throughout other laboratories. By 1972, environmental research received greater emphasis, but the research was still divided among other major staff elements. In June 1972, for example, the Special Projects Division, formerly the Special Projects Branch, was organized into three branches, one of them being the Environmental Systems Branch. The Electromechanical and Environmental Systems Division was also concerned with some aspect of pollution abatement. Although environmental research became more important over the years, this early period did not see a concerted effort to raise this research to the level it deserved. The few professionals who labored in this field did so largely to ensure that the Army complied with environmental legislation; research was not designed to improve the soldier's environment in a more direct way. Environmental research would have to wait a few more years before achieving this goal.¹³

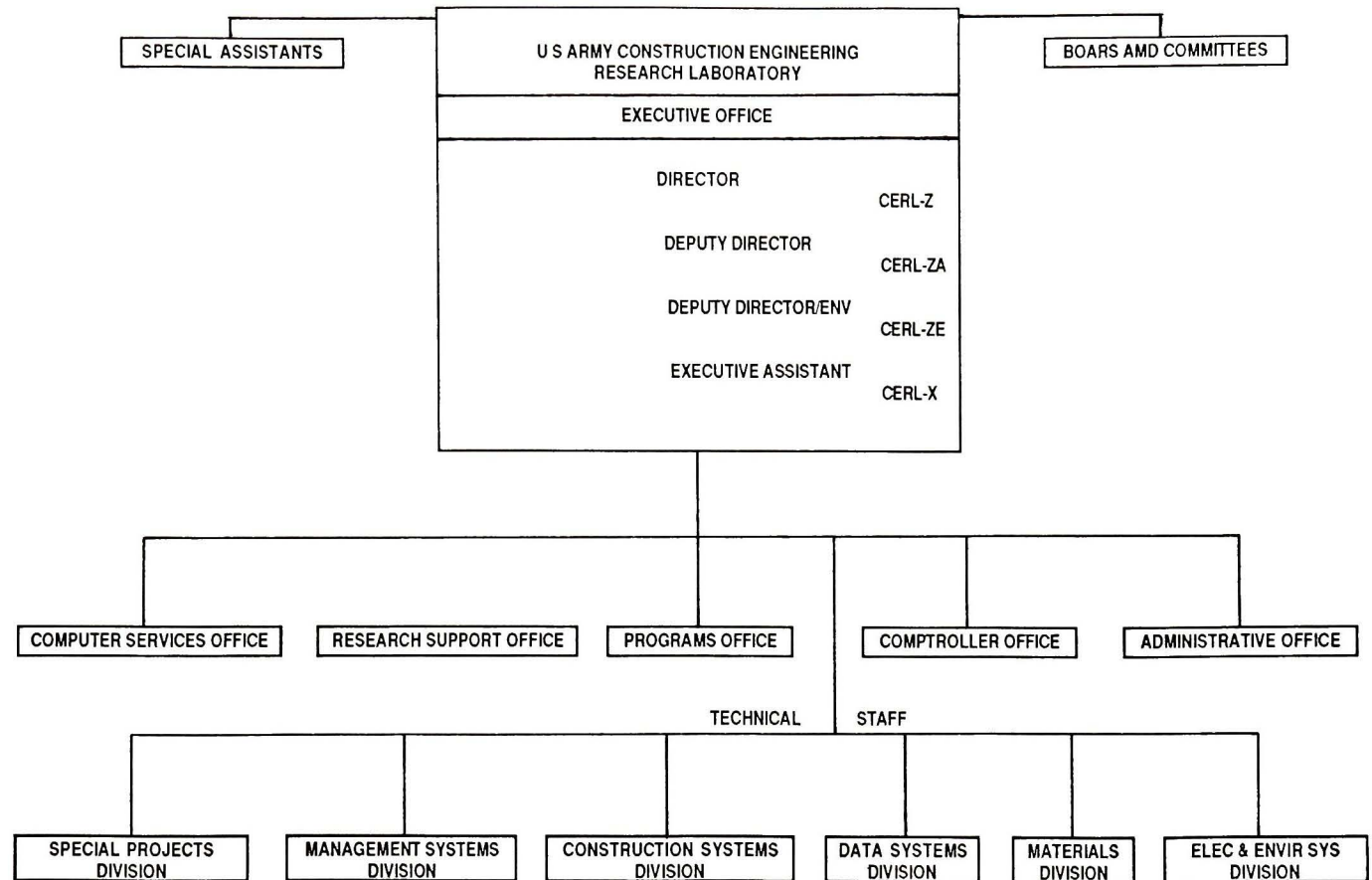
Energy and environmental research that was later associated with the Facility Systems Division was originally performed by other laboratories and branches. It was not until the mid-Seventies that it began to receive greater recognition, and the research functions were absorbed into one recognizable operational laboratory.¹⁴

In 1971, the seven branches and laboratories were organized into six divisions. The Test and Evaluation Laboratory remained untouched, but the Engineering Development Division and Laboratories Division were discontinued. The six operating divisions reported to the Director. This reorganization remained essentially unchanged until 1974, although by that time the Test and Evaluation Laboratory was discontinued (Table 7).

The goals of the Management Systems Division were to improve the quality of construction management, while reducing costs, by developing techniques and procedures which streamlined and integrated planning, resource allocation, construction time, and contract administration. The Special Projects Division was responsible for accomplishing research which was designed to improve the quality of work and living facilities for military personnel and their families. One research area determined space requirements and comfortable living conditions. A second area involved research to determine building criteria to meet space requirements, taking into consideration design, construction procedures, operation and maintenance costs, and the potential alterations of the structure over the years. The third area studied the relationship of man to the natural environment. Much of this research was aimed at the Volunteer Army.¹⁵

The Data Systems Division was primarily concerned with evaluating computer software systems and apply them to master planning, engineering, cost management, and maintenance. The Materials Division was responsible for research in three areas: the technical and economic feasibility of incorporating into military facilities new materials developed by the private sector; the development of materials unique to certain facilities such as antiballistic missile systems, fortifications, and airfields; and the development of techniques and procedures for determining the

Table 7
Organizational Plan, 1973



1973

strength and structural integrity of building systems components by nondestructive testing methods.¹⁶

The research of the Construction Systems Division was directed at cost savings and improving functional performance of structural systems. The research dealt with Army posts, camps, and stations; design and construction of the Safeguard Antiballistic Missile Systems; and advanced concepts for ballistic missile defense systems. Finally, the Electromechanical and Environmental Systems Division was responsible for conducting research on electric power generation and distribution; heating, ventilating, and air conditioning systems; and water supply, waste collection, and treatment. The division was also responsible for developing pollution control and abatement techniques for existing facilities and establishing criteria for controlling air, water, solid waste, and noise pollution in constructing and operating future power and utilities systems.¹⁷

The organizational structure of the Laboratory permitted interdisciplinary teams of engineers, scientists, and architects to separate problems into components based on the team's professional training and experience. All components of a problem were thus subject to a detailed scrutiny and the interaction of problem solving through the team approach was maintained. The systems approach was developed from this team concept. The typical engineering disciplines, such as concrete, soils, and hydrology, were not distinguishable in such an approach. Major research projects could require the expertise of more than one division laboratory. To manage such a program, the Laboratory created the concept of the "lead laboratory," which assigned the primary responsibility for managing and executing the project to one laboratory while employing the special talents of other laboratories. The Laboratory carried this concept one step further by creating the "lead division." In essence, the Construction Engineering Research Laboratory program placed each of its research projects under the management of one division while maintaining the capability of using the task force system of expertise on any problem. The Special Projects Division, for example, was the lead division for industrial construction research. In conjunction with an interdisciplinary team, the chief of the division was responsible for identifying the major research topics. He also identified other divisions of the Laboratory which might be able to assist. Since the lead division was always responsible for integrating research in all divisions, the chief of the lead division could suggest tradeoffs between research activities performed. In this capacity he practiced systems engineering in the management of research and in the research itself.¹⁸

By the end of 1973, it was becoming evident that the existing organizational make-up would not meet the needs of an expanding research program containing a diversity of projects. The growing importance of energy and environmental problems throughout the country was beginning to influence the research conducted at the Laboratory. It was time to alter the organizational resources of the Laboratory to make them more responsive to these problems. In October and November 1973, a study group was called together to evaluate the existing organization and to make recommendations for changes so that the personnel resources could be used more effectively. In October 1973, on the eve of his retirement,

Colonel Reisacher outlined the difficulties facing the Laboratory's organization. He told the division chiefs that he was finding himself drawn into situations where he had to resolve jurisdictional disputes among the divisions because similar expertise existed in more than one division. Thus, he noted that:

During the last 6 months, and particularly since the beginning of this fiscal year, it has become more difficult to clearly place research work that is received into the existing categories assigned to the various operating divisions. It is obvious that these jurisdictional issues arise because of the close correspondence in certain missions and functions among the operating divisions.¹⁹

The experiences of the first 5 years of the Laboratory had revealed that its organization could not remain unaffected while new research was being assigned. If the Laboratory were to meet these challenges quickly and effectively, it would have to be ready to alter its organization. Flexibility was important, regardless of how this might affect morale. Nevertheless, to effect organizational changes while maintaining high morale was in itself a challenge to the Laboratory.

Equipment. In addition to the laboratory equipment transferred from the Ohio River Division Laboratory in 1969, several pieces of special purpose equipment totaling nearly \$2.5 million, were either on order or had been received by mid-1973. Some of the more significant items are described below.

The Closed Loop Materials Analysis System was a highly complex piece of equipment designed for a variety of purposes, such as testing conventional stress-strain relationships, testing through-zero tension compression; performing short-term and long-term creep tests, testing conventional constant amplitude fatigue; performing low-cycle fatigue testing, conducting crack propagation studies in stress, corrosion, and fatigue; performing service simulation; performing fracture mechanics studies; and conducting environmental tests.

The X-Ray Unit 400KV was used to analyze material crystalline structure and to identify discontinuities that might affect strength. It was employed extensively to study welding techniques and procedures to determine the effect of defects such as porosity on the welding joints.

The Dynamic Tension Analysis System was used to determine the minimum dynamic tensional stress required to rupture materials.

The Scanning Electron Microscope, which was new in the field of research at the time it was acquired, was used to obtain chemical analysis of surfaces with both energy-dispersive and wave-length dispersive x-ray spectrometers. The microscope was used in metallurgy studies, specialty concrete research, air pollution research, and materials failure and analysis.

The X-Ray Defraction and Vacuum Spectroscopy System was used to analyze the crystal structure and elemental composition of materials.

The Vacuum Induction Melting Furnace was employed for close composition control melting to obtain alloys of desired composition for use in alloy research and directional transformations in steel.

The Heated Rolling Mill and Pole Figure Device was used in metallurgy studies to control the crystal orientation in metals. The physical properties of metals could be more completely defined through the study of crystal orientation.

The Welding Facilities were used to study nondestructive testing of field welds, strength of welding connections, and the development of engineering criteria for welds.

The Structural Test Floor Loading System was employed to test structural systems and subsystems. This system did not exist in the research and development resources of the construction industry anywhere else in the United States.

The display and recording equipment included oscilloscope recorders, spectrum analyzers, multitrace amplifiers, multichannel magnetic tape recorders, and a correlation function computer for recording and subsequent analysis of the test data.

The Biaxial Shock Test Machine (Fig. 6), or shaketable, as it was more commonly called, was undoubtedly the most expensive and largest piece of equipment acquired by the Laboratory. Planned and designed by the Laboratory in 1970, it was finally installed in 1973. The procurement and installation of this equipment was a jointly-funded effort by the Corps' Huntsville Division and the Laboratory. The shaketable's platform was 12 by 12 feet with a maximum weight capacity of 12,000 pounds. The table's movement and frequency was controlled by a closed loop electrohydraulic system in the horizontal and vertical directions. The instrumentation included 70 channels of electronic signal conditioning and recording equipment, analog to digital conversion units, and a 14-channel magnetic tape recorder. Because of the potential frequency response in the Laboratory's existing buildings, the shaketable was housed in a separate structure designed especially for this purpose.

Initially, the shaketable was procured to conduct shock and vibration studies on critical equipment in the Safeguard Antiballistic Missile System, for which the Huntsville Division had principal construction responsibility. Because the machine had the capability of inducing shock and vibration on power and energy equipment and on experimental structures, it was also used to test structures under earthquake conditions. With the addition of this machine, the Laboratory became one of the first research institutions to have equipment shake on three axes.

The contract for the shaketable and electronic control equipment was \$1.45 million. The Huntsville Division contributed \$870,000 and the Laboratory provided \$580,000 for its design, construction, and installation. The Laboratory provided another \$334,000 for construction of the reaction mass.²⁰

In addition to its own equipment, the Laboratory had access to the University's equipment, especially computers, whenever necessary. The Laboratory was also able to tie into the large Navy-owned computer center located outside Washington, D.C. This opportunity gave the Laboratory almost unlimited use of the center at a reasonable cost.²¹

For the amount and kinds of research the Laboratory was performing, the equipment it had by 1973 was considered satisfactory. However, some people at the Laboratory believed that in the next 5 years an additional \$2 million would be needed if the Laboratory were to realize its greatest potential. This amount was to be used not only to purchase new equipment, but to pay for maintenance, calibration, and repair of the equipment on hand.²²

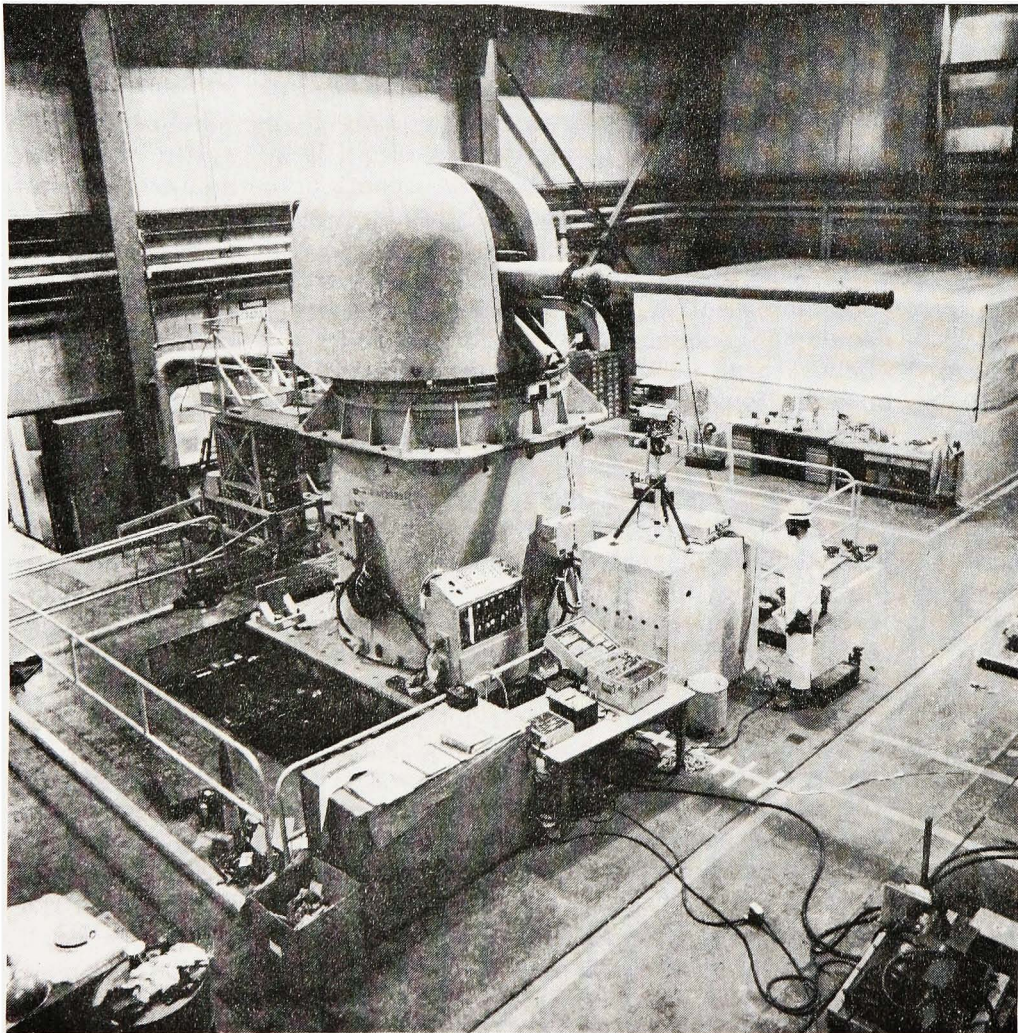


Fig. 6

**Biaxial Shock Test Machine
Testing an Item of Equipment
c. 1980**

Facilities. After an inspection on 16 December 1969, at which representatives of the Laboratory, Office of the Chief of Engineers, University, architect, and contractor were present, the facilities were declared acceptable, although a number of items were not completed. Representatives of the Office of the Chief of Engineers found that in general "the quality of construction was excellent [sic] and in accordance with our functional requirements." On 31 December 1969, the facilities were officially declared "suitable" for occupancy, and the rent was recomputed in accordance with the conditions of the lease at an annual rent of \$347,848, excluding the cost of utilities. Constructing the facilities cost the University \$3.5 million.²³

The Construction Systems Laboratory, the Materials Laboratory, and a small utility building were completed under Phase I of construction. The operating divisions were allocated 68,875 square feet of space. The executive and administrative offices, maintenance shops, warehouse, and storage were allocated the remaining 27,125 square feet.

During these early years, the facilities were considered adequate for the amount of research the Laboratory was assigned. There would have been no immediate need for additional facilities had it not been for the acquisition of the shaketable. Such a machine required a building with a foundation well above the average strength in order to withstand the table's powerful movements and vibrations. In 1970, Alfred J. Hendron Ph.D., of the University of Illinois conducted tests in the area occupied by the Laboratory to determine whether the land was capable of withstanding such severe pressure. The tests led to the conclusion that as long as the Laboratory operated within the ranges suitable for Safeguard studies, the shaketable could be safely housed in the existing high bay area of the Construction Systems Laboratory if shock isolated reaction masses were incorporated in the building. On the other hand, if the Laboratory was to employ the shaketable with oscillations that simulated earthquake phenomena, the vibration frequency introduced into the foundation would be more than it could sustain.²⁴

Another important consideration which favored placing the shaketable in a separate structure was the impact of such a machine on the surrounding work area. The University found that its own shaketable, which was smaller than the one proposed for the Laboratory, interfered with other tests being conducted in the same building. Moreover, the machine was noisy and annoying to the people in the nearby offices. After weighing the pros and cons, Townsley concluded that "because the costs do not seem to mitigate against a separate building and because of the desirability of flexibility in use for foreseeable future application of the machine, I favor a separate building."²⁵

Three possible locations for the shaketable were examined. One was to locate it inside the high bay area of the Construction Systems Laboratory. Placing the shaketable in that building would have required shock isolation reaction masses to minimize vibrations. This would have involved excavating to a depth of 30 feet under the foundation. Such an operation, plus accomplishing other necessary modifications to the building, would have made the cost almost prohibitive. A second possibility was to locate the shaketable in a separate structure adjacent to the Construction

Systems Laboratory. However, there was sufficient reason to believe that the structural safety of the existing building might be compromised. The third alternative was to locate the shaketable in a separate building about 300 feet east of the Construction Systems Laboratory. This site was the preferred one because it was sufficiently isolated from the existing structures to ensure their safety. Moreover, the construction costs would be far less than the other alternatives.

Colonel Townsley pushed his argument for a building entirely separate from the existing structures. The lease already contained a provision permitting the acquisition of an additional 15.2 acres and additional construction. The problem, however, was how to accommodate the added facility in the lease. Townsley proposed two alternatives: either the University could build the structure and increase the value of the property and the rent, or the Corps could pay for the building outright. He favored the former course. There was "one fly in the ointment," as he put it, and that was that the local building codes demanded brickfacing on its industrial structures. Since brickfacing was sensitive to vibration, this would not be feasible. A brick building could be strengthened, but this would be too expensive. The best solution, said Townsley, was to build a metal structure since this method would provide greater soundness and economy.²⁶

While Colonel Townsley was arguing for a separate building for the shaketable, he also believed that it was time to consider combining the proposed structure with Phase II of construction. When first planned in the Sixties, Phase II called for building a shop and warehouse and an administrative structure. The added office space would be welcome because the existing structures were designed for laboratories not offices. Townsley also felt that the Laboratory was getting crowded. While he expressed his views for more space, he was reluctant to take on additional rent in the overhead costs especially if the proposed facilities were not related to an operational capability. "For that reason," said Townsley, "I don't anticipate at this time asking for the administrative building unless somebody can assure us that our program is suddenly going to go sky high."²⁷

The tests conducted by Professor Hendron and supported by Colonel Townsley's strong arguments convinced the Office of the Chief of Engineers that a separate building was the proper course to take. In its request to the Chief of Engineers for permission to undertake negotiations with the University, the Laboratory suggested that the new building should consist of steel and interior partitions. The building was to be designed and constructed by the University of Illinois Foundation under the supervision of the University Architect.²⁸

No additional land was required to build the new structure since it would be located on the original 15.2 acres. Nevertheless, in September 1972 the Corps exercised its option to lease the other 15.2 acres on the north tract. This action was considered necessary if the Laboratory was to accomplish future construction. A supplemental agreement was then signed. The agreement allowed the Laboratory to lease the additional parcel of land and build a structure on the original 15.2 acres to house the shaketable.²⁹

The new shaketable building was to have a floor space of 4,500 square feet. The pump room was to be 288 square feet, and the office and instrumentation annex was to consist of 1,650 square feet. On 27 November 1973, with the shaketable in place, the new building was dedicated (Fig. 7). The MTS Corporation of Minneapolis, Minnesota, built the machine, using a design prepared by the Laboratory's Construction Systems Division, at a cost of \$2 million.³⁰

While some need was felt to begin Phase II of construction, there was no firm agreement on the need for an administrative building and warehouse. A study of the anticipated research program, which envisioned a greater effort in environmental research, precipitated a reevaluation of the total future building program. The choice now was whether to build the administrative building (consisting of an estimated 30,000 square feet) or to construct an environmental systems building (consisting of about 43,000 square feet). By the end of 1973, these alternatives were being seriously considered in relation to the costs and physical resources essential to continuing an effective research program. In either case, an additional building would have provided much needed space to house research personnel. If an administrative building was constructed, areas in the existing structures vacated by administrative personnel would have provided sufficient space for research personnel, but little practical space for equipment. On the other hand, a new operational building would have provided adequate space for both research personnel and equipment. By the end of 1973, the Laboratory had not decided which course to take.³¹

Funding: An Overall View. Colonel Reisacher described the Construction Engineering Research Laboratory during these early years as the "new kid on the block." The other, much older Corps laboratories were better established and funded. Funding was a constant problem in these early years since most research projects were initiated at the Laboratory; only a few projects were handed to it with appropriate funding from the Office of the Chief of Engineers and the Army's Chief of Staff for Research and Development.³² During this period, funding came from three sources: Research, Development, Testing, and Evaluation (RDT&E); Operations and Maintenance, Army (OMA); and Reimbursable Funds. The Army's Chief of Staff for Research and Development supplied RDT&E funding. OMA money came from the Office of the Chief of Engineers, and Reimbursable Funds were available to the Laboratory by other agencies, including the Corps' Divisions and Districts, for research and investigations accomplished for them. A fourth fund was added in Fiscal Year 1984 when the Office of the Chief of Engineers made available the Facilities Technology Applications Test (FTAT) Funds. This money was to encourage Army installations to employ the latest proven technologies in their maintenance procedures. The Laboratory accomplished this through demonstrations and workshops at which facilities engineers were present.

