History of Hydraulics and Fluid Mechanics at Colorado State University

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Abstract

The historical contribution of Colorado State University to hydraulics and fluid mechanics is reviewed in reference to those who pioneered the analysis of hydraulic and wind engineering. The article first covers the "early developments" with Elwood Meade, Charles Lory, Ralph Parshall and Emory Lane during the Colorado A&M period. The name change to Colorado State University initiated considerable expansion through fruitful collaboration with the U.S. Geological Survey and the U.S. Bureau of Reclamation. The "expansion years" featured the contributions of Maury Albertson, Hunter Rouse, Jack Cermak and Everett Richardson under the leadership of Lionel Baldwin, Daryl Simons and Ray Chamberlain. The more recent "mature period" saw broadening of the programs and expansion into environmental engineering. Some of the key scientific achievements are reviewed, and the interaction between faculty activities, academic programs and research facilities that led to rapid growth and development are retraced. The success and visibility of the hydraulics and fluid mechanics programs also hinged on several other factors including significant contributions at the international level through projects in Pakistan, Columbia, and Egypt.

Introduction

In 1862, the United States Congress passed the Morrill Act granting land to each state in the amount of 30,000 acres for every senator and representative. As a result of this Act, the Territory of Colorado received 90,000 acres. The receipts from the sale of this land were designated for perpetual fund to support "at least one college to teach agriculture and the mechanic arts". Although the 1862 Act gave the state a grant of federal land for a college, it was not necessary to locate the college on that land. In 1870 Governor Edward M. McCook signed the Territorial Bill establishing the Agricultural College of Colorado at Fort Collins. In November of 1874 the first

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small building, called the "claim shanty," was completed. According to tradition, it was built in eight days in order to prevent the site of the college from being moved to some other town. It is known that both Greeley and Boulder were circulating petitions to get the college away from Fort Collins.

Colorado was admitted to statehood in 1876, and the first State Legislature established the State Board of Agriculture in 1877, the governing body for the agricultural college. The Agricultural College of Colorado was to be governed by the Board consisting of eight members, at least four of whom had to be practicing farmers. It was about this time that a member of the legislature stated that money spent for an agricultural college would be money thrown away because Colorado would never be an agricultural state; "it was only fit for cow pasture and mining". Not until 1878 were funds for the College actually appropriated. Ground was broken for the "college building" later known as Old Main about June 20, 1878, and the formal laying of the cornerstone was on July 27 the same year at public ceremonies.

The Pioneers

Elwood Mead (1858-1936) was to play a pivotal role in hydraulics (Figure 1). The College originally employed him in 1882 as an instructor in mathematics, but he had studied civil engineering at Purdue and Iowa State. In 1883, Mead received approval to teach a two-term senior course on irrigation, one term to be "devoted to the pressure and flow of water, and methods of determining the same;" and the other "to the survey and construction of canals and reservoirs." That year Mead also became assistant state engineer doing practical fieldwork in irrigation. It is said that the State Board of Agriculture was interested in Mead because he would accept a position without the promise of a professorship the second year. In view of the shortage of funds, this could well be true. Mead evidently believed that the opportunity to serve in a needed capacity was more desirable than rank. He was immediately thrown almost literally and physically into the complicated problems of irrigation as they were developing in the Cache la Poudre Valley.


Figure 1. Elwood Mead.

If any place ever needed irrigation, Colorado was it. Men fought and threatened to kill in order to obtain water for irrigation, and a way of measuring water so that each farmer could receive his fair share was urgently needed. Serving as assistant to the State Engineer E.S. Nettleton, Mead struggled with problems of measuring water, building ditches to direct water onto the land and storing water. Few laws existed at that time to control the use of water for irrigation, and before laws could be passed the concept of water as property had to be accepted. How was a man to acquire a right to water and to how much water? How was water to be measured? These were questions of great social and economic relevance.

In 1886, Mead became the first professor of irrigation engineering in the United States. He taught courses in "measurement and flow of water for irrigation." This was followed by work in hydraulics, canals, and dams. Surprisingly, one of their first class projects was not how to get water onto the land, but how to get it off. Working through head-high cattails, they surveyed and drained the swampy streams that crossed the campus.

