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Thomas Kimes, University of Missouri-Kansas City
Thomas J. Kimes, P.E. is an Adjunct Professor of Civil Engineering at the University of Missouri-Kansas City. He has held positions in municipal, state, federal, large private and small private employers. He has been the co-instructor of the Civil Engineering capstone design class since 2003 (816-468-5858, kimes@kveng.com).
Design-to-build = Civil Engineering Capstone + Municipality

Abstract
A partnership between a municipality and the civil engineering department created the opportunity for a civil engineering capstone class to design a small traffic bridge replacement and intersection improvement in a residential area. The design work included hydrology, hydraulics, site management, construction budget, constructability, detour, permits, easement requests and blueprint preparation. The students completed the work within the two semester class time and worked closely with City of Kansas City engineering staff. The construction is planned for late 2006 and will use the students’ design.

Introduction
The Civil Engineering Capstone Design course at the University of Missouri-Kansas City has partnered with the City of Kansas City, Missouri Department of Public Works to design useful, traffic-bearing structures since 2003. Civil engineering projects for the senior design class are particularly difficult to identify because civil engineering projects are typically large and complex. Past projects at the University of Missouri-Kansas City were usually either retrospective/paper designs or projects of such great scope that the students seldom got a sense of completion from the work: “projects have to be scoped to the right size or level of involvement as to guard against being unmanageably large or so narrowly focused that they do not provide enough challenge or latitude for the students”.1

“Capstone courses offered by civil engineering departments are generally simulation-type courses. Paper designs or economic evaluations are often the desired final product in such courses. Construction is usually impossible since large structures and systems are involved.”2

The University of Missouri-Kansas City’s mission areas are the arts, life sciences and as an urban university. The university created the Center for the City in 2001 to help foster and coordinate partnerships with local municipalities and agencies. Other departments’ capstone projects often culminate in a real public benefit.

Municipal Partner

The City of Kansas City, Missouri funds Capital Improvement Projects through a 1-cent sales tax. When the tax was passed by the voters, it was under the promise that 25% of the funds collected would go towards the repair and replacement of the City's dilapidated bridge stock. With over four hundred bridges in the City's inventory, numerous bridge projects are funded each year. In addition to having a ready supply of well-funded projects, the City also enjoys staff, at the executive level, that support cooperation with local educational institutions.

From a staffing perspective, the City has a long-term interest in developing expertise in municipal infrastructure specialists. The City frequently seeks to hire engineers who can adapt readily to the demands for working in the public sector. The City may hire those engineers either as employees, or through hiring consulting engineering firms who provide that expertise. As a
client that must competitively select the designer for every project, the City has a long-term interest in developing professionals who understand the complexities of designing projects for a municipal government.

When the City made a commitment to partner with the University of Missouri-Kansas City, one objective of the program would be the encouragement of engineering students to consider municipal government as a desirable employer or client. The logical outcome of the project would be the replacement of one of the City's bridges. The selection of an appropriate project had to include consideration of the time and experience limitations of the students who would perform the bulk of the work. To ensure that the design process would follow the City's design-and quality-assurance processes, the project would be monitored by an experienced professional engineer who could guide the project team. In addition, the City selected a project that could be constructed by City staff.

The project management philosophy from the City staff representative was not to direct the students through task management, but instead to allow the students enough latitude to develop the project through their own judgment. Guidance to the students was often provided as a suggestion of next steps to take, rather than as a task to be accomplished. On occasion, more specific direction would be provided to the students. The goal, from a City perspective, however, was to produce professionals at the beginning of their careers with enough understanding, and eventually, self-confidence, to identify project needs and develop strategies for completing the project.

The City of Kansas City, as the design client for the senior design group, is able to tolerate the extended design time needed by students. Coordination of civil engineering student designs with private firms need to keep the lead time on the projects in mind.

The Project

A bridge replacement for a two-lane water crossing on a residential street was chosen. The specific location is NE53rd Street in Kansas City. The site is located in a neighborhood, and the intersection close to the bridge had sprawled over the years. The culvert bridge was cited for replacement through a normal bridge inspection schedule. The reasons for replacement were degraded guardrails, and posted weight limits.

The bridge was a cast-in-place single box (5 ft x 7 ft) culvert which was 34 feet long, and could handle the 50-year flood (390 cfs) from the 59-acre watershed. The City’s constraints on the design were

- Constructability by City staff (no cast-in-place bridge, pre-cast preferred)
- Elimination of guard rails
- Eliminate weight posting on bridge
- Capacity to pass 100-year flow with one foot freeboard
- Minimize roadway realignment
- Improve intersection
- Protect water main
- Prevent downstream erosion
The design would need to be completed within the two-semester class period.

**Student Team**

The entire class of fourteen students formed the single design team. The prerequisites were updated from the vague “senior standing” to specific requirements of either steel or concrete design, and hydraulics. All students had completed a course in basic computer-aided drafting, but the need to produce construction blueprints required the students to learn Bentley Microstation® with GeoPak® during the senior design class. The students elected a Project Manager, and a Director of Drawings (student with drafting experience) was selected by the instructor to ensure blueprint completion.

