Bringing Monet's Japanese Garden Bridge To The Quadrangle

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ENGR090 Senior Design Project Proposal
Advisor: Professor Faruq M. A. Siddiqui
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Abstract

In this project we intend to design from beginning to end a pedestrian bridge to be situated on the grounds of The Quadrangle, a retirement community in Haverford. As a part of our finished project, we will generate a topographical survey of the site, a hydrological analysis, an environmental impact statement, complete CAD generated structural drawings, and check for compliance with all related AASHTO, LRFD and municipal codes. In addition, we will provide a cost analysis and a construction bid documents.

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Introduction

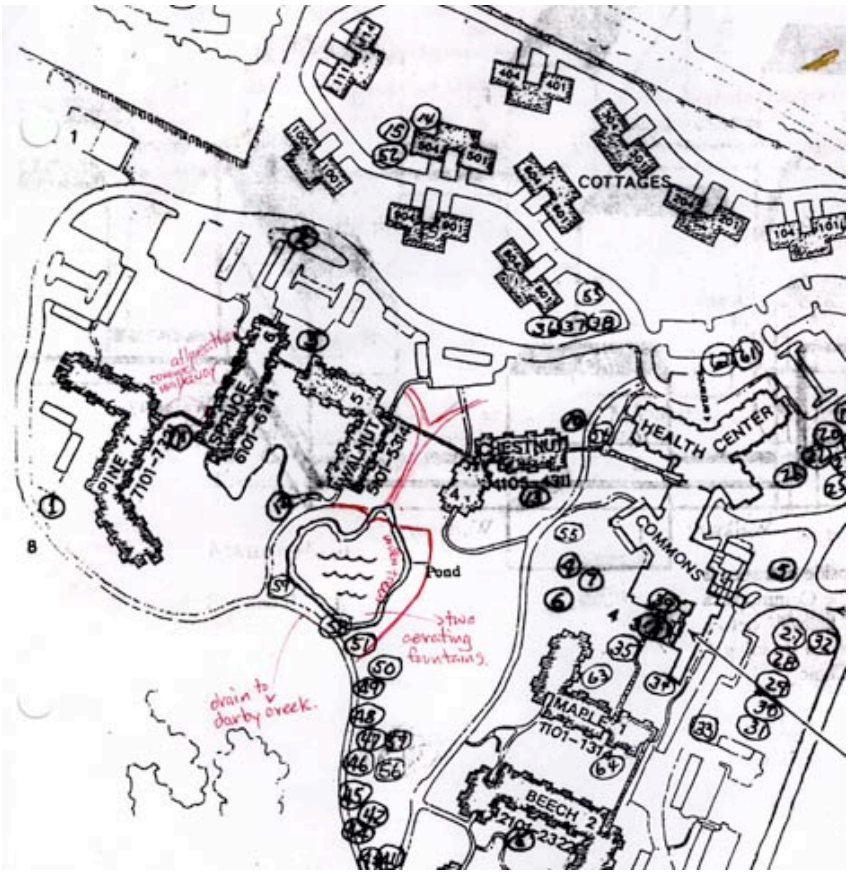
Dr. Steven Phillips, professor emeritus at Temple University, contacted Professor Siddiqui in the early spring of 2004 about a potential engineering design project. Dr. Phillips is a resident of the Quadrangle, an illustrious retirement community in Haverford, PA. The community grounds contain a pond fed by a creek that resembles the garden depicted in Claude Monet's *Japanese Footbridge*. Dr. Phillips hopes to replicate the picturesque scene.

We propose to design a pedestrian bridge resembling the Japanese footbridge for Dr. Phillips and the Quadrangle community. This project will require us to perform a topographical survey, a hydrological analysis, an environmental impact statement, and prepare the structural and foundation designs in accordance with all relevant AASHTO and LRFD regulations. A cost analysis and construction documents will also be prepared.

In this proposal it will be demonstrated that this project meets the realistic design constraints set forth by ABET, given that it considers economic, environmental, sustainability, manufacturability, ethical, health/safety, and political issues. In accordance with the criteria for E90 projects, an oral presentation of the final report will be presented in May, 2005.

