Enhancing Student Learning and Community Service Through Senior Engineering Projects

William J. Davis¹ and Philip D. Strope²

Abstract
The curriculums of most undergraduate engineering programs require students to complete either a senior engineering project or capstone engineering course as part of the requirements for a B.S. degree in engineering. In the past few years, increased emphasis has been placed on these types of course requirements due to the creation of specific ABET 2000 criteria that focuses on practical application of academic theory. A senior engineering project was conducted in the 1998/1999 school year at The Citadel which not only embodied the criteria established in ABET 2000 but resulted in other beneficial outcomes. Working in conjunction, two civil engineering students conducted their senior engineering project for the Berkeley-Dorchester-Charleston (BCD) Council of Governments. Their project involved collecting data and conducting traffic analysis studies on a variety of roadway improvement projects being considered for funding by local government agencies. Students worked with the BCD transportation planning department, attended meetings, collected data, conducted analysis and identified recommended roadway improvements. The students’ interaction with transportation professionals in state, regional and city government organizations resulted in an extremely valuable “real world” experience. Conversely, the students’ work constituted a useful resource to local agencies that often have limited means for addressing the significant demands associated with transportation needs of a large urban area.

Introduction
With adoption of new ABET 2000 criteria [1], new approaches [2] for senior engineering projects are needed to engage students within a new learning environment. This paper describes a senior engineering project conducted by two Citadel Cadets structured to enhance student learning through involvement in a technical community service activity. During their senior year, civil engineering students at The Citadel conduct a senior engineering project consisting of two one-hour credit semester courses. The initial one-hour course Civl 430, Senior Research I is conducted as a seminar type course in which various speakers present topics related to research, report writing, project development and engineering issues. Through the first course and principally during the second course, Civl 431 Senior Research II, students’ work with a faculty advisor to conduct a meaningful evaluation on a chosen topic of study, submitting a comprehensive final report near the end of the semester. Oral presentations are frequently required at the end of the school year. An award is presented to the top project by the Civil Engineering faculty and recognition is given to other exemplary senior engineering projects. Criteria used in evaluating student work are summarized as follows:

1. Selection of a current technical topic for engineering evaluation.
2. Literature review, research and data collection.
4. Documentation of the technical analysis.
5. Creation of drawings/exhibits to augment and explain technical analysis.

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2000 ASEE Southeast Section Conference
6. Identification of conclusions and recommendations, supported by the technical analysis performed.

7. Project coordination and communication with technical advisor.

**Guidelines for Senior Project with BCD-COG**

A proposal for conducting senior engineering projects was submitted to the BCD Council of Governments. This document provided basic guidelines for student work being conducted as part of the senior engineering projects. Towards fulfillment of requirements for their one-credit hour courses and in commitment to the BCD Council of Governments, both students agreed to log a minimum of 75 hours per semester (average of five hours per week) on activities related to their senior engineering project. Thus, over the course of two semesters each student was expected to conduct approximately 150 hours of work. A total of 300 student work hours were provided as technical support to the BCD staff. “The work and energy of Citadel students was a valuable contribution in assisting our staff with special studies requested by our local member jurisdictions,” remarked Dan Hatley, BCD-COG Planning Services Manager. Professorial oversight and coordination of student work contributed an additional 60 hours of effort over the course of the two-semester period.

All student work was reviewed by the advisor who is a registered professional engineer with 15 years of experience in the field of traffic engineering and transportation planning. Periodic meetings were held with the students and advisor to monitor the progress on project activities and to provide suggestions for dealing with technical aspects of the work. Students were required to prepare several intermediate progress reports and a final project report for submission to The Citadel Civil & Environmental Engineering Department. The results of their report were also provided to the BCD Council of Governments for use in addressing local traffic issues.