The class was run as a studio class with only limited regular classroom activities. Guest speakers were limited to needed project expertise (prefabricated bridge sales representative, right-of-way expert) to allow design time and blueprint preparation. A Microsoft Project (scheduling software) text and homework was assigned.

**Deliverables**

The students, under the supervision of the instructor and a City P.E.,

- evaluated the hydrology (100-year flood flow = 455 cfs) and hydraulics, and sized the culvert,
- specified the geotechnical and land surveys (completed by outside contractors),
- presented the preferred design alternative to City supervisory staff,
- fitted the designed culvert into the site and planned the grading and riprap placement,
- redesigned intersection,
- prepared the US Army Corps of Engineers 404 wetlands permit and Missouri Dept. of Natural Resources 401 permit applications,
- prepared the easement requests for right-of-way coordinator,
- generated a project and construction budget,
- produced a project and construction schedule,
- generated a set of construction drawings (see attached drawings):
  - title/location sheet
  - specifications and quantities
  - overall site plan
  - plan/profile
  - grading plan
  - stream armoring
  - culvert and headwall design
  - culvert footings
  - storm drainage (CMP relocation)
  - detour
  - intersection plan
  - erosion control plan
  - longitudinal road cross-sections
The designed bridge is a precast concrete arch bridge culvert (12 ft wide x 7 ft rise x 40 ft long) with wingwalls and riprap reinforcement of the channel. The road width was extended to allow for a clear zone and eliminate guardrails. The culvert was specified for future weight loading, eliminating the bridge posting. The culvert allows a 100-year flow to pass, and accommodates the one-foot freeboard requirement. The intersection design included improved sightlines and signage, and grading which eliminated guardrails. The wingwalls were designed to avoid the relocated water line, and riprap was extended to cover the waterline location. A localized drainage problem was resolved by extending a corrugated metal pipe to discharge directly into the stream.

ABET

A number of ABET outcomes were measured in this class, including

- ethics (f): the ASCE/NSPE ethics workshop was utilized as a formal training event. Students complete assignments using NIEE ethics cases.
- communication skills (g): the students made a formal design presentation to the senior staff of the Public Works Department, and submitted a companion report with the design calculations. Several of the students had video interviews on the project, and participated in a service-learning conference.
- broad education (h): the design must meet the budget, prepare the USCOE 404 permit, and easements must be acquirable.
- life-long learning (I): life-long learning was assessed by pre- and post-surveys of the students where they outlined their training needs over the next five years.
- current issues (j): all students were required to attend a public meeting of their choice where an engineering issue was discussed, and complete an assessment form (attached) on the meeting.
- ASCE Criterion 8: the project meets the expectation of procurement of work and constructability.

Benefits

This hands-on civil engineering project had multiple benefits for the students and City:

- high degree of professionalism required of the students;
- engagement in self-teaching;
- interaction with professionals in city/county records, surveyors, etc.;
- new engineering professionals who understand civil engineering projects;
- tremendous sense of accomplishment;
- City’s bridge was designed for construction under the budget limit;
- renewed linkages between the university and the City.

Critique

The NE 53rd Street bridge design was a professionally-enriching experience for the capstone design class. In order to complete the design and permit preparation during the school year, the land survey and 100-year flow for the bridge are needed at the beginning of the school year. The supervising engineering from the City was included in all instructional decisions, including
student grades.

The design room was upgraded from a standard classroom. Two printers were installed (B size for draft output, and a full-size (D) printer for construction drawings). The computer in the room is login-limited to the senior design students to ensure that they have access to complete their design. Map rails were added to help display designs in progress. Blueprint-size storage cases were acquired and added to the room.

A new project was designed with the City during the 2005-2006 academic year, and two parallel projects are planned for 2006-2007 because of increased enrollments.

Challenges

The implementation challenges are not specific to the NE53rd Street bridge replacement:

- a project that is just small enough for senior civil engineering students. The projects that the University of Missouri-Kansas City have chosen often seem trivial to practicing engineers. The students have a good background in civil engineering basics, but each project has demands which are outside the curriculum and require on-the-job learning in the capstone class (e.g. earthwork, stream armoring, right-of-ways/easements).
- a key to class morale is the guaranty by the partner to construct the project according to the students’ construction drawings. The work conducted in the class helps the students build their engineering reputations, and the public nature of the project reminds the students that their designs have consequences. The students have great pride in their work and look forward to taking their families to the constructed project.
- a learning curve exists on the partner’s side, as the practicing engineers start out treating the students gingerly at the onset of the relationship. The partners need to be assured that these are young engineers, but can be treated as other consultants. Since the partner has been the same since 2003, the relationship between the City engineers and the class has matured into a relationship with high expectations.

