2006-700: HYDRAULICS AND DRAINAGE COURSE IN A CONSTRUCTION MANAGEMENT PROGRAM

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Hydraulic and Drainage Course in a Construction Management Program

Abstract

This paper focuses on what to teach students in a Construction Management program within a Hydraulics and Drainage course or similarly named courses. The first author, who has taught the course for the past twenty years in an academic setting has partnered with a practitioner from the industry to evaluate the relevance of the materials taught in the course from the perspective of a construction manager in actual practice. The objective was to redesign the course, if needed, in a way so that it addresses its real life purposes efficiently and effectively. The paper details the topics that are taught and the reasons why. The paper's emphasis is on what has resulted from this academia-industry cooperation to enhance the course and elevate it from its present state to one that is more practical and hopefully more applicable for the construction management students. The conclusion is that this course and similarly named courses in the construction management programs probably suffer from being taught more with a civil engineering emphasis than with a construction management emphasis to the disadvantage of prospective construction managers. A way to correct this tendency is suggested in terms of what other topics will be relevant in a course of this nature to go in parallel with the engineering fundamentals. These are topics that inevitably need to be conveyed so that the construction managers of the future know exactly the reasons and the importance of why things are done the way they are done and what to watch out for. Put in another way, even though the construction managers of tomorrow may not ever get involved in the civil engineering aspects of hydraulics and drainage, an understanding of the fundamentals is needed in general to appreciate why things are specified the way they are and why things need to be built the way they are specified to be built. It is hoped that this paper may generate further discussion during its presentation or after, to bring forward valuable input for enhancing courses of this nature.

Introduction

The first author of this paper has taught the senior level Hydraulic and Drainage course in the Department of Construction Technology at the Purdue School of Engineering and Technology at IUPUI (Indiana University-Purdue University of Indianapolis) for the past 20 years. During the first thirteen years or so, this course was taught with a civil engineering emphasis since the department offered A.S. and B.S. degrees in the areas of Civil Engineering Technology and Construction Technology. According to the State of Indiana rules for registering to become a professional engineer, graduates holding the B.S. degree could sit for the EIT and FE exams, provided they had enough experience, to become registered professional engineers if they opted to do so and they still can. However, later on, the emphasis for the B.S. degree graduates of the Department became more focused on construction management than on civil or construction engineering and preparing students for the P.E. license was no longer a part of the mission.

The said course was revised to reflect the changes in the Department's focus but probably never to the degree that it would serve the needs of the current graduates more aptly in today's construction management workplace. Thus the reason why the first author, increasingly bothered by relevance of the course the way he was teaching it, decided to partner with a

practitioner from the industry to allow himself to be challenged as to what is appropriate in a course of this nature in view of current demands from the industry [4, 8, 14]. What follows will detail what the topics are in the course currently and what will be added or subtracted to make it more in line with the purpose stated above. It pleases the first author to mention the fact that what he was teaching was found to be still quite relevant despite changing missions and objectives for the Department itself in general. Having said that, it was also obvious that the industry could be better served by incorporating several new topics in this course so that would specifically benefit the construction managers of the future.

Course Details

The senior level Hydraulics and Drainage course, which currently uses the text by Mott [11] and previously used to use the text by Simon [12], is divided into three main groups of topics in terms of its design:

1.) Fluids at rest: Hydrostatics, Buoyancy, Pascal's law, etc.
2.) Fluids in motion: Pressure flow, Bernouilli's equation and General Energy equation, Momentum equation and applications.
3.) Drainage: Hydrology, open-channel flow, sewer and storm water flow, detention and retention basins, flow through hydraulic structures, etc.

