

CONSTRUCTION MANAGEMENT STATICS

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Abstract: Construction Management has become a growing discipline across the US in recent years. Construction Management graduates basically build structures based on designs by engineers and engineering technologists. Construction managers need to understand the nature of forces acting on the structures they construct, and that is why they need Statics. However, they are neither expected nor should they be allowed to design, and that is why they need a different kind of Statics.

This paper presents the approach developed to teach Statics to Construction Management students at Sam Houston State University where the author has taught in the past three years. It shows the similarities and differences of teaching Statics to both Construction Management students on one side and to Engineering and Engineering Technology students on the other side. But more importantly, it outlines what needs to be implemented to fit the needs of Construction Management graduates at actual construction sites. Recommendations are made based on this new approach of teaching Statics to Construction Management students.

Key Words: Statics, Construction Management, Design.

Introduction:

Statics is an important subject in many Engineering and Engineering Technology disciplines especially Civil Engineering and Civil Engineering Technology, and Architectural Engineering fields. Construction Management graduates deal extensively with architects to construct structures which are designed by civil engineers. Statics is a fundamental and required course in Civil and Architectural Engineering curricula. Many Construction Management programs require Statics in their curriculum for various reasons including accreditation requirements.

The author has taught Statics to Engineering students for ten years at Penn State University. Simultaneously, he also taught Statics to Engineering Technology students at the same institute. He made several presentations and published papers on the differences on teaching Engineering Mechanics courses which include Statics and Strength of Materials between Engineering and Engineering Technology students [1, 2]. In these papers and presentations, it was demonstrated that teaching Statics to Engineering students should be different than teaching it to Engineering Technology students despite being the same subject because of the fundamental differences between the two disciplines. Engineering is based on

theoretical components while Engineering Technology is more concerned with the applied side of Engineering.

At Sam Houston State University in Huntsville, Texas, the Construction Management Program offers Statics to its students. The author has taught this course for the past three years. The course is an elective course, but soon it will be a required course. Because of the fundamental differences between Construction Management and Engineering, Statics needs to be taught differently. The author has developed an approach to teach Statics to Construction Management students based on his experience in the construction industry including seven years with the North Carolina Department of Transportation, and on his teaching at Penn State University.

Statics:

A branch of Engineering Mechanics, Statics deals with bodies in equilibrium [3, 4, 5]. It is a fundamental course for most Engineering disciplines. The few exceptions include Chemical, Electrical and Computer Engineering. Statics is a foundation Engineering course in the fields where it is needed. In Mechanical Engineering, Statics is needed for subsequent design courses like Machine Design. Civil Engineering curriculum contains many courses that depend extensively on Statics including Strength of Materials, Structural Analysis, Steel Design, Concrete Design, Timber Design, Foundation, and Bridge Engineering among other advanced courses.

Students learn how to deal with the different types of forces acting on an object. Equilibrium analysis is the crux of this subject. At the end of the course, Statics can be summarized as: $\sum \mathbf{F} = 0$ and $\sum \mathbf{M} = 0$ using the popular Newton's 2nd Law of motion: $\mathbf{F} = \mathbf{M}\mathbf{a}$ with the acceleration $\mathbf{a}=0$ for bodies in equilibrium. Students have to learn how to handle all kinds of forces and moments to use the above equilibrium equations.

Statics in Engineering and Engineering Technology:

Engineering programs and Engineering Technology programs have different missions. Engineering is more theoretical while Engineering Technology is more applied. Accordingly, the two fields have different entry requirements especially Math and Physics, curriculum components, and job placement after graduation. All Engineering programs (with very few exceptions) require four-year education. Engineering Technology can either be a 4 year program in which graduates are called technologists, or two-year programs which graduate technicians.

The above paragraph demonstrates exactly why Statics should be different in these two programs. Engineering Statics should be Calculus based and students should be able to establish everything from scratch and in all general cases. For example, they need vector analysis in 2-D and 3-D applications, and they need to find the centroid and moment of inertia of any shape using integration. On the other hand, Engineering Technology is Algebra based. Students need to learn the more common and practical 2-D applications only. The 3-D real-life applications are usually handed to engineers to design. Engineering Technology students need to learn more

practical techniques like finding the centroids and moment of inertia using tables and computer software programs like AutoCAD.

ABET Requirements:

In its curriculum criterion for Engineering programs [6], ABET requires “one and one-half years of engineering topics, consisting of engineering sciences and engineering design appropriate to the student's field of study.” For many Engineering disciplines, Statics is one of those engineering topics. For Engineering Technology programs, ABET curriculum criterion [7] states that “the technical content of the program must focus on the applied aspects of science and engineering.” Statics is one way to fulfill this ABET requirement for many Engineering Technology programs.

Construction Management:

The Occupational Outlook Handbook by the US Bureau of Labor Statistics [8] states: “Construction managers plan, coordinate, budget, and supervise construction projects from early development to completion.” Construction Management is a vital field nationally and internationally. Construction activities serve as an index to the strength of the economy in the US and across the World [9]. Poor construction indicates a poor economy status and vice versa [10].

Many universities offer various Construction Management programs across the US from certificates, BS degrees, to official Master's and even Ph. D. degrees. Currently, it is one of the most rapidly growing fields in the institutes of higher education. Traditionally, Construction Management has been a program within the Civil Engineering Discipline. However, it has been also offered relatively recently outside Civil Engineering departments. In some cases, it is a standalone department like the case with Texas A&M University.

Accreditation of Construction Management:

The American Council for Construction Education (ACCE) located in San Antonio, Texas is the main accreditation agency for Construction Management Programs. Many programs seek ACCE accreditation including for example the Construction Management program at the Central Connecticut State University.