Conclusion

Constructable projects for civil engineering capstone design courses are possible when a strong partnership between the university and municipality are in place. A constructed project offers excellent public relations opportunities for both the university and municipality, and builds a cadre of new professionals who understand the complexity and bureaucracy of civil engineering projects. The students’ interactions with professionals (U.S. Army Corps of Engineers, various municipal officials, and the senior engineering staff who approved the bridge design) developed a degree of professionalism in the students that was not generally present in graduating seniors.

Acknowledgments

The authors thank the Public Works Department of the City of Kansas City, Missouri, UMKC’s Center for the City, and the students of UMKC civil engineering capstone design.
References


CITY OF KANSAS CITY, MISSOURI
N.E. 53RD STREET CULVERT REPLACEMENT

KANSAS CITY
CLAY COUNTY
PROJECT LENGTH: 237 FT.
KCMO PROJECT NUMBER: 210-089-7702-YXX-65533

SCOPE OF WORK
IMPROVE SITE DRAINAGE
IMPROVE INTERSECTION SIGHT DISTANCE
REPLACE LOAD-POSTED BRIDGE

DRAFT
SPECIFICATIONS

ALL WORK SHALL BE DONE IN ACCORDANCE WITH CURRENT ADOPTED SPECIFICATIONS AND DETAILS AS
ADOPTED BY THE CITY OF KANSAS CITY, MISSOURI, AND CONSTRUCTED IN ACCORDANCE WITH THE
KANSAS CITY, MISSOURI, PUBLIC WORKS DEPARTMENT DRAWING PLANS AND SPECIFICATIONS.

ALL WORKSHOPS AND MATERIALS SHALL BE SUBJECT TO THE INSPECTION AND APPROVAL OF THE
ENGINEERING DEPARTMENT OF THE CITY OF KANSAS CITY, MISSOURI.

DRAIN

ALL DRAINS ARE TO BE CONSTRUCTED TO THE CITY OF KANSAS CITY, MISSOURI, STANDARDS.

REINFORCED CONCRETE STRUCTURE

THE CONCRETE STRUCTURE SHALL BE REINFORCED IN ACCORDANCE WITH MANUFACTURER'S
SPECIFICATIONS. THE CONCRETE STRUCTURE IS TO BE DESIGNED FOR A MINIMUM LOAD CAPACITY CONSISTENT
WITH MINIMUM ESPECIFIED LOADS. THE CONCRETE STRUCTURE SHALL BE REINFORCED IN ACCORDANCE
WITH MANUFACTURER'S SPECIFICATIONS.

DRAIN PLACING CONCRETE WALLS

ALL DRAIN PLACING CONCRETE WALLS ARE TO BE IN ACCORDANCE WITH KANSAS CITY, MISSOURI,
STANDARDS.

REINFORCED STEEL

REINFORCED STEEL CONCRETE WALLS ARE TO BE IN ACCORDANCE WITH THE MISSOURI DEPARTMENT
OF TRANSPORTATION SPECIFICATIONS.

PLANT SCALE

THE PLANT SCALE SPECIFIED IN THESE PLANS ARE FOR FULL-SIZED DRAWS. THE DRAWS SHOULDN'T
BE USED WHEN WORKING WITH REDUCED PLOTS.

UTILITIES

THE UTILITY INFORMATION SHOWN ON THIS DRAWING SET IS NOT GUARANTEED TO BE ACCURATE OR
TO INCLUDE ALL UTILITIES. THE CONTRACTOR SHALL VERIFY ALL UTILITY LOCATIONS PRIOR TO CONSTRUCTION.

ALL UTILITIES SHOWN ARE TO BE CONNECTED TO THE APPROPRIATE UTILITIES PRIOR TO
CONSTRUCTION.

The CONTRACTOR shall be responsible for connecting all utilities during construction.

DRAINS

DRAINAGE SYSTEMS shall be responsible for disposing of all debris resulting from
drainage in an adjacent location.

PROPERTY OWNERS

DRAINAGE SYSTEMS shall notify property owners twenty-(20) hours in advance
before commencing work that affects the owners' property.

DRAINAGE CONTROL

DRAINAGE SYSTEMS shall control the drainage and sediment during construction and keep
the street clean of mud and debris. All drainage and sedimentation controls shall
be made in accordance with the CITY OF KANSAS CITY, MISSOURI DRAINAGE CONTROL MANUAL.
See Sheet 10 for typical section and act for steel reinforcing detail.
CE411/412 Public Meeting Report

Meeting date and time:

Meeting location:

Meeting purpose:

Significant interested parties (e.g. government, neighborhoods, interest groups):

What were the major issues?

Describe the meeting dynamics (e.g. dominated by one person, apathetic, many people expressed their positions)

 Were any issues resolved in the meeting?

How did the engineers handle the situations? Could you have handled the meeting?

What training would be helpful to you in participating in these types of meetings in the future?

If we had a public meeting on the NE 53rd Street culvert replacement, what do you think would happen?

Was an agenda distributed or made available?

Meeting duration: