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Research Experiences for Undergraduates: Advanced Engineered Wood Composites

Eric N. Landis
Principal Investigator; University of Maine, Orono, landis@maine.edu

Habib J. Dagher
Co-Principal Investigator; University of Maine, Orono, hd@maine.edu

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Principal Investigator: Landis, Eric N.
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Title:
Research Experiences for Undergraduates: Advanced Engineered Wood Composites

Project Participants

Senior Personnel

Name: Landis, Eric
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Dagher, Habib
Worked for more than 160 Hours: No
Contribution to Project:
Research Mentor

Name: Shaler, Stephen
Worked for more than 160 Hours: No
Contribution to Project:
Research Mentor

Name: Goodell, Barry
Worked for more than 160 Hours: No
Contribution to Project:
Research Mentor

Name: Lopez-Anido, Roberto
Worked for more than 160 Hours: No
Contribution to Project:
Research Mentor

Name: Abdel-Magid, Beckry
Worked for more than 160 Hours: No
Contribution to Project:
Research Mentor

Name: Davids, William
Worked for more than 160 Hours: No
Contribution to Project:
REU Advisor

Name: Gardner, Douglas
Worked for more than 160 Hours: No
Contribution to Project:
REU Advisor

Name: Peterson, Michael
Worked for more than 160 Hours: No
Contribution to Project:
Faculty Mentor

Post-doc

Graduate Student

Undergraduate Student

Name: Druffner, Edward
Worked for more than 160 Hours: Yes
Contribution to Project:
REU participant

Name: Mittelstadt, Benjamin
Worked for more than 160 Hours: Yes
Contribution to Project:
REU participant

Name: Brown, Rebecca
Worked for more than 160 Hours: Yes
Contribution to Project:
REU Participant

Name: Echard, Matthew
Worked for more than 160 Hours: Yes
Contribution to Project:
REU Participant

Name: Falker, Eric
Worked for more than 160 Hours: Yes
Contribution to Project:
REU Participant

Name: Goodwin, Jane
Worked for more than 160 Hours: Yes
Contribution to Project:
REU participant

Name: Holzman, Lloyd
Worked for more than 160 Hours: Yes
Contribution to Project:
REU Participant

Name: Jack, Jeff
Worked for more than 160 Hours: Yes
Contribution to Project:
REU Participant

Name: Tudryn, Carissa
Worked for more than 160 Hours: Yes
Contribution to Project:
REU participant

Name: Yelle, Daniel
Worked for more than 160 Hours: Yes
Contribution to Project:
REU Participant

Name: Brody, John
Worked for more than 160 Hours: Yes
Contribution to Project:

REU program participant

Name: Hensley, Janelle
Worked for more than 160 Hours: Yes
Contribution to Project:
REU Program Participant

Name: Heuscher, Sonja
Worked for more than 160 Hours: Yes
Contribution to Project:
REU Program Participant

Name: Johnson, Judy
Worked for more than 160 Hours: Yes
Contribution to Project:
REU Program Participant

Name: Morris, Jennifer
Worked for more than 160 Hours: Yes
Contribution to Project:
REU Program Participant

Name: Petrocine, Kyle
Worked for more than 160 Hours: Yes
Contribution to Project:
REU Program Participant

Name: Richard, Annette
Worked for more than 160 Hours: Yes
Contribution to Project:
REU Program Participant

Name: Sebesta, Kenneth
Worked for more than 160 Hours: Yes
Contribution to Project:
REU Participant

Name: Wallace, Kenneth
Worked for more than 160 Hours: Yes
Contribution to Project:
REU Program Participant

Name: Watkins, Andrew
Worked for more than 160 Hours: Yes
Contribution to Project:
REU Program Participant

Name: Agudelo Lopez, Andrea
Worked for more than 160 Hours: Yes
Contribution to Project:
REU Program Participant

Name: Botting, Joshua
Worked for more than 160 Hours: Yes
Contribution to Project:
REU Program Participant

Name: Espinosa, Wilhelmina

Worked for more than 160 Hours: Yes
Contribution to Project:
REU Program Participant

Name: Gonzales, John
Worked for more than 160 Hours: Yes
Contribution to Project:
REU Program Participant

Name: Mulherin, Jason
Worked for more than 160 Hours: Yes
Contribution to Project:
REU Program Participant

Name: Ngai, Jerry
Worked for more than 160 Hours: Yes
Contribution to Project:
REU Program Participant

Name: Pressman, Emily
Worked for more than 160 Hours: Yes
Contribution to Project:
REU Program Participant

Name: Ritter, Stephen
Worked for more than 160 Hours: Yes
Contribution to Project:
REU Program Participant

Name: Su, Susan
Worked for more than 160 Hours: Yes
Contribution to Project:
REU Program Participant

Name: Tomlinson, Scott
Worked for more than 160 Hours: Yes
Contribution to Project:
REU Program Participant

Name: Viskupic, Eric
Worked for more than 160 Hours: Yes
Contribution to Project:
REU Program Participant

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

Other Collaborators or Contacts

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)

Introduction and Structure of this Report

This progress report summarizes the REU program in Advanced Engineered Wood Composites conducted at the University of Maine during the nine week period from June 14 through August 15, 1998. In order it describes student recruiting, student activities, follow-up activities, program assessment, and changes for the 1999 program. A budget report is provided at the end.

Recruiting

Approach

We focused our recruiting efforts on an internet-based strategy. We prepared electronic versions of our promotional information and our student application. We then conducted a 'shotgun' e-mailing to both selected faculty and student organizations. Specifically, we identified about 200 faculty contacts who we knew would distribute our informational material to interested students. These faculty were primarily in fields of civil and mechanical engineering, and wood science and wood technology programs at national universities, including several minority institutions. In addition we identified approximately 20 New England liberal arts colleges, (including all womenÆs colleges). At these schools we contacted science (physics, chemistry, biology and computer science) faculty to which we sent our materials.

In addition to the faculty contacts we combed the web for contacts in student chapters of professional societies. These societies included the American Society of Civil Engineers, American Society of Mechanical Engineers, Society of Women Engineers, Society of Black Engineers, and the Forest Products Society. We sent our materials to as many student contacts as we could find published on the web. Our thinking was that if possible it is best to get the information directly into the hands of those who can most benefit.

Of our final group of ten REU students, we found five found out about us from student contacts, and five found out through faculty contacts. Thus in the future we will continue with this strategy, although we will expand the contact list.

Applicant Pool

A total of 20 students formally applied to our program. We believe a late start reduced the pool to some extent, however, we were quite pleased with the overall quality of applicants (average GPA of 3.4). By gender we had nine women. By race we had one of Asian descent and one African. By college major we had eleven civil engineering, two mechanical engineering, two chemical engineering, two architectural engineering, and two wood science, and one environmental engineering major. Geographically our applicants came from all parts of the country. Applicants came from the following universities: Catholic University, Cornell, Georgia Tech (2), Colorado State, Milwaukee School of Engineering, Northwestern, Oregon State, Penn State, Rice (2), Tufts, University of Colorado (2), University of Illinois, University of Minnesota, University of Pittsburgh, Utah State, and West Virginia University. Of these schools, all are research universities with the exception of the Milwaukee School of Engineering. One of our goals was to attract students from non-research universities. While we had several inquiries from students at liberal arts colleges, there were no applications. We hope in the future to be able to attract more students from these schools by adding to our contact lists.

In selecting the students for our program we looked at a combination of academic achievement (evaluated through grades, activities, and recommendations) and mutual interests with participating faculty (evaluated through their required statement of interest). We had little trouble matching students to faculty, and we were successful in attracting eight out of our initial list of ten. Four applicants who were offered positions turned us down. Three out of these four turned us down after accepting summer positions elsewhere. (The fourth spent the summer traveling abroad). So overall we were quite please with our yield. As the summer program progressed, all our students met or exceeded expectations, proving that our choices were good.

Table 1 presents a list of the student participants. The demographic characteristics of the students participating in the program are shown in Table 2.

Student Activities

We tried in all our activities to strike a balance between structure and independence, group and individual learning, and educational and social activities. A summary of the various activities is shown in Table 3. The program was structured so that all ten students would be part of a single team working toward a common goal. Although individual research projects were quite different, at the end of the nine weeks, there could be no doubt about their shared goal.

Interaction with Mentors and Research Groups

Student-faculty interaction was a strong point of our program from both the student and the faculty viewpoints. All REU students were part of research teams that consisted of faculty and professional staff, graduate students and other UMaine undergraduate research assistants. In all cases there was vary little group hierarchy, so all students were free to approach and interact with all others in the groups. On the average the REU students spent 3-4 hours per week individually with their advisors, and another 3-4 hours per week with their research groups. These times exclude the time spent working together in the laboratories.

StudentÆs Current and Future Plans

At the end of the summer, all ten students expressed a strong interest in pursuing an advanced degree. It should be noted, however, that all ten expressed a similar interest at the beginning of the program as well. Our conclusion from this is that the REU program either reinforced or strengthened an interest that was already present. Currently one of the ten (Dan Yelle) is enrolled in a graduate program (at the University of Maine studying under his REU advisor Dr. Barry Goodell), while a second (Rebecca Brown) is applying to graduate school. All of the remaining students are back at their home institution finishing their undergraduate degrees.

All but one of the ten students has remained in close contact with their advisor. One (Carissa Tudryn) is continuing the work started during the summer back at her home institution. Although we had planned to publish an 'electronic newsletter' to keep all the students posted on each others whereabouts and activities, it has proved unnecessary as the students have maintained close contact on their own.

Project Assessment and Future Changes

Our project assessment consisted of two parts: A quantitative measure of certain benchmarks, and an open-ended student questionaire for more qualitative measures of program effectiveness.