As The Citadel is a military college, orders had to be arranged with school officials to permit students to work off campus. A schedule was developed that allowed students to conduct data collection activities and office work at the BCD Council of Governments on an average of two afternoons per week. Students worked within the context of a staff employee under the direction of BCD transportation planners in conducting all project-related work. For the purpose of establishing an initial context of student work to be performed, the following technical activities were identified as candidate senior engineering projects:

- Berlin Meyers Parkway – Preliminary design and traffic impact analysis
- Folly Beach - Intersection capacity and operations study
- Charleston County – Sea Island traffic variation and truck volume studies
- Sidewalk Construction - Feasibility studies and preliminary cost estimates
- Dennis Boulevard – Traffic operations analysis and roadway improvements
- Enhancement Project Requests – Evaluation of technical requirements
- Tri-County Intersection Improvement Program – Evaluation of high accident locations
- Johns Island – Kiawah and Seabrook sea island parkway alignment study
- Bohicket Road – Roadway capacity improvement study
- Roundabouts – Before and after studies
- TRANPLAN - Modeling of truck traffic and flows
- Rifle Range Road – Roadway improvement and widening study
- Ashley River District – Evaluation of traffic calming treatments
At the discretion of BCD staff, other projects of a similar nature could be included, as part of the senior engineering work, on an as needed basis. For the purpose of adhering to course objectives, it was requested that students work on projects that address engineering related issues. From a practical view, it was acceptable for students to work on data collection efforts and other related field inventory activities conducted for the purpose of supporting engineering analysis and preliminary design evaluations. The ideal situation was for students to concentrate on a subset of the proposed projects listed above, so they would have more time to conduct detailed and significant evaluations of engineering and design related project development issues.

**Technical Activities and Projects Conducted for BCD-COG**

Once the framework was established for conducting senior engineering work with the BCD Council of Governments, students began performing technical activities for the agency. In conducting project assignments, the students’ worked within the context of a BCD staff employee. Typically, students would report to the BCD offices to coordinate assignments, pick up equipment and/or conduct analysis. As work progressed, periodic meetings would be held with the faculty advisor. As occasions arose, the students and faculty advisor would take trips to field locations to evaluate existing conditions, discuss data collection procedures, identify possible solutions and suggest analysis needed to support design recommendations. Over a six-month period, student’s efforts focused on four major projects. Each of these projects is summarized in Table 1 along with the percent of time spent on each project. This percentage should be applied to the total 300 hours of student time spent to determine the number of work hours expended on each of the major projects.

<table>
<thead>
<tr>
<th>%Time</th>
<th>Project</th>
<th>Location</th>
<th>Project Activities</th>
</tr>
</thead>
</table>
| 10%   | Seasonal traffic variation | Five (5) Sea Islands, Charleston County | • Conducted truck & traffic ADT counts  
• Compiled and compared traffic data  
• Prepared report of findings for local agencies |
| 10%   | Regional traffic model validation | US Rte. 17 Alt., Dorchester County | • Collected ADT traffic counts  
• Compiled data for use in regional model |
| 15%   | New alignment road construction | Berlin Meyers Pkwy., Summerville, SC | • Conducted travel speed & traffic volume data  
• Evaluated impact of new road construction |
| 65%   | Traffic operations & road widening | Dennis Boulevard, Moncks Corner, SC | • Met with city & state officials to gather data  
• Evaluated traffic signal warrants  
• Evaluated road capacity & traffic operations |

**Summer Internship**

Based on activities conducted through the senior engineering project, a summer internship was offered to one of The Citadel students. The intern position resulted in a valuable work experience for the student over the course of three months of summer work. The position required 30-hours of work per week and lead to a variety of assignments including traffic operation studies, traffic data collection, road improvement studies, geographic information systems (GIS) applications and interaction with political decision-making bodies.