Technical Discussion

Background Information & Research.



We have decided to undertake this project because we feel that it will significantly improve the quality of life for residents of The Quadrangle. They will be able to enjoy the scenic nature of the site as well as being able to cross the creek more easily. This has been an ongoing wish of the residents and we feel it is important to help them realize their desire for this bridge. We will not use Monet's painting as anything more than a visual guide, given that he may have taken artistic license in his paintings and changed any number of aspects of the true structure. Our bridge will be similar in design so as to resemble the paintings, but will attempt to create an adaptation of the original bridge that is shallow enough in slope to allow elderly and disabled pedestrians to cross with ease. It will also, obviously, need a span of about 40 feet so as to span the creek and should have a wide enough deck to allow golf carts to cross.

The design of this bridge will require the collection of a significant amount of background information concerning the site conditions and Monet's painting. The Quadrangle Residence is located at 3300 Darby Rd in Haverford, PA (see Appendix A for site plan). The community holds approximately 420 residents. We have taken several steps to obtain information about the proposed site.

We completed an initial site visit over the summer through which we gained an initial feel for the community and the proposed site. In addition, we measured that the span of the proposed bridge will have to be approximately 40 feet. We are in the process of obtaining the topographical survey and the utility survey from the architect, Wallace, Roberts, & Todd, LLC. While these surveys may not contain the most current information, they will provide a solid starting point from which we can direct any further surveying that needs to be performed.

According to Dr. Phillips, the bridge originally depicted in Monet's painting was approximately 20 feet in span. Given that a visit to the restored version of this bridge at the Monet estate is obviously outside of our budget, we did visit a replica installed at the Grounds For Sculpture, a sculpture garden near Princeton, NJ. This bridge, shown below, measures 21 feet in span, has a 7 foot wide deck, and a angle of elevation (from the base to the apex) of 22 degrees. It is constructed entirely of wood and has been in place for approximately ten years. An attempt was made to investigate the foundations, but they were found to be buried and thus inaccessible for viewing. We are currently in the process of trying to contact the sculptor who constructed this replica, as he will be a good source of empirical advice.

The methods of preparation for the hydrological analysis and the environmental impact statement have yet to be researched in full. They will be completed in accordance with PennDOT standards using examples from other projects (provided by Alexis' office), library resources and faculty direction.

The preparation of the structural and foundation designs is within our knowledge base, as both of us have prior coursework in structures/foundations and given that Alexis has been involved in drafting in both AutoCAD and Microstation through her internship this past summer.

The cost analysis and a construction plan will also be prepared using examples from other projects, provided by Alexis' office, and using faculty direction.

Structural Design Considerations

The structure for this bridge is basically an arch and is generally outlined by Monet's paintings. The span also has some flexibility given that some soil work may be required and that there are multiple possible locations for the footings. To ensure that the design is a structurally sound, the soil conditions must be determined, the type of foundations must be chosen, the joints and connections must be detailed, the material must be chosen, and the final structure must be checked against all relevant AASHTO and LRFD codes. This process will require modeling in Multiframe (with hand calculations to check these computations), drafting in AutoCad and material properties research.

Our initial research into materials has led us to some polymer-wood composites. While these materials are more expensive, they resist weathering, water and warpage better that natural wood and provide mechanical properties and aesthetics superior to those of plastic lumber and vinyl profiles.

A pedestrian bridge designed by a undergraduate at Cornell University was built in 2003 out of fiberglass-reinforced plastic lumber. This material has none of the drawbacks of pressure-treated lumber, which leaches toxic chemicals and requires sanding, staining, sealing and painting. It also has a typical life span of 75 years and requires little maintenance. This material does have a higher initial cost, greater short- and long-term deflections, greater thermal expansion, and localized melting from cutting and drilling.

The replica in Princeton is constructed entirely of wood so we know that this can be accomplished; however, this material will rot over time and can be weakened by parasites. Given these considerations, a small cost-benefit analysis would have to be performed to evaluate which material would be best and thus, a final material has not been chosen.

