

Developing a Course in Pavement Design and Management that Incorporates Recent Technologies and Meets Industry Demands

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Abstract

The area of pavement design and management has seen important changes over the years that are the results of numerous federally funded research programs and changes in professional practices. Most road networks are largely in place, and the more urgent focus of various transportation agencies is on cost-effective ways of maintaining the existing networks. Consequently, pavement design and management has become a "hot" area of research and professional development.

A pilot project involving the development of a new technical elective that incorporates recent innovations in pavement design, management, and especially maintenance has been undertaken at the University of Pittsburgh at Johnstown (UPJ). The course offers an important career path for students and insights into current practices in an important field of transportation. Interested students who take the course may have an employment advantage, especially with State Departments of Transportation. At a higher level, the course aims to ensure that the Civil Engineering Technology (CET) program not only meets accreditation requirements, but also meets the demands of industry. The development of the course also keeps the instructor abreast of the profession and allows exploring research opportunities in this area.

The major steps followed in the development process included a literature review of recent articles and books dealing with aspects of pavement design and management, contacting government and private agencies regarding current technologies and professional practices, and designing exercises utilizing the latest standards employed in the industry for hands-on student training.

Background

The University of Pittsburgh at Johnstown offers 4-year B.S. degree in Civil Engineering Technology (CET). The program has five areas of concentration: Construction, Environmental, Management, Structural/Foundation, and Transportation. The curriculum of at least one of the concentration areas must be completed in order for a student to graduate from the program. The current curriculum for students electing to concentrate on Transportation includes three required courses: Elementary Surveying, Civil Computations (computer applications of surveying), and Highway Surveying and Design. In addition, students focusing on transportation are expected take two more courses offered to students as technical electives: Transportation and Photogrammetry.

A CET graduate with concentration in the area of transportation is likely to be involved in one or more of the five major areas: planning, design (geometric and pavement), construction, operation, and maintenance. The current curriculum provides a foundation in all but the area of pavement design and management, especially maintenance. Filling this void is the motivation behind developing the new elective.

The road network in the United States is largely in place and the national highway system, in particular interstate and principal arterial highways, is now complete. However, the physical facilities of this transportation system are aging and deteriorating.⁽¹⁾ For the state of Pennsylvania, a recent survey reported the following statistics:⁽²⁾

- Roadway conditions are related to an estimated 30% of traffic fatalities. In Pennsylvania, there were 1,549 traffic deaths in 1999.
- Federal funding for Pennsylvania's road and bridge system is about \$1.5 billion in fiscal 2001.
- 37% of Pennsylvania's major roads are in poor and mediocre condition where, according to FHWA classifications: "Poor" roads are in need of immediate improvement; "Mediocre" roads need improvement in the near future to preserve usability; "Fair" roads will likely need improvement; and "Good" roads will not require improvement in the near future.
- 42% of Pennsylvania's bridges are structurally deficient or functionally obsolete.
- 14% of Pennsylvania's urban freeways are congested.
- Driving on roads in need of repair costs Pennsylvania's motorists \$1.9 billion a year in extra vehicle repairs and operating costs. This translates to an average of \$219 per motorist.

While the general area of pavement management remains an active area of academic research and professional development, it is now receiving greater attention from government and private agencies. Federally funded national research projects in recent years, for example The Strategic Highway Research Program (SHRP), have focused on finding ways to keep existing roadway systems in good physical condition and on improving the safety, capacity and the environmental conditions of the transportation system through advanced technology.⁽³⁾

The outcome from SHRP in particular has changed the ways in which state highway agencies design and build pavements, repair roads, clean up after winter storms, and build bridges. The successful implementation of SHRP products and technologies has benefited the entire country. For instance, Superpave (Super Performing Asphalt Pavement) pavements have represented about 41% of states' total hot mix asphalt road projects last year. The American Association of State Highway and Transportation Officials (AASHTO) has formed a steering group for technology deployment to facilitate the implementation of similar, high payoff and ready-to-use innovative technologies in the future.⁽³⁾