In Fiscal Year 1970, the Laboratory had a budget of about \$3.3 million; \$1.5 million of which was RDT&E money, \$0.5 million was OMA money, and \$1.3 million was in Reimbursable Funds. By Fiscal Year 1973, the budget grew to \$5 million; \$2.75 million of which was RDT&E money, \$1.25 million was OMA money, and \$1 million was in Reimbursable Funds. Except for Fiscal Year 1972, the first 5 years reflected a steady growth in the amount of money which the Laboratory was able to acquire (Table 8).

In Fiscal Year 1972, CERL experienced a slight decline in Reimbursable Funds largely because it had completed projects originally assigned to ORDL. Meanwhile, CERL had not yet developed to the point where customers were seeking its help. In succeeding years, however, as the Laboratory's reputation became more widely recognized, it was able to enjoy a steady growth in these funds.³³

By the end of 1973, there were indications that funding would continue to grow at a fairly rapid rate. The growth in environmental and energy research was largely responsible for this increase. It was obvious to many that environmental and energy research would absorb much of the research dollar in the future.³⁴

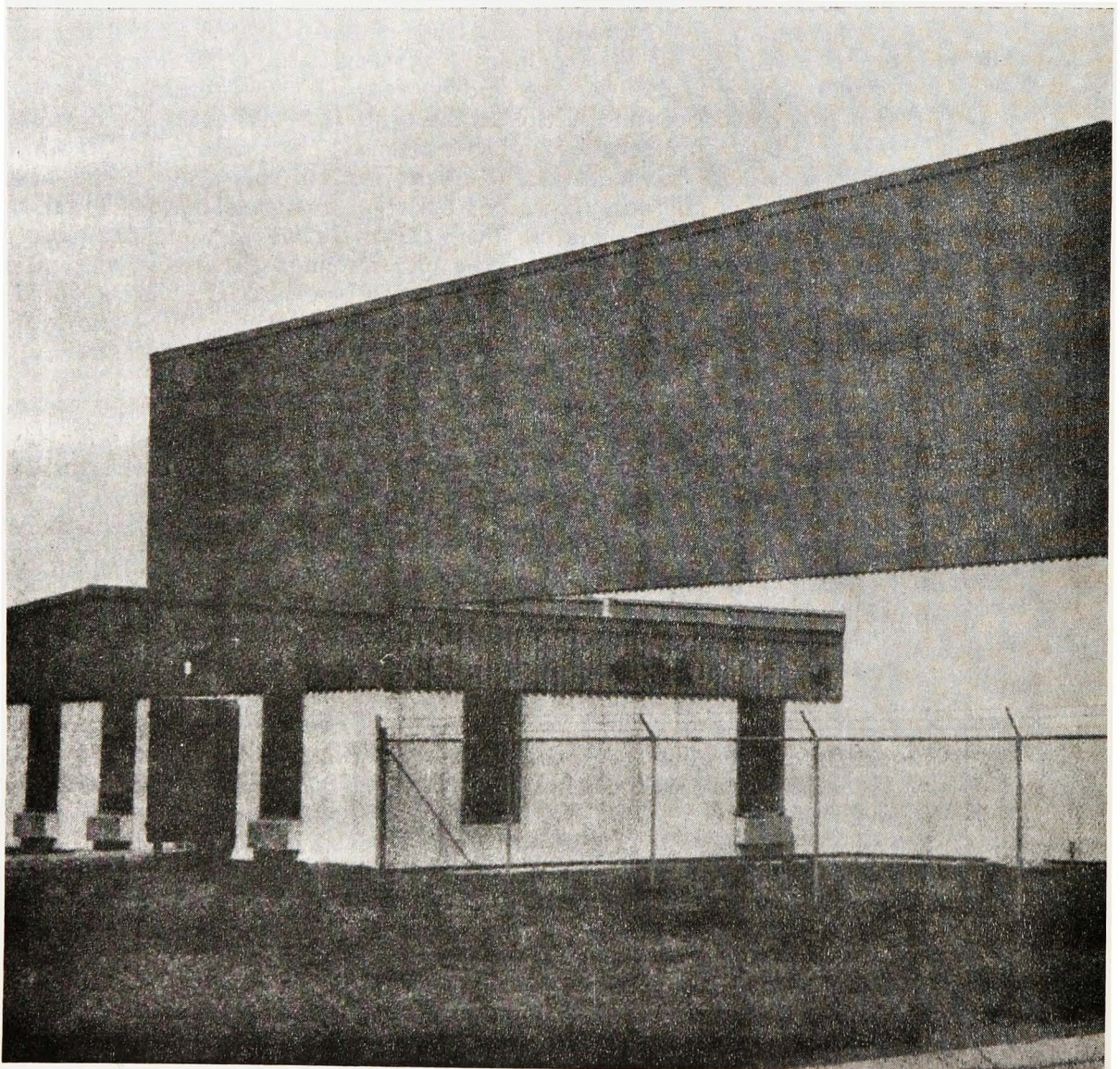
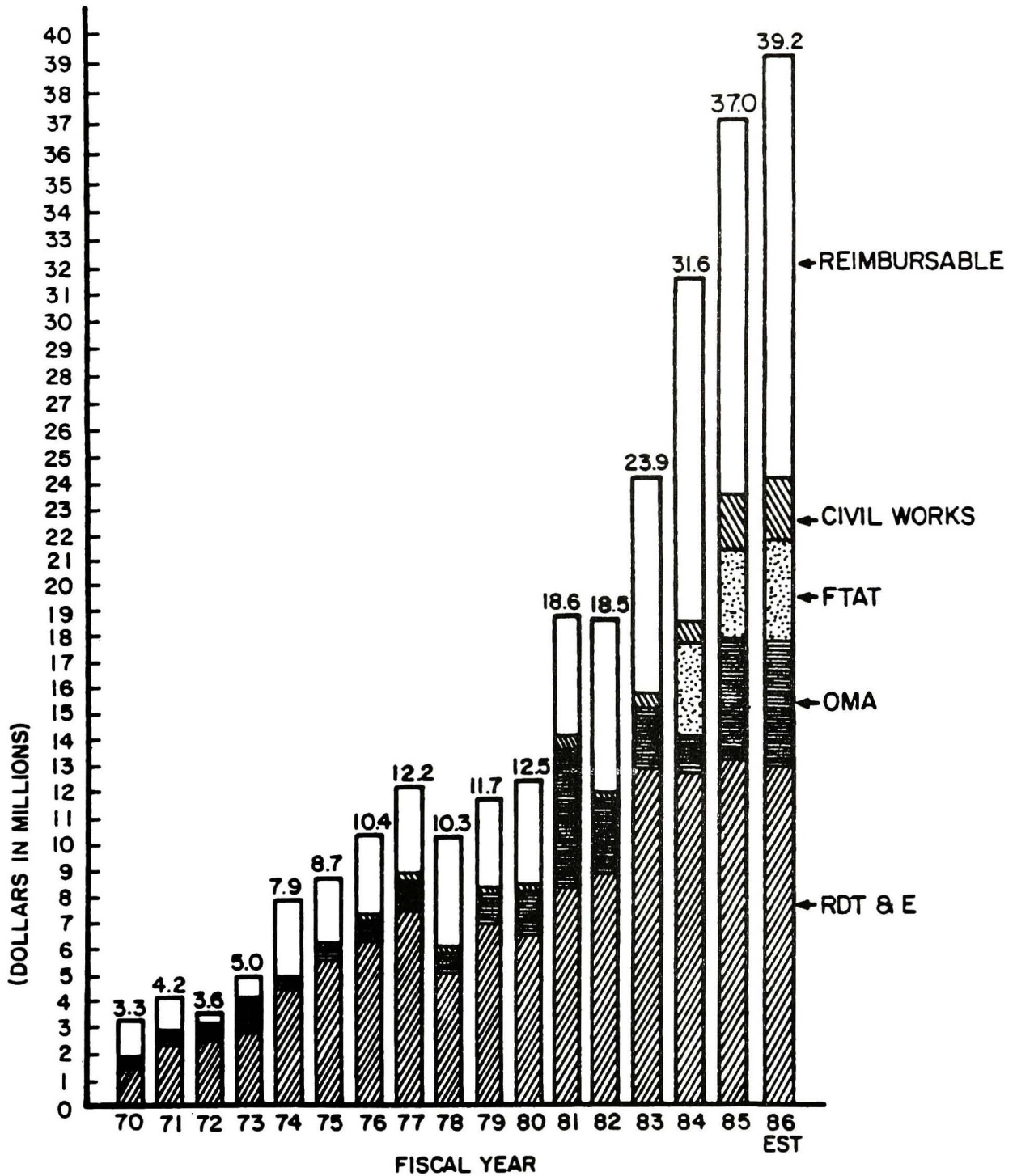


Fig. 7

**Shaketable Building
c. 1973**

Table 8

CERL Funding Summary, FY 1970 Through FY 1985



Relations With the University of Illinois and Other Agencies

Once the problems generated by the new lease and construction were settled, relations with the University of Illinois were good. Even before the Laboratory had settled into its new quarters, Colonel Cox had taken the initiative to begin a graduate assistantship program, a move that was readily approved by the University. While the official position of the University towards its military affiliate was favorable, the same could not be said for some of the University's faculty and student body. The Vietnam War protests of the Sixties and Seventies had boiled over onto the University campus, and some loud criticisms protesting the University's involvement with the new Laboratory were voiced. Strong resentment was expressed by this vocal group, who feared that any affiliation with the military complex might influence the type of research conducted by the University. Others at the University believed that these fears were unfounded, and argued that, on the contrary, such a relationship might have a salutary effect because the University could bring its civilian influence to bear on the military's research program rather than the other way around.³⁵ Arguments such as these did not prevail, however. One pamphlet issued in 1972 by the protesters denounced the association in these strong words:

War Criminals On Campus Dept.

Who designs the reinforced concrete runways that land those C-5A's and other heavy aircraft bringing anti-personnel weapons to Vietnam? It's Champaign's very own Construction Engineering Research Laboratory. An institute run by the U.S. Army Corps of Engineers, CERL's own publicity brochure proudly details its operations. They have over a hundred employees including department heads, associate deans, and professors from this University helping them do the engineering and computer work for Vietnamization.

Off CERL! Demand that the University end all ties with the military now!³⁶

These strong feelings did not last very long, nor did they affect the official relations of the University and the Laboratory in any way, although there may have been some uncomfortable moments.

Colonel Reisacher attributed much of the good relations with the University to the Laboratory's Technical Director, Dr. Shaffer, who had been on the faculty of the University for many years before coming to the Laboratory. Shaffer's close ties with the school helped to ease the way towards many cooperative ventures. As an affiliate of the University, the Laboratory provided funds for qualified graduate assistantships, giving students the opportunity to complete their academic programs while engaged in productive research in their fields of specialization. The association between the two institutions also permitted Laboratory personnel to extend their research opportunities by working on advanced degrees and postprofessional education.

The affiliation mutually benefitted the University and Laboratory, allowing them to share specialized equipment and instrumentation, and providing an opportunity for University experts and consultants to assist in Laboratory research. This arrangement allowed for a greater return on funds expended by each affiliate. The large computer center at the University was very useful to the Laboratory, especially during the first years when the Laboratory lacked computer equipment.

Several graduate students and members of the faculty divided their time between the University and the Laboratory. Colonel Reisacher found this arrangement good for the Laboratory, especially when a specialist of one discipline or another had to be consulted on short notice. To accommodate this personnel exchange, Reisacher instituted flex-time, enabling his staff of professionals to adjust their hours to the University consultants' hours.³⁷

On matters pertaining to facilities and administrative affairs common to both organizations, the Laboratory's staff met infrequently with the University. Looking back in later years, Reisacher felt that in this respect, representatives of both institutions could probably have met more often.³⁸

The Laboratory did not limit itself solely to the expertise available at the University of Illinois, although at first this may have been the case. It also attempted to reach out to other universities, research institutions, and private industry for assistance. However, the University of Illinois remained the major support for the Laboratory in research matters if only because it was within easy reach.

Relations with other Corps, Army, Air Force, Navy, and nonmilitary government agencies were good. Some rivalry and competition existed between the Laboratory and WES since the early days when the Laboratory was first established. When the proposed new Laboratory was being discussed, OCE's Directorate of Civil Works wanted WES to assume the new functions. As the oldest and largest of the Corps laboratories, WES had both the experienced personnel and the testing facilities essential to carry on a research program. The Waterways Experiment Station had been busy for years with extensive studies in asphalt pavements, while the Ohio River Division Laboratory had been involved with studies on concrete pavements. When ORDL was discontinued, CERL assumed the concrete pavement research. This created resentment because WES felt that it had the capabilities to carry on this research. This attitude was further aggravated when CERL, lacking the necessary testing equipment, resorted to using WES's testing facilities. Later, as CERL assumed greater responsibility and more research projects in which both it and WES were involved, the latter wished to be the lead laboratory. However, in two such instances--modelling combat engineering and environmental studies--CERL was able to retain its status as the lead laboratory.³⁹ See Appendix 2 for a list of investigations which the Civil Works program might support at the new laboratory.

While the major portion of the research program came from the Office of the Chief of Engineers through the Directorate of Military Construction, the Laboratory was unable to break into the Corps' Civil Works Program. In fact, after the Laboratory completed its work on

ferrous concrete, the Waterways Experiment Station was able to convince the Chief of Engineers, through his Civil Works Directorate, to assign future work to them since the concrete form had a paving application. The Laboratory did establish liaison with Air Force and Navy research facilities and with the Army's Chief of Staff for Research and Development. This proved to be worthwhile. During Reisacher's tenure, the directors of the Navy and Air Force laboratories met with the Corps' laboratory directors at different intervals to exchange information on projects that were in progress. Each laboratory would host a meeting for 1 or 2 days. These meetings improved relations between the agencies and helped to avoid any duplication in research.⁴⁰

The Research Program

Managing the Research. The Construction Engineering Research Laboratory was involved in three categories of research. One category was long-range research and investigation into military construction. Long-range research was a major reason for the Laboratory's establishment. Another category was research designed to find immediate solutions to the construction problems of other Corps organizations, especially those encountered by divisions and districts. This ad hoc approach was common in the Ohio River Division Laboratory. The new Laboratory was to continue this function. Finally, the third category was reimbursable funding research, which was sponsored by military or civilian agencies. This could be long-term or short-term research and was limited to projects which had some application to military construction. Essentially, the reimbursable funded work was not available elsewhere and expanded upon and complemented the research and development efforts.⁴¹

The broad mission of the Laboratory was to support the military construction mission of the Chief of Engineers. This meant that the Laboratory could be involved in the entire spectrum of military construction activities, including engineering, design, construction management, organization costs, materials, and construction techniques. There was no limit to the kind of problem the Laboratory could undertake, if by doing so, the military construction mission was advanced. The Laboratory's responsibilities included both basic research and investigations into current operational problems.

Shortly after the Laboratory was established, the fear persisted that the organization would not get enough research projects to justify its existence. This fear soon proved to be unfounded. As early as January 1970, prospects for research were good. The problem was whether the Laboratory's facilities and equipment were adequate enough to fulfill its commitments. Research in antiballistic missile facilities, including the Safeguard Antiballistic Missile System, and nonmilitary areas, such as those projects sponsored by the Department of Housing and Urban Development, were anticipated. This research was looked upon as favorable for the years ahead.⁴²

As the years progressed, the Laboratory's research capabilities were increasingly sought by various elements of the Department of Defense and other nonmilitary agencies that dealt in vertical construction. By 1973, as

many as 21 Federal agencies had requested the Laboratory to conduct research for them on a reimbursable basis. Table 9 shows the names of these agencies and the kinds of research conducted for them by the Laboratory.⁴³

The operating divisions and their predecessors were responsible for work in 13 major program segments of the Corps Research and Development Program. These segments centered around the major functions of the Military Construction Program. Three segments were associated with planning, two with architecture, five with engineering, two with management, and one with maintenance. In three of these segments, the Laboratory was the sole research organization in the Defense Establishment performing work that was related to vertical construction. These major segments were habitability, industrialized construction, and optimization of construction management. In other segments, such as the Army Functional Component System, fabrication technology, material synthesis, military engineering management, and the Military Construction Automated Information and Retrieval System, the Laboratory was the sole research organization in the Department of the Army. In some of the other segments, the Laboratory performed work as a secondary organization while another laboratory was the lead laboratory. In segments like Pavement Systems Management, the Waterways Experiment Station was the lead laboratory. In Nuclear Construction, the Directorate of Military Construction was program manager. However, in segments such as environmental quality management and environmental quality in construction and manufacturing, the Construction Engineering Laboratory was the lead laboratory and program manager. These two segments constituted one-third of the total environmental research program conducted by the Department of the Army; the rest was the responsibility of the Surgeon General and Army Materiel Command.⁴⁴

The Office of the Chief of Engineers created Technical Monitors whose purpose was to establish priorities for research projects and to prevent duplicate research by Corps laboratories. Laboratories were sometimes competitive, and were often accused of attempting to establish their own priorities. The Technical Monitors were usually staff engineers with a special expertise who had the responsibility of preparing technical manuals and guide specifications. Together with the OCE directorates, Technical Monitors used established guidelines to determine what research was to be performed at laboratories. Since Technical Monitors dealt directly with Corps Divisions and Districts, they knew exactly what research was needed. Each unit of research and investigation was identified with a principal investigator at CERL and a Technical Monitor at OCE. This strong link between the two provided some assurance that CERL was producing what was required by the Chief of Engineers. Eventually, Technical Monitors played a major role in technology transfer.⁴⁵

During the early years, CERL felt some resentment towards Technical Monitors. Researchers felt that monitors were often too restrictive in fostering their guidelines upon them, but this attitude gradually gave way to full acceptance.⁴⁶

Table 9

**Sources of CERL Reimbursable Funding
by Major Program Segments**

Major Segment	Source*
<u>Planning</u>	
Environmental Quality Management	- DSCLOG, DSCPR, SAD, NASA
Pavement Systems Management	- AFWL, SAC (WES), FAA
Army Functional Component System	OCE
<u>Architecture</u>	
Habitability	- NATICK, TSA, NCD, OCE
Industrialized Construction	- OCE, Post Office
<u>Engineering</u>	
Nuclear Construction	- ABMDA, HND
Fabrication Technology	- LMVD, OCE
Material Synthesis	- AMMRC, ARO
Environmental Quality: Construction & Manufacturing	- SWD, SAD, MRD, NAD, NCD
Field Army Systems	- CDC
<u>Construction Management</u>	
Optimization of Construction Management	None
Military Engineering Management	None
<u>Maintenance</u>	
Military Construction Automated Information and Retrieval System	- HND, OCE, 5th Army

*Key to Symbols

ABMDA - Anti-Ballistic Missile Defense Agency (USA)	FAA - Federal Aviation Administration
AFWL - Air Force Weapons Laboratory (Albuquerque, New Mexico)	HND - Huntsville Division, CE
AMMRC - Army Materials and Mechanics Research Center	LMVD - Lower Mississippi, Valley Division, CE
ARO - Army Research Office	MRD - Missouri River Division, CE
CDC - Combat Developments Command	NAD - North Atlantic Division, CE
DSCLOG - Deputy Chief of Staff for Logistics	NASA - National Aeronautical and Space Administration
DCSPER - Deputy Chief of Staff for Personnel	NATICK - Natick Labs
	NCD - North Central Division, CE
	OCE - Office, Chief of Engineers
	SAC - Strategic Air Command
	SAD - South Atlantic Division, CE
	SWD - Southwestern Division, CE
	TSA - Troop Support Agency, USA
	WES - Waterways Experiment Station

Projects. During the Laboratory's first year, most of the research was on pavement design and power reliability programs.⁴⁷ However, in time the Laboratory became involved in a variety of projects. The greatest change was the gradual but sustained emphasis placed on environmental and energy research. From what might have been a negative approach to environmental research--research that was aimed more at protecting the military and its housing from the effects of a hostile environment--the Laboratory was, by 1973, moving towards a more positive approach aimed at finding solutions to air and water pollution and making military housing and working conditions more attractive. Similarly, early energy research had concentrated on efforts to provide more power to the Army, but by 1973, energy research was beginning to move in the direction of avoiding waste and conserving energy. In the wake of a national concern for the environment and energy, the Corps saw a strong need to provide more generous funding and research in these neglected areas.