**Moncks Corner, SC Traffic Study**

For the purpose of demonstrating the type of work conducted and level of detail achieved by the students, a summary of the analysis conducted for Dennis Boulevard in Moncks Corner, SC is presented. An overview of the project is summarized through data and exhibits identifying project objectives, data collection efforts, analytical procedures and recommended improvements. The project was initiated at the request of the Moncks Corner City Manager to the BCD Council of Governments staff. Moncks Corner is an outlying community in the Charleston Metropolitan area. Moncks Corner has a population of approximately 6,000 and is located 30 miles northeast of downtown Charleston. Two major regional routes, US 52 and US 17A, converge within the area.
city limits of Moncks Corner. As the overall Charleston metropolitan area has grown, traffic along these major routes has increased. 1997 traffic volumes along these routes ranged from 15,000 to 21,000 vehicles per day. Within the city limits these daily volumes are carried on four-lane roadways with two-way left turn lanes. As traffic congestion continues to increase along these roadways, the need to strengthen the roadway network within the city of Moncks Corner has become evident. Dennis Boulevard was built in 1971 as a two-lane bypass route around the commercial district of Moncks Corner. For Dennis Boulevard to help in reducing traffic congestion in the Moncks Corner area, some improvements will need to be implemented to increase the capacity of the roadway. In addition, other operational issues also need to be addressed to improve traffic operations along the corridor. The roadway corridor is approximately two-miles long. The study limits and general configuration of the roadway network are summarized in Figure 1.

![Figure 1 – Project Location Map](image)

Some of the primary issues to be addressed in this study included: traffic signalization, roadway capacity, intersection configuration, adjacent land use, and driveway access. An initial step in conducting this study was to perform an extensive data collection effort that included meeting with various agencies to gather existing documents pertaining to the project area, conducting field inventories and performing traffic counts. A summary of the data collected for the study is summarized in Table 2. Data was analyzed and used to recommend both short-term and long-term modifications that should be implemented along the roadway corridor to improve traffic operations. Short-term improvements were identified as modifications that should be implemented within the next five years. Long-term improvements included roadway modifications that should be implemented beyond five years.

For the purpose of evaluating future traffic conditions, existing traffic volumes had to be projected to reflect future urban land use and area mobility conditions [3]. As Moncks Corner is located on the peripheral of BCD regional traffic model, traffic volume projections for this area of the metropolitan area were judged as not reliable by BCD staff. Therefore, traffic volumes from the past four years were utilized to determine historical values for annual traffic growth. Using traffic data occurring from 1993 to 1997 along major roadways in
Moncks Corner, the annual average growth rate was 5.6 percent. In projecting future traffic volumes for various periods over the next 20 years, a more moderate growth rate of 4 percent per year was utilized. High growth rates such as the 5.6% determined from a four-year period during the mid 1990's generally constitute a spike in the growth rate when evaluated over an extended period of 15 years or longer. Even using a lower 4% annual growth rate, projected traffic volumes will more than double over a 20-year design period. A summary of the traffic rate projection method using a compound growth rate formula is summarized in Table 3 and the results of the traffic projections for major roadways in Moncks Corner are summarized in Figure 2. The figure includes Average Daily Traffic (ADT) volumes from the most recent available SC DOT traffic counts in 1997 are listed along with the projected current year 1999 volume, a 5-year design volume and 10-year design volume. 20-year design volumes were also calculated but were not included in the figure, due to limited space.

### Table 2 – Data Collected for Moncks Corner Traffic Study

<table>
<thead>
<tr>
<th>Description</th>
<th>Date</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Initial Dennis Boulevard Construction Plans</td>
<td>1970</td>
<td>SC DOT</td>
</tr>
<tr>
<td>2. Zoning Ordinance City of Moncks Corner</td>
<td>1992</td>
<td>Moncks Corner</td>
</tr>
<tr>
<td>5. ADT Traffic Counts &amp; Count Station Map</td>
<td>1997</td>
<td>BCD COG</td>
</tr>
<tr>
<td>6. Relocation Plans for Reid Hill Rd. @ US 52/17 A</td>
<td>1997</td>
<td>SC DOT</td>
</tr>
<tr>
<td>7. Field Inventory and Project Photo Logging</td>
<td>2/99</td>
<td>The Citadel</td>
</tr>
<tr>
<td>8. Intersection Traffic Counts</td>
<td>2/99</td>
<td>The Citadel</td>
</tr>
<tr>
<td>9. Main St. Ext. intersection analysis</td>
<td>7/5/95</td>
<td>SC DOT</td>
</tr>
<tr>
<td>10. Main St. Ext. intersection analysis</td>
<td>8/20/97</td>
<td>SC DOT</td>
</tr>
<tr>
<td>11. Main St. Ext. intersection analysis</td>
<td>11/12/97</td>
<td>SC DOT</td>
</tr>
<tr>
<td>15. Reid Hill Rd. intersection study</td>
<td>2/10/98</td>
<td>SC DOT</td>
</tr>
</tbody>
</table>