It probably is noteworthy to mention that each of the above segments took about 1/3 of the semester (16 weeks) including a few sessions in a computer lab and a fluid mechanics hands-on lab session. A more detailed description of the topics, whether they were deemed to be relevant or not and what needed to be added, subtracted or changed to make the course more construction management focused, is given below.

a. Hydrostatics: This topics is covered in terms of forces on plain and curved surfaces from stationary bodies of water. Even though the examples used in terms of finding the force on the face of a dam and checking the stability of it were not judged to be totally relevant since there was not even a slim chance of the graduate being involved in the design of a dam per se, it was deemed appropriate that this topic still needed to be taught with more appropriate examples. These would be forces on embankment structures whether permanent or temporary during construction, forces on basement walls when proper drainage is not provided, and force consequences on underground tanks manufactured/built from different kinds of materials. There also needs to be emphasis on what can happen when one in not knowledgeable about the possible consequences resulting from hydrostatics during or even after construction.

b. Buoyancy: It was decided that teaching of this topic should continue with probably no specific emphasis on stability of floating objects, meta-center concepts etc. but continuing and increasing the focus on uplift during construction or thereafter due to ground water level and flood consequences. Construction of piping temporarily or permanently under water and related anchorage construction needed to be emphasized. Construction of items that need to float for diverse reasons also makes coverage of buoyancy concepts relevant (despite being usually an academic

undertaking, construction of a concrete canoe is an example characterizing the situations when civil engineers and construction managers have to collaborate towards a mutual goal). Buoyancy concepts also reinforce or sometimes newly introduce, it seems, the fundamentals related to specific unit weight, specific gravity, density, volumetric centroid, center of gravity etc which need to be in the repertoire of any technical person.

c. Pressure flow – Bernoulli's Equation, General Energy equation, Continuity equation, Momentum equation. It was decided that even though the construction manager would not be involved in detail with the application of such equations, the concepts are very fundamental in diverse types of construction work such as: forced main construction, lift station construction, pump installation, construction pumps, construction of proper backfills, construction of anchorage blocks for pressure pipe flow with directional changes, vacuum pressures for pipelines constructed over undulating terrain, construction pump operation not knowing about suction head, pressure head, friction and local losses etc., concepts. It was decided that teaching of these mostly civil engineering topics should continue even though maybe at a less rigorous level and with more concentration on practical applications related to construction. It was also decided that use of software for solution of problems related to pressure flow also continue at least to make the student aware of these tools. Bentley software (formally Haested methods software) titled Flowmaster, Culvert Master and Pond Pack are used in the course [10].

d. Pressurized flow-- pipes in series and parallel [11]. It was decided that this already pretty brief coverage should be left intact in view of proficiency needed during construction work, at times, to replace or change sizes depending on diverse controlling factors, as well as, due to non-availability of all sizes of pipes prescribed etc. It was also decided that in line with the item above, there should be some coverage of modern pipe materials finding use in different types of construction using various types of pipes.

e. Hydrology – rainfall characteristics and statistics, magnitude of floods, unit hydrograph concepts, calculation of maximum run-off using the Rational Method and the SCS Curve Number Methods. It was decided that these topics should stay in view of their being so basic even to site grading and site drainage work before any construction begins, as well as, to the construction of detention and retention basins [1, 3]. It was also reasoned that since the Hydraulics and Drainage course was a prerequisite course for the course on Subdivision Design and Construction, the above information was crucial [9]. Along the same line, it was deemed appropriate to continue to use software tools such as TR-55, FlowMaster, etc for applications related to above topics [10].

f. Open Channel Flow- Manning coefficient and equation, optimal channel shapes, erosion and scour: It was decided that this coverage should stay together with related software use, so that prospective construction managers grasp the importance of construction specs related to open channel and similar construction (sewer, storm

water, culverts, etc) and related environmental issues encompassing erosion, scour, etc. Technical issues related to construction of optimum sections, importance of surface texture of channels and smoothness of pipes with respect to Manning's coefficient also needed to be continued to be given emphasis. Also emphasized within this context is the construction layout of sewer, water, storm water, etc lines with the appropriate reasoning that leads to such a layout [5, 6]. Within this topic, as well as others mentioned so far, the aim is to be able to have a graduate who will develop the common sense to be able to say "this will not work" despite the presence of construction drawings based on civil engineering design indicating to the contrary. In a way, we are after creating a culture that can picture the design basics and do their best to make sure the construction conforms to the specific intentions of the designing engineers.