It is said that President Ingersoll and the State Board of Agriculture created the professor position in an attempt to hold Mead on campus. At any rate, he left in 1888 to go to Wyoming where he wrote the irrigation code for that territory. As Wyoming's first State Engineer, Elwood Mead framed a revolutionary code of water law for arid and semiarid regions that was written into Wyoming's constitution and which became a model for irrigation laws adopted not only by four-fifths of the western states but also Canada, Australia, South Africa, and New Zealand. This new water law rejected the old English common-law principle of riparian rights as inappropriate for arid regions. Instead it declared all water, surface and underground, to be state property, thus giving them the same status as minerals and land and thereby ending legal conflicts between those who owned the land through which the water flowed and those who wished to use the water.

Mead was subsequently employed by the U.S. Department of Agriculture in Washington in 1899, the Australian Water Supply Commission, the University of California, and finally the U.S. Bureau of Reclamation in 1923. There is little doubt that the caliber of Dr. Mead's work was one reason for his appointment in 1924 as Chief of the Bureau of Reclamation. He served in this capacity for 12 years, until his death in 1936. F.D. Roosevelt said of Elwood Mead, "He was a builder with vision."

Mead's work as State Engineer provided him with an excellent knowledge of the terrain of northern Colorado and Wyoming. With a young assistant, he had surveyed for the first time much of Yellowstone. He knew "Buffalo Bill" Cody and in 1888 explored with him some of Wyoming's wild rivers. As commissioner of Reclamation he toured the West every year, and he was out west planning for a new project only a few weeks before his death. The lake above Hoover Dam now bears his name.

Engineering at the Agricultural College grew more rapidly than agriculture because of the high demand for engineers in irrigation. Also, engineering was a profession backed by the American Society of Civil Engineers, which was founded in 1852. Engineering had developed and tested principles it could rely and build upon, whereas agriculture did not have this foundation either nationally or in the state. A common attitude was "if my boy wants to be an engineer, I'll send him to college; but if he wants to be a farmer, I can teach him all he needs to know." About the turn of the century the emphasis of engineering over agriculture at the Agricultural College rose to the level of a controversy when an editorial writer pointed out that one student trained in irrigation engineering at the college was worth more to the state of Colorado than the cost of the college.

By 1903 the school had grown to an enrollment of 448. Included in the graduating class of 1904 in Civil and Irrigation Engineering (C&IE) was Ralph L. Parshall. Had the college kept a guest book during the early 1900's, many famous names would have been recorded. For example, in August 1904, a commissioner and a prince from Ceylon, and a representative from Egypt came to the college to learn about agriculture and irrigation. About the time the new C&IE building was first occupied, an expert sent by the Chilean government to study methods of irrigation and instruction in irrigation engineering in America, Egypt, Europe, and India reported that there was only one other institution in the world that had equipment for teaching and investigation of irrigation engineering equal to that of Colorado Agricultural College (CAC).

In 1910, the U.S. Department of Agriculture (USDA) stationed Victor M. Cone (1883-1970) at Fort Collins to take charge of U.S. Irrigation Investigations, an agency of the Bureau of Public Roads. This agency (forerunner of the Agricultural Research Service) in cooperation with the Colorado Agricultural Experiment Station was instrumental in building the new hydraulics laboratory of the C&IE department, and in 1912 Cone and Parshall helped in its design. The next year, Parshall was promoted to assistant professor, but he then resigned from the college to accept a position with the USDA, but remained in residence in the C&IE building. He was replaced at the college by Oliver P. Pennock (1879-1968), a rather reserved 1902 graduate who 40 years later became department head. In 1914, Carl H. Rohwer (1890-1958) of Nebraska and Cornell was transferred to Fort Collins by the USDA. Cone, Parshall, and Rohwer made the region, and vicariously the College, well recognized for irrigation research.

