

Lehigh University Lehigh Preserve

Fritz Laboratory Reports

Civil and Environmental Engineering

1979

Fritz lab equipment needs-hydraulics-soils laboratory-data aquisition(sic) system and loading equipment, November, 1979

David A. VanHorn

Lynn S. Beedle

Follow this and additional works at: <http://preserve.lehigh.edu/engr-civil-environmental-fritz-lab-reports>

Recommended Citation

VanHorn, David A. and Beedle, Lynn S., "Fritz lab equipment needs-hydraulics-soils laboratory-data aquisition(sic) system and loading equipment, November, 1979" (1979). *Fritz Laboratory Reports*. Paper 1598.
<http://preserve.lehigh.edu/engr-civil-environmental-fritz-lab-reports/1598>

This Technical Report is brought to you for free and open access by the Civil and Environmental Engineering at Lehigh Preserve. It has been accepted for inclusion in Fritz Laboratory Reports by an authorized administrator of Lehigh Preserve. For more information, please contact preserve@lehigh.edu.

**Lehigh
University**



FRITZ LAB EQUIPMENT NEEDS

- Hydraulics
- Soils Laboratory
- Data Aquisition System and Loading Equipment

FRITZ ENGINEERING
LABORATORY LIBRARY.

November , 1979

**Fritz
Engineering
Laboratory**

Report No. 237.III

LEHIGH UNIVERSITY

BETHLEHEM, PENNSYLVANIA 18015

TELEPHONE (215) 691-7000

DEPARTMENT OF CIVIL ENGINEERING
FRITZ ENGINEERING LABORATORY #13

November 16, 1979

Mr. Donald B. Stabler
Stabler Companies, Inc.
635 Lucknow Road
Harrisburg, PA 17110

Mr. Philip J. Berg
Dravo Corporation
One Oliver Plaza
Pittsburgh, PA 15222

Equipment and Renovation Needs

Gentlemen:

At the last meeting of the Visiting Committee, it was agreed that we would send you information on equipment and renovation needs in three areas. Statements have been developed on each of these and they are included in the attached document under these headings:

Hydraulic Engineering Renovation and Equipment
(prepared by R. L. Johnson) (pp 1-7)

Geotechnical Engineering Equipment
(prepared by R. C. Chaney and H. Y. Fang) (pp 8-18)

Data Acquisition System and Loading Equipment
(prepared by G. C. Driscoll) (pp 19-23)

The first two categories are instructional. The third item (data acquisition) is for research.

We will be sending the formal statements through the normal channels at Lehigh. In the meanwhile, we would appreciate any suggestions that you might have.

David A. VanHorn

Lynn S. Beedle

LSB:dcp

cc: Members of Visiting Committee: Messrs. V. T. Chow, J. R. Kiely,
T. W. Lambe, G. A. Rohlich, C. Scheffey, W. F. Swiger, F. C. Turner,
G. Winter
W. Deming Lewis
Joseph F. Libsch
John J. Karakash

Enclosure

HYDRAULIC ENGINEERING LABORATORY RENOVATION AND EQUIPMENT

The equipment needs and basic facilities in the hydraulic engineering area of the Fritz Laboratory have had minimal attention in the last 25 years. Some of the apparatus dates back more than 50 years. The hydraulics laboratory must be updated in order to provide an effective instructional program in this Civil Engineering area.

To highlight the difficulties with the present facility, we cite the following:

The two main pumps are quite old, and one of the motors has been rewound at least once. One of the pumps is completely inoperable. The recommended solution is to replace them both.

The present pump/piping/head-tank/water supply system is such that it will only feed water to the first floor and the basement -- not the instructional area on the balcony. And yet the balcony area is where most of the hydraulics instructional/experimental facilities are located, and where they will be in the future. In years past, the installation of a constant head pressure tank was intended to correct this water supply problem, but it has not worked satisfactorily, besides occupying valuable space on all three floor levels of the hydraulics area. Hence, the need to raise the head tank and to renovate the complete system.

There is a serious overcrowding problem. The proposed instructional-demonstration hydraulic laboratory units are self-contained, portable experimental facilities. They will allow all students to observe phenomena and collect data. When not in use, they can be stored out of the way and leave space available for larger scale experimental work.