The diversity of disciplines in the Laboratory proved to be one of the biggest factors which led several military and nonmilitary agencies to seek its advice. One example of this was the very impressive nondestructive welding test program conducted by the Laboratory which attracted work from customers of the various military agencies. The Laboratory also had a small but dedicated group of acoustical engineers who experimented with electromagnetic screening devices on sound problems encountered by Corps districts in their special construction projects (Fig. 8). Not only did the Laboratory find satisfied customers in this research, but by taking on such work at frequent intervals, it was able to bring relief to a budget that was sometimes restricted.⁴⁸

Some of the research projects the laboratory was involved in during its first 5 years received national acclaim. In its first year, the Laboratory successfully applied its systems approach to problems dealing with rigid airfield pavements, troop construction in theaters of operation, military family housing, and the Safeguard Antiballistic Missile System. Research in airfield pavement resulted in a major breakthrough. Prototype pavement sections were traffic-tested at an accelerated rate of speed with a 12-wheel landing gear from a Lockheed C-5A aircraft. The C-5A had a gross weight of three-quarters of a million pounds. While plain concrete sections designed with existing criteria deteriorated after only 700 passes of the C-5A simulator, the fibrous concrete section developed by the Laboratory, consisting of only half the thickness of the ordinary concrete, showed only limited signs of deterioration after 1,800 passes. Fibrous concrete was a composite material containing a random dispersion of small fibers. The fibers acted as crack arrestors, preventing flaws in the concrete from enlarging while under stress and ultimately causing cracks and failure. The life of the pavement was therefore extended by retarding its deterioration. Fibrous reinforced concrete was used in applications besides pavement: revetments along the Pacific shoreline, surfacing for a pier in Oakland, California, and roofs and floor slabs at the Libby Dam in Washington State.⁴⁹

The use of reinforced concrete led the Laboratory to explore the possibilities of using it in inflatable construction. An Italian engineer had already patented a form of concrete reinforced with a system of bars. The concrete was then placed over a membrane which was subsequently inflated,



Fig. 8

Environmental Acoustic Team Monitoring Noise

causing the concrete to cure in the shape of a dome. This process, which was used in Europe and Saudi Arabia, was called the Bini Dome after its inventor. Using the same principles as the Bini method, the Laboratory studied using this concrete on inflatable structures for battlefield purposes. Unfortunately, because of a misunderstanding, the Italian inventor accused the Laboratory of infringing upon his patent. Before bringing a suit against the Laboratory, the inventor was invited to Champaign where he was convinced that the Laboratory was using a different type of reinforced concrete than the one he had patented. His suit was dropped. Meanwhile, the Laboratory did enjoy some success in inflating small (12 feet in diameter) domes covered with concrete.⁵⁰

The Laboratory's research in habitability was a significant contribution to military construction. As a pioneer in habitability research, the Laboratory was able to develop criteria making the interior designs of Army facilities compatible with the desires of its troops. Turning its attention to the needs of the Volunteer Army, the Laboratory found that as many as 35 percent of reenlistments could be encouraged by attractive and convenient living quarters and that productivity could be improved as much as 40 percent with a more pleasing office environment. The information derived from this research was used in designing family housing and offices at Army posts in North Dakota and Montana. Studies undertaken to improve dining halls lead to significant changes in designs. Based upon these investigations, the Laboratory prepared an interior decor catalog for the Troop Support Agency and the Office of the Chief of Engineers.⁵¹

The Laboratory also conducted pollution abatement studies at Rock Island Arsenal, Illinois, Holston Army Ammunition Plant, Tennessee, Louisiana Army Ammunition Plant, Louisiana, Red River Army Depot, Texas, Fort Bragg, North Carolina, Watervliet Arsenal, New York, and Letterkenny Army Depot, Pennsylvania. The Laboratory, together with other governmental agencies, including the Environmental Protection Agency and state and local authorities, conducted a comprehensive research program in water and air pollution, solid waste disposal, and noise abatement. The research ranged from developing design criteria for specific projects to developing the hardware essential to meet "zero-pollution" goals by the mid-1980s. The problems being attacked were unique to Army industrial, manufacturing, and construction operations, as well as theater of operations facilities. One major area of study was developing and designing criteria for waste water treatment, controlling nitrogen oxides, and sludge disposal at Army Ammunition Plants. The criteria provided by CERL met all current Federal and state standards at a savings of about \$3 million.⁵²

In the area of noise abatement, CERL developed a computer-aided noise prediction method to provide base planners with contour plots of noise from such sources as artillery firing, vehicles, and aircraft.⁵³

Other important research projects undertaken by the Laboratory were the development of the Biaxial Shaketable, already mentioned, a turbo-alternator system for antiballistic sites, a Ballistic Missile Division Vulnerability Manual, an electromagnetic protective shielding for conduits, a catalog of prefabricated buildings that were retrievable and relocatable, and a fabric for river mats for the Directorate of Civil Works.

Research on river mats produced very interesting results. As many as 600,000 concrete mattresses were used each year as revetments on the Mississippi River to stop the waters from eroding the banks, cutting new channels, and flooding large areas of land. Because of the need for extended corrosion resistance, copper-clad steel was used to reinforce the revetments, but the shortage of copper had driven up the price of manufacturing the mattresses by 65 percent since 1963. The Laboratory's Materials Division conducted investigations to determine the feasibility of using less costly metals and reinforcement designs. The investigations resulted in using stainless steel alloy in the mattresses at a savings of \$500,000. Future tests in this area anticipated further cost reductions of as much as 25 percent.⁵⁴

Because of the nature of the Laboratory's research, its output was measured in terms of cost savings, that is, in getting more construction for the dollar and in reducing the costs of professional services needed to plan, program, procure, and maintain the constructed facilities. Since these savings were not reportable in the usual manner, as was the case in Corps Divisions and Districts, the Laboratory's output was passed on to the customer, benefitting them rather than the Laboratory. There were several examples of cost savings for which the Laboratory was responsible. Table 10 reflects these savings in major research projects accomplished.

Reporting the Research. The research accomplished by the Laboratory was usually published and disseminated through reports, symposia, computer programs, short courses, and technical manuals--all of which were made available to the interested public through the Defense Documentation Center at Cameron Station, Virginia. In addition, the Laboratory issued a quarterly publication which highlighted the status of current work, listed recently published reports, and presented professional news about the staff.

Table 10
Cost Savings in Research⁵⁵

Projects	Savings	
Automated Construction Reporting	\$150,000	(annually)
Pollution Control	\$2,800,000	
Safeguard Testing Support	\$50,000	
Fibrous Concrete	\$7,750,000	
Industrialized Building	\$40,000,000	(annually)
Habitability	\$5,700,000	(annually)
Ballistic Missile Division Systems	\$1,000,000	(per site)
Computer Based Specifications and Airfield Pavements	\$6,500,000	(annually)
Life-1 Computerized Design for Airfield Pavements	\$1,000,000	(annually)
Automated Integrated Facilities System	\$3,500,000	(annually)
River Mats	\$500,000	(annually)

By the end of 1972, the Laboratory had published 64 reports (Appendix 8). Eighteen other reports were in the final stages of publication (Appendix 9). Of the 46 reports carried over from the Ohio River Division Laboratories, 20 were completed, 7 were in the process of completion, and the remainder were either consolidated with other reports or were not selected to be published (Appendix 10).⁵⁶

Soon after Colonel Reisacher arrived at the Laboratory, he became convinced that the research publications were not effectively serving their purpose. He believed that too many researchers were writing reports in language that many people in the field did not understand. "After all," said Reisacher, "those were the people for whom we were working, not other Ph.D.s at the University of Illinois." He felt that the reports were too technical, complex, and scholarly to be understood by people in the field. He realized that scholarly reports were unavoidable and indeed necessary in an agency like the Laboratory, but he felt that there was latitude in these technical publications for providing a thesis which could be understood by a wide audience.⁵⁷

Assessing the Research Program

The Construction Engineering Research Laboratory was a unique organization established at a time when government agencies dealing largely in building construction research were unheard of and were therefore looked upon with some puzzlement. Without precedents, many people both inside and outside the Corps found it difficult to gain a clear picture of what such a research laboratory's capabilities might be. The Laboratory's charter was quite emphatic in delineating its responsibilities. Its mission covered the entire spectrum of military construction, including engineering, design, construction management, organization, fiscal matters, procedures, materials, and techniques. There was no limit to the kind of problem it could engage in. The Laboratory was to conduct both long- and short-term research. It was to engage in basic research and research related to operational matters. It was not to duplicate basic research undertaken by the private sector or other government agencies, but it was to be aware of and take advantage of the research accomplished by others.⁵⁸

Undertaking these responsibilities was no small matter for a young organization with little experience. Neither the Laboratory nor the Office of the Chief of Engineers was completely certain that the Laboratory was on the right course. Early in 1970, the Office of the Chief of Engineers was quite concerned that project costs were accumulating without commensurate progress in engineering results.⁵⁹ Such a feeling was understandable at this early stage of the Laboratory's development. Nevertheless, it did arouse concern.

Some of the difficulty rested with the nature of the Laboratory. Its research was spread out in many directions, covering the entire building industry. In one way this was a benefit since the "sky was the limit of imagination." On the other hand, this was also seen as a drawback because the research was so widespread that it would take years for the Laboratory to be recognized as an expert in any one particular field. This problem did not exist in the Waterways Experiment Station or the Cold Regions

Research and Engineering Laboratory, since both laboratories had a limited mission and customers with extensive research budgets.⁶⁰ To compete with these older laboratories for the limited research funds, CERL frequently concentrated its efforts on short-term research that was of immediate concern to the customer, to the exclusion of some long-term research. The Laboratory benefitted from this short-term research because funding was quickly available. Moreover, this research was appreciated because the results were quickly realized. The immediate research problems convinced the sponsors to develop a research program. Consequently, a lower priority was placed on long-term research.⁶¹

It soon became evident that such an imbalance in the research program was contrary to the Laboratory's mission. After all, a major reason for the Laboratory's existence was to satisfy the Army's long range needs; to do otherwise would defeat its purpose. In 1973, the publication of the Five Year Research and Investigation Plan for Fiscal Years 1974 through 1978 was designed to rectify this problem and to place greater emphasis on long-term research. In speaking of the need for research that would solve future construction problems, the plan said:

To fulfill the CERL mission and achieve the long term goals, the research program must focus on future problems in military construction. The current program development procedures are not attuned to the identification and definition of the future problems in military construction. As a consequence the majority of research and investigation activities address immediate problems which do require solution, but do not necessarily require research to obtain the solution. The sustaining research program sponsored by the Operating Directorates in OCE should be developed on the basis of military and construction industry forecasts.

In recognizing the need to correct this imbalance, the Chief of Engineers created a Military Construction Board of Directors which was to meet annually to define and review the Corps' role in future military construction and the research that was needed to achieve this goal. The board was to provide the technological forecasts to identify the long-term research needed to produce the methods, techniques, and materials which would meet future military construction requirements. The projects were expected to shift from short-term to long-term research, although it was clearly recognized that the investigation of immediate problems would never be entirely eliminated.⁶³ The future alone would show how well this plan would operate at the Laboratory. The problem was more easily recognized than corrected.

While this matter was being carefully explored, the Office of the Chief of Engineers asked questions about the very nature of the research at the Laboratory. At a meeting held at OCE in September 1972, the question "Is CERL producing what we want?" was bluntly raised. In the presence of Colonel Reisacher and Dr. Shaffer, Lieutenant General Frederick J. Clarke, Chief of Engineers and earlier a staunch supporter of the idea of a construction laboratory, expressed deep concern about whether the Laboratory was fulfilling its mission. In referring to the results of a housing survey conducted by the Laboratory, Clarke stated that the survey contained information which could have been intuitively recognized by the

people designing family housing. He did not feel that the study produced any new information for the designer. Clarke also questioned both the effort that went into composing data banks and their usefulness. He was also concerned that he did not see more evidence of work on three important areas of military construction: (1) types of structures that the Corps should be planning for theaters of operation for the next emergency, (2) kinds of structures needed to accommodate troop and administrative buildup in the next mobilization, and (3) guidelines that should be followed to accomplish future permanent construction.⁶⁴

Not everyone agreed with General Clarke's position. Many at the conference believed that the housing studies did serve a useful purpose. A statistical approach to an investigation of housing needs revealed much information about the desires of the military family. This data could confirm what may have already been suspected and was therefore effective in presenting arguments before the Department of Defense and Congress when requesting housing changes and funds. Insofar as data banks were concerned, many felt that there were two types. One contained data collected to establish a statistical base which would provide reliable and available answers needed by the engineer. This system was useful because it reduced the difficult and time-consuming task of collecting data for individual projects. The second type of data bank contained specific information which could be quickly and conveniently recalled by the customer. Many, including Dr. Quarles, Chief Scientific Adviser, thought that this was a feasible type of data bank, but there were doubts about the cost effectiveness of using computers. General Clarke remained unconvinced that such data banks were a cost effective activity, and the question was left for future study.⁶⁵

Others agreed with General Clarke's position that although some research was being done by the Laboratory in the three areas of construction he had enumerated, not enough was being accomplished. They believed that the Office of the Chief of Engineers should prepare proper guidance to insure that the Laboratory would develop adequate research programs in the three areas.⁶⁶

Other questions raised at this meeting cast doubts on the relevance and adequacy of some of the research accomplished by the Laboratory. To what extent was the Laboratory engaged in basic research which produced new information as opposed to activities concerned with collecting, integrating, and analyzing technology produced by others? Everyone at the meeting realized it was important to know what research was going on in other areas. The question that remained unanswered was whether there was a minimum ratio of new work that should be undertaken as compared to investigations performed by others.⁶⁷

A final question raised at the conference concerned the Technical Monitors employed by the Office of the Chief of Engineers. Although there was general agreement that the monitoring system was working well, some people expressed concern that the system may have placed too much OCE control over the Laboratory. This question also remained unanswered, but the consensus was that the matter should be tested in the future.⁶⁸

Raising these doubts was a healthy and natural outcome of management's policy review. The 5-year period was, after all, an experimental one; a time when the Laboratory was going through some growing pains. It was proper for the Chief of Engineers to raise such questions. Quarles and Shaffer were inclined to think that General Clarke's criticisms seemed unjustified. Clarke had been a strong supporter of CERL before and after its establishment, and it may be that he held expectations for the new Laboratory that were more than realistic. The Construction Engineering Research Laboratory had performed its research in close cooperation with OCE and according to OCE's guidelines. If there were any weaknesses in the quality or kinds of research CERL was doing, OCE would have to share part of the blame. Moreover, much of the research in military construction which Clarke criticized CERL for not undertaking had not been assigned to the Laboratory.⁶⁹

The September 1972 meeting did not result in any major changes in the research undertaken at CERL. The Laboratory continued to perform as it had in the past, although its responsibilities were clearly broadened. As 1973 came to a close, few could dispute the Laboratory's main research accomplishments. Like Colonel Reisacher, one could conclude that CERL had indeed "overcome some of the growing pains that are associated with . . . establishment."⁷⁰

ACCEPTANCE AND GROWTH: 1974-1985**Commanders/Directors**

In November 1973 Colonel Reisacher retired, and Dr. Shaffer served as Commander/Director until 11 July 1974 when Colonel Melvin D. Remus (Fig. 9) assumed command.¹ Remus was introduced to CERL in the early Seventies while he was a research coordinator for engineering laboratories in the Army's Office of the Chief of Research and Development. In 1976, Colonel Remus was reassigned to the Detroit District as its District Engineer, and Colonel James E. Hays (Fig. 10), who held that position, became Commander/Director of the Laboratory. Colonel Louis J. Circeo, Jr. (Fig. 11) took over the command of the Laboratory in August 1979 after a tour of duty with the Nuclear Plans Section, Operations Division, of the Supreme Headquarters Allied Powers Europe (SHAPE). Colonel Circeo had the longest tenure of any Commander/Director of the Laboratory, commanding CERL until August 1983 when Colonel Paul J. Theuer (Fig. 12) assumed command. Colonel Theuer came from the Office of the Chief of Engineers where he served as Assistant Director of Engineering and Construction.

CERL commanders had very similar educational backgrounds, and their military experience was very broad. Their appointments to CERL were based upon similarities in background that were considered important to such an assignment. Some were chosen because at one time or another they had had dealings with the Laboratory or the University of Illinois. Townsley, for example, received his Doctorate at the University of Illinois, and he was acquainted with many members of the faculty. Remus, who had worked in the Army's Office of Research and Development, and Circeo, who had been Research and Development Officer of the Defense Nuclear Agency, understood problems in research and development. Remus was able to learn much about CERL's mission and its relationship to other Corps laboratories before joining the Laboratory.

Other commanders were selected because they had been District Engineers or facility engineers at one time as in the case of Reisacher and Hays. The Office of the Chief of Engineers believed that by selecting these men, CERL would gain a greater understanding and appreciation for the problems of the field. Colonel Theuer's previous assignment in the Office of the Chief of Engineers made him an excellent candidate to head CERL.



Fig. 9

**Col. Melvin D. Remus
Commander/Director
1974 to 1976**

Colonel Remus was a graduate of the U.S. Military Academy. He had a Master of Science Degree in Civil Engineering from Iowa State University, and he was a graduate of the Command and General Staff College and the Army War College. At one time he commanded the 84th Engineer Battalion in Vietnam.



Fig. 10

**Col. James E. Hays
Commander/Director
1976 to 1979**

Colonel Hays graduated from the U.S. Military Academy in 1954. He had a Master of Science Degree in Civil Engineering from the University of Illinois, and he was a graduate of the Command and General Staff College and the Army War College. He served in an Engineer Construction Battalion in Vietnam and in Headquarters, U.S. Army, Republic of Vietnam.



Fig. 11

**Col. Louis J. Circeo, Jr.
Commander/Director
1979 to 1983**

A graduate of the U.S. Military Academy, Colonel Circeo received a Masters Degree in Soils Engineering and a Ph.D. in Civil Engineering from Iowa State University. He attended the Armed Forces Staff College and was a registered engineer in the District of Columbia. Circeo held several posts, among them being Commander of the 20th Engineering Battalion (Combat), Research and Development Officer of the Defense Nuclear Agency, Company Commander in the 809th Engineer Battalion (Construction) in Thailand, and Engineer Adviser to the 11th and 101st Airborne Divisions in Vietnam.



Fig. 12

**Col. Paul J. Theuer
Commander/Director
1983 to 1986**

Colonel Theuer received a Bachelor Degree in Civil Engineering from Iowa State University and a Masters Degree in Engineering from Pennsylvania State University. He was a graduate of the Command and General Staff College and the Army War College, and he was a registered engineer in the District of Columbia and the State of Maryland. Theuer held several positions during his career, including Commander of the 808th Engineer Battalion (Construction), Chief of Operations in the U.S. Support Command in Vietnam, Commandant of Cadets and Director of Instruction for the Corps of Cadets at Pennsylvania State University, ROTC, Executive to the Deputy Chief of Staff, Engineer, at Headquarters, U.S. Army Europe (USAREUR), and Washington's representative for the Commander-in-Chief, USAREUR.

Organization

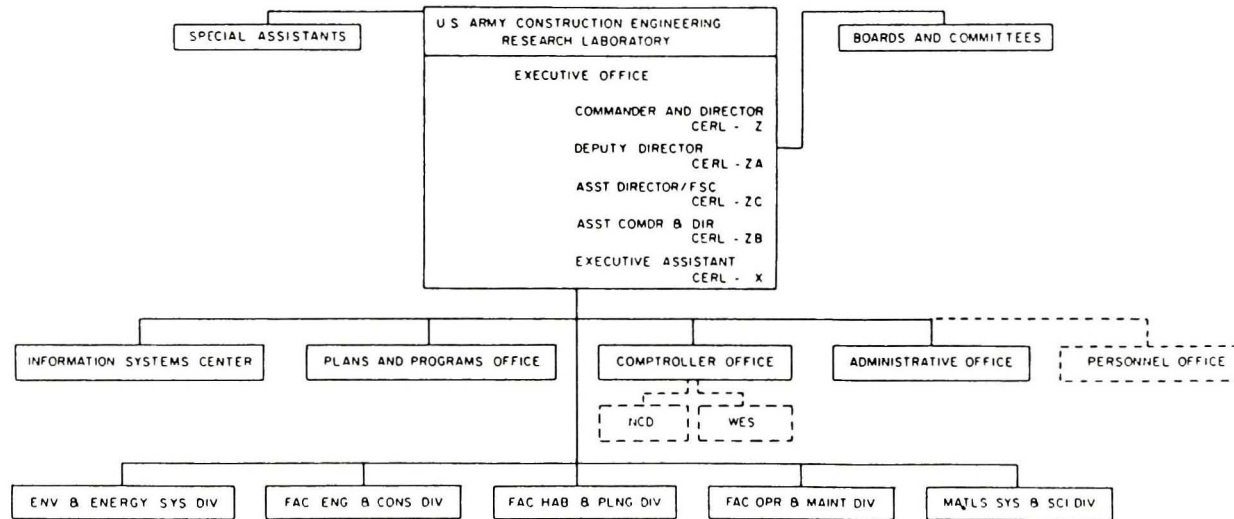
In 1974, the Laboratory was removed from the staff supervision of the Directorate of Military Construction and placed under the Directorate of Research and Development.² Dr. Shaffer joined CERL as the Assistant Director in 1969. In 1970 his title was changed to Deputy Director, a Senior Executive Service Position, but as in his previous appointment, he continued to be responsible for the technical program. In 1976, an additional military officer was assigned to the Executive Office as the Deputy Commander and Director. He was given some of the responsibilities which the Commander/Director and Dr. Shaffer had managed previously, specifically the support organizations except the Plans and Programs Office and the Comptroller Office, which Dr. Shaffer maintained. In 1978, Shaffer's title was changed to Technical Director/Deputy Director more accurately reflecting the responsibilities of his position.

The study group appointed by Colonel Reisacher in 1973 to evaluate the organization of the Laboratory concluded that because of the uniqueness of the mission, no one organizational plan would entirely eliminate jurisdictional disputes. On the other hand, the nature of the ever-expanding research program demanded that the Laboratory be always ready to alter its organization to meet new challenges. Flexibility and readiness to make changes were imperative. The study group recommended that a reorganization was essential to reduce jurisdictional disputes. Some division chiefs resisted major changes because they believed it was not always easy to meet constantly changing requirements while providing their people with a clear pattern of growth and development.³ They were concerned that frequent reorganizations might have an unsalutary effect on the morale of their people. However, when the reorganization did finally occur, the division chiefs agreed that it resulted in greater efficiency in meeting research goals. Moreover, there had been a minimum loss of morale.⁴

The reorganization that took place in 1974 reduced the number of operating divisions from six to five. These were designated the Environmental and Energy Systems Division, Facilities Habitability and Planning Division, Facilities Engineering and Construction Division, Materials Systems and Science Division, and Facilities Operations and Maintenance Division (Table 11). Reducing the number of divisions narrowed the managerial responsibility of the Executive Office and the jurisdictional disputes that occurred. Although raised to the level of a division, environmental research shared this distinction with energy research. It was not until 1976 that the energy and environmental research programs had grown to the sizes required to have them separated as an Environmental Systems Division and an Energy Systems Division.

In 1978 two important events occurred. First, the five operating divisions were consolidated into four: the Energy and Habitability Division, headed by Richard G. Donaghy, the Environmental Division, headed by Dr. Ravinder K. Jain, the Facility Systems Division, headed by Edward A. Lotz, and the Engineering and Materials Division, headed by Dr. Gilbert R. Williamson. The three advisory and administrative offices remained essentially unchanged (Table 12).