Project Plan

The following is a list of important benchmarks in the completion of our project. Also, Appendix C shows our Critical Path Method diagram. At this point it is impossible (and unreasonable) to know the break down of labor for each of the project divisions. There should be some means of determining how much effort each student puts into the project and thus, each team member will keep a careful log of the amount of time and effort expended on the project on a daily basis as well as the tasks he/she has performed. This process obviates the need to assign each task to a team member. It is our expectation that, because there are only two of us on this project, division of labor will be minimal and most tasks will require effort from both team members.

Deliverables:

- A calculation and design book containing all geotechnical, foundation, and structural calculations.
- A set of design drawings for construction, including general site plans and surveying records.
- A set of foundation drawings.
- A set of structural drawings.
- A written report detailing all aspects of the project, including a log of time spent on the various divisions of the project, a construction cost estimate, and suggestions for further construction planning.

Major Benchmarks and Project Components:

- Preliminary Site Development
  - Surveying
  - Topographical mapping
  - Hydrological analysis
  - Materials research
- Geotechnical Engineering and Foundations
  - Soil property determination
  - Environmental Impact Statement
  - Foundations
  - Earthwork calculations
- Design and Calculations
  - Structural design and calculations
  - Material selection
  - Lighting
- Code Compliance
  - Determination of allowable structural loads (including snow, wind, and seismic)
  - Determination of allowable service loads
  - Fire code compliance (if lighting included in design)
- CAD design/ANSYS analysis
  - Drafting in CAD
  - Organization of CAD drawings into complete set
  - Structural analysis using ANSYS
  - Reporting of bid documents

Project Qualifications

The qualifications required for this project consist of three categories: academic experience, skills, and resources. Academically, beyond the core courses, we each have E59, E60, and E61 to draw from for the mechanical, structural, and foundation design. In addition, Alexis will have completed E62 and E14/E57, which will further our structural knowledge and contribute to our planning ability. Jesse will have taken E63, which, although not directly related to the environmental impact of this project, will provide insight into potential hazards that might occur due to the project to the stream, pond, and in the form of run-off.

The skills involved include proficiency with CAD, ANSYS, and Multiframe. Both of us have practical experience with these programs obtained through jobs and class work.

The resources we have include the engineering department and its facilities. This includes access to survey equipment, soil sampling materials and computers equipped with CAD, ANSYS, and Multiframe. In addition, we both hold jobs with Professional Engineers, who hold incalculable amount of knowledge and advice.

All tasks will be logged and weekly reports will be submitted. We propose to meet with our supervisor for weekly progress reports and advice.

Project Cost

The projected costs for this project will be minimal. Because this is a design project, no major building materials will be required. The Engineering Department already owns all of the software required to design this project. The department does need to acquire up-to-date elementary surveying equipment. Surveying equipment may include plumb bobs, gammon reels, leveling rods, measuring wheels, tri/bi-pods, hand/topographic levels, and others. Any surveying equipment purchased will not only be used for our project, but will go to the engineering department and benefit and future surveying needs or education. Other expenses will be for travel (gas, etc), printing costs, and physical model materials. The cost of construction of the bridge will be estimated and submitted with the report. These costs would be born by The Quadrangle, were the bridge ever constructed.

• Printing Costs	$ 50
• Surveying Equipment	$350
• Travel Costs	$ 50
• Physical Model Materials	$100
	$550