Quantitative Measures
We made quantitative measures in the following areas:
Publicity and Recruitment:
o number on inquiries (about 45)
o number of applicants (20)
o number of women and minorities applied (10)
o number of women and minorities accepting offers (3)
o number of offers turned down (4)
Student interest in research:
o number of students who continue research project beyond ten week program (2)
o number of students who apply to graduate science or engineering programs (2 to date)
o number of students who enroll in graduate science or engineering programs (1 to date)
Scientific merit:
o number of refereed journal publications resulting from program (0 to date)
o number of internal of external published reports (3 to date)
o number of conference and other publications resulting from program (2 to date) (in order to qualify, student must be co-author)
o external research support that results from pilot studies conducted under REU program (2 pending)

We were relatively pleased with the Publicity and Recruitment given that the program was in its first year, and it got off to a somewhat late start. We anticipate a significantly larger applicant pool this year (as inquiries have been steady for the last four months). As previously indicated we would like to focus more on applicants from non-research universities and minority institutions. An internet-based strategy will be used to identify and contact students and faculty at these institutions.

We believe it is too early to gage the effectiveness of student interest in research, but our initial response was promising. As indicated above, all ten of the students have shown an interest in persuing advanced degrees in science or engineering. We will continue to track the students so we may better evaluate this in the future.
The scientific merit is difficult for us to judge. Overall we were quite pleased with the quality of the work conducted. All student prepared and presented excellent posters. As is often the case in science and engineering, not all work led to publishable results. We are presently contacting other REU sites to gage our results against theirs. Preliminary indications are that we are about average. In the future we would like to improve on the publication totals by designing projects that have a better likelihood of producing publishable results.

Qualitative Measures

We opted for a more qualitative approach to gage the studentÆs overall impression of our program. Specifically, we asked them to answer the following questions:
- Overall has the program met your expectations?
- Has there been too much/too little structure?
- Has the workload been too much/too little?
- Have you been treated well by your advisor?
- What should we be doing differently?

Our intention with these questions was to let the students express their opinions in whatever manner was appropriate. They were given the option of following these questions or producing their own format.
The response to the first question was overwhelmingly positive. All students were happy with the experience, and they all felt the program provided a good indication of what they could expect of graduate research. Overall we feel comfortable that we were able to provide the students with a worthwhile research experience.

The second question provided a more mixed response. Although none of the students were unhappy with the amount of structure in the program, some believed there to be a bit too much while some believed there to be a bit too little. The responses addressed 'structure' from two angles. The first was the overall program structure, including the seminars, workshops, field trips, and social activities. The students seemed happy with how the overall program was set up, however some indicated they would like to see fewer activities toward the end of the program when their time becomes quite precious. The second angle of 'structure' addressed was that of the individual research projects. This structure was more a function of the mentor and the student reaching an appropriate level of comfort with the required tasks. Again, some students would have liked to be more free, while some would have liked to have more structure. In the future we will try to do a more careful job sizing up the students in the first few days to try and gage how much freedom they are comfortable with.

The third question led to responses with which we were quite pleased. All students commented that the workload was quite large, but they were happy with the large workload. We were obviously lucky to have been able to recruit a group of students who were eager to work and learn.

On question number 4 we found all students to be happy with their advisor. All students felt their advisor treated them with respect and in a professional manner. The only negative comment was that one advisor had a fairly extensive travel schedule that led to reduced attention to the students. We will try to minimize this problem in the future by only using advisors who are able to make a proper commitment to their students.

The fifth question gave us many ideas for improving the program. These ranged from the aforementioned reduction in outside activities later in the summer, to specific comments about what activities were worthwhile and which were not. General program changes that arose from the student (as well as faculty) comments are described below.
We are not entirely convinced our self-assessment was as good as it could have been. Based on discussions with other REU site directors we plan to develop an assessment procedure that while allowing for free expression as we did, will also address some specific issues. Sample surveys from other REU sites, sent to us by our NSF Program manager this fall will serve as a guideline for future self-assessment.

Program Changes for Summer 1999

Overall we believe we met or exceeded expectations in this past summerÆs program. Our comments from both students and faculty show that we really need to make only minor adjustments to our program. The two most significant program changes will come in the following areas:
1. Broader recruiting, particularly of minority applicants.
2. Better student-faculty interaction prior to studentÆs arrival on campus.

Improvements in these areas will produce additional changes as described below.

Recruiting
As discussed earlier in this report we would like to increase our applicant pool, particularly the number of minority students, and students from non-research universities. Last year we were somewhat restricted by a late start, but we still were able to assemble a group of highly qualified applicants. We were also pleased by the number of qualified women applicants. However, we were disappointed by the small pool of minority applicants. This year we will build on previous success (i.e. reach a broad population of students), and expand it by identifying additional contacts at minority and non-research institutions. As last year we will use web contacts at the National Society of Black Engineers (NSBE), and contacts provided to us by colleagues at minority institutions. Last year we focused some of our recruiting efforts on womenÆs liberal arts colleges in New England. This year we will expand that list in an effort to broaden our pool of non-research university applicants.

In addition to our efforts we have found NSF to be an excellent clearing house of information that connects prospective students to our program. We have already received several dozen inquiries from students who found out about our site through their own research. We expect over the years that word-of-mouth will help us to expand our applicant pool.

Student-faculty interaction prior to studentÆs arrival on campus
Our greatest shortcoming on the research side last year was that some of the students were not able to 'hit the ground running' when they arrived on campus. Pre-arrival contact between students and advisors was pretty much limited to a few phone calls, e-mails, and mailings of papers and background reading. In some cases this was not enough preparation for the students. The result of this less-than-adequate homework, some of the students were not really up to speed with their project until 3-5 weeks into the program. Obviously in a 9 week program this is unacceptable.

Therefore this year we will increase the level of interaction between students and faculty prior to arrival on campus. Specifically, in addition to technical background discussions we will have advisors become more familiar with the studentÆs motivation, ambition and independence, so that we can better set up a project that suits both the studentÆs goals. In doing a better job of this we hope to get a better response to the question of 'too much' or 'too little structure.' In addition, those students who would be better served by working either alone, or with a partner, can be accommodated.

Other program changes
Seminar on industrial research. We feel last summer that perhaps we had too much emphasis on the academic side of research since all the advisors were university faculty. This year we plan to add a seminar on industrial research to be presented by a representative of either a local wood products, or composite materials company.

Student teams. While there was excellent interaction between REU students and current UMaine graduate and undergraduate students, we would like to more formally integrate the two groups, particularly the undergraduates. We would like to avoid the perception of a two-tiered group, where REU students have a number of activities from which UMaine undergrad research assistants are seemingly excluded. We are currently considering a formal expansion of our REU program to include UMaine undergraduate research assistants working on related research projects. In the case of pairs of students, we are exploring the possibility of pairing each REU student 'from away' with an undergrad from Maine.

Better student-to-faculty ratio. Recent additions to our Advanced Wood Composites group will allow us to improve on the previous ratio of two REU students per faculty. We now have eight faculty participating to support the ten REU students.

Budget Information

A summary of our project budget and expenses is shown in Table 4. As can be seen in the table, expenditures were fairly close to budgeted amounts with the exception of faculty salaries. In many cases faculty did not draw salary for their time spent on the project from the REU account, but rather charged their time to the project on which the student worked. Since basic support for many of the REU projects came from other funding sources, we could avoid paying faculty salaries in some cases.

For the next project year we would like to keep the NSF budget the same, however we will plan to supplement the project more with money from additional funding sources. Specifically, a casual survey of other REU sites showed us that we are on the low end of the range of stipends offered. Our plan for this summer is to increase the amount of the stipend from $3,000 to about $3,500, by charging some of the REU student time to other projects. Although none of our participants indicated that the stipend was inadequate, we believe it may be partially responsible for our four rejected offers.

Findings:

Research Projects

The scope of the research projects varied based on the interests, abilities, and motivation of the students. In all cases the motivation of the students was excellent, and exceeded the expectations of the faculty mentors. Presented below is a brief summary of each research project. As is described, in some projects the students work individually, whereas in others the students worked in small groups.

Wet-Preg Processing and Materials Characterization of FRP-Wood Hybrids (Rebecca Brown and Jane Goodwin).
The objective was to evaluate different types of 'wet-layup' reinforcement schemes for reinforcing both new and existing solid timber construction. This project consisted of three phases: wet preg processing of fiber reinforced polymer (FRP)-wood hybrid, shear strength and

durability of the FRP-wood hybrid, and the physical and mechanical characterization of the FRP reinforcement. In this project a study was conducted to determine the best (within the materials selected) combination of resin, curing agents, and E-glass fabrics to obtain good consolidation at room temperature processing. Specific parameters investigated were resin material, curing agent, and process time.

Shear Tests of FRP Pultruded Beam-to-Column Connection with Clip Angles (Eric Falker and Benjamin Mittlestadt)
The objective of the work was to characterize the experimental response of FRP pultruded beam-column shear connections using clip angles and discuss the design implications. The pultruded sections utilized in the connection tests were reinforced with E-glass rovings and multi-axial stitched fabric in a vinyl-ester resin matrix. A double-cantilever experimental setup was designed by the students and a total of eight connection tests were conducted. Three different variables were studied: torque pressure, diameter of bolt, and use of adhesive bonding. In addition, bearing tests were conducted by the students to evaluate the bearing strength of the clip angles.
The main outcomes of the work conducted by the students are: 1) The characterization of the structural response of FRP pultruded beam-column shear connections with clip angles; 2) The load-slip behavior and mode of failure of bolted and bonded connections under shear loading; 3) The development of a testing procedure for double angle simple framed shear connections; and 5) A discussion on design guidelines for FRP pultruded connections.

Design and Feasibility of OSB Composite Road Panels (Matthew Echard and Jeff Jack)
The focus of this project was the feasibility of constructing temporary roadway panels for construction using oriented strand board (OSB), an engineered wood composite consisting of small wood fragments mixed with resin and pressed into panels. Currently only solid sawn timber is used for this application. The use of reinforced OSB has the potential to significantly lower the cost of temporary roadway panels, by utilizing a much lower grade raw material. In this project the students designed and developed composite wood road panels that have sufficient strength and durability to replace the existing road panels. As a part of the project, a brief cost analysis was conducted. Limitations of the use of OSB panels were also investigated, including directional strength deficiencies and susceptibility to weathering.
The outcome of this work was an initial conclusion that the reinforced FRP panels are a viable alternative to solid sawn timber. The REU project report is currently serving as a basis for further work, (in collaboration with a large Maine construction company and an OSB manufacturer), on commercialization.

New System for Bonding Wood Fibers to Composite Board Products (Dan Yelle)
Typically fibers are bonded using resin adhesives which, as oil-based products, fluctuate in cost with fluctuating petroleum prices. The student worked on a system to 'activate' the lignin, a natural polymer on the surface of wood fibers. The activated lignin permitted the wood fibers to bond together using conventional pressing techniques to produce fiberboard panels.

Chemical Mechanisms of Brown-Rot Fungi (Carissa Tudryn)
This project focused on understanding the basic chemical mechanisms involved in wood degradation by brown-rot fungi. The studentÆs work focussed on a unique redox cycling mechanism that is mediated by low-molecular weight chelators produced by the fungi. She also studied ways that the fungi could be used in waste (metal pollutents) remmediation strategies.

Mechanical Tests for Wood-FRP Bond (Edward Druffner)
This project was aimed at developing standard testing protocols for wood-FRP bond strength. Since existing ASTM wood composite test standards are necessarily appropriate for wood-FRP hybrids, their use often produces misleading results. In this study, different mechanical tests, including direct tension and shear blocks, were used on FRP-wood formulations used in larger scale experiments. The question to be answered here is which of the standard tests is the most discriminating, or is the pest predictor of structural performance.

Microstructural Investigations of Wood-FRP Interface (Lloyd Holzman)
In this project advance microscopy and radiographic techniques were used to characterize the critical interfaces between the wood and the FRP reinforcement. A portion of the experimental work was conducted at the National Synchrotron Light Source at Brookhaven National Laboratory, where high resolution x-ray microtomography was used to investigate the internal structure of the interface. Three dimensional computer analysis and rendering techniques were applied to the data. Based on these analyses, variations in surface preparation and bonding techniques were observed.

Training and Development:

Outreach Activities:

Journal Publications

Lopez-Anido, R., D. J. Gardner, and J. L. Hensley, "Adhesive Bonding of Eastern Hemlock glulam panels with E-glass/vinyl ester reinforcement", Forest Products Journal, p. 43, vol. 50, (2000). Published,

Lopez-Anido, R., D. J. Gardner, and J. L. Hensley, "New methods for bonding wood to E-glass/vinyl ester composites", Adhesives Age, p. 25, vol. Nov., (2000). Published,

Books or Other One-time Publications

S. Shaler, H. Wang, D. Keane, L. Mott, E. Landis, and L. Holzman, "Microtomography of Cellulosic Structures", (1998). Proceedings, Published
Collection: TAPPI Meeting on Product and Process Quality
Bibliography: S. Shaler, H. Wang, D. Keane, L. Mott, E. Landis, and L. Holzman, 'Microtomography of Cellulosic Structures,' in TAPPI Meeting on Product and Process Quality, Milwaukee, WI, 1998.

R. Lopez-Anido, E. Falker, B. Mittelstadt and D. Troutman, "Shear Tests of FRP Pultruded Beam-to-Column Connection with Clip Angles", (1999). proceedings, Accepted
Collection: Proceedings of the 5th ASCE Materials Conference
Bibliography: 5th Construction Materials Congress

Janelle Hensley, Roberto Lopez-Anido and Douglas J. Gardner, "Adhesive Bonding of Wood With Vinyl Ester Resin", (2000). Conference Proceedings, Accepted
Collection: Proceedings of the 2000 Adhesion Society Meeting
Bibliography: Proceedings of the 2000 Adhesion Society Meeting

John Brody, Annette Richard, Kenneth Sebesta, Kenneth Wallace, Yong Hong, Roberto Lopez Anido, William Davids, and Eric Landis, "FRP-Wood-Concrete Composite Bridge Girders", (2000). Conference Proceedings, Published
Collection: Proceedings of the 2000 ASCE Structures Congress
Bibliography: Proceedings of the 2000 ASCE Structures Congress

Web/Internet Site

URL(s):
http://www.umeciv.maine.edu/REU
Description:
Currenty the site is primarily used for program recruitment, however, in the future we plan to use the site to both to track former REU participants, and to present and promote research results from the projects.

Other Specific Products

Contributions

Contributions within Discipline:

Contributions to Other Disciplines:

Contributions to Human Resource Development:

Contributions to Resources for Research and Education:

Contributions Beyond Science and Engineering:

Categories for which nothing is reported:

Organizational Partners
Activities and Findings: Any Training and Development
Activities and Findings: Any Outreach Activities
Any Product
Contributions: To Any within Discipline
Contributions: To Any Other Disciplines
Contributions: To Any Human Resource Development
Contributions: To Any Resources for Research and Education
Contributions: To Any Beyond Science and Engineering

Advanced Engineered Wood Composites

Research Experience for Undergraduates Program

Participant Survey

1. How did you learn about the program?
   a) NSF Web Site
   b) Received information from faculty. (who? __________________)
   c) Received direct e-mail message
   d) Other (please list: __________________________________)

2. Did you apply to other similar summer programs? If so, how many?

3. Was the information you received on travel, housing, and program prior to your trip to Maine adequate?

4. How much did the stipend amount ($3,000) weigh into your decision to accept this position?

1	2	3	4	5
not at all				a lot

5. Was the on-campus housing acceptable? If not what would you suggest we do in future years?

6. Did you like living with the other REU students, or would you have preferred to be on your own?

7. One of the objectives of the program was to put you into a multi-disciplinary research environment. How well do you think this goal was achieved?

1	2	3	4	5
I spent the summer in a cocoon				I was aware of the wide range of activities

8. Do you feel the research you were engaged in was of importance?

1	2	3	4	5
not important				very important

9. Do you think you will continue to correspond with your research group?
   - (a) Other REUs? (y/n)
   - (b) Your advisor (y/n)
   - (c) Other UMaine students, staff, faculty (y/n)

10. Is it likely you will apply to graduate school in science or engineering?

11. How did this REU program affect your decision?

1	2	3	4	5
not at all				very much

11. How might this REU program experience affect your education? (check any that apply).

By integrating your research results into course material
By choosing different courses
By sharing research experiences
By revealing opportunities for future career options
By deepening your enthusiasm and understanding
Will have little or no impact

12. Do you think prospective employers (or graduate admissions officials) will think highly of your participation in this program?

1	2	3	4	5
not at all				very much

13. Did you develop new areas of interest as a result of your interaction with the REU program and/or research colleagues?

1	2	3	4	5
none				many

comments?

14. Do you feel you were adequately challenged by your research project?

1	2	3	4	5
not at all				very challenged

If not what would improve it?

15. Do you think the program gave you a taste of graduate research? (y/n)

comments?

Please rate the following on a scale of 1 to 10. (1 being lowest/worst, 10 being highest/best)

16. Program administration. (e.g. application process, communication, etc…)

1 2 3 4 5 6 7 8 9 10

comments?

17. Planned social activities.

1 2 3 4 5 6 7 8 9 10

comments?

18. Faculty research seminars.

1 2 3 4 5 6 7 8 9 10

comments?

19. Your participation in the AEWC conference in Bar Harbor.

1 2 3 4 5 6 7 8 9 10

comments?

20. The Diversity Awareness Workshop.

1 2 3 4 5 6 7 8 9 10

comments?

21. Individual research presentations.

1 2 3 4 5 6 7 8 9 10

comments?

22. Rate your advisor on the following (1 to 10):

(a) Explained project objectives and relevance ____
(b) Approachability ____
(c) Helpfulness ____
(d) Enthusiasm ____
(e) Knowledge ____
(f) Ability to explain ____
(g) Ability to advise ____

Comments:

23. Your overall evaluation of the program.

1 2 3 4 5 6 7 8 9 10
Sucked Totally Cool

comments?

23. Your overall impression of the AEWC and the University of Maine.

1 2 3 4 5 6 7 8 9 10
Sucked Totally Cool

comments?

24. What are the two most significant changes you would like to see for future summers?


AEWC

Research Experiences for Undergraduates

Annual Report

Data for 1999 – 2000

Principal Investigator: Eric Landis

Award Number: EEC-9732218

STUDENTS	FEMALE	MALE	TOTAL
Black			
Hispanic	2	1	3
Native American			
Disabled			
Other	2	6	8
Senior	1		1
Junior	1	5	6
Sophomore	1	2	3
Freshman	1		1
From Own Institution		2	2
From Other Schools	4	5	9

WWW Page Address: www.umeciv.maine.edu

E-mail Address: landis@maine.edu

Fax Number: 207 581-3888

Phone Number: 207 581-2173

Introduction and Structure of this Report Section

This report section summarizes the REU program in Advanced Engineered Wood Composites conducted at the University of Maine during the nine week period from June 12 through August 11, 2000. In order it describes student recruiting, student activities, follow-up activities, program assessment. The program assessment includes overall comments on three year project.

1. Recruiting

The same recruiting approach used in both 1998 and 1999 was used in 2000. That is, we sent out hundreds of emails to students identified as leaders in certain student organizations. The organizations targeted included the American Society of Civil Engineers, American Society of Mechanical Engineers, American Society of Chemical Engineers, Society of Women Engineers, Society of Black Engineers, and the Forest Products Society. These were in addition to emails sent to faculty known to have an interest related to our fields, as well as faculty and students at a number New England liberal arts colleges.

Applicant Pool

A total of 26 students formally applied to our program. The total number was down from 30 in 1999, but the quality and diversity of the applicant pool was better. The mean grade point average was 3.52. By gender we had 15 women, 11 men. The racial background was 17 white, 2 African American, and 3 Asian American (4 did not report). The ethnicity breakdown was 5 Hispanic and 17 non Hispanic. By college major we had nine chemical engineering majors, three civil and three mechanical engineering majors, 2 materials science, 2 environmental engineering, and one wood products engineering major. The balance included biochemistry, physics, and undeclared.

Geographically our applicants came from all parts of the country. Applicants came from the following universities:

California Polytechnic University
Colorado State University
Columbia University (2)
Cooper Union
Emory University
Grinnell College
Homboldt State University
Louisiana State University
Mercer University (2)
Northwestern University
Rose-Hulmon Institute of Technology
Rutgers University
University of Maine (2)
SUNY Binghamton
SUNY Stony Brook
SUNY College of Environmental Science and Forestry
University of North Carolina Wilmington
University of Puerto Rico
University of Texas Austin
University of Virginia (2)
Virginia Tech

Washington State University	Youngstown State University
West Virginia Wesleyan College	

Our response to initial offers was not quite as good as past years, as five of our initial offers were turned down (most often due to other REU offers either closer to home, closer to their major field of study, or offering higher stipends). Regardless of the high initial rejection rate, we still were able to recruit 11 motivated students. Table 1 presents a list of the student participants.

Table 1. 2000 UMaine AEWC-REU Participants

Student	***Home Institution***	***Major***
Andrea Agudelo Lopez	University of Puerto Rico	Civil Engineering
Josh Botting*	University of Maine	Mechanical Engineering
Lala Espinosa	California Polytechnic University	Materials Engineering
Rangel Gonzales	Humboldt State University	Environ. Resouces Engineering
Jason Mulherin*	University of Maine	Mechanical Engineering
Jerry Ngai	Columbia University	Chemical Engineering
Emily Pressman	Columbia University	Civil Engineering
Greg Ritter	Louisiana State University	Chemical Engineering
Susan Su	SUNY Binghamton	Mechanical Engineering
Scott Tomlinson	Rose-Hulmon Institute of Technology	Civil Engineering
Eric Viskupic	SUNY College of Environ. Science and Forestry	Wood Products Engineering

2. Student Activities

As with previous summers, the students' time was divided primarily between individual or team research projects, organized workshops, field trips, and group social activities. A summary of the summer's activities is shown in Table 2. The activities are very similar to previous summers as they were deemed to be quite successful.

In response to previous comments, we reduced the amount of scheduled activities towards the end of the summer so students would have more time to wrap up their project.

Research Projects

Abstracts of all the projects conducted this past summer are presented at the end of this report section. The abstracts were written by the students for use in this report.

* Students who participated in REU program, but whose stipends were not covered as part of NSF grant.

Table 2. Summary Schedule

2000 AEWC - REU Program, University of Maine

Week	*Research Activities*	*Seminars & Workshops*	*Field Trips and Special Events*
1	• Tour of campus and center research facilities • Advisors to introduce each student to their research topic • Develop Research Plan.	"Introduction to Advanced Engineered Wood Composites" Dr. Habib Dagher "Science, Philosophy and Writing Research Objectives" Dr. Eric Landis	• Monday morning coffee and bagel get acquainted and orientation meeting • Friday afternoon cookout at Acadia National Park
2	↑	Student presentations of Research Plans "Overview of Wood and Wood Composites: Properties and Applications" Dr. Stephen Shaler	Attend Maine Composites Conference w/ side trip to Brunswick Technologies glass fiber plant
3		"FRP Composites in Construction Applications" - Dr. Roberto Lopez-Anido Graduate Schools: Funding, Applications, and Selecting	
4	• Students work on their research project	"Adhesion Issues in Wood-Nonwood Composites" - Dr. Douglas Gardner	Group field trip to Georgia Pacific OSB plant
5	• Submit weekly progress report to advisor	Reports of REU student's "Research in Progress"	Ascent of Mount Katahdin
6		"Decay Mechanisms and Wood Preservatives" Dr. Barry Goodell	
7		Graduate Student Panel (No Faculty Allowed!)	
8	↓		
9	Each student prepares research report and prepares final poster presentation		Thursday night banquet and presentation of research posters

3. Project Assessment

As with last year, our project assessment consisted of two parts: A quantitative measure of certain benchmarks, and student questionnaire for more qualitative measures of program effectiveness.

Quantitative Measures

We made quantitative measures of our 2000 class in the following areas:

Publicity and Recruitment:

- number on inquiries - 58 (3 yr total: 154)
- number of applicants – 26 (3 yr total: 76)
- number of women and minorities applied – 17 (3 yr total: 41)
- number of women and minorities accepting offers – 5 (3 yr total: 13)
- number of offers turned down – 5 (2 yr total: 13)

Student interest in research:

- number of students who continue research project beyond nine week program – 1 (2 yr total: 4)
- number of students who apply to graduate science or engineering programs – 2 to date (2 yr total: 11)
- number of students who enroll in graduate science or engineering programs – 0 to date (2 yr total: 8 to date)

Scientific quality:

- number of refereed journal publications: 0 to date (3 yr total: 2)
- number of internal or external published reports – 2 (3 yr. Total 7)
- number of conference and other publications resulting from program (in order to qualify, student must be co-author) – 2 (2 yr total: 6)
- external research support that results from pilot studies conducted under REU program – 1 pending.

As with previous years, the scientific quality has been quite mixed, ranging from outstanding (likely publishable in refereed journal) to fair. Again, the key seems to be to match the students up with a project that excites them and motivates them to do good work. While each year gives us more experience in gauging student interests and abilities, we still do not have a perfect system. While we design each project to produce publishable results in the nine week period, to date only two projects have produced publishable results. Both are currently in preparation.

Participant Survey

A 22 question survey was given to the students at the end of the summer to give us feedback on students' opinions of the program. A copy of the survey is included at the end of this section.

We found the students to be overall fairly happy with the program. (mean response to question 20 – “Your overall evaluation of the program” – was 8.7 on a 10 point scale). The survey gave us lots of feedback on housing (most want as cheap as possible), the most valuable activities (field trips), least valuable activities (faculty research seminars), and general administration.

Comments were also very encouraging:

- “I learned more this summer than I ever have before.”
- “Very valuable experience.”
- “A very interesting, enjoyable, educational experience for me. I’d do it again. I’m soooo glad I chose Maine. Learning has never been this much fun.”
- “I really appreciated the freedom I had with my project. It will be greater challenge to get it published!”

We are quite confident of our ability to provide a polished program for our students based a combination of our growing research facilities and our experienced faculty. We hope to continue the program in the future.

Three Year Outcome on Graduate School Attendance

As one measure of program effectiveness, we tracked the progress of our program alumni over the three-year life of the program. As many of the students are still completing their undergraduate degrees, our data set is not complete. However, of the 17 program alumni who have completed their undergraduate degree, 8 are known to be enrolled in graduate science or engineering programs (5 M.S., and 2 Ph.D.) We believe, based on experience with our own undergraduates, that the thriving economy and high salaries are luring students directly to industry. Two of the alumni currently in industry have indicated an interest in pursuing a graduate degree at some time in the future.

While we have indicated in the past that it is difficult to gage the impact that the program had on the students’ decisions regarding graduate school (for many students, an existing interest in research led them to our program), based on student comments, we believe the students had a realistic taste of graduate research. Their decisions will be informed ones.

A summary of alumni and their current positions is presented in Table 3.

Table 3. "Where are they Now?…

Three Year Summary of AEWC-REU Alumni

Student	REU Class	Current Position
Andrea Agudelo Lopez	2000	Finishing Undergrad Degree
Josh Botting	2000	Finishing Undergrad Degree
Lala Espinosa	2000	Finishing Undergrad Degree
Rangel Gonzales	2000	Finishing Undergrad Degree
Jason Mulherin	2000	Finishing Undergrad Degree
Jerry Ngai	2000	Finishing Undergrad Degree
Emily Pressman	2000	Finishing Undergrad Degree
Greg Ritter	2000	Finishing Undergrad Degree
Susan Su	2000	Finishing Undergrad Degree, Applying to Grad School
Scott Tomlinson	2000	Finishing Undergrad Degree
Eric Viskupic	2000	Finishing Undergrad Degree, Applying to Grad School
John Brody	1999	Finishing Undergrad Degree
Janelle Hensley	1999	Pursuing M.S. - Wood Products, Univ. of Calif. Berkeley
Sonja Heuscher	1999	Finishing Undergrad Degree
Judy Johnson	1999	Pursuing M.S. - Civil Engineering, Georgia Tech
Jennifer Morris	1999	Pursuing M.S. - Civil Engineering, West Virginia Univ.
Kyle Petrocine	1999	whereabouts unknown
Annette Richard	1999	whereabouts unknown
Kenneth Sebesta	1999	Finishing Undergrad Degree, Applying to Grad School
Kenneth Wallace	1999	Applying to Graduate schools
Andrew Watkins	1999	Pursuing M.S. - Materials Science, Univ. of Colorado Boulder
Rebecca Brown	1998	Pursuing PhD - Mechanical Engineering, M.I.T.
Edward Druffner	1998	whereabouts unknown
Matthew Echard	1998	Pursuing M.S. - Mechanical Engineering, M.I.T.
Eric Falker	1998	Educational Fellowship - Germany
Jane Goodwin	1998	Working for Engineering Firm
Lloyd Holzman	1998	Working for Computer Consultant
Jeff Jack	1998	Working for Engineering Firm
Benjamin Mittelstadt	1998	whereabouts unknown
Carissa Tudryn	1998	Pursuing PhD - Mechanical Engineering, M.I.T.
Daniel Yelle	1998	Pursuing M.S. - Wood Science, Univ. of Maine

Budget Information

The three-year project came in over budget because of our decision to increase the stipend we offered the students from $3000 to about $3500 for the nine-week period. We made up the difference by using money budgeted for faculty salaries to students, and by charging two of the eleven student stipends to other funded projects on which the students worked. We felt the increase was necessary to compete with the many other options the students have.