Table 11
Organizational Plan, 1974



1974

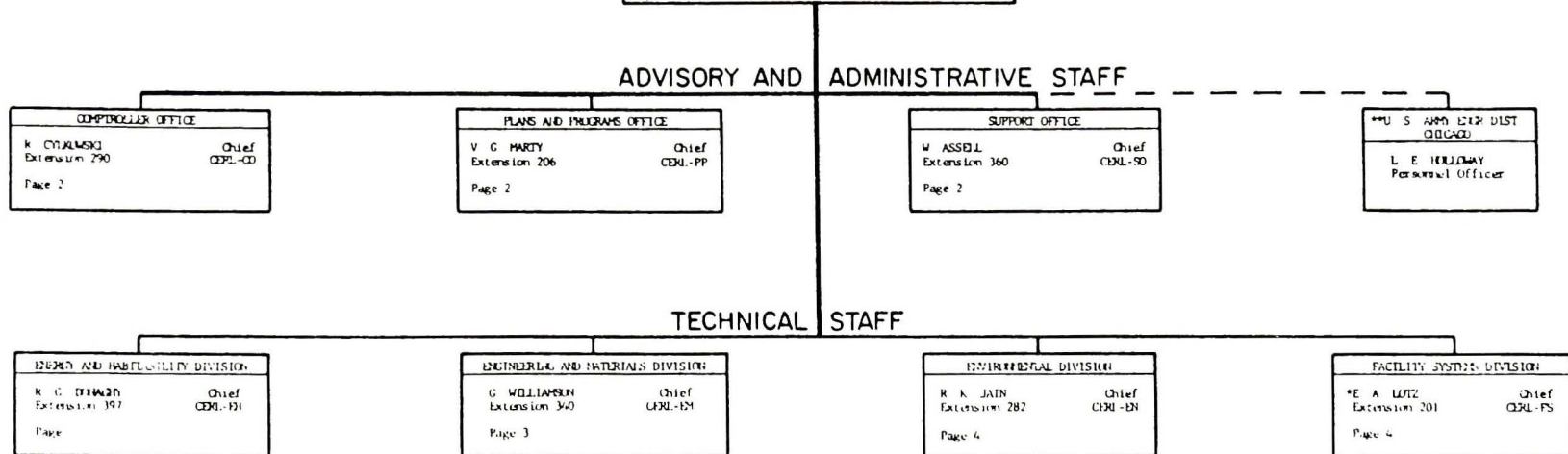
Table 12

Directory Chart, 1978

SPECIAL ASSISTANTS	
* J. B. BROWN	Safety/Security Mgr. (SSM) Equal Emp. Officer (EEO)
	Public Affairs Officer (PAO)
* J. A. CONNOR	Military Engineering (ME)
* E. A. LUTZ	Value Engineer (VE)
* R. MUNCH	Radiological Prot. Officer (RPO)
* J. J. SCHMIDT	ADB Coordinator (ADB)

U. S. ARMY CONSTRUCTION ENGINEERING	
RESEARCH LABORATORY	
EXECUTIVE OFFICE	
COL JAMES E. HAYS	COMMANDER AND DIRECTOR CERL-Z
MAJ JUDITH R. BRUNS	Deputy Commander and Director CERL-ZD
L. R. SWARTZ	Technical Director CERL-ZT
* E. A. LUTZ	Assistant Director CERL-ZC
R. M. DUNNAT	Associate Technical Director CERL-ZTA
2901 Research Drive Interstate Research Park P. O. Box 6205 Champaign, IL 61820 Phone: 217-352-6511 FTS 958-7011	

BOARDS AND COMMITTEES
Architect-Engineer Presselection Board
Architect-Engineer Selection Board
Board of Awards (Contracts)
Energy Conservation Committee
Equal Employment Advisory Council
Equipment Evaluation Committee
Federal Women's Program Committee
Master Planning Committee
Research and Development Grade Evaluation Panel
Safety Committees
Executive Safety and Health Council
Occupational Safety and Health Committee
Ionizing Radiation Control Committee
Training Committee
Value Engineering Committee



*Detail Assignment

219 S. Dearborn Street
Chicago, Illinois 60644
FIS AC 153-Extension

James E. Hays
JAMES E. HAYS
COLONEL, USAR
COMMANDER AND DIRECTOR

1 August 1978

A second major event to occur during this period represented a unique concept to the Laboratory and was largely the brainchild of Dr. Shaffer. This event was the establishment of the team management system. Previously, operating divisions consisted of branches, each designated according to the general field of research they performed. As was frequently the case, funds allotted to CERL varied from year to year and from one research project to another, affecting the research each branch was permitted to accomplish. Moreover, in the reimbursable area of research, few people could anticipate the research projects. Faced with such uncertainties, some branches might have little work, while others could be overburdened. Under such circumstances, it was difficult to move people whenever and wherever they were needed without creating problems in grades, management, and morale. The team system based upon Civilian Personnel Regulations available to research organizations in the Department of Defense eliminated the branches in the division and created teams in their place. The teams were not a fixed entity like the branches. Therefore, they provided greater flexibility and mobility in the divisions, allowing people to be shifted from team to team whenever necessary. Division chiefs could establish teams and eliminate them after they served their purpose. The team concept was so successful that it has remained in effect to the present.⁵

After the 1978 reorganization, the Laboratory's organizational plan did not change perceptibly (Table 13). Whatever minor changes occurred were below the division level in the technical organization and in services mandated by higher headquarters in the support organization.

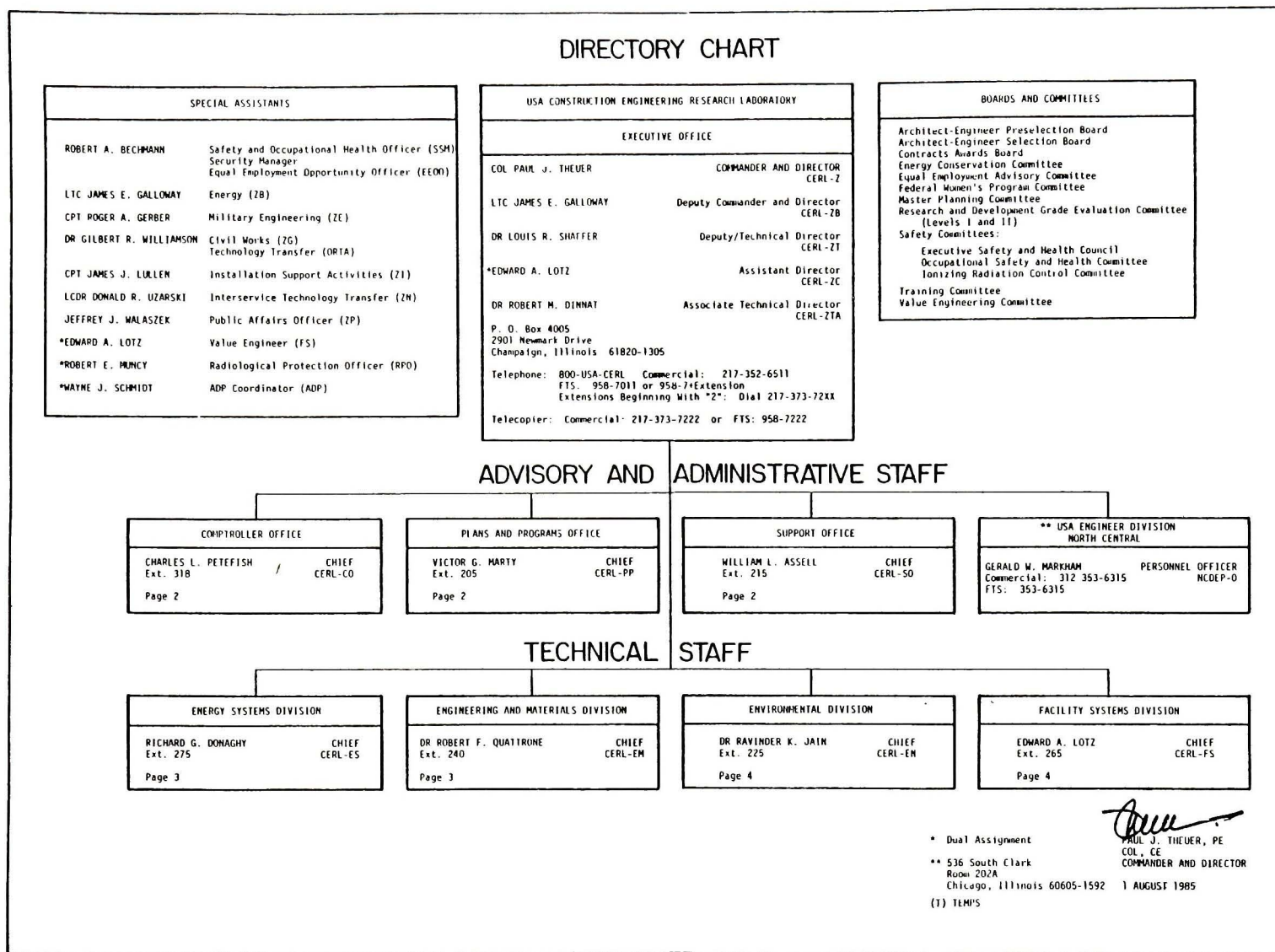
The Energy and Habitability Division was responsible for research in energy systems and methods designed to enhance living quarters and work areas at military installations. It emphasized the development of tools, techniques, and criteria for energy conservation, energy management, use of alternate energy sources, development of facility functional requirements, and methods for evaluating habitability satisfaction of occupants.

The Engineering and Materials Division conducted research and development studies designed to advance military technology in the field of metallic and nonmetallic materials for improving the design, construction, maintenance, and repairs of military and civil works facilities. Studies dealing with material characteristics and performance of facilities designed to resist earthquakes, nuclear weapon shock and the accompanying electromagnetic influences, and other adverse environments were included. Particular emphasis was placed on developing construction quality procedures and equipment, protective coatings, and corrosion mitigating techniques, introducing new materials, preparing manuals and guide specifications, and the presenting courses.

The Environmental Division was responsible for research in environmental systems and environmental effects of Army activities. The Facility Systems Division was responsible for research and investigations related to management engineering for planning, design, construction, operation, and maintenance of military and civil works facilities.⁶

Table 13

Directory Chart, 1985



Personnel

CERL was authorized 221 permanent civilian spaces in 1973. However, the following year the Laboratory lost 18 spaces, bringing the authorization down to 203. The number of permanent spaces remained stable over the next decade, but in 1984 it rose to 267.⁷

While the permanent workforce remained relatively unchanged throughout most of the years, the research responsibilities continued to grow significantly. To absorb this increase, more and more of the research was performed by contract.⁸ One of the major sources of contracting was the University of Illinois, but other academic institutions like the University of Michigan and the Massachusetts Institute of Technology also held contracts. CERL was fortunate to have been affiliated with the University of Illinois where it received the assistance of graduate students under the Graduate Assistant Program. While this program provided some of the much-needed help, another program initiated during the period proved to be even more significant. This program was the Intergovernmental Personnel Act (IPA) passed in 1970. CERL Regulation 690-3 defined the Laboratory's policy toward this program. The act permitted civilians employed by Federal agencies, state and local governments, and academic institutions to accept temporary assignments to other Federal agencies. When their assignments were completed, employees were expected to return to their former employers. Temporary assignments were as long as 2 years, but they could be extended to 4 years provided they received approval from the Department of the Army. Technically speaking, these employees were members of other agencies, but while they were working at CERL, they were subject to the latter's policies and procedures. The program turned out to be a success at CERL where there was always a long list of applicants. The supply of professional personnel was never a problem at CERL, only manpower constraints imposed by higher authority prevented additional assignments.

Personnel from government agencies and private institutions were quick to take advantage of these opportunities. Personnel from the University of Illinois were among the first. In 1982, CERL and the University worked out a plan under this program permitting faculty members to work a certain number of hours at the Laboratory while receiving an additional stipend to their University salary.⁹

By the end of 1982, the University had 107 graduate students and 11 faculty members, who were IPA appointments, working at CERL. In Fiscal Year 1983, the Laboratory spent \$534,000 in salaries for University of Illinois IPAs. The following fiscal year, it spent \$1.42 million. The University of Illinois was not the only institution providing IPAs to CERL. Purdue University, the University of Colorado, the University of Texas at El Paso, and Stanford University also participated in this program. In 1984 12 universities were cooperating in this program.¹⁰

Programs like the IPA alleviated many of the personnel problems experienced by the Laboratory. Since individuals in these programs did not count as part of the permanent workforce, the Laboratory was able to live within its personnel budget and authorized spaces and still have the necessary workforce to perform the research. These programs also benefitted the universities, especially the University of Illinois, by helping

to solve the fluctuating faculty problems that went with the uncertainties of the academic year. Moreover, students working at CERL received valuable experience which they very often used in the preparation of a thesis. In 1985, five graduate students were copatent-holders of three products developed at the Laboratory.¹¹ Thus, the benefits derived from these programs were mutually satisfying to both CERL and to the University.

The Laboratory's professional staff is highly trained; among the highest in the Army. In 1985, 34 professionals had doctorates, 79 had Masters Degrees, and 78 had Bachelors Degrees. That same year, 31 professionals published articles in scientific and engineering journals, and 51 presented papers at professional meetings. Fifteen professionals held some form of office in scientific organizations and 34 were chairmen of committees.¹² A few of these organizations were the International Council for Information Coordination for the Building Process; American Society of Safety Engineers; Building Futures Council; National Institute for Building Sciences Subcommittee on Indoor Air Quality; Federal Laboratory Consortium; and Technical Council for Research, American Society of Civil Engineers. In addition to these accomplishments, at least 17 members of the Laboratory staff bore titles of Adjunct Professor or Assistant Professor at the University of Illinois and three other universities. This number varied from year to year, emphasizing the interaction between the Laboratory and the university community.¹³

The Laboratory's professional staff were also recipients of national awards. In 1982, for example, 10 such awards were received. In 1985, five awards were received. Among these awards, the more notable ones were the U.S. Army Research and Development Achievement Award, Culberson Award, and nomination to the American Academy of Environmental Engineers. The number of awards varied from year to year, but there was no denying that each year a substantial number of CERL professionals were being recognized by their peers.¹⁴

Facilities

The Biaxial Shock Test (shaketable) Building was considered a great resource when it was first built, but early on it was discovered that the building was not being used to its fullest extent. There was not enough research in this area to make the new machine economically feasible. The Laboratory's effort to seek a group of customers who might be interested in its use, proved futile. In the meantime, staff sections like the Materials Division needed additional space to accommodate its research staff. Research into plastics was growing rapidly, and plastics took up immense space. Since the shaketable building was large enough, the Materials Division was permitted to use it for its research. However, even this spill-over into the shaketable building was not sufficient to serve the expanding research needs of the Laboratory, and soon more facilities were needed.¹⁵

To alleviate the space problems, the Laboratory also purchased trailers, placing them near the main buildings. Although for the moment these temporary facilities seemed to help the situation, they presented other problems. They created inconveniences for the people who had to

work in them as well as for those who had to communicate with those employees. The severe high winds that occur frequently in central Illinois also threatened to overturn the trailers. They had to be anchored to the ground to prevent any accidents.¹⁶

The space restrictions were becoming so severe at the Laboratory that Colonel Remus saw the possibility of renting or purchasing what was then known as the Capital Records Building across from the Laboratory on Interstate Research Road. The building was then available for a reasonable price. Although Colonel Remus was convinced that acquiring the structure would have done much to lessen the space problem, he was unable to convince the Office of the Chief of Engineers, which felt that the Corps had a commitment with the University in any future expansion. Years later, Remus commented that "it was an opportunity that could have solved CERL's office and space problems for some time to come. It was a missed opportunity."

When Colonel Hays assumed command in 1976, a study was made of all rental facilities in the area. The study concluded that parts of the Capital Records Building should be rented to provide work space for the growing number of temporary employees at CERL. The Office of the Chief of Engineers agreed to such a plan, and a lease was immediately drawn up. Unfortunately, cuts in funds eliminated what otherwise would have been an excellent temporary measure for alleviating the space problem at CERL.¹⁸

By 1978, with the addition of small temporary structures, the Laboratory's facilities totaled about 110,000 square feet, all located on the original 15.2 acres leased from the University.¹⁹ The problem of space was becoming very critical at CERL.

Soon after Colonel Theuer assumed command in 1983, he approached the University with his space problems. He pointed out that the Laboratory's growth in recent years had placed it in a situation where it was unable to accommodate further growth within its existing walls. Researchers were overcrowded into work areas, and space that lacked adequate lighting, ventilation, and privacy was being converted to work areas. If CERL were to continue to grow to meet its responsibilities, additional facilities were needed immediately. Similar pleas made by former commanders had fallen on deaf ears. Colonel Theuer's pleas also went unheeded.

One reason for the University's unwillingness to accede to CERL's wishes was the problem of how to finance the construction of new facilities. The original facilities had been funded through the issuance of bonds to a private source. A similar source for new funds was not available. Ironically, the University had contributed to the shortage of space at CERL. Of almost 400 full- and part-time employees working at the Laboratory, about 100 were University faculty members and graduate and undergraduate students (Table 14). Moreover, in 1983 alone, CERL had provided about \$2.5 million to the University and its personnel through contracts and salaries. Colonel Theuer pointed out that the Laboratory also had an economic impact on the entire local community approximating \$15 million during that year.

Table 14**Assigned Permanent and Temporary Personnel**

	<u>FY 83</u>	<u>FY 84</u>
Full-time Civilians	204	208
Part-time University civilians	134	70
Full-time military	9	11
Student hires/IPAs	26	100

The total expenditures, including payrolls, rent, utilities, contracts, and other miscellaneous costs of the Laboratory were \$23.9 million for Fiscal Year 1983 and an estimated \$26.6 million for Fiscal Year 1984.²⁰ Colonel Theuer was convinced that the University should have been more sympathetic to the space problems facing the Laboratory in view of the benefits that accrued to the University and to the community.

Colonel Theuer originally proposed that the University construct a facility, as part of Phase II of construction, consisting of about 20,000 square feet to be located just to the north of the existing buildings. The new building would be connected to the old buildings by a walkway. It would be built on the original 15.2 acres leased by CERL, and would include administrative space for 124 employees and a large conference room. The heating and cooling systems were to be furnished by the existing utility building. The new facility was envisioned primarily as open space and would also be leased to the Corps on an annual renewable basis. The Chief of Engineers authorized CERL to enter into negotiations with the University.²¹

After Colonel Theuer's strong appeal, the University became more sympathetic. The College of Engineering, which had much to gain from an increase in joint research programs, was most sympathetic. "There must be a reasonable means available to us to construct a building for CERL," read a letter from the Vice-Chancellor to the Chancellor of the University.²²

With a more amenable attitude on the part of the University, both parties finally began serious negotiations. The Laboratory agreed to develop the concept design using its architectural staff and the products of their research. The University was to obtain the estimated \$1.7 million construction costs through the sale of bonds. The University proposed to do this in two steps: first, by selling bonds that would provide advance refunding of the existing obligation of \$2.5 million from Phase I of construction; second, by the sale of new bonds to finance the new construction. A new agreement was to be made between the University and CERL, transferring the property from the University Foundation to the University, and a new lease was to be signed between the University and the Laboratory. The new lease was to provide a uniform annual payment for debt service from 1986 (the estimated date of completion of the new building) to 1999, or later, and insurance, administration, and contingencies. The Laboratory was to pay for all utilities and routine operational costs as it had done under the existing agreement.²³

Ultimately, it was agreed that the size of the new building would be 26,540 square feet and would cost about \$1.65 million. When completed and occupied, the annual rent was to rise from the existing \$392,372 to \$600,000. Although, as part of Phase I of construction the building was intended to house the administrative staff, this plan was later changed so that the proposed structure became part of the Facility Systems Division. This change vindicated Colonel Townsley who had said, some 13 years earlier, that if Phase II was ever undertaken, it was best to use the new structure for research purposes rather than administration.²⁴

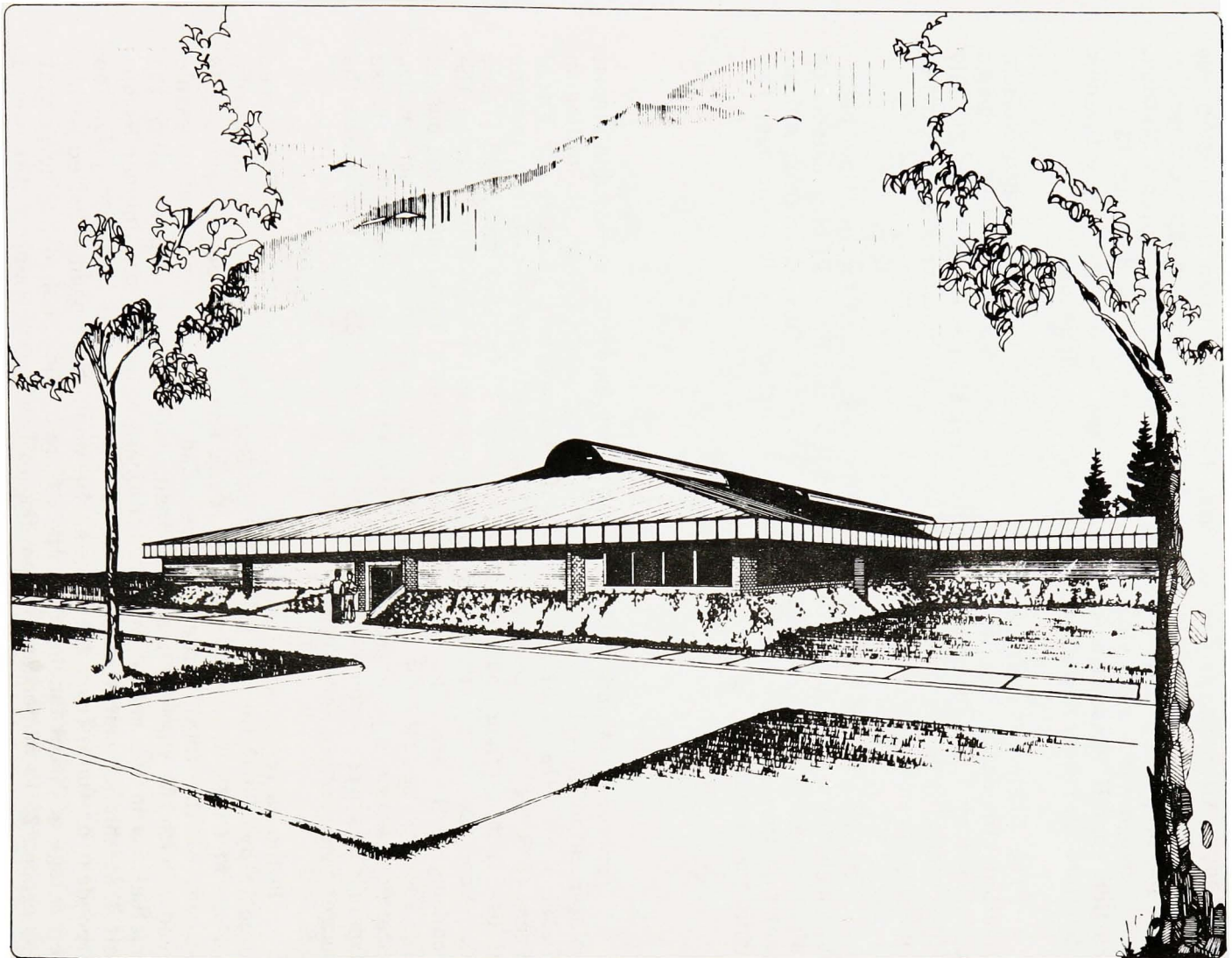
The University selected the local firm of Unteed, Scaggs, Nelson, Limited, to design the new facility based upon a schematic design developed by the Laboratory's architectural staff (Fig. 13). On 26 July 1985, ground-breaking ceremonies were held. The building was expected to be ready for occupancy in 1986.²⁵

The question of adequate facilities was settled for the time being. Although there were some at CERL who felt that Phase III of construction might some day follow, others were less sanguine. This latter group did not feel that the Laboratory would grow to the extent that it would need two additional buildings.²⁶

Funding

Between 1974 and 1985, the Laboratory enjoyed a steady and almost uninterrupted growth in its budget. Funding jumped from \$5 million in Fiscal Year 1973 to \$7.9 million the following year. Except for Fiscal Years 1978 and 1982, the budget rose consistently and even sharply in some cases. It more than doubled between Fiscal Years 1981 and 1986 (Table 8). Needless to say, the local community saw this as a benefit to the economy of the area. In Fiscal year 1984, about \$19 million of the budget was spent on salaries for about 450 permanent and part-time employees, local contracts and purchases, and the payment of rent and utilities. These expenditures were even higher in Fiscal Years 1985 and 1986 when the budget rose close to \$40 million.²⁷

In the early years of the Laboratory, most of the research was funded directly by the Office of the Chief of Engineers. Colonel Remus, who arrived at CERL in 1974, believed that this amount was somewhere near 75 percent of the total budget, the remainder coming from Reimbursable Funds. With the vagaries that accompanied direct government funding, the fluctuations in the annual budget, and changing priorities, Colonel Remus felt that this amount was unwise, since it made the Laboratory far too dependent on funds from one source. He would have been satisfied with a percentage of direct funding from the Office of the Chief of Engineers that was around 25 to 50 percent. According to Remus, such a proportion would have given CERL greater flexibility in its operations. Greater dependence on research that relied on reimbursable funding meant that the Laboratory had to rely upon its own ingenuity to get customers. Remus had no doubts about the ability of his staff to go out and "sell" their program.