In 1920, Parshall and Rohwer made a search for an outdoor laboratory site, not too far from the city and with an ample supply of water. The waste gate on Jackson Ditch, leading from a branch of the Cache La Poudre River near Bellevue, northwest of Fort Collins, was found to meet their requirements, and a 7x14x75 foot concrete channel, tapering over another 50 feet to an outlet width of 25 feet, was connected to the gate. The latter permitted some adjustment to the flow, and a 15-foot weir was used for discharge measurement. It was in this channel that Parshall developed his adaptation of the Venturi flume for discharge measurement (Figure 2). Patented in 1922, it became widely known under his name and used around the world. Two of the advantages of the Parshall flume are: (1) it does not fill with silt, and (2) it is accurate, even on a relatively flat land where the velocity of water is low. Parshall is also known for a series of sand traps he designed to keep irrigation canals free of deposits.

Growth on Campus

In 1919, President Lory reported to the State Board of Agriculture that the college was out of debt, and between 1920 and 1930, eleven buildings were added to the campus. Local fraternity and sorority chapters began nationally affiliations around 1915. The first dormitory was remodeled for civil engineering and no new dormitories were built on campus until the construction of Rockwell Hall about 1939.

In 1919, Lory recommended that the College resume research into the possibility of diverting western slope snowmelt through the Continental Divide and onto the eastern plains. The drought and depression of the 1930's took their toll on the State, but Lory was instrumental in organizing support and lobbying Reclamation commissioner Mead for backing. With the help of Parshall and others, Lory then acquired a grant for the College from the Works Project Administration to conduct a feasibility study. By 1938, the construction of the $160 million Colorado-Big-Thompson River Project was underway.

Figure 2. Ralph L. Parshall. (Rouse, 1976; reproduced by permission of IIHR)

In August 1930, the Bureau of Reclamation sent a dozen engineers, technicians, and shop people from Denver to Fort Collins to work in the laboratory, which had been designed by Cone and Parshall for the USDA. The Bureau program began with a study of proposed shaft spillways for Hoover Dam. As a result of these tests, the shaft was changed to side-channel structure. Thereafter, many other studies were undertaken, in particular for the Bureau's Grand Coulee and Imperial Dams and for the Tennessee Valley Authority's Wheeler and Norris Dams.

Emory W. Lane (1891-1963), who had studied at Purdue and Cornell and who gained considerable experience both in the United States and in China, was administrative head of the Fort Collins operation. This involved duties at the laboratory during the Hoover spillway tests under Charles W. Thomas (1906-1978) and James W. Ball (1905 -...), both Coloradoans educated at Fort Collins. Lane later went back to Denver, turning the Fort Collins work over to Jacob E. Warnock (1903-1949), who held degrees from Purdue and Colorado. Upon Warnock's move to Denver, Ball was left in charge of the laboratory. By 1936, the laboratory had undergone a fourfold expansion, but for political and financial reasons the Bureau brought its work there to a close only two years later and withdrew to its Denver quarters in the New Customhouse. On his retirement from the Bureau of Reclamation in 1953, Emory Lane received a temporary appointment at Fort Collins, which he held until illness forced an end of his activities in 1957. By then he was well along in the formulation of a general philosophy of sediment transport.

The name of the Colorado Agricultural College was changed in 1935 to Colorado State College of Agriculture and Mechanic Arts (only to change again to

Colorado Agricultural and Mechanical College in 1944). Three years later in 1938, Pennock was replaced as Department Head and Dean by Nephi A. Christensen (1903 -...), a native of Utah who had just obtained a Caltech doctorate under Theodor von Karman and Robert T. Knapp. Christensen's first accomplishment was to gain accreditation (previously refused) of his three engineering departments by the Engineers Council for Professional Development. One of his former colleagues at Caltech was the Toledoan, Hunter Rouse (1906-1992), who had just become a professor at the State University of Iowa. He was invited by Christensen to give a 1940 summer class at Fort Collins in fluids mechanics. This attracted some two-dozen graduate students (among them J.C. Stevens, later president of the ASCE, and C.P. Better, sediment specialist of the Bureau of Reclamation), thus becoming the first of a continuing series of summer courses and conferences.