Abstracts

Summer 2000 AEWC, REU Program

Composite Bridge Deck Design

Andrea M. Agudelo, University of Puerto Rico, Mayagüez Campus;
Professor Habib J. Dagher, Advisor

Abstract

Our research is based on a composite bridge deck that is durable, strong and affordable. Timber bridges are economical, but for long spans it does not have an adequate stiffness. The design of wood bridges are controlled by deflection rather than the strength and this is due to the fact that wood has a relatively low modulus of elasticity.

The combination of wood and concrete on a bridge deck replace the concrete and rebars by solid wood deck that acts as a structural component on the bridge and also as form work. The wood has to be removed from the bridge after the concrete hardens when its presence increase the strength of the bridge and reduces the quantity of concrete. The increase of stiffness due to concrete and ductility provided by the Fiber Reinforced Polymer (FRP) reinforcement is significant.

Deck panels are designed as individual Glulam beams with rectangular cross section and also designed for the maximum forces and deflection produced by the design vehicle (HS25-44) that weights 90 kips, assuming that the wheel load acts as point load in the direction of the deck span. The deck was designed for a bridge with one traffic lane and the neutral axis occurring at the interface of wood and concrete. This indicates that the concrete will be in compression and the glulam deck will be in tension. This reduces the risk of cracking in the concrete produced by tension forces. The design was assumed to be a shored construction; this means that the weight of concrete is completely supported by the shoring under the glulam deck, rather than the deck itself.

The section consists of 32 glued-laminated pieces of 2 x 6's of local specie of wood (Spruce) reinforced with five (5) layers of FRP on the tension face (bottom) and a concrete slab on top. Just 2% of FRP is applied in this deck design to increase the ductility and the strength of wood. Each deck is four (4) feet wide by twenty (20) feet long and the pieces run parallel to traffic direction. The concrete and the glulam are connected with steel bars to avoid slip at the interface; making this two materials act as one composite deck. This connection has to be strong to support the shear forces developed at the interface on the entire panel and three (3) specimens were made to test the shear strength in the connector.

The test setup for the three decks will be according to ASTM D198-97 Standard Test Methods of Static Tests of Lumber in Structural Sizes (1997). The decks will be tested in three point bending until a complete failure is achieve.

At this day, the research is not completed. The three decks and the three specimens for the shear test are constructed, but with the lack of time in my schedule I cannot run the test before I leave. The next step is to test the shear strength in the connector and to apply the static and fatigue test in the decks. According to the design values, the predictions for the failure mode are close to shear and compression due to bending in concrete and also tension due to bending in wood.

SHEAR PROPERTIES OF ELASTOMER-SOIL INTTERFACES

ABSTRACT

Cyclocross racing is a sport that is rapidly increasing in popularity. The sport is extremely competitive and due to the nature of the courses weight is a critical factor in performance. In these bikes weight is minimized. In particular, rotating weights such as tires and rims are targeted for weight reduction. However due to racing surface, traction is also limited. Traction also needs to be maximized. The goal then is to balance maximized traction with minimized weight. This could potentially help riders to choose tires that best suit their needs. An apparatus has been designed to test the traction characteristics of cyclocross tires. Tires can slip in a combination of 2 ways, slipping due to sliding without rotation, or due to work input at the hub. This apparatus is capable of testing both. The apparatus consists of a bike frame mounted at the front dropout on a carriage which slides freely on bearings. For sliding without rotation test a constant force is applied to the carriage with the brakes locked, until the tire slips. For the case where work is input at the hub, the force is applied to the crank rather than to the carriage, and the carriage position is locked. There are two experimental variables, the tire and the force applied. The soil characteristics are held constant with the same constant, water content, density, and compaction. The soil will be characterized using gradation, and Atterburg limits. The testing procedure is also applicable to work boot testing. The setup allows boot designs, as well as soils to be tested. The apparatus is also designed to be mobile to allow it to test any soil on site.

Josh Botting
University of Maine
Mechanical Engineering
REU Program, Summer 2000
Advised by Mick Peterson

Wilhelmina Lala Espinosa
REU Student from California Polytechnic University, Pomona, CA
NSF-REU Summer 2000
University Of Maine
Orono, ME
Advisor: Professor Michael Peterson

PROJECT ABSTRACT

Eighty-one Ponderosa pine logs from the north rim at the Grand Canyon were broken in a three-point bend configuration. An 8-foot span was used between support points to determine the strength of small diameter timber in flexure. The load at failure was recorded as well as the time taken to break the logs. The broken logs were cut in three sections. The middle section was saved for cube harvesting. 1 _" thick disks were cut from each end of the middle section, just beyond the break. From these disks, 1" cubes were harvested from the juvenile and mature portions of the log. It is assumed that the first 20 rings from the center of the disk is juvenile wood or heartwood. The outer portion of the disk is mature wood or sapwood.

Each cube was then tested ultrasonically. The ultrasonic testing apparatus is composed of a square wave pulser, which excites an ultrasonic transducer. The transducer generates an elastic pulse that propagates through the wood cube sample. The ultrasonic transducer is then excited by the received signal and is converted to a small voltage. The signal from the piezoelectric ultrasonic transducer is sent to an ultrasonic preamplifier that is in turn connected to a digital oscilloscope, which displays the data as a wave.

The ultrasonic wave velocities of juvenile wood compared to mature wood in the longitudinal and tangential directions were different, whereas those in the radial direction were approximately the same.

J. Rangel Gonzales

ABSTRACT

In the near future, our world will be faced with a dilemma. As the world's population grows our natural resources will be threatened. The integrity of our natural environment must be protected. This report is a brief analysis of some of the contributing aspects that define the use of resources including mentalities of different sectors of the economic system. Sustainable development is an evolving but important topic that is also discussed. Possible solutions to future demand for materials are recommended. The analysis of many different building materials in regards to sustainable construction are addressed.

ABSTRACT

ULTRASONIC WAVE PROPAGATION IN THIN FILM MEMBRANES

Jason Mulherin

The purpose of this project is to develop a test system that may be used for monitoring of membrane filters. The tests will allow further development of existing systems to allow them to run more efficiently. System monitorind includes using the filter in all of its normal operating states.These conditions of filter operation would be; fouled(clogged), clean, and defective. The ultrasonic data is to be taken on a test set up running in steady state conditions or in normal operating conditions. Normal operating conditions include a minimum pressure of 70 psi and a flow of around 25 gpm supplied to the filter. Ultrasonic monitoring will be correlated to pressure drop across the filter . Pressures and flow rates will also be monitored to ensure the test is performed at steady state conditions.Longer term objectives include correlating the operational variables to models of the ultrasonic waves.

Jerry Ngai
Research Abstract

Gloeophyllum trabeum was cultured, then grown in sterile soil block chambers containing 12 spruce blocks. The blocks were decayed for various lengths of time (from zero to twelve weeks) and then subjected to dry-coupled transmission ultrasound. The decayed blocks were then conditioned to 12% moisture content and then dried completely to determine the effects of moisture content on the ultrasound readings. Time delay, the time it takes a wave to travel through a sample, was used to determine degrees of decay; longer time delays were hypothesized to indicate greater fungal biodegradation of wood by altering the crystalline structure of cellulose present in wood cells. Results revealed that ultrasound reliably detected decay from the four-week mark on. Yet upon correlation with weight loss tests, the ultrasound was found to detect decay only after considerable damage to the wood microstructure had occurred, lowering the weights of decayed samples and causing browning of the wood. Moisture content did not have much effect on the waveform, except at extremely dry levels. Ongoing research, including use of more fungi species, a larger sample set, and analysis of more wave parameters, may prove beneficial in more precisely and accurately indicating wood decay at earlier stages.

Creep of Wood at High Stress Levels

Emily Pressman and Susan Su
William Davids and Eric Landis, Advisors

Creep, or time-dependent deformation under a constant load, is an important element of structural engineering. With the development of fiber-reinforced wood composites, creep is becoming more significant in the design of wood structures. Compression becomes the major determining factor in FRP's because the wood is strengthened by fibers with extremely high tensile strength. Until now, extensive research has been done studying the creep of wood in bending. We are examining a new form of creep, that of wood in compression under heavy loads. We have developed a model to predict the creep behavior of wood as a function of time and have performed tests to compare with our model. By using small clear-grain specimens of wood we can more easily control the moisture and temperature of the test samples. We hope to eventually repeat these tests with varying conditions of temperature and moisture in order to study the effects of different atmospheres on wood creep.