### Table 3 – Traffic Projection Method Based on 4% Growth per year

<table>
<thead>
<tr>
<th>Year</th>
<th>Condition</th>
<th>Projection formula</th>
<th>ADT</th>
<th>DDHV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>Base year count</td>
<td>---</td>
<td>7,900</td>
<td>395</td>
</tr>
<tr>
<td>1999</td>
<td>Current year estimate</td>
<td>ADT= 7900 3 (1+0.04)^2</td>
<td>8,540</td>
<td>427</td>
</tr>
<tr>
<td>2004</td>
<td>5-year traffic estimate</td>
<td>ADT= 7900 3 (1+0.04)^7</td>
<td>10,400</td>
<td>520</td>
</tr>
<tr>
<td>2009</td>
<td>10-year traffic estimate</td>
<td>ADT= 7900 3 (1+0.04)^12</td>
<td>12,650</td>
<td>633</td>
</tr>
<tr>
<td>2019</td>
<td>20-year traffic estimate</td>
<td>ADT= 7900 3 (1+0.04)^22</td>
<td>18,720</td>
<td>936</td>
</tr>
</tbody>
</table>

NOTES:  
1. DDHV is Directional Design Hour Volume, used in HCM analysis.  
2. DDHV is based on K= 10% and D= 50%, taken from existing data.
Once traffic volume projections were determined for various design periods, a level of service (LOS) analysis was conducted using Highway Capacity Manual procedures [4] to determine how well Dennis Boulevard would operate under future traffic conditions. The existing conditions of a two-lane roadway were evaluated along with a proposed four-lane divided roadway. As shown in the analysis summary provided in Table 4, the current level of operation for the roadway is LOS D and traffic operation would further deteriorate to LOS E in approximately 10-years given a constant annual traffic growth of 4 percent. If traffic growth continues at 5.5 percent per year, LOS E would be reached earlier, possibly in less than seven years. At LOS D, the roadway is approaching unstable flow conditions and traffic entering the roadway from un-signalized side streets is likely to encounter considerable delays in waiting for acceptable gaps between vehicles. At LOS E, highly unstable traffic flow conditions will result and motorists are likely to experience stop and go traffic for lengthy periods of time during peak hour conditions. Conversely, construction of a four-lane divided highway would accommodate LOS B or better throughout a 20-year design life of the roadway. This typical section was evaluated because of the functional characteristics of the roadway and 100-ft. available right-of-way width along Dennis Boulevard. Dimensions for a proposed four-lane typical section are provided in Figure 3.

Table 4 – Capacity and LOS analysis for Dennis Boulevard

<table>
<thead>
<tr>
<th>Design Year</th>
<th>Traffic Condition</th>
<th>V/C</th>
<th>LOS</th>
<th>LOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>Existing</td>
<td>0.40</td>
<td>D</td>
<td>0.16</td>
</tr>
<tr>
<td>2004</td>
<td>5-year</td>
<td>0.49</td>
<td>D</td>
<td>0.20</td>
</tr>
<tr>
<td>2009</td>
<td>10-year</td>
<td>0.59</td>
<td>E</td>
<td>0.24</td>
</tr>
<tr>
<td>2019</td>
<td>20-year</td>
<td>0.87</td>
<td>E</td>
<td>0.36</td>
</tr>
</tbody>
</table>