The Pennsylvania Department of Transportation (PennDOT) has placed "MAINTENANCE FIRST" at the top of a list of items that represent strategic focus areas developed by the Strategic Management Committee. In support of a maintenance-first policy, PennDOT-District 9 has awarded this past year about 11 million dollars in maintenance contracts totaling 116 miles in contract resurfacing, a 36% increase in miles from the previous year.⁽⁴⁾

Accreditation Board for Engineering and Technology (ABET) outlined in the new criteria that programs must demonstrate that graduates are capable of applying basic technical concepts to the solutions of civil problems as well as performing standard analysis and design in at least three civil engineering areas.⁽⁵⁾ These areas are likely to include transportation. Pavement design and management contains analysis and design in an important area of transportation, so offering a technical elective in this area will help achieve the above mentioned ABET accreditation criteria.

Implementation Process

The author conducted a survey with a colleague to learn about summer internship experiences for the CET students at UPJ.⁽⁶⁾ The survey revealed that of the summer work experiences students reported, 41% were with the PennDOT Internship program. More importantly, of the PennDOT interns, about 40% of the students indicated that their primary duties were related to maintenance or road inspection.

Meeting with members of the ET division Industry Advisory Committee (IAC) regarding this issue resulted in recommendation to offer the technical elective in pavement design and management to replace Photogrammetry (the previously offered elective). The idea of offering the course was then presented and discussed at both the CET department and college levels. The proposed efforts to develop and offer the new elective were found to support at least two objectives under the division Strategic Goal 1(Engineering Technology (ET) will offer students a high-quality undergraduate education that constructs a bridge between theory and application and includes sensitivity to the needs for others through the study of liberal arts and science).⁽⁷⁾

The two related objectives under this strategic goal are:

- “ET will monitor the marketplace; evaluate current programs to develop/revise its niche in the local, state, and national market through the use of the Industrial Advisory Committee and the current consulting experience of the faculty”
- “ET will provide technical elective offerings that provide greater concentration in depth and a broader technical experience for the students”

The Engineering Technology (ET) division eventually recommended the development and offering of the course, which was ultimately approved by the university. The course was first offered to students in Fall 2002.

Developing the course included a literature review of recent articles and books dealing with topics in pavement design and management. It was also necessary to contact government and private agencies to learn about up-to-date technologies and professional practices in the area of pavement design and management. Special attention was paid to current PennDOT practices since it is the state agency with the greatest relevance to the CET program and its graduates. As mentioned, many of our students intern with PennDOT during summers. Moreover, PennDOT has hired, and continues to recruit many of our CET graduates.

A copy of portions of the course syllabus that was developed for this course is given in Appendix A. The syllabus outlines the course objectives, expectations, grading system, lecture schedule, and reading assignments. A number of references have been given to students along with a carefully selected textbook. Students also get handouts for a number of topics as shown in the lecture schedule of the syllabus because some recent publications are only available in papers, reports and other textbooks.

An inventory survey of the lab facilities at UPJ was conducted to determine the suitability of available equipment for the exercises envisioned. The survey revealed that the available facilities could support testing of soils and concrete but not asphalt and asphalt mixes that will need additional equipment. The author is currently exploring inside and outside funding opportunities, especially possible grants from National Science Foundation, to assist in the purchase of needed equipment, materials, and computer software.

In the first offering of the course and to compensate for the lack of testing equipment, a number of field trips were planned to well- equipped testing labs in the region. The excellent relationship that UPJ has with industry and the small number in the class allowed students to get hands-on experience and closely witness and participate in the testing and operation of the plants visited.

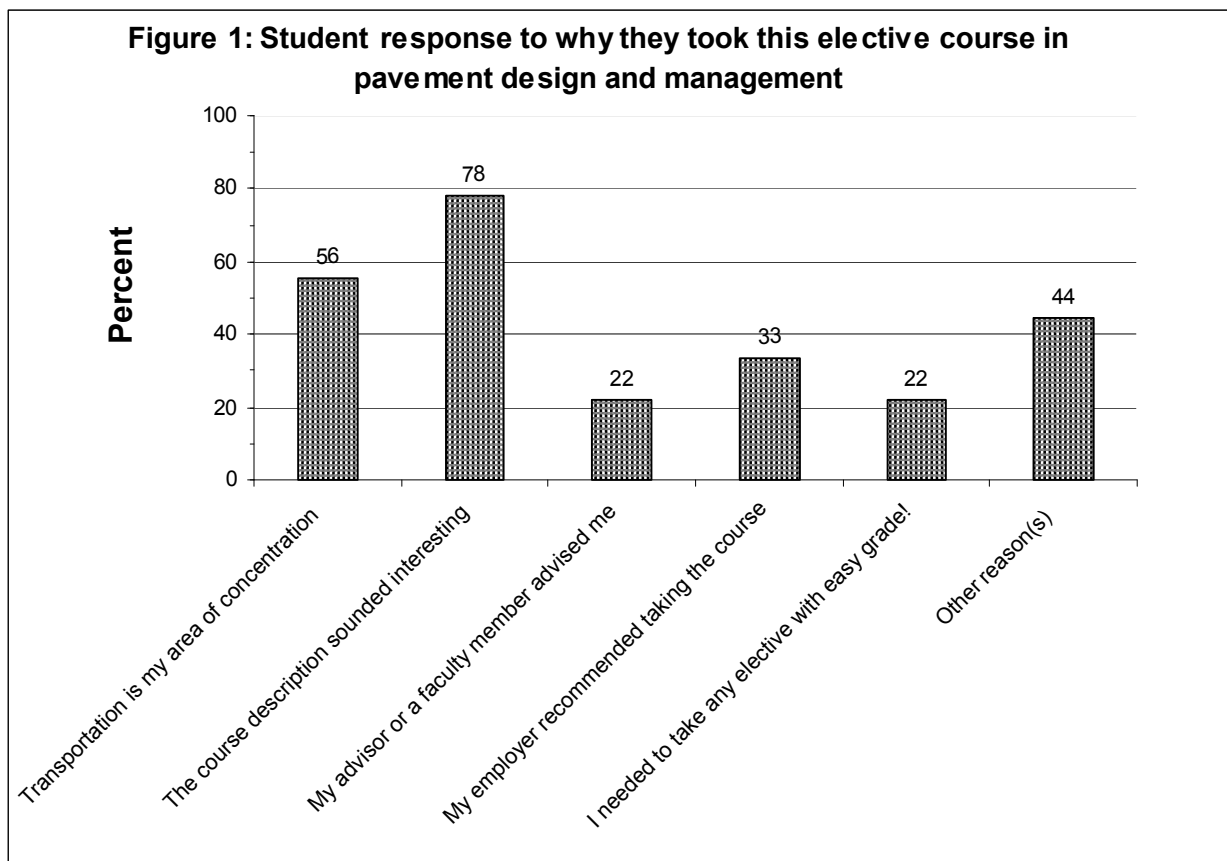
Other supporting activities included field visits to road construction sites. Students had the opportunity to observe the construction of both flexible (asphalt) and rigid (concrete) pavements. For each site visited, the project manager gave a brief presentation of the project history and construction progress and allowed students to ask questions. Digital pictures of the construction equipment and operation were also taken and were later referred to during class discussions. Each student was required to submit a memo to the instructor describing his/her experience from the field trip.

In addition, short videos of pavement construction and especially maintenance activities were shown to students. One of the course requirements was also searching the library and the Internet, writing and presenting a paper on a topic related to pavement design and management especially recent technologies.

Feedback from Students

A questionnaire was administered at the end of the semester to obtain feedback from students on their experience with the new elective. The questions in the questionnaire are only related to the course offering, content and course activities. It does not address the instructor or teaching methods. A copy of the actual form can be found in Appendix B. The questionnaire consists of 9 questions. The class consists primarily of seniors with few juniors. Juniors are allowed to take the course only if they had or are currently taking the highway surveying and design course, which is the prerequisite/co-requisite for this course.