In its criteria [11] and rules for accrediting BS Construction Management programs, ACCE requires 20 credit hours out of the 120 minimum total credit hours in the Construction Sciences Category. Out of these 20 credit hours, three must be in Fundamentals of Design Theory. The ACCE manual cites Statics as an example to fulfill this requirement.

Statics for Construction Management:

Many Construction Management programs offer and require Statics in their curriculum. For instance, the ITT has CM330-Statics and Strength of Materials in its Construction Management curriculum. Another example is Fairleigh Dickenson University which has EGTG 2221- Statics as a required course in its Construction Engineering Technology program.

Looking at available online Statics syllabi for many Construction Management programs and talking to many faculty members who teach it, the following observation can be made. Statics in Construction Management is being taught the same way by which it is taught in Engineering and Engineering Technology. Little or nothing is done differently than the traditional approach.

Statics in Construction Management at Sam Houston State University:

Sam Houston State University offers a Construction Management Program. The curriculum program currently does not require Statics. Knowing the importance of design courses to Construction Management, the author offered Statics as an elective course for the past three years. The process of making Statics a required course was initiated, and it is expected to be completed soon. The course ITEC 3375- Statics will be a required course in the 2013/2014 year.

The author took this chance to develop this Statics course at Sam Houston State University to fit Construction Management based on his professional experience as a structural and transportation engineer, and as a faculty member teaching Statics to Engineering and Engineering Technology students at Penn State University.

To start with, Construction Management graduates are exclusively concerned with managing the construction phase and not with the design aspects of the project. Typically, the architect who is in charge of the project consults with various engineers to produce the design. Besides civil, structural, mechanical and electrical engineers, the architect might consult with interior designers as well. The design will then be drawn by CAD technicians prior to the construction phase. That is, the actual design will be transformed from design documents to construction drawings.

Construction managers are those who build structures. That is, they transform the engineering design presented to them as construction drawings into standing structures. This is the reason why they need some exposure to design in their education. They need minimum knowledge of design concepts to construct structures. However, they are neither able nor expected to design. In fact, construction managers are legally required and they should always get written approval from the architect or engineer before any change in design is made. Otherwise, catastrophes will likely happen. A case in point is the infamous structural collapse of the Hyatt Regency Hotel in Kansas City, Missouri in 1981. In that incident, 114 people were killed and many more were injured. The collapse resulted because of a simple change in the design during the construction phase [12]. The contractors used a rode connection that is slightly different from the original design.

Accordingly, there is a need for Statics in Construction Management. However, there is a need for a different kind of Statics: a Statics course that fits the background of the students and prepares graduates to perform their job in the field. This has been the focus of this Statics course at Sam Houston State University.

The emphasis in this course has been on concepts rather than details. Students need to know the type of forces acting on structures. They need to quantify them in a general manner and not in

detailed ways. They do not need vector analysis. Rather, they only need to know simple addition of forces using the method of rectangular components. Unlike Engineering and Engineering Technology Statics, treatment of forces should be and is limited to 2-D applications as most of the structural frames are 2-D in real life. Students have to understand the concept of moment. Equilibrium analysis should be an integral part of the course. Construction Management students do not have extensive Calculus and Physics background, and that is taken into account. An introduction to the mathematical concepts needed in this course is made at the beginning of the semester. This serves as review for many students. It also serves as a stress relief for them.

A lot of emphases are made on field applications. Examples of using Statics concepts in actual construction sites are frequently cited. Such examples are cited from day one until the end of the course.

An important goal is to enhance communications between construction managers and engineers especially when changes in design are warranted. This course allows construction managers to identify potential problems and communicate them to engineers. Construction managers will have the background needed to interact with the engineers. It gives construction managers the confidence to question design choices based on practical considerations. In essence, a more conceptual approach with little attention to design details is followed.

Students loved this approach for many reasons. First, they seem to like it because it involves the use of Statics in real life. They like it because it illustrates the interaction between construction managers and engineers in the construction industry. The use of more concepts and less design details seems to be the most liked feature of this approach. Several graduates indicated that they are using what they have learned in this course in their line of work.

Challenges:

The biggest challenge in teaching Statics to Construction Management students is their background prior to entering the program. The course must take into account that these students do not have strong and extensive Math and Physics backgrounds. The course must therefore allocate enough portions to introduce and review relevant Math and Physics concepts.

Motivating students who are focused on management rather than sciences is another challenge that needs to be accounted for. This can be done by avoiding unnecessary detailed design calculations. Instead, a conceptual approach needs to be adopted.

To teach such a course, the instructor must have enough professional and educational backgrounds. He/she must be able to understand the connection between Engineering and Construction Management.

Another challenge is finding a suitable textbook for this subject. There are abundant Engineering Statics textbooks in the market. Very few textbooks are suitable for Engineering

Technology Statics. Suitable textbooks for Construction Management Statics do not seem to exist at this point in time. Accordingly, the instructor needs to use existing textbooks with many and various modifications.

Many educators especially in Engineering and Sciences are likely going to question this approach. This is based on their theoretical background. Many of those lack industrial experience as they always focus on theory more than real-life applications.

Summary and Recommendations:

A new approach to teach Statics in Construction Management has been implemented at Sam Houston State University. This approach takes into account the background of the students prior to entering the Construction Management program as well as their needs upon exiting college life into the workforce. It focuses more on concepts rather than design details. The approach seems to fulfill its goals. One of which is to make graduates capable of communicating more effectively with the design team in the workplace.

It is suggested that this approach be adopted by other instructors at other institutes of higher education. Other instructors who are using similar approaches need to share their experience. A new textbook in Statics addressing the needs of students in Construction Management programs is needed.

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