NOTES: 1. Existing 2-lane road, assumes existing roadway remains in place
2. 4-lane divided road, assumes new road would be constructed
3. V/C is volume to capacity ratio, ranging from 0.00 to 1.00
4. LOS is Level of Service, ranging from A to F
Traffic signalization for the intersection of Dennis Boulevard and Main Street Ext. was evaluated to determine if a traffic signal is warranted for this location. Volume related warrants from the Manual on Uniform Traffic Control Devices (MUTCD) [5] were evaluated for existing and future traffic conditions. Existing turning movement counts taken by the SC DOT in 1997 were projected using the same method described for the ADT volumes. The signal warrant analysis is conducted to determine if an adequate number of hours of the criteria are met on a daily basis. Typically, the criteria must be met for either eight or four hours of daily traffic depending on the specific warrant requirements. Results of the traffic signal warrant are summarized in Table 5, along with previous analysis conducted by the SC DOT. Based on analysis of volume related warrants, a traffic signal at this location is justified based on 1999 traffic demand.

Additional analysis was conducted for the project related to land use issues [6], access management [7], intersection configuration and roadway alignment. Based on data collected, analysis conducted, comparative evaluations and discussions with local officials, a series of recommendations were identified for implementation along Dennis Boulevard. Improvement recommendations were separated into short-term and long-term modifications. These improvements are considered necessary towards assuring the roadway remains a functional transportation facility within the Moncks Corner roadway network. Recommended improvements are summarized as follows:

**Short Term Recommendations**

1. Construct left turn lanes along Dennis Boulevard at Main Street Ext. intersection.
2. Implement alignment improvements between Reid Hill Rd. and the northern terminus of Dennis Boulevard along with installation of a traffic actuated, multi-phase traffic signal. (currently planed by SC DOT)
3. Implement side street horizontal alignment improvements at Stoney Landing Rd. intersection.
4. Install traffic actuated, multi-phase traffic signal at Main Street Ext. intersection with Dennis Boulevard.
5. Modify turn lane configuration at Old 52 intersection with Dennis Boulevard to improve traffic flow and allow concurrent overlapping traffic signal phases.

Notes:
1. Existing two-lane roadway to be reused or removed.
2. Raised 20-ft. median with mountable concrete curbs.
4. Underground storm drainage system with inlets required.

Figure 3 – Proposed Four-lane Typical Section
6. Begin design of widening improvements for Dennis Boulevard to a four-lane divided typical section.

7. Adopt access management plan to encourage shared driveways, back access connections with side streets, alignment with future median openings and minimum driveway access spacing of 300-ft.

### Table 5 – Traffic Signal Warrant Analysis Summary

<table>
<thead>
<tr>
<th>Study</th>
<th>Performed By</th>
<th>100% (8)</th>
<th>80% (8)</th>
<th>100% (8)</th>
<th>80% (8)</th>
<th>No. 8 (8)</th>
<th>No. 9 (4)</th>
<th>Warrant No. 11 (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/1995</td>
<td>SC DOT</td>
<td>3</td>
<td>-</td>
<td>5</td>
<td>-</td>
<td>3</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>8/1997</td>
<td>SC DOT</td>
<td>0</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>1</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>9/1997</td>
<td>SC DOT</td>
<td>0</td>
<td>-</td>
<td>4</td>
<td>-</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>1999</td>
<td>Citadel</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>7</td>
<td>0</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>2000</td>
<td>Citadel</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>7</td>
<td>0</td>
<td>4</td>
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<tr>
<td>2001</td>
<td>Citadel</td>
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<td>1</td>
<td>5</td>
<td>7</td>
<td>1</td>
<td>4</td>
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</tr>
<tr>
<td>2002</td>
<td>Citadel</td>
<td>0</td>
<td>1</td>
<td>6</td>
<td>8</td>
<td>1</td>
<td>4</td>
<td>4</td>
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<tr>
<td>2003</td>
<td>Citadel</td>
<td>0</td>
<td>1</td>
<td>7</td>
<td>9</td>
<td>1</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>2004</td>
<td>Citadel</td>
<td>0</td>
<td>1</td>
<td>7</td>
<td>9</td>
<td>1</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

**NOTES:**
1. Traffic signal warrants as specified by the MUTCD.
2. Values shown in parenthesis are the number of hours required to meet warrant.
3. Only signal warrants related to traffic volume are included in this table.
4. Fulfillment of 80% values are used in combination of warrants.
5. Based on projected values for 1999, the traffic signal would be warranted.