Background Research

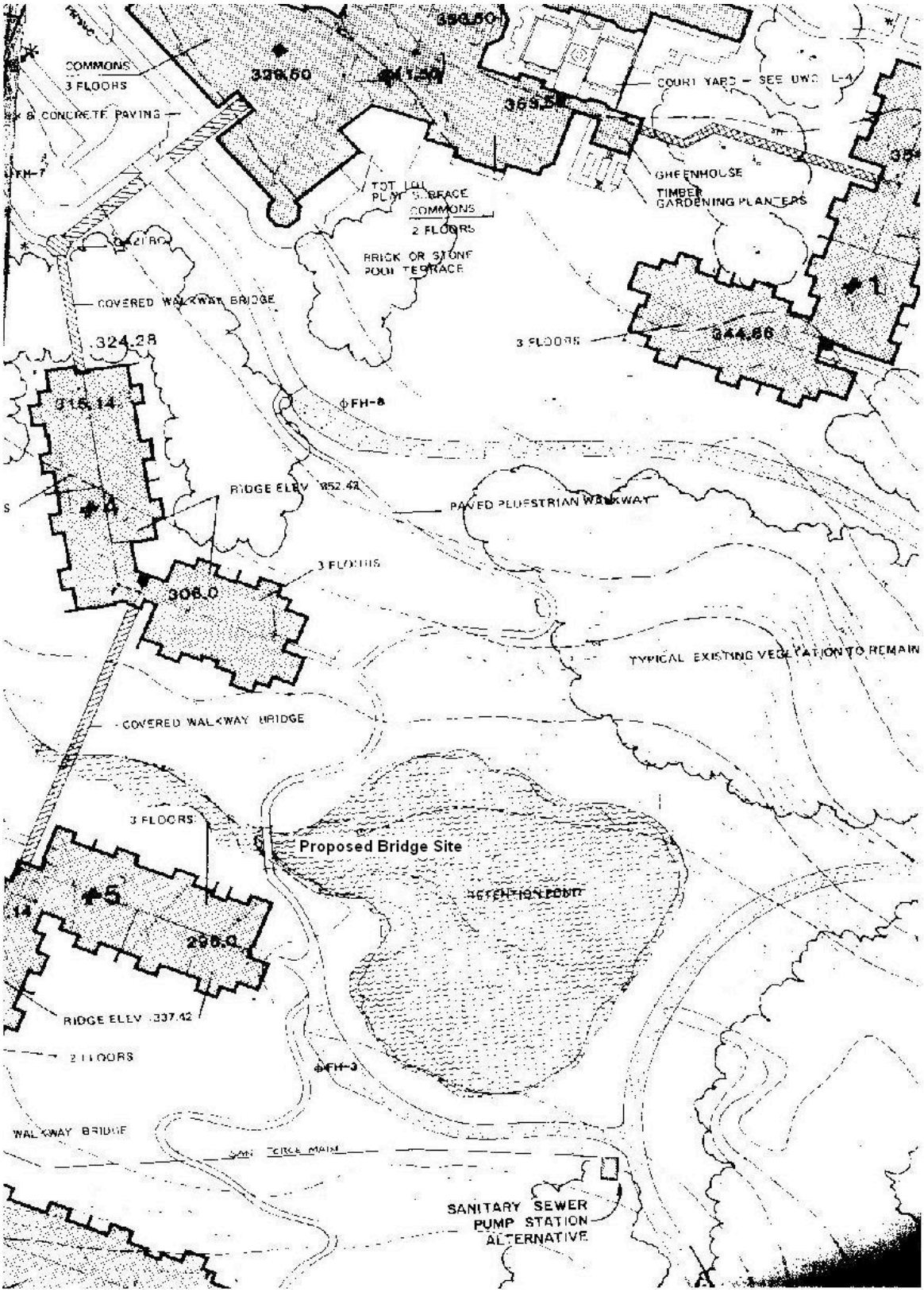
To prepare for this project we have done research both in the library and in the field. Specifically, we have spoken with Don Duckert, Head of Engineering at The Quadrangle, about the site specifics. We have also contacted the architects, who have offered their help in providing the site plan drawings that we need.

We have spoken with Dan Honig, Principal of Structures Consulting Engineers, who has offered his expertise throughout the project. Don Gusic, Jeremy Colello (civil engineers at Parsons Brinckerhoff), and Brian Smith(structural engineer at PB) have offered to loan us sample environmental impact statements and full sets of structural drawings in addition to their advice and expertise.

