GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

no action OAH

Date: March 17, 1977

Project Title: Undergraduate Research Participation

Project No: E-20-543

Project Director: Dr. Richard D. Barksdale

Sponsor: National Science Foundation

Agreement Period: From 3/1/77 Until 5/31/78 (Grant Period)

Type Agreement: Grant No. SMI76-82981

Amount: $11,060

Reports Required: Brief Status Report; Summary of Completed Project; Final Report

Sponsor Contact Person (s):

Technical Matters

Student-Oriented Programs
Division of Science
Manpower Improvement
National Science Foundation
Washington,D. C.
202/282-7150

Contractual Matters
(thru OCA)

James L. Bostick
Grants Officer
National Science Foundation
Washington, D. C. 20550

Defense Priority Rating: none

Assigned to: Civil Engineering (School/Laboratory)

COPIES TO:

- Project Director
- Division Chief (EES)
- School/Laboratory Director
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- Accounting Office
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- Project Code (GTRI)
- Other _____

CA-3 (3/76)

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION

no action
ADL
OAL

Date: May 25, 1978

Project Title: Undergraduate Research Participation

Project No: E-20-543

Project Director: Dr. R. D. Barksdale

Sponsor: National Science Foundation

Effective Termination Date: 5/31/78

Clearance of Accounting Charges: 5/31/78

Grant/Contract Closeout Actions Remaining:

- _ Final Invoice and Closing Documents
- X Final Fiscal Report
- _ Final Report of Inventions
- _ Govt. Property Inventory & Related Certificate
- _ Classified Material Certificate
- _ Other _____

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- Other _____

CA—4 (3/76)

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
CIVIL ENGINEERING

TELEPHONE:
(404) 894-2284

April 28, 1978

National Science Foundation
Division of Grants and Contracts
Washington, D.C. 20550

Subject: University Research Program, Undergraduate
Research Participation Project - SMI 76-82981

Gentlemen:

Enclosed is the Final Technical Report and summaries of the five completed student projects. As described in the proposal, the students worked on selected active research projects to learn all phases of the study. In addition, they performed research in a selected area pertaining to their project, and wrote a formal report. The enclosed five "Summary of Completed Project" forms describe the results of the student's research.

It is felt that the Undergraduate Research Participation Project was very worthwhile, and we look forward to participating in this project again in the future.

Sincerely,

Richard D. Barksdale
Professor

RDB:vc
Enclosures

OVERALL PROJECT EVALUATION

Both the instructors and the participants found the NSF Undergraduate Research Participation Project to be a very valuable mechanism for giving the participants a good overall perspective into the specialty area of civil engineering materials. The overall performance of the students in this NSF program was excellent. Of great interest was the fact that all students, regardless of their previous academic grades, were felt to perform about equally well. Probably one of the big factors for this high level of performance was that the students participating in the program were highly motivated. Because of the relatively small amount of money provided, they participated in the program for the learning experience and not for the money. Four of the six participants have continued working in the area of materials either as undergraduate or graduate students. All of these students have done outstanding in their classroom and related research activities in this area. The technical training received during the program in their research area has helped to develop these students into leaders in terms of research capability.

The NSF Undergraduate Research Participation Project appeared to greatly motivate the participants to attend graduate school. Of the six participants, it appears that four will go to graduate school. Three of these participants plan to do graduate studies in the materials area. The program has been of great success to the School of Civil Engineering, Georgia Institute of Technology since all of the participants going on for a graduate degree will attend Georgia Tech. Based on their performance during this program, they will make a very positive contribution to the graduate program, and be leaders in the area of research during their

graduate studies.

One of the most surprising aspects of the project was the fact that the students participating were all extremely motivated in the area of engineering materials. I strongly feel that one of the best aspects of the program is the motivation which these students demonstrated. This motivation is probably directly related to a relatively low stipend associated with the NSF program. Therefore it is felt the stipend should remain below the level of compensation which students could get during summer employment. However, in the field of engineering at least, the stipend should probably be increased to a somewhat higher level. The overall program was a great success for both the students and the Georgia Institute of Technology. We are looking forward to participating in this program again in the future.

SUMMARY OF FACTUAL INFORMATION

1. Distribution of Project Announcement: Since the Georgia Institute of Technology is the only engineering school in Georgia, problems existed for the recruitment of students from other engineering schools. An announcement was prepared and sent to all civil engineering students at the Georgia Institute of Technology. A meeting was subsequently held for interested students, with approximately 25 Georgia Tech students attending. In addition, a similar announcement together with application forms were sent to the following ten schools located in the southeastern states surrounding Georgia:

    1. Florida A&M University
    2. Tuskegee Institute
    3. Auburn University

4. University of South Carolina
5. Clemson University
6. University of Florida
7. University of Alabama
8. The Citadel
9. Memphis State University
10. Vanderbilt University

Approximately 26 inquiries were received in response to the notices sent to the civil engineering students at Georgia Tech, and to the civil engineering schools in the surrounding states. Only one inquiry was received from students going to schools outside the state. Twelve completed applications were subsequently submitted for evaluation.

2. Method of Selection of Participants: The participants were selected by a panel of outstanding material engineers as described in the proposal. This selection process worked very well, with some outstanding students being selected.

3. Instructors and Visiting Lecturers: The formal instructors from the Georgia Institute of Technology for the course were as follows:

1. Dr. Richard D. Barksdale, Professor, School of Civil Engineering
2. Dr. James S. Lai, Associate Professor, School of Civil Engineering
3. Dr. Quentin L. Robnett, Associate Professor, School of Civil Engineering.

Further, the following practicing material engineers gave formal lectures for the program:

1. Mr. Edwin Jones, District Engineer, The Asphalt Institute
2. Mr. Woodrow Fitzgerald, Executive Director, The Georgia Asphalt Paving Association.

In addition to the formal lectures presented during the course of this NSF Summer Research Participation Program, the participants took field trips to three construction projects, an asphalt plant and a rock quarry.

4. Roster of Participants: Antoinette L. Serena, Route 8, Hillsboro Road, Franklin, Tennessee; Mark W. Crisp, 422 Atwood Drive, Marietta, Georgia; Wayne G. Thigpen, 801 Techwood Drive, Atlanta, Georgia; Thomas Wm. Wilhite, P. O. Box 35507, Georgia Tech, Atlanta, Ga.; Charles T. Gore, 1120 Snyder St., Atlanta, Georgia; and Howard S. Stein, Box 33695, Ga. Tech, Atlanta, Georgia.

5. New Unique or Modified Procedures Not Covered in the Proposal: The procedures and activities followed during the course of this project were as described in the proposal. In general, a number of formal presentations were made outlining the scope of the various projects which the students could work on. In addition, several technical sessions were held by the faculty of the School of Civil Engineering for these participants. Also, outside lectures as previously described presented discussions of various aspects of material technology. Five field trips were taken during the course of the project. The students spent most of their time working on all aspects of the ongoing research projects described in the proposal. They became thoroughly familiar with all phases of a particular project, and wrote a detailed report on the project at the end of the work period. An abstract of the reports are given in Appendix A of this report.

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550

Form Approved
OMB No. 99-R0289

UNDERGRADUATE RESEARCH PARTICIPATION PROGRAMS STATUS REPORT

INSTITUTION	PROPOSAL NUMBER	GRANT NUMBER	DIRECTOR'S NAME
Georgia Institute of Technology	SMI 76-82981	SMI 76-82981	Dr. Richard D. Barksdale

ADDRESS	DATE OF ACTIVITY	DISCIPLINE
School of Civil Engineering Atlanta, Georgia 30332	TO: August 26 FROM: June 20, 1977	Engineering, Civil, Materials ENGCIVIL:5400000