### Long-Term Recommendations

1. Widen Dennis Boulevard to a four-lane divided typical section as shown in Figure 3.
2. Sign Dennis Boulevard as US 52 and resign existing US 52 through Moncks corner as Business Rte. 52.
3. Develop access management plan to limit median openings to a minimum to spacing of 660-ft.
4. Modify horizontal alignment of Dennis Boulevard at northern terminus along approach to intersection with US 52/17A to improve intersection configuration.

In the event that traffic in the area grows faster than the assumed 4-percent annual rate used in the analysis, the anticipated schedule of long-term recommendations may need to be accelerated. Continued monitoring of traffic conditions and re-evaluation of roadway capacity would be helpful in determining an actual schedule with milestone dates for implementation of required road improvements along the Dennis Boulevard corridor.

### Conclusion

The work conducted by The Citadel students under the direction of the BCD Council of Governments constituted a valuable learning experience in understanding the dynamics of conducting engineering work in a public and political environment. Results from the students’ work were of value to the BCD staff and in most cases was immediately put to use in addressing transportation issues facing the Charleston metropolitan area. Senior engineering projects conducted within this context, by students who will soon enter the workforce, have proven to be a highly effective “real world” learning experience. At the same time student efforts are a useful resource to local agencies trying to meet the demands of an active and growing urban area within the con-
constraints of limited resources. “Results of the study conducted by Citadel students for Dennis Boulevard in Moncks Corner will be useful in coordinating road improvements needed to accommodate future growth in the area,” concluded Dan Hatley of the BCD-COG. Projects of this nature challenge students to work on issues beyond the limitation of conventional theoretic assumptions and convenient academic confines. We believe that this type learning environment embodies the spirit in which the new ABET 2000 criteria were written. Opportunities for expanding this pilot effort in community oriented senior projects are currently being explored to include a broader range of topics and civil engineering issues.

Acknowledgements

The authors would like to thank Mr. Dan Hatley and Mr. John Hodge of the BCD Council of Governments for patiently working with The Citadel students to make this a meaningful learning experience. The contributions of Mr. Darrin Shoemaker, Assistant Traffic Engineer, South Carolina DOT, District 6, are acknowledged in helping the students search DOT files for documents and data related to the Moncks Corner traffic study. Finally, the efforts of this project are dedicated to Mr. Marion Graham, City Manager of Moncks Corner who passed away this year. The Citadel gratefully appreciates the enthusiasm and support exhibited by Mr. Graham for student activities conducted on behalf of his city government.

References


**William J. Davis**

William Davis is an Assistant Professor in the Department of Civil & Environmental Engineering at The Citadel in Charleston, South Carolina. He obtained a B.S. in Civil Engineering from the University of Alabama in 1981, M.S. from Auburn University in 1987 and earned a Ph.D. in Transportation Engineering from Georgia Institute of Technology in 1997. He is a registered Professional Engineer and has over 15 years of experience in highway design and traffic engineering projects. Dr. Davis is a member of ASEE, ASCE, Institute of Transportation Engineers and Transportation Research Board. He currently serves as Secretary of the Southeastern Section ASEE Research Branch, Executive Committee Secretary for the Urban Transportation Division of the American Society of Civil Engineers and is a subcommittee member of the TRB Highway Capacity and Quality of Service Committee.

**Philip D. Strope**

Cadet Strope is a senior undergraduate student at The Citadel studying Civil and Environmental Engineering. He has been named to the Dean’s List for academic performance, and to the Commandant’s List and President’s List for excellence in academics and the military. His work on the senior design project led him to a summer internship at the Berkeley-Charleston-Dorchester Council of Governments in the transportation planning department. He is a member of The Citadel’s Student Chapter of the American Society of Civil Engineers.