Greg Ritter
REU 2000
Louisiana State University
Douglas Gardner, Advisor

Determination of Aldehydes and Ketones from Hot-Press Southern Pine Particleboard with 2,4-Dinitrophenylhydrazine

In order to optimize time and personal usage, low molecular weight (LMW) carbonyl compounds were detected using a GC/MS with the 2,4-Dinitrophenylhydrazine (DNPH) method instead of previous HPLC methods. At first, Standard curves needed to be determined for the following LMW carbonyl compounds: acetaldehyde, acetone, acrolien, 2-butanone, butyraldehyde, formaldehyde, and propionaldehyde. Next, known mixtures of the previous compounds will be compared to the results of the standard curves. Finally, these results will be used to determine the effect of change in time, temperature, and density in the hot pressing of Southern Yellow Pine Particleboard. The DNPH method first requires that the sample react with the 2,4-DNPH in 1M HCl for a period of at least an hour; the resulting solution is reacted with Methylene Chloride for at least an hour. The organic layer is than extracted and run in the GC/MS to determine the concentration. While standard curves were determined for all seven compounds, acetone, acrolein, and propionaldehyde could not be distinguished among each other since they have similar chemical structures. Overall, as time increased the amount of carbonyls emitted also increased. However, as density increased only formaldehyde increased while the others decreased; this could be the result of a denser board allowing only the smallest compounds to escape while the others remain in the board. This also was true for the effect of temperature change as only formaldehyde slightly increased while the others decreased. Further study would provide more insight into this effect

Technical Report Abstract – REU – NSF Summer 2000

Fatigue Response of FRP Bridge Decks under Extreme Temperature Conditions: Statistical Analysis

Student: Scott Tomlinson[1]

Advisor: Roberto Lopez-Anido[2]

This report presents information about the load-deflection ratios in the longitudinal (X) direction and change in slope-angle in the transverse (Y) direction for fiber reinforced polymer (FRP) bridge decks over steel W-section girders. Included in this report is information about five deck systems being studied (3 FRP decks, 1 FRP-concrete deck, and 1 reinforced concrete baseline deck). Degradation characteristics with load cycles and temperature changes are studied and analyzed. X-direction analysis uses data on maximum support-corrected-deflection versus applied-load ratios. Y-direction calculations use data on non-support-corrected-deflections. These deflections are divided into linear segments for each deck section and the difference in slope is computed and used for further analysis. Analysis of both X and Y direction data was done with one-way analysis of variance and pair-wise t-tests. These tests determined levels of significance for data on each deck. Overall the X-direction tests went well with very small variances, and can be used to meaningfully predict deflections under given loads. The Y-direction analysis however proved less useful due to large variances, incorporation of many variables in one number, joint degradation, and support degradation. The FRP decks behaved fundamentally different from reinforced concrete in the y-direction and degraded due to different factors in the x-direction.

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[1] ASCE Student Member, Rose-Hulman Institute of Technology, Terre Haute, IN.

[2] ASCE Member, Department of Civil and Environmental Engineering, Advanced Engineered Wood Composites Center, University of Maine, Orono, ME.

Eric Viskupic
NSF-REU Program 2000
University of Maine - AEWC

Abstract:

Development of new technologies to analyze wood and wood products may lead to discoveries to new applications of wood, better utilization for current applications, and an overall more efficient use of our resources. One such technology is the use of fluorescence to examine wood products. Red maple and PRF resin film samples were imaged using a laser scanning confocal microscope (LSCM) by way of visual light spectrum laser excited fluorescence microscopy. Emission spectra were obtained from the images and were analyzed. It was found that the smallest frequency range (6nm) allowed by the equipment for detecting emissions was needed to produce an acceptable resolution of the emission spectra. By collecting data with this resolution, there were noticeable differences between the emission spectra of the maple and the PRF. Both the maximum intensity and the skewness of the emission spectra of the maple versus the PRF make them distinguishable using fluorescence.

Advanced Engineered Wood Composites

2000 Research Experience for Undergraduates Program

Participant Survey

1. How did you learn about the program?
   a) NSF Web Site
   b) Received information from faculty. (who? __________________)
   c) Received direct e-mail message
   d) Other (please list: __________________________________)

2. Did you apply to other similar summer programs? If so, how many?

3. Was the information you received on travel, housing, and program prior to your trip to Maine adequate?

4. How much did the stipend amount ($3,000) weigh into your decision to accept this position?

1	2	3	4	5
not at all				a lot

5. Was the fraternity housing acceptable? If not what would you suggest we do in future years? Would you pay more money (or receive a smaller stipend) in exchange for a nicer apartment?

6. Did you like living with the other REU students, or would you have preferred to be on your own?

7. One of the objectives of the program was to put you into a multi-disciplinary research environment. How well do you think this goal was achieved?

1	2	3	4	5
I spent the summer in a cocoon				I was aware of the wide range of activities

8. Do you feel the research you were engaged in was of importance?

1	2	3	4	5
not important				very important

9. Do you think you will continue to correspond with your research group?
   (a) Other REUs? (y/n)
   (b) Your advisor (y/n)
   (c) Other UMaine students, staff, faculty (y/n)

10. Is it likely you will apply to graduate school in science or engineering?

11. How do you think this REU program will affect your decision?

1	2	3	4	5
not at all				very much

11. How might this REU program experience affect your education? (check any that apply).
   ❒ By integrating your research results into course material
   ❒ By choosing different courses
   ❒ By sharing research experiences
   ❒ By revealing opportunities for future career options
   ❒ By deepening your enthusiasm and understanding
   ❒ Will have little or no impact

12. Do you think prospective employers (or graduate admissions officials) will think highly of your participation in this program?

1	2	3	4	5
not at all				very much

13. Did you develop new areas of interest as a result of your interaction with the REU program and/or research colleagues?

1	2	3	4	5
none				many

comments?

14. Do you feel you were adequately challenged by your research project?

1	2	3	4	5
not at all				very challenged

If not what would improve it?

15. Do you think the program gave you a taste of graduate research? (y/n)

comments?

Please rate the following on a scale of 1 to 10. (1 being lowest/worst, 10 being highest/best)

16. Program administration. (e.g. application process, communication, etc…)

1 2 3 4 5 6 7 8 9 10

comments?

17. Organized social activities.

1 2 3 4 5 6 7 8 9 10

comments?

18. Faculty seminars.

1 2 3 4 5 6 7 8 9 10

comments?

19. Rate your advisor on the following (1 to 10):

(a) Explained project objectives and relevance ____
(b) Approachability ____
(c) Helpfulness ____
(d) Enthusiasm ____
(e) Knowledge ____
(f) Ability to explain ____
(g) Ability to advise ____

Comments:

20. Your overall evaluation of the program.

1 2 3 4 5 6 7 8 9 10
Sucked Totally Cool

comments?

21. Your overall impression of the AEWC and the University of Maine.

1 2 3 4 5 6 7 8 9 10
Sucked Totally Cool

comments?

22. What are the three most significant changes you would make to improve the experience for future students?

Annual NSF Grant Progress Report

Grant No: EEC-9732218

Title: Research Experience for Undergraduates in Advanced Engineered Wood Composites

PI: Eric N. Landis and Habib Dagher, University of Maine

REU PROJECT SUMMARY FORM

NSF RESEARCH EXPERIENCES FOR UNDERGRADUATES PROGRAM

Type all entries.

1. Major Field: Civil Engineering
2. Highest Degree Code: D
3. Subfields: structures, mechanics, materials
4. Focus Code: UP
5. Audience Code(s): W M D
6. Scope Code N
7. Type of Project: SI
8. Name of Institution: University of Maine
9. Inst. Code: PUBL
10. Name of Principal Investigator: Eric N. Landis
    PI Tel. No.: (207) 581-2173 PI e-mail address: landis@maine.edu
    REU Web Site Address: http://www.umeciv.maine.edu/REU/
11. Name of Student Recruitment Point of Contact: Eric N. Landis
    SRPOC Tel. No.: (207) 581-2173 SRPOC e-mail address: landis@maine.edu
12. Project Title: Undergraduate Research Experience in Advanced Engineered Wood Composites
13. Number of Students Involved: 10
14. Activity Period: B; if S or B, No. of summer weeks on site: 9
15. Other Institutions Involved: None
16. Summary of Work:

The focus of this REU site was interdisciplinary research aimed at the development of the next generation of engineered wood composites for construction. The disciplines involved included structural engineering, mechanics, composite materials, wood science, wood chemistry, and biology. We recruited ten students from all parts of the country to work on individual projects all with a common theme of wood composites science and engineering. Projects included wood-FRP-concrete girders for bridges, FRP-wood adhesion issues, free radical generation by wood degrading fungi, laboratory instrumentation, and wood fracture mechanics. These projects were integrated into a general program that included seminars on research activities, workshops on professional development, field trips to various manufacturing and industrial research facilities, and numerous social programs. Student research programs were designed to produce publishable results in the nine-week program period. To date, four of the ten students are authors or co-authors on resulting research publications.

Introduction and Structure of this Report

This progress report summarizes the REU program in Advanced Engineered Wood Composites conducted at the University of Maine during the nine week period from June 13 through August 14, 1999. In order it describes student recruiting, student activities, follow-up activities, program assessment, and changes for the 2000 program. A budget report is provided at the end.

Recruiting

Approach

As with 1998 we focused our recruiting efforts on an internet-based strategy. We prepared electronic versions of our promotional information and our student application. We then conducted a “shotgun” e-mailing to both selected faculty and student organizations. Specifically, we identified about 200 faculty contacts who we knew would distribute our informational material to interested students. These faculty were primarily in fields of civil and mechanical engineering, wood science, and wood technology programs at national universities, including several minority institutions. In addition we identified approximately 20 New England liberal arts colleges, (including all women’s colleges). At these schools we contacted science (physics, chemistry, biology, math and computer science) faculty to whom we sent our materials.