As the United States became involved in World War II, some college laboratories undertook war related research while other staff members moved to federal laboratories for similar work. Christensen played an important part in the development of rocketry at the Army's Aberdeen Proving Grounds, taking with him a number of the College staff, in particular Dwight Gunder (1905-1964), a professor of engineering mathematics. At the same time, Maurice L. Albertson (1918-...) with degrees from Iowa State College and the State University of Iowa, and who was to play a leading role in later developments at CSU, was called back from TVA to the Iowa Institute of Hydraulic Research for war related work under Rouse. This involved air tunnel tests on fog dispersal, turbulence, and jet diffusion, in the course of which he completed a doctoral dissertation on boundary-layer evaporation. Since he had long hoped to take part in the irrigation research at Colorado State, a position for him there was arranged in 1947.

At the time, Rouse opposed Albertson's move to CSU and warned him that if he'd move to CSU, nobody would ever hear of him again! Ironically, Rouse moved to Sun City, Arizona, and began teaching the summer course "Intermediate Fluid Mechanics" at CSU in 1976. Reminiscing Rouse's teaching, it quickly became clear that student involvement was insufficient for the study of fluid mechanics and that a full commitment was required of the students. Daryl Simons aptly clarified the difference between involvement and commitment, "if you have eggs and bacon for breakfast, the chicken was involved but the pig was committed." Hunter's summer teaching included a weekly classroom oral quiz where students answered various fluid mechanics questions in front of the class. After a student's answer, Rouse paused and said, "I have been teaching Fluid Mechanics for 50 years and this is the worst answer I ever heard." It is with pride that students were wearing "I survived Hunter Rouse" T-shirts in Fort Collins. Rouse retired in 1986.

Albertson contributed to the entrepreneurial spirit and served as catalyst for unprecedented research at the College of Engineering. At the same time that graduate engineering programs were implemented, the college embarked in the 1950's on international programs, thereby establishing one of the hallmark characteristics of the modern engineering program. The cold war battle for the loyalties of third world countries centered on the efforts on President Truman's Point IV program designed to aid the economic development of these third world regions. As part of this program, Colorado A&M became involved in a faculty exchange program with its sister school, the University of Peshawar in Pakistan. Four years later, the State Department approached Maury Albertson with a request for a feasibility study for a proposed graduate engineering school in Southeast Asia. With members of the Southeast Asia Treaty Organization (SEATO) seeking the region's economic and social development, the SEATO Graduate School of Engineering in Bangkok, Thailand, opened in the Fall on 1959 with Maury Albertson as campus coordinator. In 1967, the college turned into the Asian Institute of Technology. During the decade 1950-1960, most of the research activity in engineering at Fort Collins was within the Civil Engineering Department. Research reached a funding level of approximately $160,000 in 1955-56 and $277,000 in 1956-57. Contracts and grants provided most of the funding for research that exceeded $600,000 in 1961.

Growth as Colorado State University

College enrollment reached 1,000 in 1924, 2,000 in 1939, 6,000 in 1960 and 16,000 in 1969. In 1957 the institution's name changed to Colorado State University, and the academic divisions became colleges. T.H. Evans was Dean of the College of Engineering and D.F. Peterson was Head of the Civil Engineering Department. In 1958, M.E. Bender succeeded Peterson as Head of the Civil Engineering Department.

1957 was a memorable year, when the U.S. Geological Survey stationed Daryl B. Simons (1918-...) at Fort Collins to lead, with Everett V. Richardson (1924-...), the growing research program on river mechanics and sediment transport. Simons not only supervised the USGS program, but also completed work toward CSU's second engineering doctorate and taught courses in civil engineering. His primary contribution was the analysis of bedforms and resistance to flow in alluvial channels. He retired from CSU in 1983 and his expertise in sedimentation and river engineering has been sought throughout the world. In 1957, hydrologist Vujica Yevjevich (1913-...) came to CSU from the former Yugoslavia where he previously headed a research institute. The same year, A.R. Chamberlain, professor of civil engineering, was made chief of the Civil Engineering Section. This was a position created to administer the burgeoning research section of Civil Engineering.