Figure 1 presents the student responses with respect to reasons why they took this elective. Students can mark more than reason if they wish. More than half of the class took this elective because transportation is simply their area of concentration and they had no choice but to take this course. Most students indicated the number one reason for taking the course is the course description sounded interesting and they wanted to learn more about the topics outlined. About a third of the class was advised to take the course by their employer or someone outside the university. Many of the students work part-time and almost all students do summer internships. Few students took the course with expectation of an easy grade in the course. Some students had other reasons for taking the course including possible use of the material in the future, especially summer jobs with PennDOT.



Most students (almost 90%) would have still chosen this technical elective if other transportation related electives such as Photogrammetry were also offered. It should be noted that Photogrammetry used to be offered in recent years as an elective until this course was offered as a replacement.

Table 1 gives the student responses with respect to their interest in the topics that were covered in this course. Students were asked to rank the covered topics with respect to their usefulness and interest to them (1 being most favorable and 9 is least favorable).

Table 1: Student Ranking of Course Topics

Topic No.	Topic	Average Rank	Relative Rank
T1	Soil engineering for highway design	5.6	7
T2	Tests of asphaltic materials	4.6	6
T3	Marshall and Superpave mixes	3.2	2
T4	Design of flexible pavements using AI method	4.2	5
T5	Design of flexible pavements using AASHTO method	3.1	1
T6	Design of rigid pavements using AASHTO method	3.9	3
T7	Design of rigid pavements using PCA method	4.1	4
T8	Methods for measuring roadway condition	5.9	8
T9	Pavement rehabilitation programming	6.8	9

The following comments can be made on Table 1:

- The topics “Design of flexible pavements using American Association of State Highways and Transportation Officials (AASHTO) method” and “Marshall and Superpave mixes” received the best ranking from students, first and second rank respectively. Reasons for students’ choice may include the fact that these topics have seen significant changes in recent years with respect to analysis and design. The topics also address flexible pavement, which is used much more than rigid pavement in road construction. In addition, AASHTO method is the most popular design method for flexible pavements and PennDOT adopts this method.
- “Design of rigid pavements using AASHTO and using the Portland Cement Association (PCA) methods” took the next best two ranks, third and fourth respectively. Students are design oriented in general and many have interests in concrete as a construction material. Again, the popularity of AASHTO is believed to increase the level of students’ interest to learn this method.
- “Design of flexible pavements using Asphalt Institute (AI) method” took the fifth rank. Students liked the simplicity present in the method but perhaps the popularity of AASHTO method affected the relative rank of the AI method.
- “Tests of asphaltic materials” and “soil engineering for highway design” claimed the sixth and seventh ranks respectively. Tests on asphaltic material should be more interesting to students but the reason for the relatively low ranking could be because a great deal of the discussions did not involve actual testing due to lack of equipment even though, students did witness many of the tests as demonstrations during a field trip to asphalt plant.

- Finally, “methods for measuring roadway condition” and “pavement rehabilitation programming” surprisingly were ranked last. The nature of material in these two important topics is largely descriptive and may be considered relatively dry compared to design. Maintenance decisions do not necessarily lead to a single solution but rather alternative options with engineering judgment involved and that could be frustrating to students looking for a definite single answer.

Field trips in general were favorable activities compared to watching videos as shown in Figure 2. Sites related to asphalt were ranked the best and that is consistent with students’ ranking of course topics as discussed earlier.

Table 2 includes a list of the remaining questions in the questionnaire. The percent of maximum score and average student response have been used to quantify the responses by students to these questions as shown in Table 2. The maximum score is the number when all students select “Definitely Yes” which has a value of five (5) as their response in favor of the idea (i.e. maximum score = 100 for a class of 20 students).