The renovation plan for the hydraulic engineering facilities was first formally proposed in February, 1976. This has now been revised and has been subject to evaluation over the past three years by the Civil Engineering faculty, and particularly by the five faculty members who are teaching courses which involve the renovated facility.

Sketches of working drawings for the renovation have been developed to the point that it is possible to get a better estimate for the piping, valves, and other physical renovation work. Work is continuing on these plans, and when completed, it will be possible to develop a more precise estimate of these particular costs. However, we feel that the several sources of information and the estimates which have been used to prepare the attached budget provide fairly well-defined costs for financial planning of the renovation project.

What follows then, is a description of the needs required to provide experimental facilities for teaching basic principles in an approach suitable for the 1980s and beyond, rather than the "training" approach of the 1930s. The latter is the orientation of much of the present hydraulics facilities for experimental work.

We call attention to the fact that even if a more extensive renovation of the entire north wing of the Fritz Laboratory were to be considered, the basement, first floor, and most of the balcony level renovation plans included in the following document would not change.

One other thought, expressed during the Visiting Committee discussions, was the possibility of moving the entire engineering instructional/experimental equipment into the old powerhouse (now the theatre). We understand the current University commitment to this latter facility, but the alternative is mentioned at this point just in case there were considerations for the relocation of the theatre -- considerations about which we might not be aware. In such an event, a more thorough study would be undertaken to determine the feasibility.

JUSTIFICATION, PHILOSOPHICAL STATEMENT AND BUDGET ESTIMATE
FOR PROPOSED HYDRAULIC ENGINEERING LABORATORY RENOVATION AND EQUIPMENT

October 30, 1979

(Prepared by R. L. Johnson)

BACKGROUND:

Recognizing the physical limitations and shortcomings of the facilities used in teaching fluid mechanics and hydraulic engineering, the five civil engineering faculty members who are teaching and conducting research in hydraulic engineering conducted a thorough review and evaluation of the laboratory equipment and capability. Throughout the 1975-76 academic year, the philosophy of teaching in this area of civil engineering was thoroughly discussed and debated internally, using our contacts throughout the profession to provide a good insight into current and future needs for civil engineering education in hydraulics, both undergraduate and graduate.

The basic result of that effort was a renovation plan which was outlined in a February 17, 1976 memorandum to Professor D. A. VanHorn, Chairman, Civil Engineering Department. It should be noted that this plan was presented to the entire civil engineering faculty for review and comment on two separate occasions; the second presentation and plan being the result of incorporating the helpful thoughts and views of our colleagues in the other areas of civil engineering.

The philosophical essence of this extensive consideration was to

"provide adequate but not excessive facilities to teach undergraduate and graduate students the area of hydraulic engineering using basic principles rather than the "training approach" appropriate to the 1930's equipment and facilities that are currently in the hydraulic engineering laboratory area of Fritz Engineering Laboratory"

The plan developed in 1975-76 for the renovation of the hydraulics laboratory has been subjected to a continuing informal and intensive evaluation of needs by the associated faculty during the subsequent 1976-79 period.

PROPOSED HYDRAULIC LABORATORY RENOVATION:

Renovations planned are entirely within the north wing of the original Fritz Engineering Laboratory and within the confines of the space presently allocated to the hydraulic engineering activity.

The major building renovation and "hardware" portions of the proposed plan are 1) replacement of the two existing main supply pumps (only one of the current pump units is operational), 2) removal of a constant pressure tank occupying space on three floor levels, 3) relocation and elevation of the existing constant head supply tank and 4) provision of a loop piping system for supply and return of water to equipment on all three floor levels. It should be noted that the present piping system supplies only one flume in the basement of the laboratory. Appreciable flexibility and utilization can be achieved with the proposed system.

A second aspect involves the important decision about teaching methods to be used. The "principles" oriented methods to be used in the future (partially reflected in present teaching efforts) will be accomplished by self-contained mobile instructional units. The mobility of this equipment is important since it will allow use of all floor levels in the laboratory for teaching instead of being restricted to the "rooted" location of the present equipment. The mobility of these laboratory units will also allow on-campus use by other departments.

The third aspect of the proposed renovation will correct a major lack in the existing hydraulics laboratory by providing flumes. The largest equipment item involved in the renovation plans is an 80 to 100 foot long tilting flume. This is a primary equipment item which should be in every major hydraulics laboratory. In addition, two other flumes are included; one a small "principles" type of unit and the other unit is a lengthened and refurbished version of the existing unit on the second floor.

Since the soil-water interface creates so many of the civil engineering problem areas (erosion, scour, etc.) much of the instructional and potential research use of the flumes will involve soil water mixtures. Rather than contaminate the entire laboratory water system, the appropriate flumes will be capable of operation from either the loop piping system of the laboratory or from self-contained pumping units to keep the soil contained in the unit.

ASSOCIATED NEEDS AND COMMENTARY RELATED
TO THE HYDRAULICS LABORATORY RENOVATION:

There are several additional items which, although mundane are of vital importance. First it should be noted that the machine shop and electrical switchgear for the entire Fritz Engineering Laboratory are located directly below the space where the wave channel is presently located and where the tilting flume will be located since this is the only 100 foot (+) space currently available. Since the wave channel and tilting flume are inevitable "wet areas", it is crucial that either the present area be effectively and completely sealed to prevent water seeping and leaking down into the vulnerable shop and electrical gear, or that the activity be shifted as noted below.

One possible solution which should be investigated further would be to swap the activities on these floor levels so that the hydraulics laboratory portion would be below the machine shop and electrical gear. Other ways of resolving this problem area in the extreme north side of the old Fritz Engineering Laboratory are possible, but they involve a major renovation of the entire north wing of the building.

Hopefully these potential solutions will be evaluated in the very near future. However it should be noted that this problem area and any of the current possible solutions do not affect the principles of the hydraulics laboratory renovations, nor for that matter, do they affect the basement and first floor level renovation plans being proposed.

A second mundane item concerns open laboratory space. Efficient utilization of any hydraulics laboratory for teaching and/or research requires uncluttered space. A necessary requisite to maintaining uncluttered space is to provide adequate storage space for the multitude of valves, pipe sections and other items which make up a hydraulics laboratory.

BUDGET COST ESTIMATEHYDRAULICS LABORATORY RENOVATION AND EQUIPMENT

October 30, 1979

<u>Major Items</u>	<u>Estimated Cost</u>
1. Removal of unusable equipment, related piping and valves	
a) Existing Constant Pressure Tank	\$ 12,000
b) West volumetric tank in basement	5,000
c) Dredge pumps, motors and controls in basement	16,000
d) Approximately 300 feet of 10 and 12 inch cast iron pipe	6,000
2. Relocation and raising of existing constant head tank	25,000
3. Supply, return and loop piping system	
a) Epoxy lined fabricated steel pipe of 12", 14" and 16" diameter	22,240
b) Related butterfly valves	19,920
c) Related fittings (elbows, tees and reducers)	17,950
4. Relocation and rehabilitation of existing equipment; Wave Channel, Water Tunnel, Small Tilting Flume and Fixed Bed Glass-Wall Flume	35,000
5. Reinforcing and waterproofing second floor level (above machine shop)	12,500
6. Equipment Items	
a) Supply Pumps (2) (Vertical Turbine Pumps 2500 gpm @ 60 foot head, complete with motor and electrical starters)	25,000
b) Adjustable Slope Flume	150,000
c) Small Teaching Flume	24,000
d) Instructional-demonstration hydraulic laboratory units	60,710
i) Fluid Properties/Hydrostatics 2 @ \$9175	\$18,350
ii) Fluid Mechanics Flowing Fluid 2 @ \$9600	19,200
iii) Hydraulic Machinery System 1 @ \$11,975	11,975
iv) Adjustable Bed Channel System 1 @ \$11,185	11,185
	<u>\$60,710</u>
	SUBTOTAL
	\$431,920
7. Contingencies (15%)	64,788
	TOTAL
	<u>\$496,708</u>

GEOTECHNICAL ENGINEERING LABORATORY EQUIPMENT

The problems of the geotechnical engineering laboratory equipment are as follows:

1. Lack of a systematic maintenance program;
2. A substantial amount of worn out or broken equipment;
3. A lack of modern apparatus.

As a result of the above problems, the existing undergraduate and graduate instructional needs cannot be met adequately (the list of courses affected is shown in Table 1). In addition, a student doing a senior project or a master's thesis in experimental soil mechanics is at a great disadvantage because of the lack of adequate facilities.

Although our equipment needs are primarily oriented for instruction, the mission of the Fritz Laboratory is also to extend knowledge. Thus, equipment should be such that it will provide an opportunity to conduct experimental research. This is next to impossible with the present apparatus.

A systematic upgrading of the laboratory is required to remedy these problems. The following statement is a proposed program for such upgrading to adequately meet the teaching requirements of existing undergraduate and graduate instruction.

GEOTECHNICAL ENGINEERING REQUIREMENTS

(prepared by R. C. Chaney and H. Y. Fang)

ITEM NO. 1 - LABORATORY MAINTENANCE PROGRAM

To upgrade the soils lab a laboratory technician assigned a minimum of one-half time is required. The duties of this individual will be to (1) repair and maintain existing laboratory equipment, (2) construct new teaching centers (i.e. permeability, static triaxial, consolidation etc.) with assistance from the soils faculty, and (3) help in setting up experiments for the various classes. The estimated costs associated with this person are covered in a separate memo.

ITEM NO. 2 - REPLACEMENT OF WORN OUT AND BROKEN EQUIPMENT

At the present time the soils laboratory has the following equipment problems:

- (1) 7 proving rings of which 5 are damaged. The 2 operable proving rings are both out of calibration.
- (2) 2 electronic balances both out of calibration and adjustment and therefore not useable at the present time.
- (3) 12 dial gauges of which 7 of these are broken
- (4) 4 drying ovens that are 10 yrs beyond their life expectancy resulting in large variations in temperatures
- (5) 2 direct shear devices of which 1 is working
- (6) The majority of pans for handling soils are rusted and are no longer useable.
- (7) Humidifer unit in humidity room is worn out therefore the humidity room is no longer operable
- (8) 1 useable soil compaction mold, 5 others are worn out
- (9) 4 load frames of which 3 are damaged

This is just a sample list of the equipment problems. Effectively, a large portion of the lab is just worn out, or damaged. The laboratory needs \$15,000 to replace or repair broken and/or worn out equipment to alleviate this problem. The laboratory also needs a yearly budget to maintain itself as a viable teaching facility. The subject of a laboratory budget will be covered in a separate memo.

ITEM NO. 3 - UPGRADING GEOTECHNICAL ENGINEERING LABORATORY EQUIPMENT

The existing soils laboratory has not kept pace with changing technology. For example, the lab currently has no electronic instrumentation or recording devices of any kind. In addition we have no equipment for students to conduct experiments or demonstrations using current methodologies in the field of soil dynamics, which has developed over the past fifteen years.

To bring our instrumentation up to date the laboratory proposes to acquire the equipment presented in Table 2. Also included in Table 2 is a cost estimate of renovating the static triaxial system, and permeability system. The total cost of these various systems and renovations is \$165,000. A detailed breakdown of the various equipment items is presented in Appendix A.

The actual utilization of the various major systems is presented in Table 3. A review of Table 3 indicates that all systems except the cyclic simple shear (CSS) would be utilized in both the undergraduate and graduate programs. The CSS system would be used primarily for graduate course work and graduate research.

In summary, the cost of upgrading the soils laboratory into a viable teaching facility is estimated to be \$180,500.

TABLE 1 - EXISTING COURSES UTILIZING SOIL LABORATORY FACILITIES

<u>Course Number</u>	<u>Course Title</u>
143	Soil Mechanics
342	Experimental Soil Mechanics
381	Special Topics
439	Ocean Engineering Research
447	Advanced Topics in Geotechnical Engineering
449	Geotechnical Research
460	Civil Engineering Project
481	Special Problems
483	Graduate Seminar
491	Thesis

TABLE 2 - PRELIMINARY COST ESTIMATE FOR UPGRADING SOILS LABORATORY EQUIPMENT*

<u>Major Equipment Items</u>	
1. Renovation of Static Triaxial System	\$ 10,000.00
2. Renovation of Permeability Test System	2,500.00
3. New MTS Hydraulic Servo controlled cyclic triaxial system	70,000.00
4. New Resonant Column Test System	13,000.00
5. New Cyclic Simple Shear Test System	20,000.00
6. New Modular Instrumentation Packages	10,000.00
7. Pneumatic Cyclic Loader and Actuator System	5,500.00
8. New Gould pressurized pen 6 channel recorder	12,000.00
9. New Hewett-Packard x-y'-y'' flat bed recorder	4,500.00
10. New Pressure cells	10,000.00
11. New Pressure/Flushing Panel Boards	8,000.00
	<hr/>
TOTAL	\$ 165,500.00

*See Appendix A for details.