NUMBER OF PARTICIPANTS PROVIDED BY THE GRANT 6
NUMBER OF PARTICIPANTS IN THE PROJECT 6

ADDITIONAL PARTICIPANTS SUPPORTED BY: (a) GRANT FUNDS _____ (b) OTHER SOURCES _____

PARTICIPANT ROSTER

NAME AND HOME ADDRESS	HOME INSTITUTION AND ADDRESS	CLASS AS OF MAY 1 CURRENT YEAR	RESEARCH TOPIC	RESEARCH SUPERVISOR
Antoinette L. Serena (E) Rt. 8, Hillsboro Rd. Franklin, TN 37064	Vanderbilt University Box 1533 - Station B Nashville, Tenn. 37235	Senior*	Development of a Simple Test for Evaluating Sand-Asphalt Mixes	Dr. R. D. Barksdale
Mark W. Crisp (E) 422 Atwood Dr. Marietta, Ga. 30064	Georgia Tech 225 North Avenue Atlanta, Ga. 30332	Senior	Effect of Embedment Depth on Pressure Distribution Beneath a Rigid Footing	Dr. R. D. Barksdale
Wayne G. Thigpen (E) 801 Techwood Dr. Atlanta, Ga. 30313	Georgia Tech 225 North Avenue Atlanta, Ga. 30332	Senior	Fatigue Performance of a Portion of I-285	Dr. R. D. Barksdale
Thomas Wm. Wilhite (A) Ga. Tech, Box 35507 Atlanta, Ga. 30332	Georgia Tech 225 North Avenue Atlanta, Ga. 30332	Grad. Student**	Development of a Bicycle Path Pavement	Dr. J. S. Lai
Charles T. Gore (E) 1120 Snyder St. Atlanta, Ga. 30318	Georgia Tech 225 North Avenue Atlanta, Ga. 30332	Senior	Development of a Bicycle Path Pavement	Dr. J. S. Lai
Howard S. Stein (E) Box 33695, Ga. Tech Atlanta, Ga.	Georgia Tech 225 North Ave., Atlanta	Senior	Preliminary Evaluation of the Influence of a Vacuum-Saturation Treatment on the Fatigue & Rutting Characteristics of Asphalt Concrete Mixes	Dr. Q. Robnett

* As of May 1, 1978
** Not Graduate Student During Project

DATE April 3, 1978

DIRECTOR'S SIGNATURE

NSF Form 541, Apr. 72

(Use additional pages as necessary) Page 1 of 1 Pages

APPENDIX A

ABSTRACTS OF PROJECT REPORTS WRITTEN BY PARTICIPANTS

NATIONAL SCIENCE FOUNDATION
Washington, D.C. 20550

SUMMARY OF COMPLETED PROJECT

Form Approved
OMB No. 99R0013

Please read instructions on reverse carefully before completing this form.

1. INSTITUTION AND ADDRESS	2. NSF PROGRAM	3. GRANT PERIOD
Georgia Institute of Technology Atlanta, Georgia 30332	Undergraduate Research Participation	from 3-1-77 to May 31, 1978

4. GRANT NUMBER	5. BUDGET DUR. (MOS)	6. PRINCIPAL INVESTIGATOR(S)	7. GRANTEE ACCOUNT NUMBER
SMI-76-82981	15	Barksdale/Lai/Robnett	E-20-543

8. SUMMARY (Attach list of publications to form)

Student Report by Antoinette L. Serena

DEVELOPMENT OF A SIMPLE TEST FOR EVALUATING SAND-ASPHALT MIXES

Project objectives were to (1) determine the physical characteristics of a sand-asphalt mixture predicting a stable pavement mix design, (2) determine what characteristics of a completed mix design influence stability, and (3) develop a simple test procedure for predicting whether a sand-aggregate mixture will give a stable mix.

Seven pit sands from southwest Georgia and one from Florida were tested for clay content and shape factor. A simple bearing capacity test was developed, in which a cylinder of sand was loaded to failure with a round piston. Loads and corresponding deflections were measured and the ratio of load to deflection and ultimate load to deflection at ultimate load were calculated.

Other characteristics studied included sand equivalent, percent fines, coefficient of uniformity, fineness modulus, percent voids, percent voids filled, and asphalt content. These variables were correlated with Marshall stability using a statistical computer program PEA CORE. Factors found to have high correlations were clay content, sand equivalent, bearing modulus, ratio of ultimate load to deflection at ultimate load, asphalt content, and uniformity coefficient.

Sand equivalent was inversely proportional to Marshall stability; an acceptable relationship because clay content, itself inversely proportional to sand equivalent, was directly proportional to stability. A high bearing modulus predicted a high stability; the inverse was found for ratio of ultimate load to deflection at ultimate load. Relationships between asphalt content and uniformity coefficient were not regarded realistic because most values of these variables lay in a very narrow range and because a considerable amount of scatter existed.

Test results indicated that clay content, sand equivalent, and bearing modulus are important factors affecting mix stability. However, tests of a large number of samples are needed before dismissing as unimportant the other factors studied in this project.

9. SIGNATURE OF PRINCIPAL INVESTIGATOR/ PROJECT DIRECTOR	TYPED OR PRINTED NAME	DATE
	Dr. Richard D. Barksdale	4-28-78

NATIONAL SCIENCE FOUNDATION
Washington, D.C 20550

SUMMARY OF COMPLETED PROJECT

Form Approved
OMB No. 99R0013

Please read instructions on reverse carefully before completing this form.

1. INSTITUTION AND ADDRESS	2. NSF PROGRAM	3. GRANT PERIOD
Georgia Institute of Technology Atlanta, Georgia 30332	Undergraduate Research Participation	*from* 3-1-77 *to* May 31, 1978

4. GRANT NUMBER	5. BUDGET DUR. (MOS)	6. PRINCIPAL INVESTIGATOR(S)	7. GRANTEE ACCOUNT NUMBER
SMI-76-82981	15	Barksdale/Lai/Robnett	E-20-543

8. SUMMARY (Attach list of publications to form)

Student Report by Mark L. Crisp

EFFECT OF EMBEDMENT DEPTH ON PRESSURE DISTRIBUTION
BENEATH A RIGID FOOTING

The contact pressure distribution and effect of embedment beneath a rigid footing was evaluated for a footing placed on a micaceous silty sand. The concrete footing was 18 inches in diameter and 6 inches thick. Small diaphram load cells were arranged beneath the footing to measure the stress distribution as a function of radial distances from the center of the footing. A hydraulic pump was used to apply the load to the footing. The embedment depths used were 9, 18, and 27 inches, including a surface test. A hole the diameter of the footing was dug out to the center of the footing in the embedment tests. This allowed the load to be directly applied to the footing, and not cause any friction along the load column. A cyclic loading sequence was applied using 500, 1000, and 2000 psf. The footing was allowed to rebound after each cycle to determine the effect of the cyclic loading.

The pressure distribution beneath the footing was generally parabolic with the highest pressure at the edge of the footing, decreasing to one-half the edge pressure at the center of the footing. This type of pressure distribution was similar for the surface test and the embedment tests. The embedment of the footing caused the vertical stress to decrease as the depth of the footing was increased. This stress reduction was due to greater confining pressure along the sides of the footing causing higher friction and, and due to the soil above the footing carrying some of the footing load in tension.

The cycling effort aided in seating the footing, but caused no other effects. The first load cycle seated the footing making a good contact between the base of the footing and the soil above the stress cells. Without a proper seating, a stress concentration would develop giving inconsistent data. After the first load cycle, the data remained consistent throughout the second, third, and fourth load cycles.

9. SIGNATURE OF PRINCIPAL INVESTIGATOR/ PROJECT DIRECTOR	TYPED OR PRINTED NAME	DATE
	Dr. Richard D. Barksdale	4-28-78

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SUMMARY OF COMPLETED PROJECT

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1. INSTITUTION AND ADDRESS		2. NSF PROGRAM	3. GRANT PERIOD
Georgia Institute of Technology Atlanta, Georgia 30332		Undergraduate Research Participation	*from* 3-1-77 *to* May 31, 1978
4. GRANT NUMBER	5. BUDGET DUR. (MOS)	6. PRINCIPAL INVESTIGATOR(S)	7. GRANTEE ACCOUNT NUMBER
SMI-76-82981	15	Barksdale/Lai/Robnett	E-20-543

8. SUMMARY (Attach list of publications to form)

Student Report by Wayne Thigpen

FATIGUE PERFORMANCE OF A PORTION OF I-285

This project consisted of performing fatigue tests on the asphaltic concretes that were used on I-285. The materials used in the fatigue tests were simulated using the results of three trenching studies performed across the roadway. Computer models of the roadway were developed, and typical truck loads were applied to the model to determine the stresses and strains that would develop in the roadway. These strains were then compared to strains that developed in actual fatigue test samples to determine the fatigue life of the roadway.

The theoretical analysis showed good agreement with the observed fatigue pavement life of seven years. The results indicate that the pavement was not designed sufficiently strong to withstand the applied traffic loadings. The fatigue, resilient modulus and the computer simulation results are presented in the report.