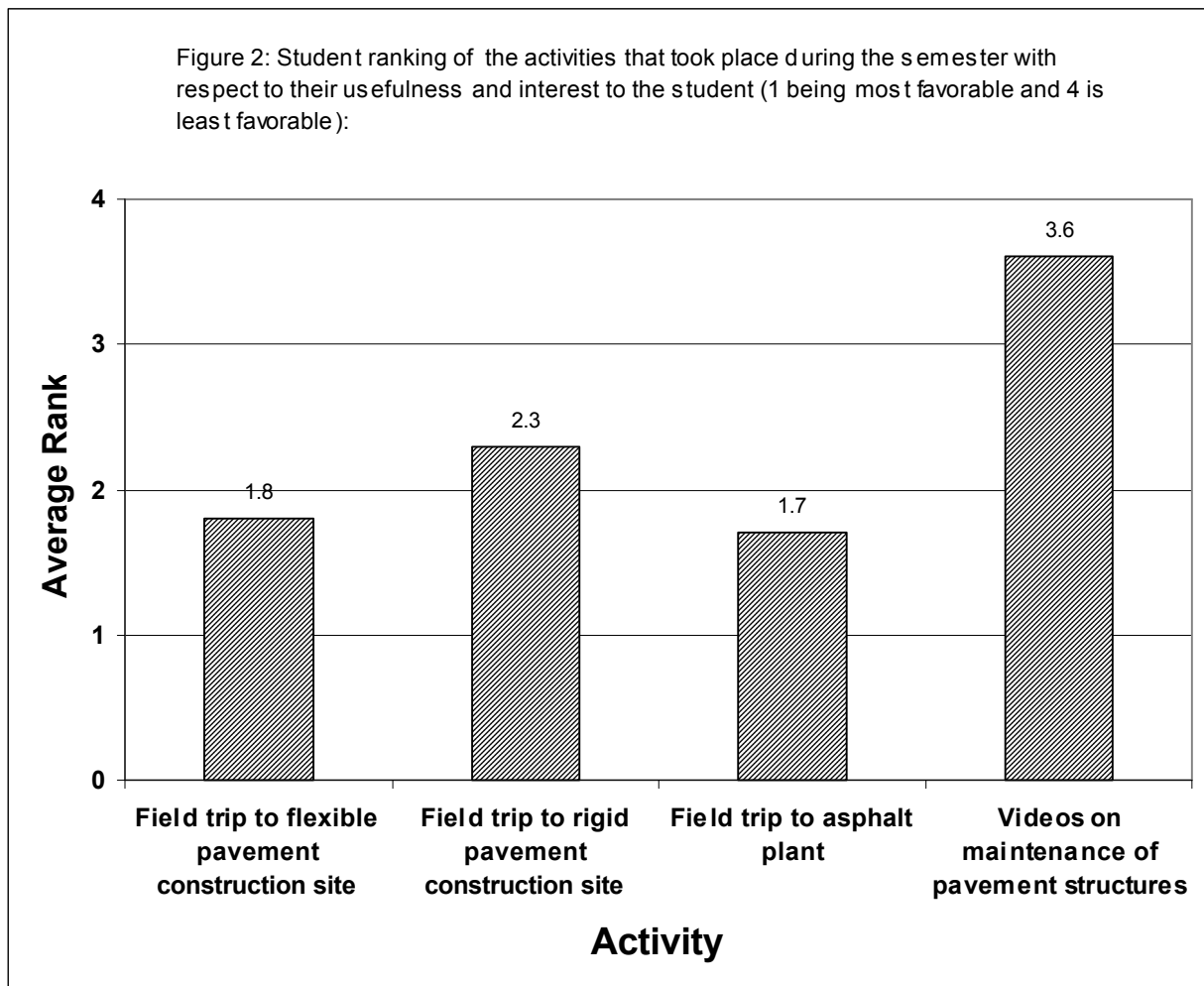


Table 2: Feedback from students on the new elective

No.	Question	Response	
		% of Maximum Score (Max=100)	Average Response (5 for strongly agree)
5	This course helped me learn recent technologies in Pavement Design and Management	95.6	4.8
6	This course offers an important career path and insights into current practices in an important field of transportation.	80.0	4.3
7	The knowledge included in this course is in demand by industry, especially DOT's.	91.1	4.6
8	By taking this course, I may have an employment advantage in transportation jobs.	91.1	4.6
9	I recommend that the course be offered again next year for interested students	93.3	4.7

The following comments can be made on the results of Table 2:

- Almost all students indicated that this course helped them learn recent technologies in Pavement Design and Management. Topics such as “Superpave mixes” and “AASHTO Flexible Pavement Design” were among the topics that have seen changes in recent years and were discussed.
- Many but not all students agree that the course offers an important career path and insights into current practices in an important field of transportation.
- Most students agreed that the knowledge included in this course is in demand by industry, especially departments of transportation. Most students also indicated that by taking this elective course, they might have an employment advantage in transportation jobs.
- Finally, the vast majority of students recommend that the course be offered again next year for interested students.

Summary

- A new technical elective in pavement design and management was offered to students at University of Pittsburgh at Johnstown (UPJ) in order to support the concentration area of transportation. The process involved revising the CET curriculum and getting input from the Industry Advisory Committee (IAC).
- The course offers an important career path for students and insights into current practices in an important field of transportation. The course aims to ensure that the Civil Engineering Technology (CET) program not only meets accreditation requirements, but also meets the demands of the industry. The development of the course was also consistent with the university and college strategic goals and objectives.
- For first time offering of the course, field trips to construction sites and plants as well as videos were utilized to support the theory and to compensate for the lack of testing facilities.
- Most students expressed appreciation for offering the technical elective, endorsing the opportunity provided to learn recent technologies in Pavement Design and Management. Most students also recommended that the course be offered again next year for interested students.

References

1. American Society of Civil Engineers (ASCE) homepage in the world wide web(WWW), address: <http://www.asce.org/reportcard/>.
2. Federal Highway Administration (FHWA), "The Road Information Project (TRIP): Analysis of Federal Highway Administration Data," 1999.
3. James Informational Media Incorporated, "SUPERPAVE AND SHRP: THEY'VE CHANGED OUR ROADS," Journal: Better Roads Vol: 71 No: 1, 2001.
4. Pennsylvania Department of Transportation (PennDOT), Engineering District 9-0, 2002-2003 Business Plan, September 2001.
5. Accreditation Board for Engineering and Technology (ABET), "Criteria for Accrediting Engineering Technology Programs: Effective for Evaluations During the 2002-2003 Accreditation Cycle," Baltimore, MD. , November 2001.
6. Rose, A., Murad, M., "Summer Internships for Engineering Technology Students: Sharing the Experiences," Proceedings, ASEE Annual Conference, Montreal, Canada, 2002.
7. University of Pittsburgh at Johnstown, "Questionnaire for Review of Programs in Engineering Technology, Volume 2, Civil Engineering Programs," Submitted to the Technology Accreditation Commission of the Accreditation Board for Engineering and Technology, 2002.

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Appendix A: Course Syllabus

UNIVERSITY OF PITTSBURGH AT JOHNSTOWN CIVIL ENGINEERING TECHNOLOGY

Course Outline

COURSE:	CET 1124 – Pavement Design and Management
CREDIT:	Three Credit Hours
TERM:	Sixth, Seventh, Eighth
TEXT:	“Traffic and Highway Engineering”, by Garber and Hoel, Third Edition, 2002.
REFERENCES:	<ol style="list-style-type: none">1. “Pavement Policy Manual”, Publication No. 242, Pennsylvania Department of Transportation (PennDOT), 2001.2. “Bituminous Concrete Mixtures, Design Procedures and Specifications for Special Bituminous Mixtures”, Bulletin No. 27, Pennsylvania Department of Transportation (PennDOT), 1990.3. “Automated Pavement Condition Survey Field Manual”, Publication No. 336, Pennsylvania Department of Transportation (PennDOT), 2001.4. “Pavement Analysis and Design” by Yang H. Huang, Prentice Hall, 1993.
PREREQUISITES:	CET 1121 and CET 1131
OBJECTIVE:	To incorporate recent innovations in pavement design, management, and maintenance. The course offers a new and important career path for students who wish to have transportation as an area of concentration.
DESCRIPTION:	A study of materials, design and maintenance of highway pavements. Topics include characteristics and surveys of soils for highway construction, properties and tests of asphaltic materials including Superpave, stresses in pavement layers, design of flexible and rigid pavements using AI, AASHTO and PCA methods. Other topics include subsurface drainage, roadway condition surveys, pavement distress and maintenance, and roadway management systems. The latest AASHTO and PennDOT guidelines and policies will be used.
TIME DISTRIBUTION:	Two hours of lecture and three hours of lab/recitation per week
STUDENT PREPARATION:	Reading assignments, homework problems, and lab work.
GRADING:	Two term exams, a final exam, term paper, and lab reports.