TABLE 3 - LABORATORY SYSTEMS UTILIZATION

System	Educational Usage			
	Undergraduate Instructional	Projects	Graduate Instructional	Research
Static Triaxial	X	X	X	X
Permeability	X	X	X	
Cyclic Triaxial	X	X	X	X
Resonant Column	X	X	X	X
Cyclic Simple Shear			X	X
Instrumentation Package	X	X	X	X
Fritz Lab Renovation	X	X	X	X

APPENDIX AEQUIPMENT REQUIREMENTS FOR DEVELOPMENT OF A FULL CAPABILITY
SOIL DYNAMICS LABORATORY AT LEHIGH UNIVERSITY

Purchase of the following equipment will allow the study of soils under cyclic loading over the full range of strain levels and test configurations experienced in the field. A chart presenting the applicable strain range of each of the various equipment items is presented schematically in Fig. 1. In addition the range of strains caused by the various loading mechanisms (i.e. wave loading, earthquake and machine foundations) are also shown in Fig. 1. These items are as follows:

A. Drenevich Resonant Column Apparatus with Special Log-Tor Option

Basic Resonant Column Unit	\$5,000
Electronic Instrumentation	\$6,000
Log-Tor Option	\$2,000
Subtotal	<u>\$13,000</u>

Purpose: This device will allow the determination of the maximum shear modulus (G_{max}) and the maximum Young's modulus (E_{max}) at low shearing strain levels ($10^{-4}\%$). In addition this device will allow the determination of the shear modulus, Young's modulus and damping ratio in the shearing strain range from $10^{-4}\%$ to $10^{-2}\%$.

B. Cyclic Simple Shear Test Apparatus, Model SS104

Basic Unit	\$18,000
Accessories	\$2,000
Subtotal	<u>\$20,000</u>

B. Cyclic Simple Shear Test Apparatus, Model SS104 (Contd.)

Purpose: State of the Art testing device to simulate the application of either cyclic stress or cyclic strain to a soil specimen constrained laterally by a constant strain boundary. Device is capable of conducting both cyclic properties testing (shear modulus and damping) in the strain range $10^{-2}\%$ to 1.0% and liquefaction testing.

C. MTS Cyclic Triaxial Apparatus (Hydraulic)

25 kip load frame
 5 kip load cell
 5 kip actuator
 5 and 10 gpm servo valves
 442 controller
 413 master control panel
 417 counter panel
 410 digital function generator

Subtotal
 \$ 70,000

Purpose: This device will allow the determination of both cyclic properties and liquefaction strength of soils under both constant cyclic strain or constant cyclic load conditions. The soil specimens are constrained laterally by a constant stress boundary. In addition to these functions the device will provide the constant strain capability to the cyclic simple shear device. The device is normally capable of performing cyclic properties testing in the strain range $10^{-2}\%$ to 1.0%.

D. Pneumatic Cyclic Loader

Pneumatic Actuator (UCLA - Lee Design) \$1,500
 cpk Cyclic Pneumatic Loader \$4,000
 Subtotal
 \$5,500

D. Pneumatic Cyclic Loader (Contd.)

Purpose: This device will provide a constant cyclic stress loader for use on either the cyclic simple shear apparatus or for the development of a cyclic triaxial unit to study the long term cyclic creep properties of soils.

E. Instrumentation

1. Gould pressurized pen 6 channel recorder	\$12,000
2. H.P. x-y-y' flat bed recorder	\$4,500
3. 4 Digital indicators	\$3,200
4. 5 LVDT's (Schaevitz)	\$2,000
5. 6 Pressure Transducers (columbia)	\$2,000
6. 2 Load cells (Interpace)	\$1,600
Subtotal	<u>\$25,300</u>

F. Pressure Cells

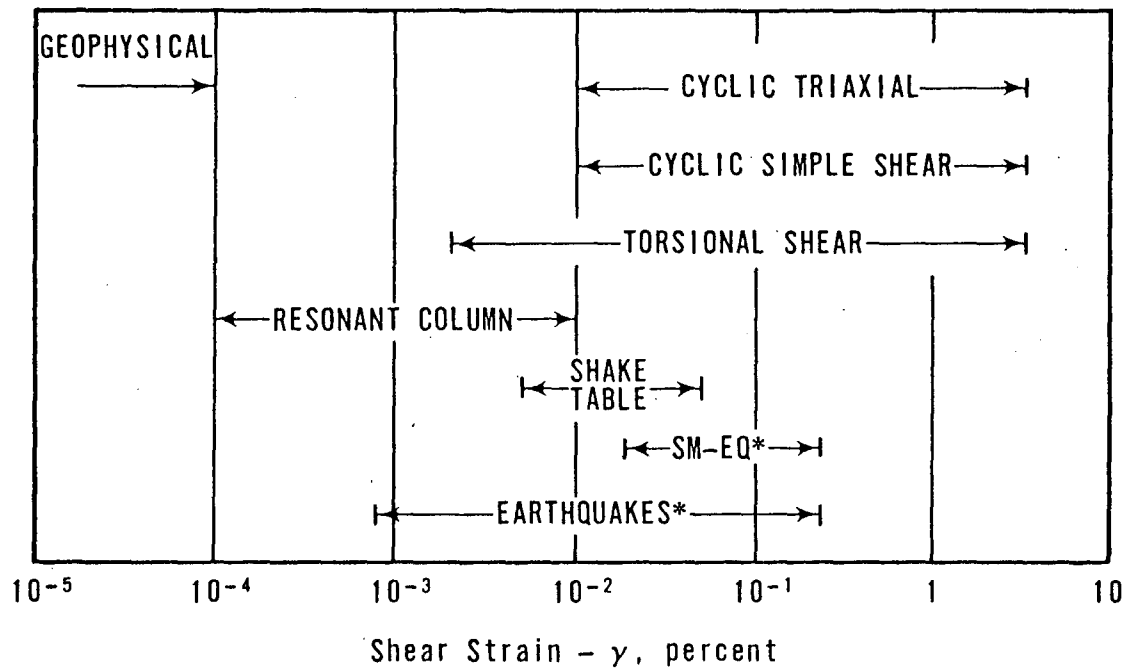
1. 3 stainless steel cells with air bearing seals	\$7,000
2. 1 high pressure (400 psi) cast acrylic cell with an air bearing seal	\$3,000
Subtotal	<u>\$10,000</u>

G. Panel Boards

1. 4 combination pressurizing and flushing panel boards	\$8,000
---	---------

H. Miscellaneous Hardware	<u>\$10,000</u>
---------------------------	-----------------

Note: All costs indicated are estimated 1978-1979 prices.



*NOTE: Range of shear strain denoted as "Earthquakes" represents an extreme range for most earthquakes. "Sm-EQ" denotes strains induced by strong motion earthquakes.

Fig. 1 - APPROXIMATE SHEARING STRAIN RANGES OF LABORATORY DYNAMIC TESTS

DATA ACQUISITION SYSTEMS AND LOADING EQUIPMENT

The present facilities for testing structures under dynamic loading were "modern" in the 1950s, but in the 1980s they will be completely out-dated. This rapid change is primarily due to developments in the field of electronics and also to the virtual explosion of computer-oriented apparatus.

As we think of the Fritz Lab facilities for cyclic load as they are now and as they should be, the difference is not one of "better" as compared with "good." It is a matter of a need for a "basic necessity" in comparison with a system that can almost be referred to as "fully inadequate."

The following is an abstract of a proposal currently being developed for submission to the National Science Foundation. It is designed to upgrade our facility in three areas:

1. Loading Equipment
2. Data Acquisition System
3. Data Reduction System.

This new equipment will enable us to compete with other laboratories and to meet our obligations to a profession that needs information on the behavior of structures under repeated, cyclic, and seismic loads. It will be one more step in the direction of establishing Fritz Lab as the major East Coast facility in the earthquake engineering research field.

DATA ACQUISITION SYSTEM AND LOADING EQUIPMENT

(prepared by G. C. Driscoll)

ABSTRACT

Funding is requested for the purchase and installation of loading equipment and components for an electronic data acquisition and reduction system. This equipment is needed to conduct research on behavior of structures and structural components under static or cyclic loading. The studies themselves are being proposed to the Division of Problem-Focused Research in the Directorate for Engineering and Applied Science of the National Science Foundation. The estimated cost of the equipment is \$134,000 of which \$104,000 is requested from National Science Foundation.