USA-CERL ADDITION
Facility Systems Division Research Center

Fig. 13

Architectural Drawing of the New Facility Systems Division Research Center

Nevertheless, before 1977 CERL made little effort to inform potential customers of its capabilities. Budget cuts in main item programs convinced CERL that it must go into the field and find potential customers who were not aware of the Laboratory's capabilities. Starting in 1978, CERL's engineers and scientists approached many of these potential customers to learn about their needs and to convince them that the Laboratory had the answers to many of their problems.²⁸

The Facilities Technology Applications Test Funds, created in 1984, provided a systematic method of informing potential customers of the many worthwhile projects CERL was undertaking that could bring greater efficiency and economy to their operations. One member of OCE's Directorate of Research and Development noted that "many of these technologies aren't being used at installations because people are either unfamiliar with their use or they aren't aware of them."²⁹

Had Colonel Remus remained with CERL longer, he might have realized his dream. Beginning in Fiscal Year 1982, reimbursable funding grew constantly until by Fiscal Year 1986, it formed a large proportion of the total budget. In Fiscal Year 1983, reimbursable funding represented almost half the budget, the research of which was for Corps divisions and districts, major Army commands, the Defense Logistics Agency, the Defense Nuclear Agency, the Defense Communication Agency, the Air Force, and other nonmilitary agencies. The following year was almost the same. Of a total budget of \$31.6 million, \$17.3 million was from RDT&E funds, and the remainder from Reimbursable Funds. By October 1985, about 60 percent of the research undertaken by the Facility Systems Division was reimbursable funding, and before that it was 50 percent.³⁰

Research dealing with Civil Works played a minor role in CERL. As late as 1980, the Laboratory had only \$300,000 for research in this area out of a budget of \$12.5 million. However, by Fiscal Year 1986, \$2.5 million was made available to the Laboratory for research in Civil Works, an amount that represented only 6.2 percent of the budget. There were two reasons for this moderate increase. First, establishing the position of Special Assistant for Civil Works at CERL in 1980 called attention to the importance of civil works, thereby generating greater funding in this area. Second, establishing energy and construction management programs as line items in Civil Works contributed significantly towards the acquisition of funds. Civil Works consisted of a series of line items in the Research and Development Program, none of which CERL had. In 1982, CERL was assigned certain Civil Works energy and construction management projects as line items. In Fiscal Year 1986, these funds amounted to \$235,000 in construction management projects and \$145,000 in energy projects. These amounts were expected to grow in Fiscal Year 1987 to \$300,000 for the former and \$245,000 for the latter.³¹

The Fiscal Year 1978 budget suffered the biggest cut in CERL's history. With Congress's proposed cut of \$700 million in the Department of Defense's RDT&E funds, CERL was expected to lose \$7.2 million. Of this amount, \$1 million had been earmarked for environmental research and \$6.2 million was for research in design, construction, operation, and maintenance technology. Some of the projects expected to be eliminated by the budget reduction were in research designed to reduce fuel

consumption at military installations and to find better use of available fuels. Another research project scheduled for elimination dealt with the enhancement of the life of roofs. If these reductions had become a reality, elimination of contracts and the transfer of that work to the Laboratory staff would have been inevitable. There was also the fear that more than 100 students from the University of Illinois would have lost their part-time jobs, and a few permanent employees would have been separated.³²

Although the House of Representatives passed the \$7.2 million cut, a compromise by a Senate-House committee reduced this amount to \$5.3 million in RDT&E funds. Dr. Shaffer was confident that much of this loss would be replaced by other sources made available through the Office of the Chief of Engineers. He also believed that the Laboratory would not suffer reductions in its permanent staff, although some contracting would be reduced.³³ Ultimately, as Dr. Shaffer had observed, the reduction in RDT&E funds was not as serious as had been anticipated. Although \$5.3 million was cut, about half this amount was later restored through Reimbursable Funds. Thus, while some important areas of research had to be curtailed, in the final analysis the cuts did not prove as serious as originally believed.

The following year research funds were again under fire from Congress as indeed they were throughout the Defense Establishment. While the House of Representatives cut \$5.7 million from CERL's RDT&E funds, a Congressional committee of the two Houses restored all but a fraction of this amount. CERL's status remained relatively unaffected. The number of permanent personnel remained untouched, and some new contracts were even awarded to the University of Illinois.³⁴

The University's Role

Relations with the University of Illinois over the years were, generally speaking, good. CERL Commanders regarded the University's contributions toward the Laboratory's success as laudatory. Years later, Colonel Remus said that such good relations "confirmed the reason for establishing CERL closely associated with a major university in the first place. There may have been a better location, but I would be hard pressed to find one, and certainly the fact that this one worked leads to confirmation that it was the right thing to do."³⁵

Although relations with the University were sound, there was a feeling in CERL that the University was not assisting in research projects as much as it should have. The University faculty, on the other hand, felt that academic priorities took precedence over CERL research. The feeling also prevailed among the faculty that the research performed at CERL did not measure up to the academic atmosphere of a university, whose research was primarily in nonmilitary engineering. This was not to say that the faculty considered the quality of research at the Laboratory inadequate. It meant only that CERL's objectives were of little interest to the academic world.³⁶

To further relations with the Laboratory, the University created a Liaison Committee of six faculty members whose purpose was to

coordinate academic and research matters with CERL. The Committee's responsibilities extended into five areas: (1) it developed and recommended working programs and policies to further the relations between the Laboratory and the University; (2) it provided the University with a direct line of communication with the Laboratory, (3) it coordinated research proposals intended for CERL by various University departments, (4) it coordinated cooperative research programs between the University and CERL, and (5) it developed and recommended policies and procedures relating to graduate assistants, joint appointments, and similar cooperative efforts.³⁷

Cooperation between the Laboratory and the University grew steadily over the years until by 1982 as many as 32 research projects, involving 23 departments, were handled by the University.³⁸ Civil, Mechanical, Mining and Metallurgy, Ceramics, and General Engineering were all departments within the College of Engineering involved with CERL research. Other colleges and departments of the University dealing in CERL research were the Coordinated Science Laboratories, Electrical and Computer Engineering, Architecture, and Urban and Regional Planning, the last two departments being in the College of Fine Arts. There was a wide representation of the University's faculty and student body in CERL's work. Much of the research accomplished by the University for the Laboratory was done on a one-to-one basis. The division chiefs of the Laboratory went directly to individual members of the faculty and requested assistance, but the faculty's work and earnings were monitored by the University.³⁹

The benefits accruing to CERL because of its affiliation with the University cannot be emphasized too strongly. Because of its geographical location, it was cost-effective for the Laboratory to take advantage of the basic research capability of the University. Daily interaction among scientists, engineers, and architects in both organizations could occur easily without the expenses normally incurred by travel. Thus, the fact that there were 36 contracts in force with the University by mid-1983, totaling \$1.4 million, was not unusual. These contracts represented 30 percent of the Laboratory's contract allocation per year. By the end of 1984, CERL had obligated \$1.7 million in contracts to the University.⁴⁰

By mid-1985, 175 University graduate students and faculty members were working at CERL either part-time or full-time. The University continued to provide support to CERL through its support centers where its personnel answered telephone requests for information, updated data bases whenever applicable, offered training courses, and, in general, assisted in research.⁴¹ In 1986, the University received \$8 million in contracts from CERL. Literature research, training people for work in CERL, and developing computer programs in artificial intelligence were some of the areas covered by these contracts.⁴²

University students were permitted to use CERL facilities and resources that were the result of research jointly developed by the two organizations. The most significant resources were four computer programs: Computer Aided Engineering and Architectural Design System (CAEADS) in the Department of Architecture; Pavement Maintenance Management System (PAVER) and Building Loads Analysis and System

Thermodynamics (BLAST) System in the College of Engineering; and the Environmental Technical Information System (ETIS) in the College of Fine Arts. The University's Department of Continuing Education called attention to CERL's products by conducting courses in PAVER, BLAST and ETIS. These courses were taught by a combined staff of the Laboratory and University. Finally, the University served as a support center for the operation and maintenance of a remote terminal user system for ETIS and BLAST. This center made it possible for the staffs of both organizations to interact on a continuous basis. The University was able to join in a new technique of public service through joint programming with a government organization.⁴³

In 1977, an agreement was made between the Laboratory and the University (College of Engineering) for the mutual use of specialized equipment. The agreement permitted the University to use CERL equipment, except for the Biaxial Shock-Test Machine, in return for the government's right to use the results of the research performed by the University. These conditions were mandated by the Armed Services procurement regulations, Army procurement procedures, and Federal law. By 1983, four equipment exchange agreements were in effect between CERL and the University.⁴⁴

Relations With Other Agencies

Some of the Laboratory's more difficult relationships were within the Office of the Chief of Engineers. Before CERL was established, the program and project managers in the Office of the Chief of Engineers were running different programs independently. The establishment of CERL diminished some of this discretionary power, inevitably creating some resistance. One of the selling jobs of the Laboratory's commanders was to reaffirm alliances and relationships within the Corps family itself. Much of the success of these efforts depended on the broad experiences and earlier contacts of the CERL commanders prior to their assignment to the Laboratory. As in the case of other commanders, Colonel Remus was fortunate in this respect. His tour of duty in the Office of the Chief of Research and Development, Department of the Army, enabled him to establish a warm relationship with both CERL and the Office of the Chief of Engineers.⁴⁵

Within the Department of the Army, CERL had difficulties establishing contacts with various facility engineers because they were not under the Chief of Engineers. The creation of the Facility Engineer Directorate within the Office of the Chief of Engineers was an important step towards establishing a close technical link between the Corps and the facility engineers at each Army installation. CERL benefitted from this link by receiving the coordinated efforts and support of both the Office of the Chief of Engineers and the Army facility engineers for whom it was providing assistance.⁴⁶

Colonel Remus found the Laboratory's relations with the Air Force at times better than those with the Army. He believed this was because the Air Force did not have many laboratories which it could turn to for assistance. The Air Force needed work and CERL was there to assist. It

was a "natural marriage." This attitude eventually spread so that even the Navy and other Federal agencies sought assistance from CERL.^{4 7}

The Research Program

The research conducted at CERL was changing rapidly from what it had been prior to 1974. In terms of size, as demonstrated by its funding, research had grown from a \$5 million program in Fiscal Year 1973 to a \$39.2 million program in Fiscal Year 1986. RDT&E funds grew from \$2.8 million to \$13.5 million in that same period. Even more surprising was the enormous growth in research attributable to reimbursable funding. This research grew from less than \$1 million in Fiscal Year 1973 to more than \$15 million in Fiscal Year 1986. About 30 percent of the research accomplished in CERL's Energy Systems Division in 1985 was the result of Reimbursable Funds. The important role these funds were to play at CERL may have been anticipated when the Laboratory was first conceived, but the extent of their growth was probably never expected.^{4 8}

By the early 1980s, CERL was becoming recognized nationally as having made significant technological contributions to the public and private sectors. This recognition was made possible through a policy of actively soliciting research needs from customers, a closely monitored and user-coordinated research program; a good working relationship with the University of Illinois, industrial community, and Federal agencies, and an aggressive technology transfer program that encompassed the entire spectrum of Federal, state, and local levels as well as the private sector.

Some of the largest growth in research during this period was in the areas of environment and energy. The energy crises of the Sixties and Seventies and the sudden rise in concern for the environment provided a great impetus to research in these areas, leading research organizations to lend their support. The National Environmental Policy Act of 1969 set the stage for various pollution control laws that followed. The law provided for a broad consideration of all factors affecting the environment in program planning by Federal agencies. Executive Order 11514 of 1970 further required that Federal agencies take the lead in originating programs that would not only control pollution but also enhance the environment. The law introduced the Environmental Impact Assessment (EIA) and Environmental Impact Statement (EIS) as two important reporting mechanisms that Federal agencies would have to employ in complying with the law. The Army, however, had no uniform assessment procedures that could be applied throughout its installations. By 1973, EIAs and EISs were still in their infancy. Department of the Army Regulation 200-1 of December 1975 also required installations to comply with Federal, state, interstate, and local standards in controlling air emissions. The regulation directed installations to identify sources of air pollution and to submit reports regularly. Meanwhile, comprehensive guidance for defining air pollution emissions at all levels was not available. CERL's early mission in this important area of research was to undertake a comprehensive research program leading to an improved and uniform method of preparing EIAs and EISs for the Army and to provide a set of procedures which aided installations in defining and assessing the air emissions at all levels of government.^{4 9}

It was inevitable that CERL would be among those laboratories at the forefront of this movement. The importance of these areas of research was ultimately reflected in a change to the organizational plan making the Energy Systems Division and the Environmental Division separate and distinct entities.

Other factors also contributed to the Laboratory's growth following 1973. The Army was becoming more sophisticated and, with a volunteer membership, it sought the means to attract and retain the volunteer. One of CERL's continuing research projects was devoted to improving housing and the work environment of military personnel.

While the Laboratory's early research was aimed primarily at the Army, as it gained greater recognition for its talents and with a broader application of its research, more of its research was directed at nonmilitary establishments. Hence, the large increase in Reimbursable Funds that resulted from this change. There was also a greater interaction between CERL and other laboratories and agencies such as the National Bureau of Standards.

These laboratories worked very closely to avoid duplication. In one project dealing with energy, both CERL and the Cold Regions Research and Engineering Laboratory worked together, but each had a different approach. The latter was concerned with the structure, whereas the former dealt with the equipment that made up the structure. When completed, the two research efforts would mesh, complementing each other rather than duplicating.⁵⁰

In its early years, CERL made no great effort to publicize itself and its accomplishments. This attitude was probably understandable since the Laboratory was young and as yet unable to measure its capabilities. But as it developed and funding became more liberal, the various commanders began to call the public's attention to CERL's capabilities. Although the Laboratory was fortunate in having dedicated professional people who gained national recognition through the results of their work, CERL commanders felt that this was not enough. Greater communication with the outside world was essential. Colonel Circeo found that the Laboratory's capabilities and services were not as well known to the public as they should have been.⁵¹

As the research extended into many different areas, a greater effort was made to publicize the research outside Army circles. Contacts were made with Federal agencies, states, and local communities throughout the country. At the Federal level, the Environmental Protection Agency, Department of Energy, General Services Administration, Federal Aeronautics Administration, Bureau of Mines, and Federal Highway Administration became interested in CERL's work. Not only was the Laboratory able to work closely with these agencies, but also with groups in the private sector such as the Associated General Contractors of America, the International Council for Building Research, the Building Research Advisory Board, and the Federal Laboratory Consortium for Technology Transfer. CERL was a member of the latter three organizations. In July 1979, CERL also became a charter member of the National Institute of Building Sciences Consultative Council. Employee membership and active

participation in professional organizations helped to bring CERL and these groups closer together.⁵²

One of the greatest achievements in CERL's research program in the later years was the Technology Transfer Program, a subject discussed later in this history. This program gave CERL the broad recognition it deserved by making it possible to transfer the results of the Laboratory's research to the public and private sectors. When CERL combined this invaluable program with its Small Problems Program (a subject also discussed later), it was able to give credence to those who had conceived the idea of a laboratory dedicated to the systems approach in the construction industry.

Specialized technical centers such as the Welding Technology Center were created at the Laboratory in 1984. The Corps' construction community could now seek solutions to welding problems from one central source. This center was made possible through CERL's extensive research into weld processes and failure analysis of welding systems. The services of this center ranged from answering questions to monitoring projects and analyzing major weld failures. In two civil works cases, the center was able to provide important assistance. The Old River Auxiliary Control Structure, a large dam on the Mississippi River, regulated the flow of water. In 1985 there was some concern about splicing the H beams on the dam. After the center studied the problem, it concluded that the welds were strong enough to withstand the splicing (Fig. 14). In another case, the Lock and Dam 26R in the Corps' St. Louis District suffered serious failure in which the welds were weakened. After carefully studying the problem, the center determined that the weakened welds were not the cause of the failure but were the result of other weakened members. In March 1985, Robert A. Weber, Director of the Welding Technology Center, was appointed to the Committee on Welding Controls of the National Materials Advisory Board.⁵³

In later years, CERL made greater efforts to publicize itself and its research findings through its newsletters, fact sheets, articles in the general media, and through a greater distribution of its technical reports. In 1981, through the joint efforts of the Directorate of Research and Development and the Society of American Military Engineers, a special edition of *The Military Engineer* was published, the subject of which was the technology transfer of Corps laboratory products, including those products developed by CERL, WES, and CRREL.⁵⁴

Research Projects. Many studies conducted by the Laboratory were designed to support all aspects of the Army mission in base support (such as Military Construction, Army [MCA], planning, design, and construction), installation operation and maintenance, selected aspects of combat support, force modernization, mobilization planning, and Civil Works. The Laboratory also conducted studies supporting other military and nonmilitary agencies. Several of these projects were begun prior to 1974, and although they were basically completed, the research was extended into later years with the object of improving the results still further. Space in this history does not permit a discussion of all the research that went on during the period, but only a few studies which contributed significantly to the Army's mission and to the solution of energy and environmental problems.

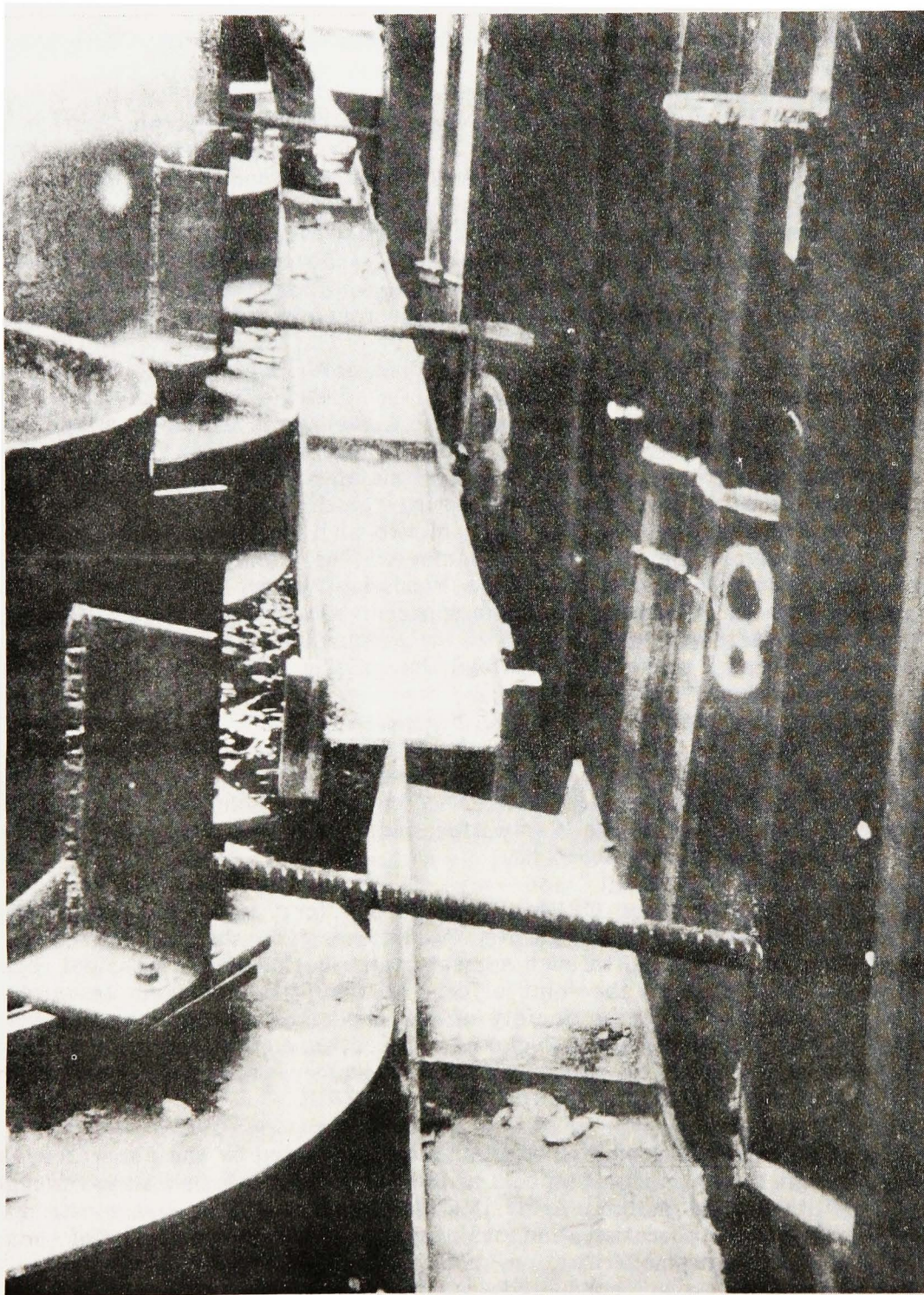


Fig. 14

**Monitoring Welds on H beams on the
Old River Auxiliary Control Structure
1985**

Work on a computer-aided equipment maintenance management system began at CERL as early as 1972 in response to a requirement for an automated means of scheduling and monitoring maintenance performed on specialized equipment at Army hospitals and installations. Colonel Reisacher praised this system as a very practical device for keeping abreast of periodic maintenance. The initial study was done at Fitzsimons Army General Hospital, Denver, Colorado. The study involved collecting and analyzing maintenance data files at the hospital. The research demonstrated that the system could be better applied at a new hospital where the equipment data collection would be accomplished while the contractor was still at work and before the building was occupied.⁵⁵ As a result, the system, which was designated the Hospital Equipment Maintenance System (HEMS), was successfully developed and implemented between 1973 and 1975 at the Dwight D. Eisenhower Medical Center at Fort Gordon, Georgia, a new hospital.

HEMS was designed to provide the capability of identifying, scheduling, monitoring, recording, and analyzing recurring maintenance activities on utility systems and equipment in Army medical facilities. HEMS automatically estimated the work that was to be done, and sorted the jobs by shop, location, and maintenance frequency.⁵⁶ The system worked so well with highly sophisticated equipment that it was used to schedule watering and fertilizing of trees planted at Fort Gordon.

In 1976, the Office of the Chief of Engineers directed CERL to develop a system whereby facility engineers at installations would have the resources and capability to schedule and monitor recurring maintenance of all types to prevent failure and insure safe operation. The study resulted in a modified HEMS, designated the Facilities Engineering Equipment Maintenance System (FEEMS). The new system was successfully tested at Fort Detrick, Maryland, in March 1978. That same year, FEEMS became part of the computerized Integrated Facilities System in use at 24 Army installations.⁵⁷

Restrictions on manpower and the shortage of water, coupled with environmental standards imposed by the Environmental Protection Agency, caused the Army to look into improving washing facilities for military tracked (tanks and related mechanisms) and wheeled vehicles. In 1975 and 1976, CERL undertook a pilot program at Fort Drum, New York, where it gathered technical information and devised solutions that ultimately proved successful. Washrack discharges were studied at Fort Drum to determine the design criteria for wastewater treatment at a proposed consolidated tactical vehicle wash facility. The studies were designed to improve the treatment facilities of wastewater produced by washing operations so as to conform to Environmental Protection Agency regulations. One of the most serious problems resulting from washing and vehicle maintenance was that motor pool operations frequently allowed the oil wastes to settle in the water, which often polluted streams. CERL's investigations revealed a need for an improved way of handling tactical equipment waste oils. The results of these studies led CERL to recommend the construction of new centralized facilities which could get rid of the sludge-ridden waters resulting from the cleaning, and to improve the washing process itself by reducing the number of people needed to do the cleaning and the amount of water used.⁵⁸

The centralized washrack concept developed by the Laboratory was implemented at Fort Lewis, Washington (Fig. 15) and Fort Polk, Louisiana. The amount of water used by the new system was reduced by 90 to 95 percent while also reducing the time spent on cleaning vehicles. Where once it took 7.5 hours to clean a tracked vehicle and 2.5 manhours to clean a wheeled vehicle at Fort Polk, after the new system was installed, the average time to clean a tracked vehicle was less than one manhour and a wheeled vehicle took only one-half manhour.⁵⁹

CERL was extremely pleased with the results of this study. It estimated that the Army would enjoy considerable savings from this research. Originally, millions of dollars were spent to treat wastewater resulting from vehicle washing, a process that was frequently unsuccessful. Those at CERL who worked on this project were convinced that the money was better spent on building facilities that could treat the water properly. In 1984, the Army approved the new facility for construction at Fort Hood, Texas, at an estimated cost of \$5.9 million. The results of this research exceeded expectations.⁶⁰



Fig. 15

Washrack System at Fort Lewis, Washington

An area which proved to be very costly to the Armed Services was the recurrent repair and maintenance of roofs at permanent installations. Reroofing contracts awarded by the three Services during Fiscal Year 1978 alone amounted to nearly \$54 million. During October and November 1978, reroofing contracts awarded by the Navy amounted to \$6.8 million; those awarded by the Air Force were \$9.2 million; and those awarded by the Army were \$12.2 million. In terms of inventory lost because of leaky roofs and energy loss, the cost was even greater.⁶¹ The problem was not only common to the Armed Services; it was prevalent throughout the private sector as well. Successes in this area of research were expected to reap considerable benefits to the construction industry as a whole.

In a joint effort between the Corps laboratories (including CERL), Navy laboratories, Air Force laboratories, the National Bureau of Standards, and the Army Facilities Engineering Support Agency, a research plan was designed to solve this roof problem in a four-pronged attack in the areas of preventive maintenance, materials systems, nondestructive testing, and energy efficiency. The overall objective of the research was to provide the essential technology and systems needed to increase the life of roofs. For new roofs, or reroofing, the goal was to increase the life span of roofs to 20 years. In the case of existing roofs, the goal was to stretch the life span by 5 years. The research was to provide the capability of improving maintenance, repair, and management procedures; develop new roof repair materials, improved roofing systems, and construction materials; develop improved methods of quality control and quality assurance, and nondestructive testing; and develop technological methods for improving the thermal insulating performance of new and existing roofs.⁶²

Each of the Services and their laboratories had a particular assignment in this research. Periodic meetings were held to coordinate work and to avoid duplication. The research began in 1976, and by 1978, CERL was in the midst of solving the problem of poor quality control during construction. The results of this research were successfully tried on four Army roof construction projects.⁶³

The energy shortage that prevailed in the 1970s prompted the Army and the Corps of Engineers to take energy conservation very seriously. The architect and engineer had to be able to evaluate the energy and economic impacts of energy conservation measures. Energy systems interacted in complex ways with a structure and its environment. Traditional methods of analysis were considered inadequate for proposed new energy systems. In 1977, CERL developed a computer analysis tool to meet these needs. It was called the Building Loads Analysis and System Thermodynamics (BLAST) System. The original version was developed by CERL under the sponsorship of the Department of the Air Force, Air Force Engineering and Services Center, and the Office of the Chief of Engineers. BLAST was a comprehensive computer program that estimated hourly space heating and cooling requirements, hourly performance of fan systems, and hourly performance of conventional heating and cooling plants and/or solar energy systems.⁶⁴ After its first release in December 1977, the program was extended and improved by CERL under the sponsorship of the General Services Administration. These improvements led to the release of a

second version of the system in June 1979.⁶⁵ However, since this version was not capable of studying passive solar applications or analyzing large-scale industrial facilities, BLAST was again modified by CERL under Air Force and Department of Energy sponsorship. This refined version of BLAST, which appeared in March 1981, could now be used to model passive solar applications and to analyze large-scale industrial facilities. The system became the most actively used energy program in the Army.⁶⁶

In the area of combat support, CERL invented a method of rapidly building structures on the battlefield using plastic foams. Research in this field had been going on as early as 1973. The invention resulted in a canvas-encapsulated foam arch which could be erected in 15 minutes, at which time it could support earth and sand bags. The invention also led to using structures made of reinforced foam for rafting in wet-gap crossings and for reinforced bridging in dry crossings employed by the Army's Rapid Deployment Force. The invention was issued a patent.⁶⁷

Because senior Army commanders were concerned that the time employed in the Military Construction, Army (MCA) process was too excessive, CERL was asked to conduct a study to streamline and shorten the MCA cycle. This study, which was undertaken in Fiscal Year 1982, resulted in 38 recommendations designed to reduce the cycle from about 4 or 6 years to as few as 2 years. The study also recommended procedures closely coordinating the MCA cycle with the Weapons System Development Cycle. This recommendation was expected to streamline the MCA process even further.⁶⁸

Because of the energy shortage, the Army was investigating the technical and economic feasibility of using alternate sources of fuels for its central heating and power plants. Oil and gas were becoming increasingly scarce and expensive, while conversion to coal required large expenditures to install equipment that removed particulate matter and sulphur oxides from the gasses before they were released to the atmosphere. Alternate fuels, especially renewable fuels, offered the Army an opportunity to meet its needs cost-effectively, dependably, and in an environmentally compatible way. One such fuel was biomass, which included all products that underwent photosynthesis such as wood, corn, and algae, as well as human and animal wastes. Of these forms of biomass, wood provided the highest potential for Army use as a renewable energy source. Wood was the most feasible product since the Army was custodian of large forest preserves. The Army managed about 1.5 million acres of forest. Other sources of wood on Army installations included construction and demolition waste, packaging, carpentry shop scrap, and waste from demilitarization activities. Moreover, there was the commercially available wood waste and processed wood fuel that was on the rise near many installations. This research project was officially called the Densified Biomass-Derived Fuel (Fig. 16).

As the largest construction activity in the world, the Corps of Engineers was often confronted with the challenge of keeping construction costs to a minimum in the face of increasing demands for energy savings

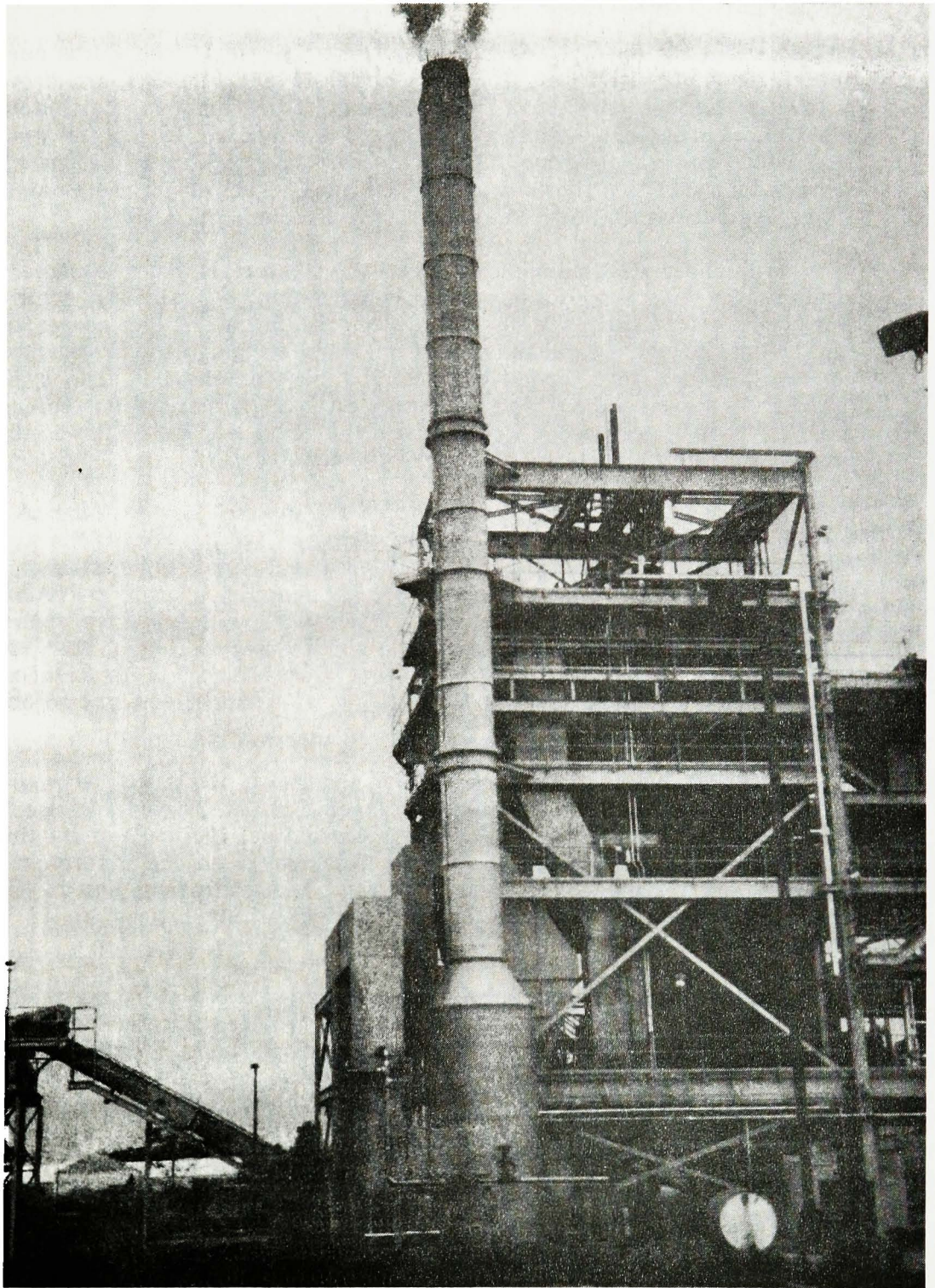


Fig. 16

Woodburning Plant at Fort Stewart, Georgia

and concerns for safety, accessibility, and efficiency. The Corps needed automated tools which would support design layout, analysis, and drawing production on repetitive and similar projects. To accomplish this objective, the Chief of Engineers directed CERL to produce an automated system that would reduce design costs and increase the quality of design. The system that CERL ultimately developed became known as the Computer Aided Engineering and Architectural Design System (CAEADS).

Still under development in 1986, this system is being designed to support the planning, design and construction of military facilities worldwide. CAEADS was to begin with the initial requirements for a facility and continue through concept and final design to the production of construction drawings, specifications, and cost estimates. The system interfaced with such programs as energy analysis, structural analysis, and drafting systems. By reducing the amount of redundant data entry in these programs, a set of tools became more time-efficient.

In October 1981, the integration of the concept design tools of the system was completed and successfully tested on 200 projects in the Fiscal Year 1984 Military Construction, Army Program. Tests conducted at the Sacramento Engineer District showed the applicability of using CAEADS in concept design studies for selecting life-cycle, cost-effective, passive energy alternatives within the available timeframe. In Fiscal Year 1985, the programs were tested at five other Corps Districts to determine further impacts and to identify ways to transfer this technology to other Corps areas.⁷⁰

CAEADS was used as a teaching mechanism in the graduate program of the University of Illinois' College of Architecture. It was also used by the College of Architecture to develop correctional facilities in the State of Illinois. The United States Military Academy used the system in its research and testing. The Navy, Veterans Administration, and industry were introduced to CAEADS through a formal public review of the system.⁷¹

Another important research project designed to assist in maintenance and repair at Army installations was the Voice-Activated Inspection System, a computer-aided device. This system allowed an inspector at an installation to log his observations orally into a hand-held tape recorder. He then submitted the tape to be played into the Voice-Activated Inspection System. The system translated his remarks into a meaningful report with no further human delay or effort. The possibilities of transferring this technology to the public and private sectors were considered enormous. As a result, the American Public Works Association entered into an agreement with CERL to test the system in four cities in 1985. CERL wrote the software programs on a reimbursable basis in each of the four applications. Each city was responsible for purchasing the hardware for the system. Both the Laboratory and the Association were to troubleshoot the systems during testing, while the latter was to write a report documenting the results of the tests.

Because of the high demand for the system in government and private industry, in 1985 CERL was in the process of writing a universal application program, permitting anyone with a knowledge of the desired application to use the system to specify the desired vocabulary and output format. Previously, the laboratory had to do this for each application. The new process required no computer programming knowledge, and it could automatically create a voice recognition program that fit the application.⁷²

Two other major projects undertaken successfully during these later years were Real-Time Weld Quality Monitor and the Ceramic Anodes for Corrosion Protection (Fig. 17). The first was a significant contribution towards locating welding flaws early in the construction phase. During the welding process, changes in arc voltage, travel speed, and heat input can occur without the operator's knowledge. These changes could cause defects in the weld such as porosity, slag inclusion, incomplete fusion, and undercut in the deposited weld metal. The cost of locating and repairing these defects was of some concern to the Army. It was estimated welding inspection constituted as much as 25 to 40 percent of the cost of weld fabrication. Moreover, defects decreased the service life of welded joints. The Corps believed it was necessary to monitor welded parameters to detect and identify flaws. To address this need, CERL developed a portable weld quality monitor (WQM) whose purpose was to provide a mechanism that would merge the welding engineer's design intent with the actual field-welding process. Use of the new device prevented costly reworking, sometimes five times as expensive as the initial placement of defective welds. The innovation led the Army to grant exclusive licensing rights of the invention to the National Standard Corporation of Niles, Michigan. No other Corps laboratory had ever enjoyed such a distinction. The Army planned to employ the monitor in developing tank and weapon systems as well as in Civil Works. The private sector was expected to enjoy the benefits of this invention when applied to the construction of pipelines, nuclear reactors, and structures in general.⁷³

The ceramic anodes represented a breakthrough in corrosion prevention by providing corrosion protection at one-fourth the cost of previous technologies and in a reduced size that permitted installation in areas previously considered too small. The Corps was responsible for maintaining many types of metallic structures that could corrode, but this corrosion could be stopped by introducing cathodic protection, that is, by applying a small electric current from an outside source to the corroding structure. In a preliminary investigation conducted by CERL in 1982 and 1983, some drawbacks were discovered in the use of this process due to the high cost of manufacturing the anodes. In later studies, CERL developed a new plasma-sprayed ceramic anode that improved performance and minimized cost. The ceramic anode that resulted from this study was much smaller (500 times lighter) than its predecessor, which was made of silicon-iron and graphite, and had the same life span. The new anode could protect 100 square feet of bare metal, or 100 times that amount of painted metal, from rusting. The ceramic anode successfully underwent field testing on

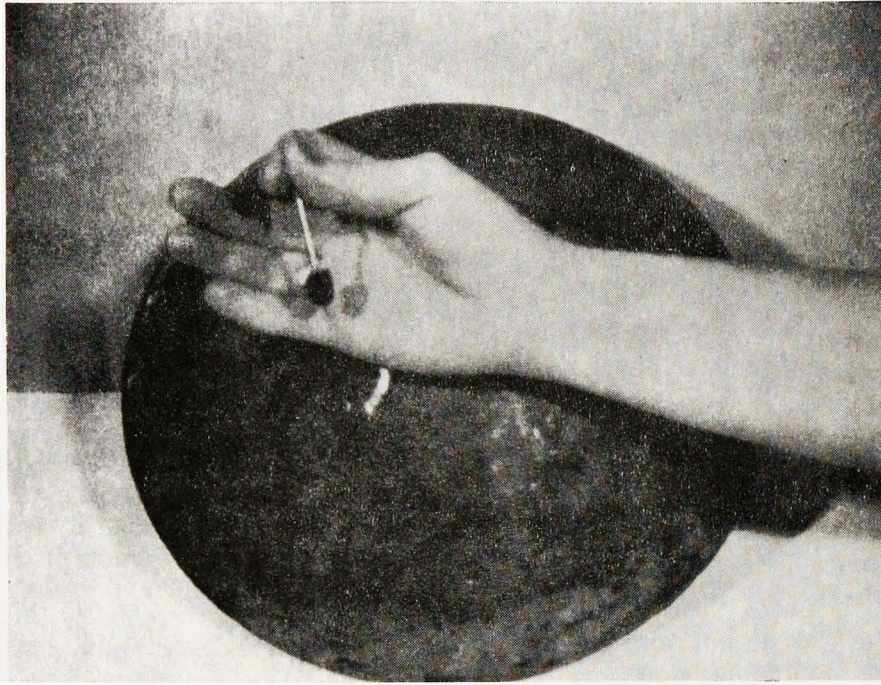


Fig. 17

Ceramic Anode

lock gates at Millers Ferry (Mobile District), on water towers at Fort Eustis, Virginia, and Fort Ord, California, and on underground pipes at Fort Carson, Colorado. The Army was to use the anode to prevent the corrosion of water towers, underground piping, and locks on waterways. The invention was granted an exclusive license by the government to APS Materials, Incorporated, of Dayton, Ohio, to produce the item.⁷⁴

Technology Transfer. Since CERL was first established, its mission mandated that whenever possible its research results would be transferred to the public and private sectors. In some instances, as in the case of runway and pavement technology, the transfer of technology was accomplished early. Moreover, new technology was always being transferred to Army installations. Within the Corps the transfer process had been the primary responsibility of the Office of the Chief of Engineers and its technical monitors. Official technical publications, training sessions, and demonstrations were used extensively as a medium of transfer of this technology. The Office of the Chief of Engineers made most of the transfer technology available through its official publications, that is, primarily through its guide specifications, engineering manuals, and

sometimes through its engineering technical letters and engineering technical notes. These publications were all intended for internal use by Corps Districts.⁷⁵

In the absence of a systematic transfer mechanism, allowing the potential user to understand what the Laboratory was accomplishing and how its research might possibly help them, research could go almost entirely unnoticed. For this reason, success was achievable only if a systematic and well organized transfer program was in operation. In the early years, such a mechanism was lacking. The result was that many of CERL's achievements went unnoticed in an industry that was largely divided, hungry for information, and lacked cost-effective methods.

To speed up the process of transferring technology developed at Federal laboratories, Congress passed the Stevenson-Wydler Innovation Act of 1980. This act mandated that Federal laboratories develop active programs for transferring technology to state and local governments and to the private sector. The mechanism to accomplish this goal would be the prerogative of the individual laboratory. The legislation gave impetus to the Technology Transfer Program at CERL. As a result, CERL established the Office of Research and Technology Application as a Special Assistant to the Commander. This designation was later changed to the Office of Civil Works and Technology Transfer. Dr. Gilbert R. Williamson, formerly Chief of the Engineering and Materials Division, was appointed to this position.⁷⁶

Establishing a Special Assistant whose primary responsibility was to coordinate the transfer of technology undertaken at CERL placed this function "onto the front burner." Unfortunately, money budgeted for this purpose was cut by the Administration soon after the legislation was passed, and costs incurred by the program had to come from RDT&E funds.⁷⁷ In spite of the cut, CERL was able to make the Technology Transfer Program a success, perhaps the best in any of the Army laboratories. Between 1980 and 1985, the Laboratory applied for 49 patents; 15 were issued. Even more remarkable was the fact that in 1984 the Laboratory granted exclusive licensing rights to private firms for the manufacture of two of its inventions--the Weld Quality Monitor and the ceramic anode--previously discussed. The licensing agreements were the first ever to be accomplished in the Corps. "These licensing arrangements," said Colonel Theuer, "ensure commercial availability of Army products to both the Army and private industry. If we've invented it, and the taxpayers have paid for it, they have a right to it."⁷⁸

The Laboratory could boast that as a result of its very active program, its research products, originally developed for the Army, were finding widespread use in the public and private sectors. The transfer of technologies at CERL was estimated to have resulted in increased productivity, improved performance, lower costs, and the creation of new jobs for the economy. The manufacture of government-developed products by the private sector, as in the case of the ceramic anode and the Weld Quality Monitor, not only ensured their availability for public use, it guaranteed their availability for government procurement. The transfer of BLAST resulted in more than 45 computer vendors and consulting engineering firms employing the system. Several architectural and

engineering firms made use of the Solar Feasibility Determination System (SOLFEAS). By 1986, at least five companies were manufacturing the Porta Washer, the prototype of which was first developed and built by CERL.⁷⁹

At least seven major research projects were transferred successfully to the general public and to the private sector. Although some of these have already been described, their transferability will be discussed here.

By February 1984, the transfer of the Pavement Maintenance Management System (PAVER) to the American Public Works Association (APWA) was completed. PAVER was a computerized system completed in 1981 which provided engineers with a practical decision-making method for identifying cost-effective maintenance and repair on roads, parking lots, and airfields.⁸⁰ After successfully testing the system at 6 cities, the APWA offered the system to 45 cities in the United States and Canada. In addition, a number of architectural and engineering firms were accessing the system for possible use in their own work. PAVER was the first system to help the city manager, pavement engineer, airport manager, and state highway engineer allocate limited repair and maintenance funds to the best advantage. The University of Illinois' Department of Continuing Education provided training in the use of PAVER to all elements of the Department of Defense and to city, state, and foreign government transportation planning commissions. More than 125 people in the public and private sectors were trained by the end of Fiscal Year 1983.⁸¹

The Building Loads and System Thermodynamics (BLAST) System was another technology transfer that was used by mechanical engineers to analyze energy requirements in facilities. A BLAST Support Office was established at the University of Illinois to provide software support to undergraduate programs in the Department of Mechanical Engineering. The system was also taught at the University of Wisconsin. BLAST was transferred to the private sector several years ago, and by 1985, more than 50 companies were employing the system. BLAST was made available to the private sector through three major software companies (McDonald Douglas, Control Data Corporation, and Boeing Computer Services). It was also distributed to the public and to private industry by the Argonne Laboratories of the Department of Energy and by the National Technical Information Service. BLAST was one of the most important examples of technology transfer in CERL history, receiving very wide attention from both the public and private sectors.⁸²

Another computer system, the Solar Feasibility Determination System (SOLFEAS), provided the building designer with a quick, simple, and inexpensive way to assess the initial cost of a solar system for a facility under construction. The program enjoyed the following advantages: it required a minimum of user input, it was inexpensive to operate, it was sufficiently accurate to perform solar feasibility studies, it could account for future variations in the critical impacting of a solar system payback, and it was structured around approved methods for performing economic feasibility studies.⁸³ SOLFEAS was made available to architectural and engineering firms throughout the country.

Computer Evaluation of Utility Plans (CEUP) consisted of a series of computer programs that analyzed electrical distribution, water distribution, sanitary sewerage, and storm drainage systems at an existing site to determine their accuracy in supporting construction.⁸⁴ This product was made available to the public through the APWA.

Three patents were issued to the Laboratory on the Weld Quality Monitor system. An exclusive right to these patents was granted to the National Standard Company for the manufacture and distribution of the WQM.

The ceramic anode was successfully used on the Millers Ferry lock gate in the Mobile District and the Racine lock gate in the Huntington District. The anode was also installed on gates in the Cordell Hull Dam in the Nashville District. Besides being used on lock gates, the anodes were also placed on water towers at Fort Eustis and Fort Ord and on underground pipes at Fort Carson and Fort Polk. On the basis of these tests, the ceramic anode was incorporated into the Corps' technical manuals for underground pipes, water storage tanks, draft guide specifications, and lock gate cathodic protection systems.⁸⁵ The anode was expected to revolutionize the way cathodic protection systems were designed. The anode could be purchased for \$150.

Finally, there was the Environmental Technical Information Systems (ETIS), which was operated and maintained by the Department of Urban and Regional Planning at the University of Illinois. This system was actively used through a toll-free telephone number by all major Army and Air Force commands, other Federal agencies, state and local governments, and nongovernment users. The University also provided ETIS training to all Department of Defense users and to city and state planning commissions. More than 600 requests for assistance were recorded each month in 1985.⁸⁶

The future of the Technology Transfer Program in CERL appears even brighter. In 1985, research studies on Remote Site Waste Treatment continued with the cooperation of several universities and the Army Surgeon General's Office. This project was being monitored and evaluated continually at several Army installations, and the transfer of this technology was nearing completion. Interaction on this project was also evident with such interested parties as the Environmental Protection Agency, National Park Service, and other government agencies. The results of this research were expected to help the military and the public sector provide human waste disposal facilities that were considered cost-effective, efficient, and environmentally sound. As 1985 was drawing to a close, Colonel Theuer was in the process of convincing the local officials of Champaign and Urbana, Illinois, of the importance of installing such a system in their cities.⁸⁷

Small Problem Program. CERL instituted the Small Problem Program in 1976 to assist potential users with a problem while it was still "small" and subject to a quick solution.⁸⁸ The program was important to CERL because it provided a vehicle for direct, quick, and positive action to people in the field. The program was a significant component of the technology transfer process, while providing CERL personnel with an

insight into the problems of the field. It was aimed at mitigating the criticism that CERL's professionals lived in an ivory tower accomplishing research, albeit important, which had little application to the immediate problems of the field. This criticism came from no less than the Office of the Chief of Engineers. CERL commanders attempted to soften criticism by placing more emphasis on research aimed at finding solutions to problems in the field.⁸⁹

The type of assistance rendered under the Small Problem Program could vary from a telephone conversation to a visit to the field or job site. For Army organizations, CERL assistance was limited to a maximum of 2 mandays without charge to the requesting agency. The cost was charged to the CERL office providing the assistance or to the Laboratory's overhead. However, any expenses incurred because of CERL travel within the 2-day period were paid by the requesting agency. Other Department of Defense agencies and nonmilitary Federal agencies could take advantage of this assistance, but this was restricted to telephone requests only; all other assistance was reimbursable.

The Laboratory gave this program wide publicity, even publishing an attractive brochure. Responses to the program were excellent. Between February 1977 and November 1978, the Laboratory handled 149 requests, including answers to new ways of painting bridges, buildings, and aircraft; methods of constructing storage areas for hazardous materials; and how to retrofit family housing units to decrease energy consumption.⁹⁰

The Small Problem Program at CERL was the forerunner of a program established by the Chief of Engineers called the One-Stop Research and Development Service Program. When the One-Stop Program was established, CERL already had one in place for 6 years. The program continued to receive well-deserved praise in CERL. During Fiscal Year 1980, the Laboratory responded to 741 requests for services, most of which came from Corps districts seeking help with problems in operations and maintenance. The following year the number almost doubled, and in Fiscal Year 1982 the story was the same. In one of his annual reports to the Chief of Engineers, Colonel Circeo proudly noted, after assessing the successes of this program, that people were "thinking CERL."⁹¹

VI

SUMMARY AND CONCLUSION

Corps Research, in its broadest sense, is as old as the Corps of Engineers itself. However, it was not until 1927, with the establishment of the Waterways Experiment Station, that Research became a separately funded item in the Corps' budget. Even then, there was no long-range research in vertical construction. Whatever research was accomplished in this area was ad hoc research usually performed by the divisions and districts. As the 1960s approached, only 0.5 percent of the Corps' research budget was in construction. If research was to be funded at this level, the Corps would be unable to serve the Army adequately at a time when some were demanding a stronger national defense. The Corps' ability to face the construction problems of the future were questioned. Many people saw flaws in the Corps' research stemming from factors that were inherent in the construction industry as a whole. They concluded that the Corps' ad hoc approach to research was nothing more than a collection of unrelated projects without any formal plan. The research was duplicative, repetitive, and, most of all, inefficient.

The construction industry was partially to blame for what prevailed in the Corps. The industry was fragmented, wasteful, the most backward of all industries, and lacking in a coordinated effort. The few academic institutions that dealt in construction research reflected this mood. The construction industry was unwilling to change.

Faced with these inherent weaknesses, the Corps needed to broaden and redirect its research so it could handle the problems of a space age, new weapons, and a more sophisticated Army. Between Fiscal Years 1965 and 1968, the Corps' research program was expected to increase almost fourfold. Research had to meet the demands of the future. This meant that research had to take on a different character. It would have to be long-range, more basic, and it would have to follow a systems approach. The ad hoc approach to unrelated problems was no longer adequate. The Ohio River Division Laboratory did not have the resources to assume this responsibility.

Harry B. Zackrison and others in the Office of the Chief of Engineers saw this as an opportune time to advance the cause of a new laboratory, one that was designed to fulfill long-range research employing the systems approach to vertical construction, while still providing solutions to the immediate and recurring problems. The new laboratory would be located near and affiliated with a major educational engineering institution, an idea very unique in government. The educational institution was to be a partner in exploring new fields in the construction industry. The new laboratory was to concern itself with all types of structures, large or small, and their related problems, beginning with the concept of a structure, its plan, design, construction, operation, maintenance, and finally, its demise.

There were some people inside and outside the Corps who proposed that the new laboratory be a center of research for all construction--military and nonmilitary--to whom the construction industry could turn for leadership. This view was obviously too unrealistic. The construction

industry was far too fragmented and competitive to imagine a research center in this sense. Moreover, the Defense establishment, and particularly the Army, had its own special problems to consider. A research center of the kind envisioned by these individuals would have to await a future time. In the meantime, the Corps of Engineers had to be satisfied with a more realistic and modest laboratory designed to satisfy the Army's needs.

The idea quickly received the sanction of the National Academy of Science's Building Research Advisory Board, and this was followed by support from the Departments of the Army and Defense. Although there were some misconceptions about the laboratory's mission at first, the Corps pushed forward its plan. After conducting a thorough survey of interested institutions, the Corps selected the University of Illinois in Champaign, Illinois, as the affiliate in this new venture.

On 1 May 1968, the U.S. Army Construction Engineering Research Laboratory (CERL) was established with temporary quarters at the Ohio River Division Laboratory in Cincinnati. The following year, CERL moved to its permanent home (which was built by the University) in Champaign.

The early years were a time of experimentation as CERL sought to improve its organizational plan, hire professionals in appropriate disciplines, and adjust to its new facilities. These problems were not always easy to overcome when both the Office of the Chief of Engineers and CERL were as yet unable to determine specifically the kind of research projects the Laboratory was to perform. At first, some duplication of research with the Waterways Experiment Station was inevitable. As the research requirements became clearer and professionals with diverse disciplines were hired, many of the problems lessened. By 1973, CERL's Commander could boast that the Laboratory's strength was not in depth of expertise but in "coverage and mix." It was not long before this competent group of professionals gained a reputation for themselves and for the Laboratory.

Funding was a problem during the early years because the Laboratory was young and few people understood its capabilities. As more funds became available and new research projects were assigned, CERL was able to purchase sophisticated equipment. Most important among these items was the Biaxial Shock Test Machine. The addition of this machine enhanced the Laboratory's reputation.

All research, whether long- or short-term, with RDT&E or Reimbursable Funds, was concerned with furthering the Corps' military construction mission. There were few limits to the kinds of problems CERL could handle. As the years progressed, nonmilitary Federal agencies also sought the Laboratory's assistance. The diversity of disciplines at the Laboratory was largely the reason. CERL received recognition in research very early in its existence. Some of its research results were successfully employed in Civil Works. Its studies in rigid pavements led to the development of a fibrous concrete used in constructing revetments along the shoreline, dams, and piers. For a young organization this was no small accomplishment.

The early years did not go by without some criticisms. To compete for funds with the older and more established laboratories, CERL sought short-term work where funds were available and results were quickly achieved. The Office of the Chief of Engineers was critical of this action, believing that too much short-term research was contrary to CERL's mission. The Five Year Research and Investigation Plan for Fiscal Years 1974 through 78 was intended to correct this imbalance. There were other criticisms directed at CERL, raising some doubts about the relevance of its work. These questions were a natural and healthy outcome of management's review of its policies. After 5 years of CERL's existence, it was time for such a review.

The years that followed 1973 saw the Laboratory come of age. It was recognized not only in military circles but outside as well. It had matured and overcome many of the problems of its earlier years. With the help of the Graduate Assistant Program and the Civilian Intergovernmental Personnel Act the workforce nearly doubled. Experimenting with new organizational plans led to the formation of a system of teams, providing greater flexibility in accomplishing diverse research projects. Phase II of construction saw the building of much-needed facilities at the Laboratory. CERL experienced its greatest change in the area of funding. From a \$5 million budget in Fiscal Year 1973, the budget jumped to almost \$40 million in Fiscal Year 1986. About half the budget was in Reimbursable Funds, a strong indication of the extent to which CERL was recognized nationally. As its reputation widened, more and more government agencies, military and nonmilitary alike, and the private sector looked to CERL for assistance.

The largest growth in research was in energy and the environment, the two great national concerns of the Seventies and Eighties. Other research areas grew as the result of an increasingly sophisticated Army, and CERL became involved in developing new ways of accommodating new weapons systems and attracting and retaining a Volunteer Army. As CERL's research assisted the Defense establishment and nonmilitary government agencies, many of the research results were eventually transferred to the public and private sectors. A formal Technology Transfer Program, instituted in these years, made this possible. The Laboratory received several patents, and granted licensing rights to two private firms, the first such achievement in Corps history.

Affiliation with an institution such as the University of Illinois was new in government, and it was fraught with misgivings when the idea was first broached. It soon became clear that these fears were unfounded. In time, the University became an asset to the Laboratory, providing it with a workforce of undergraduate and graduate students and faculty. This academic workforce contributed greatly to the Laboratory's professional standing. Many of the research contracts issued by CERL went to the University. The University collaborated with CERL in developing computer-aided programs that were placed in operation at the University. Eighteen years of experience with the University had, without a doubt, justified the affiliation between CERL and an academic Institution of high repute.

When the Laboratory was first established there were high expectations for its accomplishments. At the same time, there was a natural concern that it might not succeed. After its research became more clearly defined, its relations and interaction with the University became firmly established, and its funding increased, it was clear that CERL had more than fulfilled expectations. CERL's ability to achieve national recognition--first, by accomplishing outstanding results, and second, by transferring these results to the Army and others--was very important. As Dr. Shaffer so aptly noted, CERL had become a "beta" site for the construction industry.

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APPENDIX 1

RESEARCH ITEMS WHICH MIGHT BE ASSIGNED TO THE NEW RESEARCH FACILITY

The following are typical of studies which might be proposed for the new facility depending upon the facilities and capabilities available there and at WES at the time the studies are undertaken:

<u>Items</u>	<u>Begin FY</u>	<u>Estimated Annual Expense</u>	<u>Estimated Duration</u>
Stress Measurements in Circular Conduits by means of Elastic Models	68	25,000	4
Design of Gates (Tainter, Slide, Lock) Utilizing the Effect of Skin Plates in the Design	68	25,000	4
Development of Standard Crane Loading Diagrams for Spillway Bridges	68	15,000	3
Adhesion of Floor Tile and Separate Floor Toppings	68	10,000	2
Shear Evaluation of Rock Foundations	In Progress	20,000	3
Low Temperature Effects on Structural and Pressure Vessel Steel	68	15,000	4
Aluminum as a Structural Material	68	15,000	4
Prestressed Concrete Tainter Gate Anchorages	68	10,000	3

APPENDIX 2

ENGMC-ER

8 Feb 65

Investigations Which Civil Works Might Support at the Construction Engineering Laboratory

1. Structural Design of Pipe and Box Culverts

Testing and analysis of strength of pipe, pipe arches and box culverts under various installation conditions - high fills shallow cover, various bedding, and back fill conditions.

2. Standard Design of Head Walls, End Walls and Wing Walls

Determination of optimum sections, placement of reinforcing and principles of economic design.

3. Reinforcing

Determine value of glass, bamboo, and other fibrous items as concrete reinforcement.

4. Aggregates

Develop manufactured aggregates from synthetics for concrete structures.

5. Rock Mechanics

Develop criteria for diversion tunnels, foundations, and rock fill dams. Strengthening and excavation should also be considered.

6. Criteria for Dam Facing and Reservoir Lining

Investigate the use of asphalt, asphalt rubber, epoxy extended mixtures, membranes, and polymers.

7. Pavements

Develop criteria for access and relocated roads designed and built by Civil Works.

8. Design, Construction, and Materials

Consider shore installations, wharves, piers (including the protection of these). Consider materials for overseas construction.

9. Prestressed Concrete

Expand work done by ORDL to design of prestressed navigational structures. (WES has done some work but ORDL has been at it longer and done more. Started 1951 and well underway by 1953.)

10. Epoxy

Expand work done by ORDL in the use of epoxy and polymers in the repair of structural members. (WES has done some work but ORDL has been in the work much longer and has done more. Started in 1955 and well underway in 1957.)

11. Cofferdams

Study of stability of cofferdams; should be instrumented to measure stress. The tendency is to make the cofferdam as thin as possible. The present empirical design is not very well developed.

12. Conduits

More work is needed on reinforced concrete conduits for navigational structures.

13. Batter Bearing Piles

Better criteria are needed for the design of battered bearing piles used in navigational structures.

14. Flood Walls

More work is needed to develop better design criteria for flood walls, especially the distribution of stress on the keys and bases of flood walls. ORDL lost their instruments on the underground cells and piezometers when they made a study several years ago. They became inaccurate through moisture, dirt and mechanical failure. Instruments were not as good as those available today.

15. Reinforced Concrete

More information is needed on shear in reinforced concrete design for navigational structures. A lot of work has been done and much data collected but criteria are not good.

16. Retaining Walls

Much work should be done to improve retaining wall design. For example, the Lake Erie and Ohio River Canal estimated to cost \$1,000,000,000 has retaining walls estimated to cost \$150,000,000. A more economical design might result in considerable savings.

17. Impact Factors

Studies are needed to learn more about the impact factor of boats and barges hitting locks and dams.

18. Tainter Gates

More information is needed on the stress on the skin of tainter gates. The information can be obtained through instrumentation.

19. Concrete Placement

More information is needed on placing concrete by soil placement techniques. This could include sheepsfoot rollers to place mass concrete for dams. A very dry mixture could be used. This has been done recently in Italy.

20. Welding

Information is needed on effects on navigational structures due to defective welding. What is the mode of failure? It is very costly to go back to these structures and repair them.

21. Joint Seal

Better materials are needed to seal the joints in spillways.

22. Structural Modeling

A capability should be developed in structural modeling of concrete.

APPENDIX 3

POSITIONS TO BE TRANSFERRED FROM ORD TO CERL

(TRANSFER TO BE ACCOMPLISHED DURING FY 68 3rd
QUARTER. POSITIONS ARE SHOWN IN ORDER AS ON TDA)

<u>03 Research Support Division</u>	<u>Grade</u>	<u>BR</u>	<u>Number</u>
Technical Publ & Reports Writer	11	GS	1
Photographer	06	GS	1
Editor	05	GS	1
Clerk Typist	05	GS	1
Editorial Clerk	04	GS	1
Machinist	11	WB	2
Mechanic	08	WB	2
 <u>04 Management Support Division</u>			
Clerk	06	GS	1
Clerk Typist	05	GS	1
Clerk	04	GS	1
Bookkeeping Machine Operator	04	GS	1
Clerk Typist	04	GS	1
Chauffeur	04	WB	1
Janitor	02	WB	1
 <u>05 Engineering Development Group</u>			
Research Structural Engineer	14	GS	1
Research Physicist	13	GS	1
Mathematician	07	GS	1
Clerk Typist	05	GS	1
 <u>06 Laboratory Group</u>			
Supervisory General Engr	15	GS	1
General Engineer	14	GS	1
Civil Engineer	14	GS	1
Civil Engineer	13	GS	2
Research Soil Chemist	13	GS	1
Mining Engineer	13	GS	1
Civil Engineer	13	GS	1
Structural Engineer	12	GS	2
Electronics Engineer	12	GS	1
Mechanical Engineer	12	GS	1
Chemist	12	GS	2
Civil Engineer	12	GS	3
Electronics Engineer	12	GS	2
Civil Engineer	11	GS	2
Electronics Engineer	11	GS	1
Electronic Dev Tech	10	GS	1
Physicist	09	GS	1

Materials Engineer	09	GS	1
Chemist	09	GS	1
Civil Engineer Tech	09	GS	4
Civil Engineer	09	GS	1
Civil Engineer Tech	08	GS	1
Chemist	07	GS	1
Materials Engineer Tech	07	GS	1
Civil Engineer Tech	07	GS	2
Civil Engineer Tech	06	GS	2
Materials Engineer Tech	06	GS	1
Chemist	05	GS	2
Physicist	05	GS	1
Materials Engineer Tech	05	GS	1
Civil Engineer Tech	05	GS	3
Materials Engineer Aid	05	GS	1
Clerk Typist	04	GS	1
Materials Engineer Aid	04	GS	1
TOTAL			69

APPENDIX 4

PROPOSAL

to

**OFFICE OF THE CHIEF OF ENGINEERS
DEPARTMENT OF THE ARMY
ENGMC-ED
WASHINGTON, D.C.**

for

ENGINEERING LABORATORY FOR CONSTRUCTION RESEARCH

by

**University of Illinois
College Of Engineering**

**the
Interstate Research Park**

**and
the Communities of
Champaign, Illinois
Urbana, Illinois**

17 June 1966

GENERAL SUMMARY OF PROPOSAL

for

ENGINEERING LABORATORY FOR CONSTRUCTION RESEARCH

This proposal is submitted in reply to the request from the Office of the Chief of Engineers, dated 26 April 1966, indicating the intention of the Corps of Engineers to consider the establishment of a new engineering laboratory for research and investigations in support of its construction mission. The proposal is submitted in behalf of the University of Illinois, the Interstate Research Park, and the community of Champaign-Urbana, and indicates their joint interest in the proposed laboratory and their desire to have it located near the University of Illinois. It describes in detail the advantages of a close association both with the University and with the community in the development and operation of the laboratory.

The University of Illinois is one of the great universities of the nation. In its general stature, especially as regards graduate work, it was considered by a recent evaluation of the American Council on Education to be one of the five most distinguished universities in the country. Its College of Engineering, with nearly 1,400 academic staff personnel in 17 areas of specialization, 3,600 undergraduate students, and 1,300 engineering graduate students, is recognized both nationally and internationally as one of the leading engineering schools in the United States. The annual research budget of the College is almost \$15,000,000, most of which is closely integrated with its graduate and undergraduate instructional programs. The number of undergraduate and graduate degrees in engineering is among the highest in the country so that the proposed laboratory can draw upon graduates at both beginning and advanced levels as a source of personnel.

The Departments of Civil Engineering and Electrical Engineering are among the top four "Distinguished" engineering departments in their fields in the country, and other departments are rated very high, with the general ranking of the entire engineering college, by the ACE evaluation, as fifth in the nation, just behind MIT, Berkeley, Stanford, and California Institute of Technology.

Members of the faculty of the College of Engineering, whose outstanding prestige has led to this distinguished rating, have had close contact for many years with the Office of the Chief of Engineers and the various laboratories of the Corps of Engineers, as consultants, panel members, contractors, and advisors. Professors N.M. Newmark, R.B. Peck, C.P. Siess, W.J. Hall, D.U. Deere, H.O. Ireland, M.T. Davisson, T.H. Thornburn, J.L. Merritt, and A.J. Hendron, Jr. have been closely associated with many programs in which the Corps of Engineers has had a major interest, and all have contributed to the development of the mission of the Corps of Engineers, the Waterways Experiment Station, the Ohio River Division Laboratories, and the various divisions and districts of the Corps.

The research program in the College of Engineering is of such a nature that it will interact with and support extensively the proposed program of research in the Construction Research Laboratory. The nature and extent of the research program in the College of Engineering is described in a major section in the detailed proposal which follows, and a complete summary of the entire program of current engineering research is presented as an Appendix to this proposal.

The laboratories of the various departments in the College of Engineering are excellent and provide facilities which can be used to support fundamental research in the various fields of interests for the new laboratory, as well as to supply capabilities on an emergency basis or on a complementing, sustaining basis, when additional facilities are needed for such purposes by the proposed laboratory. With the completion of the new Civil Engineering Building in late 1966, additional laboratory space will become available to make the capabilities of the College of Engineering among the best in the country. Supporting laboratories such as the Materials Research Laboratory, the Coordinated Science Laboratory, and the Computer Laboratory in the Department of Computer Science will be available on the same basis as other laboratories in the Departments of the College of Engineering to cooperate with and to assist in the program of the proposed laboratory.

Computing facilities at the University will be available to the laboratory. Advanced computing equipment, including an IBM 1401-7094, the ILLIAC 11 computer, an IBM 1620-40K computer, and other special purpose computers, are available at the present time, and additional computing equipment will be available in the near future, including the equivalent of an IBM System 360, Model 75.