In addition to the faculty contacts we combed the web for contacts in student chapters of professional societies. These societies included the American Society of Civil Engineers, American Society of Mechanical Engineers, Society of Women Engineers, Society of Black Engineers, and the Forest Products Society. We sent our materials to as many student contacts as we could find published on the web. Our thinking was that if possible it is best to get the information directly into the hands of those who can most benefit.

Applicant Pool

A total of 30 students formally applied to our program. We were quite pleased with the overall quality of applicants (average GPA of 3.33). By gender we had 14 women. By race we had one of Asian descent and two African. There was one of Hispanic decent. By college major we had eight civil engineering, three in composite materials engineering, two in mechanical engineering, chemical engineering, computer science, and wood science. The remainder were enrolled in an array of science and engineering programs.

Geographically our applicants came from all parts of the country. Applicants came from the following universities:

- Alfred University
- Angelo State University
- Bradley University
- Catholic University of America
- Colorado School of Mines (2)
- Georgia Institute of Technology
- Michigan State University
- Michigan Technological Institute
- Milwaukee School of Engineering (2)
- Mount Holyoke College (2)
- Ohio State University
- Oregon State University (2)
- Polytechnic University of Porte Rico.
- Rice University
- Rowan University (2)
- Rutgers University
- Southeastern Oklahoma State Univ.
- Tufts University
- University of Kentucky
- University of Michigan
- University of South Carolina
- West Virginia Wesleyan College
- Winona State University (3)

In this list we note that we achieved one of our goals following our 1998 program. In that year students from research universities dominated our applicant pool. A goal for our1999 recruiting effort was to reach applicants from non-research universities as well. As can be seen from the list, we had a wide variety of institution types represented. For the 2000 recruiting effort we would like to attract even more applicants from four-year liberal arts colleges.

In selecting the students for our program we looked at a combination of academic achievement (evaluated through grades, activities, and recommendations) and mutual interests with participating faculty (evaluated through their required statement of interest). We had little trouble matching students to faculty, and we were successful in attracting eight out of our initial list of ten top choices. Three offers were turned down. So overall we were quite please with our yield.

Table 1 presents a list of the student participants. The demographic characteristics of the students participating in the program are shown in Table 2.

Table 1. 1998 UMaine AEWC-REU Participants

Student	University	Major
John Brody	Winona State University	Composite Materials Engineering
Janelle Hensley	Milwaukee School of Engineering	Architectural Engineering
Sonja Heuscher	Colorado School of Mines	Chemistry
Judy Johnson	Georgia Institute of Technology	Civil Engineering
Jennifer Morris	West Virginia Wesleyan College	Engineering Physics and Math
Kyle Petrocine	Oregon State University	Chemical Engineering
Annette Richard	Alfred University	Ceramic Engineering
Kenneth Sebesta	University of Kentucky	Math and Mechanical Engineering
Kenneth Wallace	Rowan University	Civil Engineering
Andrew Watkins	Colorado School of Mines	Metallurgical and Materials Engineering

Table 2. Demographic Characteristics of Students in Program

Principal Investigator: ***Eric N. Landis***

Award Number: ***EEC-9732218***

Students:	***Female***	***Male***	***Total***
Race:			
American Indian or Alaska Native			
Asian			
Black or African American	*1*		*1*
Native Hawaiian or Other Pacific Islander			
White	*4*	*5*	*9*
Ethnicity:			
Hispanic or Latino			
Not Hispanic or Latino	*5*	*5*	*10*
Disability Status:			
Hearing Impairment			
Visual Impairment			
Mobility/Orthopedic Impairment			
Other			
None	*5*	*5*	*10*
Classification:			
Senior	*1*	*1*	*2*
Junior	*3*	*4*	*7*
Sophomore	*1*		*1*
Freshman			
Citizenship:			
U.S. Citizen	*5*	*5*	*10*
Permanent Resident			
Other non-U.S. Citizen			
Choice:			
From own institution			
From other schools	*5*	*5*	*10*

Student Activities

We tried in all our activities to strike a balance between structure and independence, group and individual learning, and educational and social activities. A summary of the various activities is shown in Table 3. The program was structured so that all ten students would be part of a single team working toward a common goal. Although individual research projects were quite different, at the end of the nine weeks, there could be no doubt about their shared goal.

Table 3. Schedule1998 AEWC/NSF REU Program, University of Maine

Week	***Research Activities***	***Seminars***	***Field Trips and Special Events***
1 6/14-6/19	• Tour of campus and departmental research facilities • Advisors to introduce each student to their research topic • Develop Research Plan.	"Introduction to Advanced Engineered Wood Composites" Dr. Stephen Shaler "Science, Philosophy and Research Objectives" – Dr. Eric Landis	• Monday morning coffee and bagel get –acquainted/ orientation meeting • Friday afternoon cookout at Acadia National Park
2 6/21-6/26	↑	"Bridges to the 21st Century" - Dr. Habib Dagher Student presentations of Research Plans	
3 6/28-7/3	• Students work on their research project	"FRP Composites in Construction Applications" - Dr. Roberto Lopez-Anido "Adhesion Issues in Wood-Nonwood Composites" - Dr. Douglas Gardner	Field trip to Brunswick Technologies
4 7/5-7/10	• Submit weekly progress report to advisor		1st International Conference on Advanced Engineered Wood Composites, Bar Harbor, ME.
5 7/12-7/17		"Decay Mechanisms and Wood Preservatives" Dr. Barry Goodell	Ascent of Mt. Katahdin (optional)
6 7/19-7/24		Reports of REU student's "Research in Progress"	
7 7/26-7/31		"Workshop on Diversity Issues in Science and Engineering Careers" Prof. Karen Horton and Penalists	
8 8/2-8/7	↓	Graduate Student Panel (No Faculty Allowed!)	
9 8/9-8/13	Each student writes research report and prepares final poster presentation		Thursday night banquet and presentation of research posters

Research Projects

The scope of the research projects varied based on the interests, abilities, and motivation of the students. In all cases the motivation of the students was excellent, and exceeded the expectations of the faculty mentors. Presented below is a brief summary of each research project. As is described, in some projects the students work individually, whereas in others the students worked in small groups.

<u>Adesion Issues in Engineered Wood-Nonwood Composites</u>
REU Researchers: Jennifer Morris and Kyle Petrocine; Advisor: Douglas Gardner

Kyle examined the effect of adding urea and hydrogen peroxide as an additive in particleboard furnish in an effort to reduce volatile organic compound emissions from the hot-pressing process. Laboratory particleboards were manufactured using 3% phenol-formaldehyde resin and southern pine particle furnish. The 12” x 12”x 0.75” panels had a target density 42 lbs/ft3. Boards were pressed at a temperature of 375 F for five minutes. Hydrogen peroxide (50%) or urea was added to the panel furnish at 0.5, 1, 1.5, and 2% based on the oven dry weight of the wood furnish. The VOCs arising during the hot-pressing process were collected from an enclosed caul plate system via vacuum through a collection train containing two impingers. One impinger contained chilled water and the second impinger in series contained chilled methylene chloride. The emissions collected from each press run were concentrated and examined for formaldehyde using spectroscopic analysis and other VOCs emitted were identified and quantified using gas chromatography-mass spectrometry (GC/MS). The addition of the additives to the particleboard furnish reduced the amount of formaldehyde being emitted from the panels as the amount of additive was increased. It was not possible to determine the effect of the additive on the total VOCs measured by GC/MS because of the complexity of the myriad compounds identified and quantified by the analysis. It was determined that the addition of urea to particleboard furnish shows good potential for reducing formaldehyde emissions from the hot-pressing process.

Kyle’s work was helpful to the overall research effort on the study of VOC emissions from wood composite hot-pressing being done at U Maine. Kyle participated in work on VOC emissions from particleboard pressing for both southern pine and mixed hardwood furnish and also on oriented strandboard furnish.

Jennifer examined the oxidation and sizing of carbon fibers for compatibilization with phenol-formaldehyde resins. Various oxidation treatments using different ratios of NaOCl and sulfuric acid were evaluated, and several organotitanate and organozirconate sizings that are used to size aramid fibers for phenolic resins were examined. The effect of oxidation and sizing on the carbon fibers was monitored by measuring water contact angles on single carbon fibers using dynamic contact angle analysis. The results appear to be very promising since the oxidation and sizing treatments promoted improved wettability of the carbon fibers.

Results of Jennifer's work were used as preliminary data in support of a proposal submission to NSF in November on "Optimizing carbon-phenolic resin (FRP)-wood hybrid composite materials" which was submitted to Solid State Chemistry and Polymers research area.

Wood Decay and Degredation Issues

REU Researcher: Sonja Heuscher; Advisor: Barry Goodell

Sonja worked on two projects. The first was to examine a chemical mechanism employed by wood degrading fungi to generate free radicals. The fungi direct these radicals in the depolymerization of cellulose and lignin in the wood cell wall and thus prepare the cell wall constituents for further breakdown. She used dihydroxybenzoic acid (DHBA) as a model compound to mimic the catechols and quinones produced by the fungi in the decay process and examined the role of these compounds in binding and reducing iron in environments similar to those produced by the fungi in wood. We initially hypothesized that the mechanism involved redox cycling in an oxygenated environment. The DHBA repeatedly cycles to reduce iron, and the ferrous state of iron is involved in fenton chemistry reactions to produce the free radicals. Sonja's was trained and used GC-MS to examine some of the breakdown products of the reaction. Although preliminary, her inititial findings suggest that breakdown of the DHBA may contribute more to the apparent cyclic reduction of iron, and that the breakdown products of the reaction need to be explored in greater depth to determine their role in the mechanism.

Her second project related to the remediation of metal in aqueous solution by wood decay fungi. In this work she used a brown rot, and a white rot fungus to examine the role of decay fungi in sequestering chromium from solutions. The two fungi displayed limited effectiveness in taking up the metal under the conditions employed in her tests. Sonja was trained in the preparation of samples for ICP, and this technique was used for the analysis of the chromium.

Mode II Fracture Testing of Clear Grained Specimens

REU Researcher: Judy Johnson; Advisor: Eric Landis

Mode II (forward shear or "sliding" mode) was studied experimentally to measure critical values for the strain energy release rate (G_{IIC}) and stress intensity factor (K_{IIC}). Four tests were considered in determining which method(s) gives the most stable values for G_{IIC} and K_{IIC} and which methods yield comparative results. Three tests considered, each with a concentrated load in compression, are a single-edge-notched beam, center-slit beam, and tapered-end-notched flexural beam. The fourth test, uniformly loaded in tension, was a double-edge-notched specimen. Excellent agreement was shown between the single-edge-notched beam and the center-slit beam tests for K_{IIC} and between the center-slit beam and tapered-end-notched flexural beam tests for G_{IIC}. The single-edge-notched beam, center-slit beam, and tapered-end-notched flexural beam can be shown to be fairly consistent. The wood species used for these experiments was Eastern Hemlock.

The results for this work are being used in an ongoing investigation of fracture and damage mechanics approaches to predicting failure in northeastern wood species.

<u>Instrumentation and Data Collection for Automated W</u>

REU Researcher: Andrew Watkins; Advisor: Stephen Shaler

A test apparatus was developed to measure relative humidity, temperature, and sample weight in order to calculate diffusion coefficients for wood (as well as FRP and other materials). Changes in moisture content cause wood to expand and contract. This process is very significant in structural applications such as building frames and bridges, as small variations in dimensions can lead to structural damage and even catastrophic failure. The diffusion of water through the wood plays a crucial role in this process. By calculating diffusion coefficients, one can better model and thus better understand this behavior. The system was built around a LabVIEW program that controlled and collected data from an RH sensor, a load cell and a thermocouple.

<u>Adhesive Bonding of Wood with Vinyl Ester Resin</u>

REU Researcher: Janelle Hensley; Advisor: Roberto Lopez-Anido

The development of novel hybrid wood-fiber reinforced polymer (FRP) composites requires the study of resin matrices not commonly associated with wood adhesive bonding. Vinyl ester resin systems are used extensively in the production of FRP composite materials. We are currently examining vinyl ester resin as a matrix material for combining glass fibers with wood in hybrid composite systems. In this study, we examined the adhesive shear strength of vinyl ester resin bonded wood, and compared this to phenol-resorcinol-formaldehyde bonded wood using a modified ASTM D 905 Compression Shear Test and a cyclic delamination test. A hydroxymethyl resorcinol (HMR) primer was also examined as a means to improve vinyl ester bonding with wood. Testing specimens were tested dry, and wet after and accelerated aging exposure. Results indicate that vinyl ester resin can form strong and exterior durable adhesive bonds with wood.

This work will be presented at the upcoming meeting of the Adhesion Society.

Development of an FRP-Reinforced Wood-Concrete Composite Bridge Girder
REU Researchers: John Brody, Annette Richard, Kenneth Sebesta, and Kenneth Wallace; Advisors: William Davids, Eric Landis, and Roberto Lopez-Anido

The objective of this work was to obtain preliminary data on a composite bridge girder system that features glulam wood beams reinforced on the tension side by a glass fiber composite layer. On the compression side a concrete deck is connected to the girder with a series of lag bolts to form a full composite section. The four students each worked on separate project aspects. John Brody was responsible for FRP fabrication, Annette Richard was responsible for development of a lightweight concrete suitable for a bridge deck, Kenneth Sebesta was responsible for model development, and Kenneth Wallace was responsible for the shear connection between the wood and the concrete. All worked together on specimen fabrication and testing, as well as individual component (e.g. shear connection, FRP and concrete) testing.

This work will be presented at the ASCE Structures Congress 2000. In addition, a manuscript is being prepared for submission to an appropriate peer-reviewed journal.

Interaction with Mentors and Research Groups

Student-faculty interaction was a strong point of our program from both the student and the faculty viewpoints. All REU students were part of research teams that consisted of faculty and professional staff, graduate students and other UMaine undergraduate research assistants. In all cases there was vary little group hierarchy, so all students were free to approach and interact with all others in the groups. On the average the REU students spent 2-3 hours per week individually with their advisors, and another 3-4 hours per week with their research groups. These times exclude the time spent working together in the laboratories.

Student's Current and Future Plans

At the end of the summer, all ten students expressed a strong interest in pursuing an advanced degree. It should be noted, however, that all ten expressed a similar interest at the beginning of the program as well. Our conclusion from this is that our REU program either reinforced or strengthened an interest that was already present. Of the ten involved with the 1999 program, all are currently back at their home institutions working on their undergraduate degree. Four are currently in the process of applying to graduate school.

Project Assessment and Future Changes

Our project assessment consisted of two parts: A quantitative measure of certain benchmarks, and student questionaire for more qualitative measures of program effectiveness.

Quantitative Measures

We made quantitative measures of our 1999 class in the following areas:

Publicity and Recruitment:

- number on inquiries - about 51 (2 yr total: 96)
- number of applicants – 30 (2 yr total: 50)
- number of women and minorities applied – 14 (2 yr total: 24)
- number of women and minorities accepting offers – 5 (2 yr total: 8)
- number of offers turned down – 3 (2 yr total: 7)

Student interest in research:

- number of students who continue research project beyond ten week program – 1 (2 yr total: 3)
- number of students who apply to graduate science or engineering programs – 5 to date (2 yr total: 8)
- number of students who enroll in graduate science or engineering programs – 0 to date (2 yr total: 2 to date)

Scientific quality:

- number of refereed journal publications resulting from program (0 to date)
- number of internal of external published reports – 2 (2 yr. Total 5)
- number of conference and other publications resulting from program (in order to qualify, student must be co-author) – 2 (2 yr total: 4)
- external research support that results from pilot studies conducted under REU program – 2 pending.

We were relatively pleased with the improvement in recruitment over the 1998 program. Inquiries increased by 14%, applications increased by 50%, and women and minority applicants increased by 40%. Much of the increase we attribute to inclusion in NSF's REU program promotion (we saw a number of applicants directed our way from NSF's site). We anticipate a significantly larger applicant pool this year (as inquiries have been steady for the last four months). We will continue in 2000 with our internet-based strategy for identification of applicants and recruiting.

We believe it is still too early to gage our effectiveness in promoting student interest in research. A large number of program participants from both 1998 and 1999 are still undergraduate students. Of the four who have graduated, two are currently enrolled in science or engineering graduate school. We will continue to track the students so we may better evaluate this in the future.

The scientific quality has been quite mixed, ranging from outstanding (likely publishable in refereed journal) to fair. The key seems to be to match the students up with a project that excites them and motivates them to do good work. We would like to see more publishable results by this time next year.

Participant Survey

In 1998 we gave the participants a broad, open-ended questionnaire. The intention was to let the students themselves dictate what was important to them. Based on our somewhat unsatisfactory experience with that approach we developed a more detailed survey to gage student attitudes about the program. A copy of the survey is attached at the end of this report.

We found the students to be overall fairly happy with the program. (mean response to question 23 – "Your overall evaluation of the program" – was 8.6 on a 10 point scale). After two years we believe we can now provide a very polished program. The biggest issues we need to continue to work on include having all the project pieces in place *before* the student arrives on campus. With a nine-week timetable we can waste time waiting for materials to be delivered. Also, this past year the students were working in a brand new laboratory building that still had a few wrinkles to be ironed out.

Program Changes for Summer 2000

Overall we believe we met expectations in this past summer's program. Our comments from both students and faculty show that we really need to make only minor adjustments to our program. The two most significant program changes will come in the following areas:

1. Broader recruiting, particularly of minority applicants and applicants from small liberal arts colleges. We did a good job expanding our recruiting over the 1998 program year, but we believe we can do even better.
2. Modify program so that a larger proportion of the seminars and workshops are earlier in the summer. The last two weeks should be essentially clear for the students to concentrate on finishing their projects. The represented the most significant suggestion from the students this year.

In addition to those programmatic changes, we would like to set a goal to develop more projects that can produce publishable results in the nine week period.

Budget Information

A summary of our project budget and expenses is shown in Table 4. As is shown the project budget was overspent by over $5,700. This was a planned change. Based on suggestions from the 1998 students we increased the stipend by including on-campus housing in their compensation package. (Housing being the majority of the $5,811.41 shown for Interdepartmental Services). The difference has been made up by charging some of the project expenses (including student wages) to the funded projects on which the students worked.

We plan to operate in a similar manner in the 2000 project year.

Table 4. 1999 Budget Summary

	Base Budget	P-T-D	Balance Available
Faculty Wages	$5,500.00	$2,500.00	$3,000.00
Student Wages	$30,000.00	$29,659.50	$340.50
Supplies/Materials	$2,500.00	$2,643.44	($143.44)
Phone		$76.08	($76.08)
Shipping		$30.75	($30.75)
Photocopies		$40.69	($40.69)
In State Travel	$300.00	$1,265.20	($965.20)
Out of state Travel	$5,000.00	$7,014.57	($2,014.57)
Interdepartmental Services		$5,811.41	($5,811.41)
Total	$43,300.00		($5,741.64)