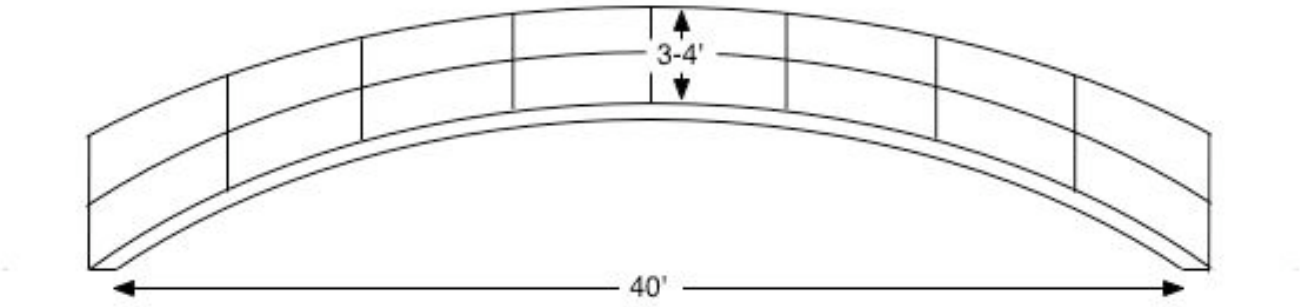
We have also done research on surveying methods using the book:

Brincker, Russel C. and Paul R Wolf. Elementary Surveying, 7th Edition. Harper & Row, New York. C 1984.

Appendix A: Site Plan



Appendix B: Conceptual Drawing.



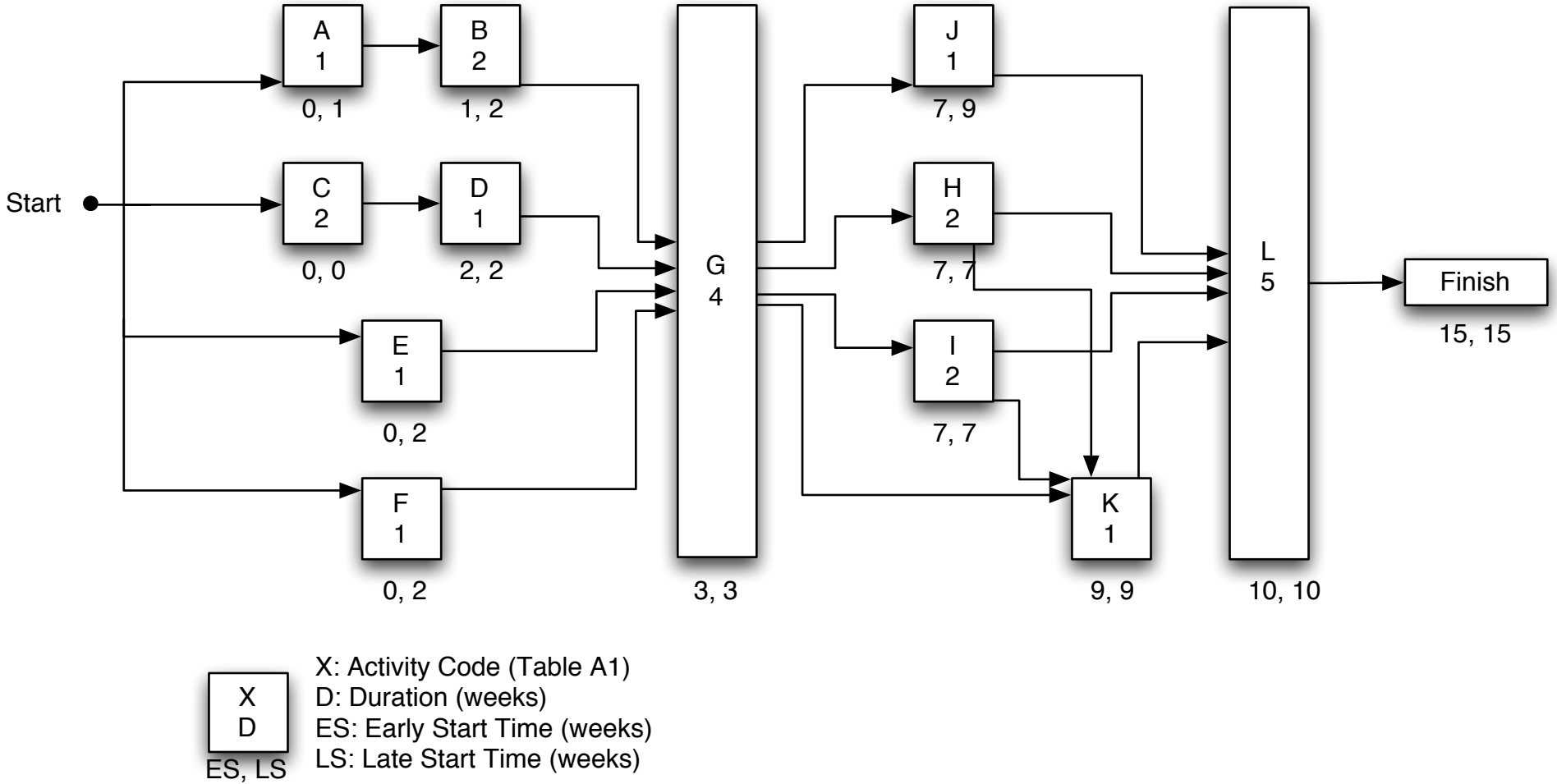
The deck should be as flat as structurally possible. The clearance from the apex of the arch to the water will be determined. Depending on the structural calculations, a column of support may be needed at the center of the bridge. The model bridge from Princeton has an angle of elevation from the base to the apex of 22°, our bridge, being twice the span, will have to be different.

Appendix C: CPM and GANTT Charts

Table A1: Activity Codes and Duration

	Activity	Needs	Feeds	Duration
A	Learn Surveying Techniques	--	B	1
B	Surveying & Topographical Mapping	A	G	2
C	Subsurface Soil Sampling & Characteristic Determination	--	D	2
D	Geotechnical Report	C	G	1
E	Materials Research	--	G	1
F	Hydrology	--	G	1
G	Structural & Foundation Design	B, D, E, F	H, I, J, K	4
H	ANSYS Calculations	G	K, L	2
I	CAD Drafting	G	K, L	2
J	Environmental Impact Report	G	L	1
K	Code & Calculations Check	G, H, I	L	1
L	Writing	H, I, J, K	--	5

Critical Path Diagram for The Quadrangle Footbridge, ENGR090 Senior Design Project by Jesse Young & Alexis Turner
Swarthmore College, Advisor: Prof. Faruq M. A. Siddiqui, Last Revised 1 Dec 2004



Time Scaled Network for The Quadrangle Footbridge, ENGR090 Senior Design Project by Jesse Young & Alexis Turner								
Swarthmore College, Advisor: Prof. Faruq M. A. Siddiqui, Last Revised 1 Dec 2004								
Week #:	1	2	3	4	5	6	7	8
Week Beg:	15-Jan-05	24-Jan-04	31-Jan-05	7-Feb-05	14-Feb-05	21-Feb-05	28-Feb-05	7-Mar-05
	Learn Surveying Techniques	Surveying & Topographical Mapping						
	Subsurface Soil Sampling & Characteristic Determination		Geotechnical Report					
				Materials Research				
				Hydrology				
					Structural and Foundation Design			
		Mid-Sem Report			*Report Draft Due*	*Practice Presentations*		*Presentation & Final Due*
Week #:	*Spring Break*	9	10	11	12	13	14	15
Week Beg:	14-Mar-05	21-Mar-05	28-Mar-05	4-Apr-05	11-Apr-05	18-Apr-05	25-Apr-05	2-May-05
		ANSYS Calculations						
		CAD Drafting						
				Environmental Impact Report				
				Code Calculations Check				
					Writing & Revisions			
						Presentation Preparation		
	Shading Coding:							
	Turner	Both						
	Young							

		activity	needs	feeds	dur
	A	Learn Surveying Techniques	--	B	1
	B	Surveying & Topographical Mapping	A	G	2
	C	Subsurface Soil Sampling & Characteristic Determination	--	D	2
	D	Geotechnical Report	C	G	1
	E	Materials Research	--	G	1
	F	Hydrology	--	G	1
	G	Structural & Foundation Design	B, D, E, F	H, I, J, K	4
	H	ANSYS Calculations	G	K, L	2
	I	CAD Drafting	G	K, L	2
	J	Environmental Impact Report	G	L	1
	K	Code & Calculations Check	G, H, I	L	1
	L	Writing	H, I, J, K	--	5