When Chamberlain became vice president for administration in 1960, he left his position as chief of the research section, which vacant until 1963. At the same time, Bender left as head of the department to become Dean of the SEATO Graduate School of Engineering. J.W.M. (Bill) Fead became acting head of the Civil Engineering Department and D.B. Simons became acting head of the research section. Lionel Baldwin (1932-...), a chemical engineer with a specialty in fluid turbulence, came to campus in 1961 after experience with NACA-NASA. William W. Sayre (1927-...) of New York and Princeton, initially a graduate student, became a member of the USGS staff in 1962, moving to Iowa in 1968 after receiving the doctorate; his particular interest was the mechanics of diffusion. Hsieh-Wen Shen (1931...), a native of China who, after study at Michigan, had taken the doctorate in sediment transport under H.A. Einstein at Berkeley (and was to become an ASCE Freeman Scholar the following year), arrived at Fort Collins in 1964. Shen led numerous NSF projects in the field of sedimentation and river mechanics before returning to Berkeley in 1985. In 1965, Fead became Head of the Civil Engineering Department and Simons became the Associate Dean for Research for the College of

Engineering. This, of course, called for some reorganization of duties and responsibilities. Lionel Baldwin was appointed Dean of Engineering in 1965; and in 1969 Ray Chamberlain, for several years Vice President, assumed the post of President as the University was preparing to celebrate its centennial year.

In most respects the College of Engineering was well prepared to meet the demands of the boom years. Faculty expanded to more than 100 by the early 1970's while funded research skyrocketed from just under $500,000 to $5,000,000. With the state supplying as little as half of the funds needed to for instruction in some departments, it became incumbent upon faculty to prove the axiom that an engineer can do as much with one dollar as others with two. This reliance on soft money was not for the faint of heart. As Fead explained: "faculty had a lot of freedom in the way they operated and a lot of pressure to bring their own salary. But they were the type of people who wanted control of their own projects and who were willing to put up with the hassles of the entrepreneurship requirement to have that kind of working environment."

Growth at the Engineering Research Center

A new Engineering Research Center was built in 1962 at a cost of $1.8 million joining three wings together to provide 69,000 square feet of space for offices, conference rooms, small laboratories, electronics shops, printing, drafting, and photographic quarters, two lecture rooms, and a cafeteria. Directly south of the main wings and connected to them are two large laboratories, each roughly 120x280 feet in plan (Figure 3).

Permanent features in the Hydraulic Laboratory are a series of interconnected sumps 8 feet in depth and 5400 square feet in area; 14 pumps ranging in capacity from 250 gpm at 50-foot head to 23,000 gpm at 19-foot head; a 4x8x200 foot power-tilting flume with a discharge capacity of 100 cubic feet per second; a 20x100 foot river-basin flume for meander, erosion, and control-structure studies; a large local-scour flume; three other tilting flumes; and ample space for temporary models.

A 100-acre outdoor laboratory adjoins the building, and makes possible large-scale model and full-scale prototype studies. A 8x20x180 foot concrete flume with a

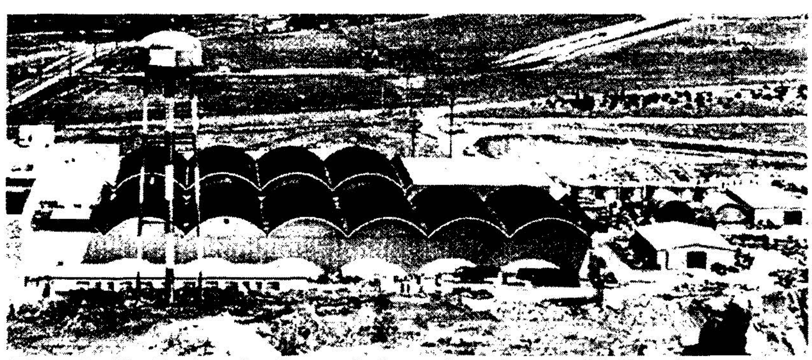

Figure 3. The Engineering Research Center from the top of Solider Canyon Dam. (Rouse, 1976; reproduced by permission of IIHR)

recessed 10 feet deep section provides a facility for large-scale tests. A 3-foot-diameter variable-slope pipe 825 feet long is also available. A hydro-machinery facility is housed in a 70x192-foot prestressed-concrete building. The concrete floor slab is 3 feet thick to eliminate vibration during testing. Water for both the indoor and outdoor laboratories comes from the U.S. Bureau of Reclamation's Horsetooth Reservoir just uphill to the west of the Research Center.

A maximum head and discharge of 200 feet and 300 cubic feet per second are available, but modifications are currently underway that will increase the maximum available discharge to 500 cubic feet per second. In addition, large stationary and movable pumps are used to recirculate water from sumps and to increase the operating head.

With such facilities and staff, not to mention the considerable support of various agencies, graduate enrollment steadily rose. In of September 1979 the staff of the combined hydraulics, fluid mechanics, and hydrology sections of the Civil Engineering Department had grown to a total membership of 125. Of these, 33 were of faculty rank, i.e., assistant professor or above, and 92 were graduate assistants. The hydraulics section was the largest, with 69 members, and fluid mechanics next with 36. About 55% of all graduate students in the Department were employed part-time, with an annual turnover of some 40-50%.

Fluid Mechanics and Wind Engineering

The beginning of the Fluid Dynamics and Diffusion Laboratory (FDDL) [currently called the Wind Engineering and Fluids Laboratory, WEFL] was in 1949 when the first wind tunnel was designed and largely build by J.E. Cermak, who was at that time an instructor in the civil engineering department (Figure 4). The wind tunnel was located in the old Industrial Research Building, now called the General Services Building. Cermak and Albertson, at that time an associate professor in the civil engineering department, worked on the first research contract for the FDDL, which was a grant from the Office of Naval Research, 1949-54, for a study on evaporation.

In 1955 the Air Force granted funds for a Meteorological Wind Tunnel, and this became operational alongside the first tunnel in the new Engineering Research Center in 1963. The Meteorological Wind Tunnel became the first wind engineering facility in the world to include a long test section in which a simulated atmospheric boundary layer grew naturally, and in which heated/cooled boundaries and thermal controls permitted simulation of day time convection and night time inversion conditions.

The Wind Engineering and Fluid Mechanics Program under the direction of Dr. Jack E. Cermak grew substantially during the late 1960s, 70s and 80s until the program included some 12 faculty and research scientists and their graduate students. A third large facility, the Environmental Wind Tunnel was added with a test section 57 feet long and a 12x8 foot cross section to investigate wind effects over large terrain areas. During this time, Wind Engineering became a recognized engineering discipline, and in 1989 the National Society of Professional Engineers declared the CSU Wind Engineering and Fluids Laboratory one of the five major engineering accomplishments of the decade.

Figure 4. Jack Cermack. (Rouse, 1976; reproduced by permission of IIHR)

Several facilities for specialized research augment the larger test facilities, including a Separated-Flow Facility that has a working section 2-foot wide with a flexible floor that can be adjusted over a length of 10 feet to provide a wide range of pressure variation in the flow direction. Aerosol dispersion can be studied in an Aerosol Test Facility with a 2x2 foot test section 15 feet long capable of producing air speeds up to 116 miles per hour and equipped with a remote-sensing laser-powered particle spectrometer. Studies of large-scale turbulence are made in a Gust Tunnel with a 3x3-foot test section equipped with two banks of airfoils whose pitch may be varied randomly by an electromechanical servo-system.

During the early 1960s models of the New York World Trade Center were examined in the Meteorological Wind Tunnel. Based on these measurements the original locations of the twin towers were reoriented, and a passive damping system was designed and installed in the towers to mitigate tower sway. Other early wind flow and loading studies included evaluations of wind effects at the Candlestick Ball Park, San Francisco, and the Oakland-Alameda County Coliseum. After the famous cladding failures that occurred in 1972 during the construction of the John Hancock building in Boston, Massachusetts, architect and design firms requested preventive model studies from CSU engineers, which resulted in many hundreds of model skyscraper studies in the CSU facilities during the 1970s and 1980s. In the late 1980s a model of the world's tallest building, the Chicago Sears Tower, was evaluated for wind effects to mitigate existing problems with glass and cladding damage.

In 1987, Robert N. Meroney, graduate of the University of California, Berkeley, led the program and emphasized research in areas of atmospheric transport of dense and buoyant gases, wind energy conversion, wind turbine siting, and computational fluid mechanics. He joined with Kishor Mehta of Texas Tech University and the two schools obtained the first multi-year US National Science Foundation Cooperative Program Grant. The grant focused on Wind Engineering and lasted from 1987 through 2001. This research program was directed to evaluate the hazards of extreme winds acting on low-rise buildings such as homes, churches, schools and shopping centers. The work resulted in a major revamping of the US National Wind Loading Design Codes, new specifications for extreme wind hazards for the continental United States, the creation of a major data base of field and laboratory wind load data, the incorporation of wind hazards into building insurability criteria, and a new understanding of the role of corner vortices in the wind loading of civil engineering structures. Other research associated with this grant included simulation of infiltration and exfiltration across building envelopes, and wind blown debris. Other contributors to the program include Jon A. Peterka, Willy Z Sadeh, and Virgil A. Sandborn.

Recent Years

In the 1980's, E.V. Richardson was leading the development of water resources at the International level and particularly in Egypt where CSU trained a generation of scientists and engineers with expertise in hydraulics and water resources. This successful program brought in about $60,000,000 to CSU from 1977-89. After his retirement in 1989, Richardson remained very active in the field of bridge hydraulics and led numerous projects on pier scour and stream stability for the Federal Highway Administration. Daniel K. Sunada took over the Egypt Water Research Center program that brought an additional $20,000,000 to CSU from 1989-93.

In the past two decades, the Hydraulics Laboratory has seen the construction and analysis of numerous large-scale physical models including several dams, spillways, energy dissipators, river models, analyses of resistance to flow, sediment transport, riprap and block stability, filter design, river morphology, local scour, bridge hydraulics, environmental hydraulics, surface runoff and sheet erosion, infiltration and contaminant transport, mudflow and debris flows, dam break, reservoir sedimentation, etc. Primary contributors to the Hydraulics Laboratory at the Engineering Research Center in the past several decades include Everett V. Richardson, Susumu Karaki, James F. Ruff, Stanley A. Schumm, Hsieh Wen Shen, Steven R. Abt, Pierre Y. Julien, Carl F. Nordin, Albert Molinas, Chester W. Watson, and many others.

During the same period, the Wind Engineering and Fluids Laboratory saw studies examining hazards associated with power plant pollution, siting of nuclear power stations, dispersion of dense gases due to chemical or liquified gas spills, flow in agricultural crops, bridge aerodynamics, pedestrian comfort around buildings, wind effects on space rocket launch facilities, snow drifting, odor pollution, wind turbine design and wind turbine facility siting, wind loads on solar collectors, etc. Currently the Wind Engineering and Fluids Laboratory is under the direction of Bogusz Bienkiewicz where he supervised the study of tornado dynamics in two new simulation facilities and evaluated wind effects on roofs and roof top pavers. David E. Neff, who continues the tradition of basic and applied research focused on wind engineering problems, manages the lab.

The past decade or so has seen the renovation of the Engineering Building at a cost of approximately $18,000,000. Recently created Civil Engineering Department faculty position include environmental hydraulics, environmental engineering, an Endowed Chair in urban hydraulics, hydrology, hydraulics and water resources. There are currently about 35 FTE faculty positions in Civil Engineering and about 25 faculty members work in water and fluid mechanics.

Summary and Conclusions

With roots dating to 1870 and a foundation in 1957, the great success and rapid growth that CSU has experienced in a short period of time can be attributed to several factors. These certainly include: (1) commitment of faculty members who could build with vision; (2) endless energy and productivity of faculty, students and staff; (3) collaborative research with numerous governmental agencies, peer institutions, consulting firms, etc.; and (4) active involvement and visibility at the national and international level. In conclusion, it can be said of CSU that its past was bright and the future...even better!

Acknowledgments

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