9. SIGNATURE OF PRINCIPAL INVESTIGATOR/ PROJECT DIRECTOR	TYPED OR PRINTED NAME	DATE
	Dr. Richard D. Barksdale	4-28-78

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NATIONAL SCIENCE FOUNDATION
Washington, D.C. 20550

SUMMARY OF COMPLETED PROJECT

Form Approved
OMB No. 99R0013

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1. INSTITUTION AND ADDRESS	2. NSF PROGRAM	3. GRANT PERIOD
Georgia Institute of Technology Atlanta, Georgia 30332	Undergraduate Research Participation	from 3-1-77 to 5-31-78

4. GRANT NUMBER	5. BUDGET DUR. (MOS)	6. PRINCIPAL INVESTIGATOR(S)	7. GRANTEE ACCOUNT NUMBER
SMI-76-82981	15	Barksdale/Lai/Robnett	E-20-543

8. SUMMARY (Attach list of publications to form)

Student Report by Charles T. Gore and Thomas W. Wilhite

DEVELOPMENT OF A BICYCLE PATH PAVEMENT

A low-cost bicycle path pavement was developed which can be placed over existing railroad roadbed with removing the railheads. The two basic pavement types considered were a portland cement mortar reinforced thin-shell, and an asphalt concrete surface treatment to a ballast roadbed. The laboratory investigation was restricted to the thin-shell reinforced mortar type of pavement.

After an initial study of the most feasible geometry of the pavement, the determination of the reactions in the pavement was performed with the aid of a structural analysis computer program (STRUDL). This analysis indicated that the material should have an ultimate flexural strength of 2150 psi.

In the actual testing of portland cement mixes, a mortar was initially developed with an ultimate flexural strength of 1000 psi. This mortar mix design, with minor modifications, was utilized with varying types of light reinforcements. The different types of reinforcements studied were welded wire mesh, expanded metal mesh, and both glass and steel fibers.

The test sample was an 8 by 24 inch panel with either a 1 or 2 inch thickness. Loading on the panel was accomplished by a two point contact configuration of the loading head that produced a constant moment in the midspan. After these static loading tests indicated the strongest materials, a cyclic loading of sixty-five percent of the ultimate load was introduced upon the sample. This dynamic test gave an indication of the service fatigue life of the sample.

The best results were obtained from the steel fiber reinforced mortar. The ultimate flexural strength of the material was sufficient to satisfy the strength criteria established by the computer analysis. The steel fiber reinforced mortar was found to produce a strong ductile precast bicycle pavement.

9. SIGNATURE OF PRINCIPAL INVESTIGATOR/ PROJECT DIRECTOR	TYPED OR PRINTED NAME	DATE
	Dr. James S. Lai	4-28-78

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SUMMARY OF COMPLETED PROJECT

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SMI-76-82981	15	Barksdale/Lai/Robnett	E-20-543

8. SUMMARY (Attach list of publications to form)

Student Report by Howard Stein

PRELIMINARY EVALUATION OF THE INFLUENCE OF A VACUUM-SATURATION TREATMENT ON THE FATIGUE AND RUTTING CHARACTERISTICS OF ASPHALT CONCRETE MIXES

The fatigue and rutting characteristics of an asphalt concrete base course mix was evaluated after a vacuum-saturation treatment to compare the results with those obtained for non-vacuum saturated samples. The purpose was to determine how important weathering is on fatigue life and rutting of asphalt concrete mixes. The sample preparation procedures and testing methods were the same for both tests. Specimens were prepared using a large kneading compactor and were then vacuum saturated using a special device prior to testing.

A vacuum-saturation treatment was used to simulate possible in-service water damage found to occur in asphalt concrete mixes. The treatment involved the removal of air from the voids in the sample by creating a vacuum and allowing water to enter the pores and fill the vacuum. The specimen was then kept moist until tested.

A comparison of the different series of tests (treated and untreated) indicates that the specimens subjected to vacuum saturation had a significant reduction of fatigue life and increased rutting. This report recommends that more testing should be conducted to establish the correlation of the performance of vacuum saturation specimens and the design characteristics of asphalt concrete mixes.

9. SIGNATURE OF PRINCIPAL INVESTIGATOR/ PROJECT DIRECTOR	TYPED OR PRINTED NAME	DATE
	Dr. Quentin L. Robnett	4-28-78

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