CET 1124 – Pavement Design and Management

Schedule

<u>Week No.</u>	<u>Topic</u>	<u>Reading</u>
1	Classification and compaction of Soils	Chap 18
2	Bituminous Materials	Chap 19 and handout
3	Tests for Asphaltic Materials	Chap 19
4	Superpave System	Chap 19 and handout
5	Soil Stabilization	Chap 20
6	Design of Flexible Pavements (AI Method)	Chap 20
7	Design of Flexible Pavements (AASHTO Method)	Chap 20 and handout
8	Stresses in Rigid Pavements	Chap 21 and handout
9	Design of Rigid Pavements (AASHTO Method)	Chap 21 and handout
10	Design of Rigid Pavements (PCA Method)	Chap 21
11	Pavement Distress	Chap 22 and handout
12	Pavement Condition Surveys	Chap 22 and handout
13	Pavement Rehabilitation and Maintenance	Chap 22 and handout
14	Pavement Management Systems	Chap 22 and handout

Grading:

Two Examinations	30%
Final Examination	25%
Homework	20%
Term Paper	5%
Laboratories	20%

Dr. Maher M. Murad
August 2002

Appendix B: A New Course in Pavement Design and Management: Questionnaire

Please answer each of the questions below based on your individual experience from taking the Pavement Design and Management Course.

Academic Level: _____ Jr. _____ Sr.

1. I took this elective course in pavement design and management because (check all that apply):

- Transportation is my area of concentration _____
- The course description sounded interesting and I wanted to learn more about the topics outlined. _____
- I was advised to take this course by my advisor or a faculty member. _____
- My employer or someone outside the university recommended that I take the course. _____
- I needed to take any elective with easy grade! _____
- Other reason(s), specify _____

2. If Photogrammetry (aerial surveying) was also offered which elective would have chosen (circle one):

Photogrammetry (aerial surveying)

Pavement Design and Management

3. Rank the following covered topics with respect to their usefulness and interest to you (1 being most favorable and 9 is least favorable):

- Soil engineering for highway design _____
- Tests of asphaltic Materials _____
- Marshall and Superpave mixes _____
- Design of flexible pavements using AI method _____
- Design of flexible pavements using AASHTO method _____
- Design of rigid pavements using AASHTO method _____
- Design of rigid pavements using PCA method _____
- Methods for measuring roadway condition _____
- Pavement rehabilitation programming _____

4. Rank the following activities that took place during the semester with respect to their usefulness and interest to you (**1 being most favorable and 4 is least favorable**):

- Ø Field trip to flexible pavement construction site _____
- Ø Field trip to rigid pavement construction site _____
- Ø Field trip to asphalt plant _____
- Ø Videos on maintenance of pavement structures _____

Please circle the appropriate response to each of the questions below. The range of responses is from "1" meaning "Definitely No" to "5" meaning "Definitely Yes".

- | | | | | | |
|---|---|---|---|---|---|
| 5. This course helped me learn recent technologies.
5
in Pavement Design and Management. | 1 | 2 | 3 | 4 | |
| 6. This course offers an important career path and insights into current practices in an important field of transportation. | 1 | 2 | 3 | 4 | 5 |
| 7. The knowledge included in this course is in demand by industry, especially DOT's. | 1 | 2 | 3 | 4 | 5 |
| 8. By taking this course, I may have an employment advantage in transportation jobs. | 1 | 2 | 3 | 4 | 5 |
| 9. I recommend that the course be offered again next year for interested students. | 1 | 2 | 3 | 4 | 5 |

Please feel free to add any comments: