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ADVANCED CONSTRUCTION TECHNOLOGY RESEARCH EQUIPMENT

FINAL REPORT

by

Joseph P. Murtha

Final Report to the
U. S. Army Research Office
on
Grant No. DAAL03-86-G-0186

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ADVANCED CONSTRUCTION TECHNOLOGY CENTER
UNIVERSITY of ILLINOIS at URBANA-CHAMPAIGN
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JOSEPH P. MURTHA
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ADVANCED CONSTRUCTION TECHNOLOGY CENTER
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
URBANA, ILLINOIS

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ADVANCED CONSTRUCTION TECHNOLOGY
RESEARCH EQUIPMENT

This report describes the equipment purchased by the University of Illinois Advanced Construction Technology Center with funds provided by the U.S. Army Research Office under Grant No. DAAL 03-86-G-0186. In September 1986 the US Army Research Office selected the University of Illinois at Urbana-Champaign to develop a center of excellence in Advanced Construction Technology. The Center's research goal is to advance the scientific and technologic base necessary to support a major infusion of advanced technology into aspects of construction engineering to reduce significantly the life cycle costs of Army base support facilities. The rationale for this goal is a large number of Army facilities nearing the end of their useful life and lack of adequate funds to replace these facilities at contemporary construction prices. Army facilities have a replacement value of approximately \$161 billion dollars and include 1.1 billion square feet of building space; 559 million square yards of surfaced areas; tens of thousands of miles of electric, water and sewer lines; and 42 thousand miles of railroads. The current military backlog is approximately \$25 million and is growing at the rate of about \$1.4 billion dollars per year. In short, the Army cannot afford to provide the physical plant required for optimum national security if restricted to using contemporary construction industry technology.

The Center's research program is organized into the following five thrust areas:

1. - Nondestructive Evaluation Technologies for Constructed Works
2. Construction Site Metrology

3. Computer Aided Construction
4. New Technologies and Materials for Building Construction
5. Special Technologies

The research equipment described in this report was essential for developing research programs described above. Since the research program of the Center is interdisciplinary involving faculty and students in the departments of Civil Engineering, Mechanical and Industrial Engineering, Electrical and Computer Engineering, Computer Science, Material Sciences, and the School of Architecture, the equipment provided makes a substantial contribution to the general research program of the University as well as specific activities of the Advanced Construction Technology Center.

A list of the current research projects in the Center is given in Table II.

The assistance given by the Army Research Office to the University of Illinois to acquire the equipment described herein and to develop the center of excellence in Advanced Construction Technology is greatly appreciated.

TABLE I

LIST OF EQUIPMENT PURCHASED

- Note: 1. The "rank number" given corresponds to that used to identify equipment in Part III of the grant agreement document.
2. Prices marked with asterisks are estimates only.

RANK NUMBER	CATEGORY TITLE/ITEM DESCRIPTION	PURCHASE PRICE	MANUFACTURER
1, 4, 18 & 22	Apollo Computer Network Components, Design Automation Computer Components, Apollo Computer Network Components - Part II, and P-300 Printer		
	P4200-10 Gateway Base Unit System	\$12,252.00	Proteon
	P3080-Fiber Optic Link (modem pair)	4,000.00	Porteon
	DN3000-C4 Apollo Color Workstation	12,422.40	Apollo Computer, Inc.
	DN3000-M4 Apollo Monochrome Workstation (2)	19,089.40	Apollo Computer, Inc.
	DN3000-M5 Apollo Monochrome Workstation (2)	21,441.40	Apollo Computer, Inc.
	Add 2mb Memory, Printer (5)	5,647.75	Apollo Computer, Inc.
	A-Add PCC (PC Emulation Hardware/Software)	1,331.00	Apollo Computer, Inc.
	Com/Ethernet Hardware/Software	3,526.20	Apollo Computer, Inc.
	Network Connection Boxes	440.00	Apollo Computer, Inc.
	Imagen Imagestation-#300-0095 (3)	15,120.00	Imagen Corporation
	2308 Image Server 2308XP-#751-002	6,615.00	Imagen Corporation
	20mb Disk & Fonts Options #206-0097	2,415.00	Imagen Corporation
	Host Software-Berkley 4.2 version	450.00	Imagen Corporation
	Virco Model 81304 CRT Station, 48x30x26" (6)	648.90	Virco Mfg Co.
	Manuals for use with Apollo Computers	1,410.00	Apollo Computer, Inc.
	DN3000 & DN4000 Workstations, & A-Add-2mb Memory and A-Add-4mb Memory	27,986.81	Apollo Computer, Inc.
	DQC-100 Electrical Boxes	440.00	Apollo Computer, Inc.
	DN3000 and DN4000 Workstations (3) and A-Add Memory	30,679.89	Apollo Computer, Inc.
	DN3000 Workstation and A-Add-2mb Memory	7,590.00	Apollo Computer, Inc.
	DN4000 Workstation & A-Add-8mb Memory	16,642.00	Apollo Computer, Inc.
	KEE Software Development System Academic Lic.	4,875.00	Intellincorp

Extension of License Agreement # 00284-03	10,000.00	Interleaf, Inc.
Security Boxes, Cables and Brackets	238.00	
Anchor Pads, Security Cables	351.50	
Anchor Pads and Adapter Feet	750.00	
Anchor Pads and Adapter Feet	150.00	
Anchor Pads and Adapter Feet	150.00	
Security Boxes, Brackets, Cables, Sec.Blk	258.00	
Swivel, Adapter Feet, Security Cable	222.50	
Miscellaneous S. S. Rods and Plates	228.59	
Software License Agreements & Service	12,600.00	Apollo Computer, Inc

SUBTOTAL	219,971.34	

2 & 3 AI Workstation, Sun Computer Network

DN4000 Monochrome Workstation & A-Add Memory	30,947.00	Apollo Computer, Inc.
20-Mbyte Main Memory Expansion Module for 3/60	7,175.00	Sun Microsystems
Macintosh II System w/40mb HD, 5mb RAM expansion kit; extended keyboard; Apple mono display; Mac II video card.	5,400.00	Apple Computer
Laserwriter (M0160) & accessories	3,528.00	Apple Computer
Aldus Page Maker for Mac	410.00	Apple Computer
Laserwriter (M0160)	3,270.00	Apple Computer
Appletalk Connector Kits (2)	100.00	Apple Computer
Apple/Mac Personal Modem & Cable	281.00	Apple Computer

Subtotal	51,111.00	

8, 9, EG&G Princeton Applied Research Boxcar
 10 & 11 Integrator & Signal Processing System,
 Install Power Supply to EMP Project
 Equipment, Laser System Components,
 Optical Table (Modern Optics), 1450a-3
 Intensified 512 Channel OMA System

Hewlett Packard 54111 Digitizing Oscilloscope with 500MHz Repetitive Bandwidth and 250MHz Single-shot Bandwidth, with 8K of Memory per Channel.	19,504.00	Hewlett Packard
HP10833C-4n HP-IB Cables	124.00	Hewlett Packard
HP2225A-Thinkjet Printer	306.90	Hewlett Packard
HP14858A-003 ASYST Scientific Software	1,147.50	Hewlett Packard
HP82964-Vectra Computer	4,904.20	Hewlett Packard
Dye Laser, Model #FL 3002E, 14% conversion efficiency at 475 OM & 0.04 cm-1 bandwidth.	32,900.00	Lambda-Physik
Nd:YAG Laser System: Model DCR-36(10) High Power Scientific Pulsed Nd:YAG Laser.	61,465.00	Spectra-Physics
ION/Dye Laser System.	13,400.00	Coherent
Digital Delay Generator, DG 535	2,995.00	Stanford Res. Sys.
Rack Mount, Option 05	120.00	" " "
Extended Keyboard (M0115)	152.00	Apple Computer
Mac SE 20mb CPU (M5251)	2,168.92	Apple Computer
Power Supply for Use with Photo Multiplier	2,545.75	John Fluke Mfg. Co.

Subtotal	141,733.27	
	<u> </u>	
12 Scanning Electron Microscope		
Model #S-53-2 Scanning Electron Microscope	49,900.00	Hitachi
Digital Beam Interface for above SEM	2,500.00	Hitachi
Preamplifier	890.00	GW Electronics
Detector Mount	1,655.00	GW Electronics
High Resolution 'Cool' Sputter Coater	4,250.00	Int'l Electron Optics
Hitachi S-530 Column Stock Pads	350.00	Hitachi

Subtotal	59,545.00	
	<u> </u>	
13 Laser Interferometer Components		
Smartt Point Diff. Interferometer & Camera Back	2,761.62	Ealing Electro-Optics
Ranchi Gratings, 101.6mm sq., 500 cycle in.	2,160.73	Rolyn Optics Co.
6" x 6" Ranchi (2) 100 & 200 lines/in.	536.95	Edmund Scientific Co.
Laser Interferometer Basic Components	37,333.00	Newport Corporation
6" x 6" Bandpass Filter	1,751.73	Corion Corporation

Mirror Mounts; Receiver Singlet Lens; Fused Silica Condenser; Pellicle Beamsplitter	4,712.82	Melles Griot
Concave Mirrors; Lens Centering Mounts; and misc. Interferometer Components.	4,454.67	Oriel Corporation
ZnSe 6 in. dia. plate with 488 coating	4,963.00	Janos Technology
INNOVA 100-10 Ar-Ion Laser System	38,950.00	Coherent
Liquid Gate/Film Plate, Holder/Processor	1,556.15	Newport Corporation
KNS48 4' x 8' Series Table Top, and XL Series Legs, 28" high.	6,072.00	Newport Corporation

Subtotal	105,252.67	
	<u> </u>	
15 Gatan Model 600 Dual Ion Milling System Components, Ion Source		
Maxmill Model 306B/TM 170 Milling System	40,050.00	VCR Group
Inert Gas Ion Source	15,061.00	Ion Tech, Inc.

Subtotal	55,111.00	
	<u> </u>	
17 & 38 Components for Scale Wall Test Rig		
20,000 lbs of 20-ft long Steel Reinforcing Bars	4,836.46	Central Steel & Wire
Threadbars, Anchor Nuts, and Couplers	9,647.00	Dywidag Systems
Orange UHMW (18)	1,729.44	Illini Plastics
PVC Sched. 40 Pipe	1,065.80	The Field & Shorb
PVC Sched. 40 Pipe	1,082.00	The Field & Shorb
Gar-Bro 2 cu. yd. General Purpose Concrete Bucket	4,672.00	S & K Air Power
DC-DC Long Stroke LVDT Ordercode (10)	2,332.37	Trans-Tek, Inc.
Gar-Bro General Purpose Concrete Bucket	2,710.00	S & K Air Power
Conveyor Belts	12,434.00	Thomas Conveyor/Equip.

Subtotal	40,509.07	
	<u> </u>	
19 Instrumentation Components for Materials, Heat & Moisture Transport Research		
Data Acquisition Unit and 4-Channel Thermocouple Board	1,225.00	Elexor Associates

	Macintosh SE, 20mb Keyboard, Security Kit & cable	2,324.47	Apple Computer
	Imagewriter, Apple M0310	426.00	Apple Computer
	Macintosh SE Computer and Keyboard	1,781.00	Apple Computer
	Voltage Regulator - Staco 10 amp variac	157.95	

	Subtotal	5,914.42	

20	Compac Portable 286 Computer, Accessories and Software		
	HP Laserjet Series II Printer, 1mb Memory Expansion & Font for Series II	2,157.00	Hewlett Packard
	Sigma Plot Computer Program	370.00	Jandel Scientific
	Computer Program UTEXAS 2	350.00	Geotechnical Engr.
	Dictating/Transcribing Machine, Sony BM75	405.86	Sony
	Microphone HU 70	66.43	Sony
	Compaq Portable III, Math co-processor, 1200 Baud Modem and Compaq DOS	4,725.00	Arends and Sons

	Subtotal	8,074.29	

27	Automated Measurements of Magnetic Properties of Concrete		
	HP8753A Network Analyzer	28,000.00	Hewlett Packard
	Z-386 System Computer, 16 MHz, 1 mb RAM	3,807.00	Zenith
	13" EGA Monitor	461.00	Zenith

	Subtotal	32,268.00	

28	Vision System DX/VR		
	Components for IRI Manufactured High Resolution Option DX/VR Vision System	41,856.90	Int'l Robomation Intelligence
	Bogen Camera Equipment for DX/VR Vision Sys.	785.95	Helix Camera Shop
	Javelin Machine Vision Lens (8)	862.00	Lukas Microscope Ser.
	General TCE-200 CCD Cameras (2), Vision Development Station Accessory Package.	5,516.00	Int'l Robomation Intelligence

	Printer, Toshiba Dot Matrix 321SL	1,078.00	Toshiba
	Bretford Adjustable Microcomputer Table, Tiffany Modular Station, and Drawers for Tiffany Desk.	1,050.00	Bretford
	Computer, IBM PC/AT, 512KB RAM	3,370.00	IBM
	320/360 KB Dual Sided Drive-AT, Math co- processor AT, AST Enhanced Graphics Card, Intel above Bcard with 128K Memory, and IBM enhanced color Display.	1,791.00	IBM
	X4 Flat Mounted Microscope Objectives	315.27	Ealing Electro-Optics

	Subtotal	56,625.12	

29	Equipment for NDE Mechanical Properties of Metals		
	V215 BA Transducer	753.52	Panametrics
	Model 9400 Digital Oscilloscope	9,603.00	LeCroy Corporation

	Subtotal	10,356.52	

30	Equipment for Real Time Concrete NDE		
	SIMS Computer Interactive Maturity System	12,500.00	Digital Site Systems
	Adiabatic Calorimeter	5,000.00	Digital Site Systems
	V-Meter, C-4901	5,950.00	James Electronics
	BCD Output Kit for V-Meter	952.00	James Electronics
	Transducers 82KHz and 150KHz	1,190.00	James Electronics
	Computer - 286/8 MHz System with Intel 80286 Processor	945.00	PC Source
	40Mb HD Controller, 128KB Memory upgrade, Hercules Graphic Card (monochrome), and AT I/O	872.64	PC Source
	Sigma-Scan Measurement System	1,495.00	Jandel Scientific
	Amdex 410A Monitor	160.00	Amdex
	Epson FX86E Printer & cable	377.00	Epson
	Monographics Card with Parallel Post	67.00	PC Source

	Subtotal	29,508.64	
31	NDE Equipment for Masonry		
	AIS-500 Vision System (2)	10,998.00	Applied Intelligent
	Additional Cameras (2)	2,334.00	Applied Intelligent
	Cables and software	222.00	Applied Intelligent
	Micro Console	6,705.04	MTS Systems Corp.
	DC Controllers (2)	5,350.00	MTS Systems Corp.
	AC Controllers (2)	5,740.00	MTS Systems Corp.
	Function Generator	970.00	MTS Systems Corp.
	Moog Servovalves (2)	3,900.00	MTS Systems Corp.
	Portable Data Acquisition System (PDAS-100) Field Computer	8,450.00	Teledyne Geotech
	Impulse Velocity "V-Meter", C4901	5,965.00	James Instruments Co.
	Computer, Z-183 Lap-top & carrying case	2,222.00	Zenith
	1200 Baud Modem and Transfer Utility Kit	321.00	Zenith
	8087 Math Co-processor for Z-183 computer	136.00	Zenith
	Subtotal	53,313.04	
32	MTS Control Kit for NDE Experiments		
	MTS Control Kit for NDE Experiments	17,795.00	MTS Systems Corp.
	Subtotal	17,795.00*	
33	Robot Grippers		
	Mac SE Computer w/20mb, HD, Extended Key- board, Imagewriter II, and Memory Expansion	3,259.20	Apple Computer
	Tooling for Robotics Lab.:		
	EEP-2-384 Two-finger Gripper	877.60	Mecanotron
	EEP-3-384 Three-finger Gripper	1,230.40	Mecanotron
	Custom Interface Plates & parts	1,083.20	Mecanotron
	Grippers for Robotics Lab	370.73	Barry Wright Corp.
	Solenoid-operated Air Valve (2)	154.30	McMaster-Carr
	Miscellaneous	36.90	

	Subtotal	7,012.33	
34	Movable Partitions for Automated Construction Lab		
	Partition Panels and Fillers	8,734.52	Allsteel, Inc.

	Subtotal	8,734.52	

35	Robotics Workcell Design, Simulation and Off-Line Programming System		
	Silma's CIMSTATION Robotic Simulation and Programming Software System.	35,750.00	Silma, Inc.

	Subtotal	35,750.00	

36	NDE for Accelerated Soils Testing		
	Box Steel	203.70	Kurland Steel Co.
	Threaded Steel Rods and Nuts	184.20	Fastenal Company
	Plexiglass Tubing (4)	76.00	Illini Plastic Sup.
	Thermometers (5) and Measuring Cylinders (4)	272.91	Thomas Scientific
	Load Cell, 2500 lb capacity	495.00	Kulite Tungsten Corp.
	Hygrosensor Type H Class A	152.20	Amer. Instrument Co.
	Miscellaneous Plates and Rods	228.59	
	Fall Cone Apparatus	1,867.20	Geonor, U. S. A.
	Cone Penetrometer for Liquid Limit; Cone for Liquid Limit Penetrometer; Test Gauge for Cone; Electric Timer for Penetrometer; and Cone Penetration Tins (5)	1,211.24	Entela, Inc.
	25KN Capacity Load Cell (2)	3,273.39	Wykeham Farrance, Inc.
	Level Load Device	1,100.00	Wykeham Farrance, Inc.
	Volume Change Indicator (2); Burettes (5); Dial Gauges (4)	2,847.04	Entela, Inc.
	Dynisco Transducers (2)	1,000.00	Dynisco
	Stainless Steel Porous Stones (8)	365.50	Pall Filter Company
	6 x 13 Channel	226.80	Kurland Steel Co.
	Stainless Steel Plates (2)	260.00	Kurland Steel Co.

	Subtotal	13,763.77	
37	Impulse Radar System for NDE		
	Geophysical Survey System, SIR SYSTEM-8	49,028.07*	Geophysical Survey
	Subsurface Interface Radar	-----	Systems, Inc.
	Subtotal	49,028.07*	

	GRAND TOTAL	\$999,764.00	

TABLE II

Thrust Area: Nondestructive Evaluation (NDE) Technologies for Constructed Works

NDE of Damage in Structures Using Forced Dynamic Response Monitoring

K.D. Hjelmstad and S.L. Wood

Electromagnetic Sensing of Concrete

W.C. Chew

Accelerated Tests for Soil Properties

G. Mesri and W. Tang

NDE Assessment of Structural Properties

K.D. Hjelmstad, S.L. Wood, and J.P. Murtha

NDE of Masonry Buildings

D.P. Abrams

An Engineering Approach to NDE of Material Properties

D.L. Marriott and R.L. Weaver

On-line Displacement Monitoring for Measuring Residual Stresses

D.F. Socie and J. Mazumder

Real-Time NDE for Hardening Concrete

J.F. Young and R.L. Berger

Thrust Area: Construction Site Metrology

Imaging and Vision Systems for Automated Construction

H. Lee

3-D Metric Vision for Engineering Construction

K.W. Wong

Thrust Area: Computer-aided Construction

The Design of Database Management Systems to Support the Construction Process

G.G. Belford

Design for Automated Construction

L.T. Boyer

Sensor-based Intelligent Manipulators for Automated Construction

S.C-Y. Lu

An Integrated Arc-Spray Depositing System

G.G. Belford, L. Boyer, H. Lee, J. W.-S. Liu, S. Lu, and K. Wong

Thrust Area: New Materials and Technologies for Building Construction

Lightweight, Energy-Efficient Building Material Concepts
T.A. Newell

High-Performance Cementitious Materials
J.F. Young and R.L. Berger

Advanced Ceramics for Building Construction
G.P. Wirtz, R.C. Buchanan, and C. Dry

A Flexible Manufacturing Systems Approach for Automation of
Building Construction
S.G. Kapoor, U.S. Palekar, and R. E. DeVor

A Unified Knowledge-based Model for Building Design and
Construction
L. Lopez and J. Garrett

Thrust Area: Special Technologies

Advanced Coatings for EMI/EMP Applications
J.M. Rigsbee

Horizontal Construction - Improved Facility Design, Construction,
and Rehabilitation
E.J. Barenberg and M.R. Thompson

In situ Soil Reinforcement - Soil Nailing
J.H. Long and E.J. Cording

EMP Testing and Assessment
J.T. Verdeyen