g. Flow through hydraulic structures-- sewers, storm-water lines, culverts, flow under gates, flow through orifices, sluiceways etc. It was decided that flow under gates through orifices or sluiceways were not very relevant and should be eliminated whereas a brief discussion about weirs introduced in view of increasing construction of ultrasonic flow meters for discharge measurement of effluents, as well as concepts related to supercritical and sub-critical flows in v-notched weirs [2, 7].

Justification for Keeping the Civil Engineering Fundamentals

Looking at the above discussion, the inevitable conclusion is that little has been deleted from the traditional content of the course even though that obviously was the objective behind this collaborative undertaking. There are several factors leading to this justification in addition to what has already been conveyed.

i. There is an inherent and unseverable relationship between design, resultant specifications and final construction. Design and specifications convey the intentions and assumptions of the engineer which needs to be implemented by the construction manager. It is often difficult to comprehend and appreciate the intent conveyed by the construction drawings and specifications unless one knows the civil engineering basics. Proper construction and/or installation and resultant functioning require the understanding of engineering fundamentals.

ii. Construction management program graduates are increasingly employed in capacities/ titles such as infrastructure specialist, compliance officer, inspector, construction observer, program manager, waste-water treatment plant operator, utilities manager, environmental aspects manager, department of public works manager, asset manager etc., all of which necessitate basic civil engineering fundamentals knowledge for proper functioning.

iii. Construction work is increasingly subject to compliance issues from ever more entities. Included in this is environmental regulatory compliance, occupational health and safety compliance, impact determinations etc., that often border on undertakings necessitating real civil engineering knowledge.

iv. It is inevitable that we prepare the work force of the future to be able to function in a more global construction environment and it is common knowledge, at least as far as developing and under developed countries go, a construction manager often finds himself or herself in the position of a civil engineer as well in terms of decisions that come up on a daily basis

Additional Topics to be Included in the Course

Keeping most if not all of the civil engineering coverage in this course does not mean that the main purpose of this collaborative undertaking, that is, what needs to be included to make it more in line with the needs of a construction manager, was forgotten. It was decided that the following topics be integrated into the civil engineering oriented coverage, both in terms of lectures if possible and/or student research and papers otherwise.

- Retention and detention basin construction
- Construction of riprap and gabions etc. for protection of earth banks from erosion.
- Construction of backfills in relation to construction of cut and cover sewers, storm water-drainage lines, etc.
- Usage of horizontal directional drilling and other trenchless technology construction methods within the context of water, sewer, storm-water and other utility construction.
- Use of geo-synthetics and geo-textiles in relation to construction involving bodies of water [13] (i.e. retention and detentions basins, construction in water, etc .)
- Processes and pipe materials used for water, sewer, and storm-water related construction.
- Construction of well-point systems and other construction techniques for construction at locations affected by the ground water table.
- Use of water under high pressure for demolition operations (hydro-demolition)
- Construction of bridge piers and other structures in large bodies of water including use of cofferdams, etc.
- Proper construction/installation of silt fences [1, 3].

Conclusion

The collaborative undertaking involving a practitioner in the field of hydraulics and drainage in the private industry has resulted in the following.

1. Most, if not all, of the fundamental civil engineering concepts that relate to the general area of the course need to be kept in the coverage due to general reasons as elaborated on above.

2. To make the course more relevant to the construction management graduates, an infusion of diverse construction related topics, detailed above, is needed for future offerings. This is to be realized through an integration of new topics in the current topics of the course so that students do not feel a forced introduction of construction related topics in a course which otherwise seems to be highly civil engineering oriented.

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