The acquisition of the proposed equipment will provide a major improvement in the ability of Fritz Laboratory to conduct successful research on the earthquake behavior of structures.

The Research

The equipment is being requested in support of research on the earthquake behavior of structures to be conducted in Fritz Engineering Laboratory. The research includes tests of steel, reinforced concrete, and composite structural components under cyclic uniaxial and biaxial loading. The components to be tested comprise key portions of building structural systems designed to resist earthquake ground motions. Prior experimental investigations on building components have covered only a few types and loading combinations which occur in three-dimensional structures. Results of such experiments have shown that some of the theories commonly used in the proportioning of structures cannot be safely extrapolated for the design of larger-sized structures. Further experimental investigations must be conducted to reveal true behavior

and provide information for design and analysis.

Currently, five programs totalling \$2,800,000 in estimated research expenditures over five years are in the planning stage and would need to use the proposed equipment. These projects would extend the beginnings made in the projects "Contribution of Floor Systems to Earthquake Resistance of Building Structures," "Minor Axis Beam-to-Column Connections," and "Connections for Industrial Installations."

The Equipment Needed

(1) Loading Equipment

Additional dual-acting actuators are needed to test four-way connections, subassemblages, and three-dimensional frame components. They will be used with an MTS Systems Corp. closed loop testing system acquired in 1976 for fatigue tests of bridge girders. The MTS system consists of control units, hydraulic power supply, and two dual-acting actuators with a maximum stroke of \pm three inches.

Funding is required for two dual-acting actuators with 10-inch stroke, and the valves, controls, and hoses needed to operate them. The total of four actuators will provide the opportunity to apply load to four points on three-dimensional structures, and the longer stroke of the two new actuators will enable the determination of the inelastic reserve required to provide resistance to earthquake effects in structures.

(2) Data Acquisition System

Fritz Laboratory presently is served by a B & F Instruments data acquisition system controlled by an SY 256 Digital System Controller. The present system has input conditioning and analog-to-digital conversion modules for 130 channels of data input. Data are printed on an ASR-33 teletype with

paper tape punch. Only simple manual data reduction can be accomplished on the test site, not enough to enable the investigator to make on-the-spot decisions when changes in test procedure are required.

It is proposed to add hardware to the system to increase capacity to 300 channels, well within the maximum 1000-channel capacity of the system. In addition, it is proposed to acquire an interface to allow the data to be processed by a MINC-11 mini-computer.

(3) Data Reduction System

To meet the needs for on-site data processing, it is proposed to purchase a MINC-11 Modular Instrument Computer, marketed by Digital Equipment Corp., Marlborough, Mass. This system is a mobile modular unit which can be wheeled from one floor location to another and does not require rigidly-controlled temperature and humidity environment. The interchangeable plug-in modules allow multiple preamplification, analog-to-digital, and digital-analog conversion and digital input and output as well as serving up to four terminals. A twin floppy disk unit to provide storage is standard. It is proposed to add twin 5.2 Mb cartridge disk drives to provide memory needed for larger tests. The standard terminal is a video graphics terminal; it is proposed to add a Decwriter LA 120 printer for hard copy of processed data output. Software in BASIC and FORTRAN will include routines for computation, graphics, and instrument control, together with mathematical, statistical, and data processing programs.

The hardware and software selected for the mini-computer system will allow it to serve the other divisions of the laboratory as well as the structural areas. In many instances, more than one experiment will be able to be served simultaneously through the multi-channel capability of the system.

Budget

The total cost of the projected systems is estimated at \$134,000. It is proposed that the National Science Foundation provide \$104,000 toward the purchase of the new equipment. Lehigh University will cover the \$30,000 remainder of the cost.

Summary of Budget

Loading Equipment	\$ 77,487
Data Acquisition System	18,335
Data Reduction System (MINC-11)	34,419
Allowance for transportation, additional wiring, site preparation, and taxes	3,759
Total Budget	\$134,000

Recapitulation

This proposal requests funds for loading equipment, data acquisition, and data reduction equipment. The more complex four-way connections, subassemblies, and three-dimensional frame components to be tested are beyond the capability of presently used loading apparatus. On-line data processing, possible with the proposed equipment, will be a new feature for Fritz Engineering Laboratory. It will permit more rapid conduct of tests--by an order of magnitude. Existing equipment in the facility cannot provide computer control of testing, which will be possible through use of the new equipment.