The University is uniquely qualified to cooperate with the Corps of Engineers in accomplishing the objective which had been assigned to the Laboratory, i.e., "securing advance knowledge of materials and techniques to provide performance, speed and economy in current and proposed construction."

The site available for the laboratory meets the criteria described in the request for proposal. This site is in the Interstate Research Park, within five minutes drive of the heart of the University, adjacent to an interchange of two major interstate highways providing access north to Chicago, west to St. Louis, and also east and south. A site of 28 acres has been allocated for immediate use, which is sufficient space for the 3 phases described in the request for proposal. Additional space is available which will permit expansion within the next few years, and the surrounding area is being reserved for such possible future expansion. The park has paved streets and all utilities including natural gas and city water and is more completely described in the following sections of this proposal.

Additional acreage at a more remote site for field testing operations, which require noise isolation and isolation from other disturbances, can be made available at one of several selected sites which are also described herein. These are all within a 30 to 40 mile radius of the laboratory location.

Detailed discussion of building plans and requirements, and estimates of costs, are contained in the following sections of this proposal. It is specifically proposed that the laboratory will be leased to the Corps of Engineers by the University of Illinois Foundation, which will make the necessary arrangements with the Interstate Research Park and with the University of Illinois to provide for the necessary interaction of the various groups participating in the program. This is another example of the excellent interaction between the University and the community in the development of forward looking programs in the community, and indicates the extent of the cooperation and support which can be expected for the laboratory.

The University would provide access to its services, facilities, and functions for the staff of the laboratory. Experience with state agencies and a U.S. Department of Agriculture Laboratory on campus have furnished a basis for cooperation which will not involve development of new policies or procedures. Joint academic appointments and

visiting lectureships in selected departments may be made if mutually appropriate. Short courses can be organized for the staff of the laboratory, who are also welcomed to numerous high-level technical and professional seminars. The staff of the laboratory will be able to audit or register for credit in undergraduate or graduate courses and will be able to pursue activities leading toward advanced degrees.

The twin communities of Champaign and Urbana, with a population of nearly 100,000 have long experience with and a tradition of cooperation with engineering and scientific endeavor. The central location, with easy access to all parts of the country, is a major advantage which should be of material assistance to the fulfillment of the mission of the laboratory.

Excellent transportation facilities are available with Ozark Airlines, a feeder airline, serving transportation needs to Chicago and St. Louis. Commercial, private, charter and freight service are also available from the two airports. Rail transportation is available through the main line of the Illinois Central Railroad. Interstate Highways 57 and 74 intersect near the proposed location of the laboratory and join other existing highways to provide superior surface transportation to all parts of the country.

The Champaign-Urbana community serves a trading area of roughly 250,000 people. The residents have a high level of education with a median age of only 27 years. Both per capita and family incomes are above the national averages.

Many cultural, recreational and athletic activities will be available to the staff of the laboratory. Cultural activities include programs in theater, musical concerts, and lectures, which are open to the public. The Krannert Art Museum, the University Auditorium, and the University Assembly Hall, all have scheduled many cultural activities which would be of interest to the staff of the laboratory. In addition the Krannert Center for Performing Arts is being developed as a \$14,000,000 project, which will be one of the finest university theater centers in the country, similar in many respects to the Lincoln Center in New York. The University Library is the largest state university library in the nation, and the third largest among all university libraries in the United States.

The community has many fine recreational facilities including two community swimming pools, two country clubs, three University golf courses and several public golf courses, ample bowling facilities, and more than 600 acres of park and playground area. Within a 50-mile radius there are numerous hunting, fishing and boating accommodations. The community facilities, coupled with those offered by the University provide residents with a wide variety of both participant and spectator recreational opportunities.

Of outstanding importance is the fact that the public school systems in the area are progressive with modern, competent facilities, and enriched instructional programs. Through the years the schools have won numerous citations and awards from both state and national organizations for educational excellence and achievement. Special accelerated programs exist for the mentally gifted as well as for the handicapped.

Housing in all price ranges is available and financing facilities are excellent. Over 20 residential subdivisions have been opened during the last two years. There also has been substantial construction of new apartment units which greatly enhances the rental opportunities for newcomers to the area.

The Champaign-Urbana area is served by three commercial radio stations, three commercial television stations representing all major TV networks, and educational radio and television stations operated by the University. We have two daily evening newspapers and a college morning daily.

Medical facilities are outstanding including five hospitals, two group practicing clinics, more than 125 physicians, over 50 dentists, and a mental health clinic.

Shopping facilities in the Champaign-Urbana area are superior with three major shopping centers, in Champaign, Urbana, and campus, and a number of suburban shopping centers.

We feel the new residents of the community of Champaign-Urbana will find a wholesome, congenial and cultural environment in which to raise their families, both to work and to play.

The support of both the University and the community is indicated by the attached letters expressing the attitude of officials concerning the proposed laboratory. Letters are attached from Governor Otto Kerner of the State of Illinois, Mayor Emerson Dexter of Champaign, Mayor Stanley Weaver of Urbana, Richard L. Thies, President of the Urbana Association of Commerce, and Mel Sample, President of the Champaign Chamber of Commerce. In behalf of the University, indications of approval and support are attached from President David D. Henry, Executive Vice-President and provost Lyle H. Lanier, Graduate Dean Daniel Alpert, and Dean of Engineering W.L. Everitt.

This proposal is submitted in behalf of the University and the College of Engineering by Nathan M. Newmark, Head of the Department of Civil Engineering, who will be the representative of the Dean of the College of Engineering in connection with technical matters pertaining to this proposal. Questions involving matters of policy or financial aspects of this proposal are to be addressed to Herbert O. Farber, Vice President and Comptroller, University of Illinois. Questions pertaining to the Interstate Research Park should be addressed to Donald C. Dodds, Jr., P.O. Box 594, Champaign, Illinois.

The representatives of the University and the community feel that the community and the University can offer outstanding facilities and opportunities for the proposed laboratory. We invite the consideration of these opportunities in order that the advantages of locating the laboratory in this community can be fully explored. It will be our intention to assist the laboratory to the maximum possible extent in developing its operations and in integrating its mission with that of our educational and research program in order that these programs can become most fully effective on the most optimum schedule.

APPENDIX 5

Personnel Requirements

<u>FY 68</u>		<u>Number of spaces</u>	
1st Quarter (July - Sept 1967)			
Commanding Officer (located in OCE)			1
2nd Quarter (Oct - Dec 1967)			
Commanding Officer (OCE)	1		
Cadre (located in OCE)	<u>4</u>		
		Total	5
3rd Quarter (Jan - Mar 1968)			
(During this quarter the Construction Engineering Research Laboratory is established by General Order as a separate unit)			
Commanding Officer (OCE)	1		
Cadre (OCE)	4		
Transfer of spaces from ORDL presently authorized CEL)	69		
Additional spaces	<u>6</u>		
		Total	80
4th Quarter (Apr - Jun 1968)			
Commanding Officer (OCE)	1		
Cadre (OCE)	4		
Transferred spaces (ORDL)	69		
3rd Quarter additional	6		
Additional spaces	<u>5</u>		
		Total	85
<u>FY 69</u>			
1st Quarter (July - Sept 1968)			
Commanding Officer (OCE)	1		
Cadre (OCE)	4		
Transferred spaces	69		
FY 68 spaces	11		
Additional spaces	<u>10</u>		
		Total	95
2nd Quarter (Oct - Dec 1968)			
Commanding Officer (located in Champaign)	1		
Cadre (Champaign)	4		
Transferred spaces	69		
FY 68 & 1st Qtr FY 69 spaces	21		
Additional spaces	<u>10</u>		
		Total	105

Number of spaces

3rd Quarter (Jan - March 1969)

Commanding Officer (Champaign)	1
Cadre (Champaign)	4
Transferred spaces	69
FY 68 & 1st & 2nd Qtr FY 69 spaces	31
Additional spaces	<u>10</u>

Total 115

4th Quarter (April - June 1969)

Commanding Officer	1
Cadre (Champaign)	4
Transferred spaces (Physical transfer Personnel from ORDL to Champaign, Ill.)	69
FY 68 & 1st, 2nd & 3rd Qtr FY 69 spaces	41
Support spaces from ORD to NCD	5
Additional spaces	<u>10</u>

Total 130

FY 70

1st Quarter (July - Sept 1969)

Spaces through FY 69	130
Extra moves from OCE to Champaign	12
Data Analysis moves from Adv Tech Br, OCE to Champaign	6
Additional spaces	

Total 153

2nd Quarter (Oct - Dec 1969)

155

3rd Quarter (Jan - Mar 1970)

160

4th Quarter (April - June 1970)

170

FY 71

1st Quarter (July - Sept 1970)

175

2nd Quarter (Oct - Dec 1970)

180

3d Quarter (Jan - Mar 1971)

185

4th Quarter (Apr - June 1971)

190

FY 72

1st Quarter (July - Sept 1971)	195
2nd Quarter (Oct - Dec 1971)	200
3rd Quarter (Jan - Mar 1972)	205
4th Quarter (Apr - June 1972)	210

FY 73

1st Quarter (July - Sept 1972)	220
2nd Quarter (Oct - Dec 1972)	230
3rd Quarter (Jan - Mar 1973)	240
4th Quarter (Apr - June 1973)	260

APPENDIX 6

DEPARTMENT OF THE ARMY Office of the Chief of Engineers

ENGAS-PF

Washington, D. C. 20315

GENERAL ORDERS
NUMBER 17

9 September 1968

ORGANIZATION OF U. S. ARMY CONSTRUCTION ENGINEERING RESEARCH LABORATORY

TC 002. Following Class II Activity ORGANIZED.

U. S. ARMY CONSTRUCTION ENGINEERING RESEARCH LABORATORY (TDA CE W2V5AA), CINCINNATI, OHIO

Assigned to: Office of the Chief of Engineers.

Effective Date: 1 May 1968.

Strength: Initial authorized strength and structure (required) strength are as follows:

	<u>Officers</u>	<u>Civilians</u>	<u>Total</u>
Structure	1	129	130
Authorized	1	34	35

Equipment: Will be provided by U. S. Army Engineer Division, Ohio River on a service agreement basis.

Personnel: One officer will be provided by Office of the Chief of Engineers; 34 civilians will be transferred from the Construction Engineering Laboratory, Ohio River Division Laboratories, U. S. Army Engineer Division, Ohio River.

Files/Records: The Division Engineer, U. S. Army Engineer Division, Ohio River will effect the necessary transfer of files and records from the Construction Engineering Laboratory.

Morning Report: Will be prepared in accordance with AR 335-60.

Mission: To develop, through investigation and analytical studies, methods of advancing the concepts and technology of the design, construction, operation and maintenance of all types of facilities. To advance and disseminate the knowledge of new and improved construction materials and techniques in the interest of national defense and the conservation of natural resources.

Authority: Letter, AGSD-CM (6 Aug 68) ACSFOR, 13 August 1968,
subject: Approval of TDA (CE No. 51, FY 68).

Fund Obligation: In accordance with current fiscal procedures.

Special Instructions: The Division Engineer, U. S. Army Engineer Division; Ohio
River will provide administrative and logistical support to
USACERL by service agreement until such time as the
Laboratory is moved to its permanent location.

FOR THE CHIEF OF ENGINEERS:

A. S. FULLERTON
Colonel, Corps of Engineers Acting
Executive

APPENDIX 7

DEPARTMENT OF THE ARMY
Office of the Chief of Engineers
Washington, D. C. 20315

GENERAL ORDERS
NUMBER 11

18 June 1969

RELOCATION OF U. S. ARMY CONSTRUCTION ENGINEERING RESEARCH LABORATORY

TC 021. Following Organization is TRANSFERRED

U.S. ARMY CONSTRUCTION ENGINEERING RESEARCH LABORATORY (TDA CE
W2V5AA), CINCINNATI, OHIO

Transferred to:	Champaign, Illinois
Effective date:	1 July 1969
Morning report:	Will be prepared in accordance with AR 335-60.
Authority:	Paragraph 6c, Enclosure 1, letter AGSD-C(M) (6 Aug. 68) ACSFOR, 13 August 1968, subject: Approval of TDA (CE No. 61, FY 68).
Special Instructions:	The Division Engineer, U. S. Army Engineer Division, North Central will provide administrative and logistical support to USACERL.

FOR THE CHIEF OF ENGINEERS:

PHILIP T. BOERGER
Colonel, Corps of Engineers
Executive

APPENDIX 8

EARLY CERL PUBLICATIONS

1. Technical Report M-1, "Critical Normal Fracture Strain of Plain and Steel Wire Fibrous-Reinforced Concrete," by D. Birkimer, October 1969, AD#695719 (DASA).
2. Technical Report M-2, "Development and Evaluation of a High-Strength Polyester Synthetic Concrete," by D. R. Bloss, S. J. Hubbard, and B. H. Gray, March 1970, AD#867374L (SAMSO).
3. Technical Report M-3, "Development Study for VFR Heliport Standard Lighting System," by T. H. Morros, Jr., August 1970, AD#710982.
4. Letter Report, "An Examination and Evaluation of Concrete Taken from the Containment Dome of the Florida Power and Light, Tukey Point 3, Reactor," September 1970 (AEC).
5. Preliminary Report, A-1, "Automated Reporting Procedures for Army Constructed Military Facilities," by R. L. Lapp, September 1970.
6. Technical Report M-4, "Strength and Durability of Stabilized Layers Under Existing Pavements," by R. E. Aufmuth, October 1970, AD#715400.
7. Technical Report M-5, "Epoxy Resin Cure Evaluation: Data Report," February 1971, AD#880626.
8. Technical Manuscript S-1, "Air Blast Attenuation," February 1971, AD#729425 (OCE Contract No. DA-49-129-ENG-549).
9. Technical Manuscript S-2R, "Nuclear Weapons Effects: Dust and Air Temperature Environment," February 1972, AD#729426 (OCE Contract No. DA-49-129-ENG-549).
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19. "Laboratory and Field Study of Rubber Removal Compounds," by R. F. Kemphues, October 1971 (prepared as Air Force Weapons Laboratory Report TR-71-79).
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34. Technical Report S-4, "Small-Scale Static Load Model Study: Behavior of Rigid Pavement Loaded Near the Edge," by R. M. Behrmann, April 1972, AD#742214.
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43. Technical Report M-17, "Stabilization Studies of Southeast Asian Soils: Vietnam," by R. E. Aufmuth, June 1972, AD#745901.
44. Technical Report M-18, "Stabilization Studies: Afghanistan Soils," by R. E. Aufmuth, June 1972, AD#745408.
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64. Preliminary Report M-26, "Rock Strengthening Through Epoxy Resin Grouting," by J. L. Lott, September 1972 (Draft).

APPENDIX 9

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1. "The User Requirements for an Airfield Pavement System," by J. L. Pfeister.
2. "Automation of Wastewater Treatment Systems," (contract).
3. "Study on the Feasibility of Manufacturing and Using Plastic Pipe in the Theater of Operations," (contract).
4. "Central Air Conditioning Systems: Evaluation of Diversity Factors and Automatic Controls," (contract).
5. "Introduction of Discontinuities in High Strength Steel Weldments," by K. W. Carlson.
6. "Protective Coatings for Concrete: Bibliography," by S. M. Kanarowski.
7. "Development of a Design Manual for PCC Floor Slabs on Grade," by J. L. Rice.
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10. "Technological Forecasting: A Case Study of Long-Term Requirements for Airfield Pavement Systems," by W. J. Pananos.
11. "Technical Evaluation Study of the Consolidated Field Maintenance Facility at Ft. Bragg, N.C.," by M. J. Rosenfield, M. L. Davis, P. Schomer and Michael Elbl.
12. "Pavement Distress Manual," (contract).
13. "Introduction to Power Plant Design," (contract).
14. Technical Report [Draft] "Technical Evaluation Study of Air Pollution from the Plating Shops at Rock Island Arsenal, Illinois," by M. L. Davis.
15. "Proceedings, Allerton Park Conference on Systems Approach to Air Field Pavement," prepared by R. W. Woodhead and R. H. Wortman.
16. "Model Tests of Lined Tunnels in a Jointed Rock Mass," (contract).
17. "Rock Strengthening Through Epoxy Resin Grouting," by J. L. Lott.
18. "Evaluation of Epoxy Resins for Bonding Fractured Rock," by B. H. Gray.

APPENDIX 10

ORDL REPORTS COMPLETED BY CERL

1. Technical Report M-1, "Critical Normal Fracture Strain of Plain and Steel Wire Fibrous-Reinforced Concrete," by D. Birkimer, October 1969, AD#695719 (DASA).
2. Technical Report M-3, "Development Study for VFR Heliport Standard Lighting System," by T. H. Morros, Jr., August 1970, AD#710982.
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4. Technical Report M-5, "Epoxy Resin Cure Evaluation: Data Report," February 1971, AD#880626.
5. Technical Report M-6, "Burma Soils: A Study of the Effects of Lime and Cement on Paddy and Laterite Material," by N. B. Schomaker and R. E. Aufmuth, March 1971, AD#720993.
6. Letter Report S-3, "Pavement Evaluation for Rhein-Main Air Base Germany," March 1971 (AFWL).
7. Technical Report M-8, "Stabilization Studies: Turkish Soils," by Raymond Aufmuth, July 1971, AD#729661.
8. Technical Report M-14, "Coefficient of Linear Thermal Expansion of Epoxy Resin Mortars," by R. F. Kemphues, March 1972, AD#742212.
9. Technical Report M-15, "Stabilization of Inorganic Silts: Panamanian Soils," by R. E. Aufmuth, April 1972, AD#742213.
10. Technical Report S-4, "Small-Scale Static Load Model Study: Behavior of Rigid Pavement Loaded Near the Edge," by R. M. Behrmann, April 1972, AD#742214.
11. Technical Report T-1, "Investigation of Techniques for Butt Splicing Rebars," by W. D. Ford, April 1972, AD#742781.
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13. Technical Report T-2, "Ultrasonic Weld Inspection," by J. Gambill, June 1972 (unpublished).
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15. Technical Report M-18, "Stabilization Studies: Afghanistan Soils," by R. E. Aufmuth, June 1972, AD#745408.
16. Technical Report M-19, "Stabilization of Contaminated Clays," by R. E. Aufmuth, June 1972, AD#745902.

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20. Preliminary Report M-26, "Rock Strengthening Through Epoxy Resin Grouting," by J. L. Lott, September 1972 (Draft).

GLOSSARY

BLAST	Building Loads Analysis and System Thermodynamics System. A computer-aided program designed to estimate the heating and cooling requirements of a structure.
BRAB	Building Research Advisory Board. A subsidiary of the National Academy of Science.
CAEADS	Computer-Aided Engineering and Architectural Design System. An automated tool that supports design, analysis, and drawings of repetitive and similar projects in order to reduce costs and improve design.
CEL	Construction Engineering Laboratory. A laboratory that was once a part of the Ohio River Division Laboratory and discontinued when CERL was established.
CERL	Construction Engineering Research Laboratory. A Corps laboratory in Champaign, Illinois.
Civil Works	Construction of facilities of a nonmilitary nature for which the Corps has responsibility.
Intergovernmental Personnel Act (IPA)	A Federal program permitting employees of Federal agencies, state, and local governments and academic institutions to work at other Federal agencies for a specific period of time while still being assigned to their permanent employers.
FEEMS	Facilities Engineering Equipment Maintenance System. A computer-aided management system designed to report periodic maintenance and repair needed on equipment at Army installations.
Graduate Assistant Program	A program designed to offer qualified graduate students the opportunity to work at CERL while pursuing academic studies.
HEMS	Hospital Equipment Maintenance System. A computer-aided management system designed to report maintenance and repair of Army hospital technical equipment.
Lead Division	When more than one CERL laboratory is involved in a research project, primary responsibility is assigned to one laboratory.
Military Construction Program	Construction of facilities of a military nature for which the Corps is responsible.

OCE	Office of the Chief of Engineers. A major Army command with headquarters in Washington, D.C.
ORDL	Ohio River Division Laboratory. A Corps laboratory under the Ohio River Division that was discontinued with the establishment of CERL.
PAVER	Pavement Maintenance Management System. A computerized system which identifies the maintenance and repair needed on roads, parking lots, and airfields.
Phase I of Construction	The first part of construction at CERL agreed upon between the Office of the Chief of Engineers and the University of Illinois in 1967 and completed in 1969.
Phase II of Construction	The second part of construction at CERL to be completed in 1986.
Phase III of Construction	The third part of construction at CERL to be realized at some future time.
RDT&E	Research, Development, Testing and Evaluation. Research that is budgeted by Congress and funded directly by the Office of the Chief of Engineers.
Reimbursable Funds	Funds made available to CERL by other organizations requesting research assistance.
Small Problem Program	A program instituted at CERL to permit customers in the public and private sectors to request solutions from CERL concerning minor construction problems.
SOLFEAS	Solar Feasibility Determination System. A computer-aided system which measures the initial cost of a solar system for a facility under construction.
Stevenson-Wydler Innovation Act	An act passed by Congress permitting Federal agencies to develop programs for transferring technology to the public and private sectors.
Technical Monitors	Staff engineers in the Office of the Chief of Engineers who establish priorities and guidelines for research projects and monitor each stage of research performed.
Technical Report	A published report of a research project conducted at CERL.
Technology Transfer	The transfer of successful technology accomplished at CERL to the public and private sector.
Voice-Activated Inspection System	A computer-aided device designed to assist maintenance and repair at Army installations.

**Welding Technology
Center**

A central source in CERL specializing in weld problems and where the construction community can seek answers to problems relating to welds.

WES

Waterways Experiment Station. A Corps laboratory located in Vicksburg, Mississippi.

WQM

Weld Quality Monitor. A device invented at CERL for locating weld defects on structures.

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Records

Champaign, Illinois. Corps of Engineers, Construction Engineering Research Laboratory. Historical Files. These files consist of about 6 linear feet of records most of which pertain to the early years of CERL. They form the bulk of records from which a history of the early period can be written.

Inactive Records. These records are held in CERL's warehouse ready for future disposition, either to be sent to the Federal Records Center or to be destroyed. Some of these records were helpful to the later period.

Staff Section and Personal Files, CERL. Most of these records are of the later period.

Technical Library, CERL. The library holds a scrapbook containing news clippings of important events, technical reports, and a variety of publications important to a history of CERL.

Champaign-Urbana, Illinois. University of Illinois, College of Engineering. Department of Civil Engineering. Records of Prof. William J. Hall. These records, some 2 linear feet in size, contain correspondence and reports relating to the University and its relations with CERL.

Cincinnati, Ohio Corps of Engineers. Ohio River Division. These records contain about 1 linear foot of records dealing with the beginnings of CERL and its relations with ORDL. Some of these records are duplicates of those found at CERL.

Washington, DC. Office of the Chief of Engineers. Directorate of Research and Development. Although small in number, these records contain many important materials concerning the beginnings of CERL and include among them the Building Research Advisory Board studies.

Office of History. A few miscellaneous records which contain some subjects pertinent to CERL's history.

Technical Library, OCE. Contains technical reports and a few miscellaneous items significant to CERL's history.

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