An End User Approach to Teaching Specifications

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This paper presents a method for teaching specifications and estimating that emphasizes linkage of drawing content to accompanying specification information to determine project details for estimating and bidding which are complete and which incorporate an intent or strategy for their execution. In this approach, the CSI *MasterFormat* is taught using an organizational approach (one that focuses on how the format is organized and how to find information within its structure) instead of a specification development approach (i.e., those approaches that teach the organizational structure of the CSI *MasterFormat* by having students develop specification content, then organize and write a specification(s) using the CSI *MasterFormat* structure). A set of non-CSI *MasterFormat* based specifications is used for this. Students are required to reorganize the content into specifications using the CSI *MasterFormat*. Thus, they must read and understand the content, and develop understanding of how CSI *MasterFormat* specifications are organized; two important learning objectives in Specifications courses. Linkage of specifications and drawing content and proficiency in developing descriptive job details which are complete and include execution strategy are taught and developed using a project that requires students to utilize the content of the specifications they converted into the CSI *MasterFormat*.

Key Words: Specifications, Estimating, CSI *MasterFormat*, Estimate Detail, Job Detail

Introduction

A good understanding of specifications and their relationship to construction drawings is a key component in good project management, planning, and execution. And while this is an undeniable fact, courses in Specifications and Estimating, quite often, do not adequately make and/or emphasize this connection to students when taught in a formal learning environment. The causes for this are sometimes rooted in the approach used to teach these courses. They include methods that focus on writing specifications, methods that focus on reading specifications and discussing the content, and methods that combine the two. Additionally, when development of estimate details is included in course content, it's taught without appropriate consideration for its execution, i.e., there is little to no indication of execution strategy included in the detail descriptions. Generally, all courses include some coverage of the CSI *MasterFormat*.

This paper presents the methodology used in a Specifications and Estimating course taught by the writer. Central to this approach is (1) a thorough understanding of the CSI *MasterFormat* Three-Part format; not just from an organization perspective, but from a structural perspective (i.e., what the category titles mean with regard to the type of information contained in each of them), (2) a thorough understanding of the CSI *MasterFormat* numerical scheme, (3) a thorough understanding of construction drawings and the symbols and terminology used by them to convey information regarding what is required, and (4) the importance of presenting all of the information gleamed and extracted from all of the construction documents into job details that conveys a clear construction management strategy and/or plan of execution. Item four highlights the end-user prospective that is the basis of this approach. In short, specifications should be utilized with drawings to develop job details that have descriptions which are complete and which convey a strategic plan and approach for their successful execution. The job details developed can be used to generate estimates for bids, schedule activities, materials list, procurement activities, project control documents, and other tools necessary for successful job management. The author uses the approach summarizes in this paper in a course that is generally taught three times a year.

Drawing Symbols and Fundamentals

The course begins with a review of common symbols on construction drawings. Building construction project management is the focus of the curriculum this course is taught in; hence, drawing symbols commonly used for materials and systems in this industry are the primary focus of this review. This occurs in week one. A review of plan reading and basic drafting fundamentals is also conducted using construction drawings assigned for the first project (Spence, 1991). This starts in week two. Major topics covered during this review include (1) category of drawings, a topic used to illustrate the alphabetized system utilized for drawings and how this system can provide the first indications of the scope required and the specifications needed to supplement and complete scope definition, and (2) types of drawings found in construction packages. Drawing symbols, and what they represent, is also covered and is a major topic in this review. This topic does not just focus on identifying drawing symbols, but discusses and emphasizes how the information gained from a symbol can aid in identifying where specification information for it can be found in specifications that utilize the *CSI MasterFormat*. Thus, the process of linking the drawings to specifications begins here. The connection of the two is facilitated by class activity that require students to identify symbols on the drawings and list or state the *MasterFormat's* Level One number(s) and/or title(s) where the accompanying specification information can be located. Additionally, this activity provides an opportunity for course participants to crystallize the drawing symbol information covered during the review in week one.

As stated, the information represented by the symbols is not just presented from the point of view of simply highlighting the information conveyed by it to the plan reader. Also emphasized is the symbol's connection to the specifications – particularly to CSI *MasterFormat*, and where in the format's organizational structure information necessary to completing the scope requirements for the item can be found. Hence, at this point, the emphasis on drawings and drawing symbols is two-fold: (1) their use in conveying project scope and other instructional information and requirements, and (2) their use as an aid for identifying the specifications needed to complete the information contained on them

The CSI *MasterFormat*

The CSI *MasterFormat* is the organizational system used for conveying, organizing, and presenting the information contained in specifications. It utilizes a numerical organizational scheme and format to locate the specification(s) needed, and a three part format system for organizing the information contained within the specification. It also utilizes additional subtitles and divisions within the three category headings that comprise the three major parts of the format to aid in the presentation of the material contained within the specification(s) (Rosen & Regener, 2005) (Construction Notebook News, 2008) (Construction Specification Institute, 2008).

The CSI *MasterFormat* is taught in distinct parts to course participants. First, the numbering scheme and titles the *MasterFormat* utilizes to locate specification information is presented. Level One numbers and titles utilized by the format are introduced first with particular emphasis on where the Level One numbers are located in the numbering scheme. This is done in week one. Next, Level Two and Level Three numbers and titles are introduced, and the location of these numbers in the numbering scheme is presented. This is also done in week one. The CSI 16 division, 5 digit numbering scheme, or the expanded 48 division, 6 digit numbering scheme can be used. Generally, this writer uses the 16 division format system to explain the concepts for the *MasterFormat* system's use, as well as for tests to assess students understanding of them, and alternately uses each system for project work assigned in class.

Finally, the Three-Part Format is presented. Titles and subtitles used within the three major categories, as well as discussion of types of information commonly found therein, are presented. Additionally, example entries are provided to illustrate the methods the format uses to conveys information to other sections within each specification, and entries are also provided that illustrate the methods the format uses to convey information to or highlight the need of information from other specifications. This is done in Week 3.

As mentioned above, week 2 is devoted to construction drawings and the topics noted. Classroom discussion centers on students identifying symbols shown on drawings, what they represent, and establishing connections to the *MasterFormat's* Level One number(s) and title(s) where specification information for the items represented by the

(1) Name the following symbols and Three (3) Level One Division Numbers in the Specifications where additional information for what the symbol depicts might be found.

A. 

B. 

Name_____

CSI Divisions_____

Name_____

CSI Divisions_____

Figure 1: Example of Quiz questions used to develop linkage between drawing symbols and CSI ***MasterFormat*** Level One division numbers.

symbol would be found. This identification procedure continues throughout the duration of the course and is utilized for all concepts presented and topics covered in it.

A quiz is given at the end of week 2 on the drawing symbols assigned for review in week one. The quiz assesses three student skills. First, it assesses the student's knowledge of the *MasterFormat's* Level One numbers and titles. Second, it assesses the student's knowledge and recognition of basic/common construction drawing symbols. Last, and important for this approach, it aids in reinforcing the process of developing the student's ability to connect information contained in the drawings to the specifications where supplemental information required for complete scope development for the item can be found (see Figure 1).

The process of developing the student's ability to connect information contained in the drawings to the specifications where supplemental information required for complete scope development for the item can be found is continued and further developed by means of the two projects. The first project, described below, is a residential house project (Spence, 1991). Students must complete this project individually. The second project is an industrial/commercial project that students complete as a part of a project team. The learning outcomes from each project are similar. However, the house project has an additional learning component that is key to the overall objective for this approach to teaching specifications and estimating: it will be discussed below.

First Project - Part I

A set of specifications from a residential home project (Spence, 1991) is used to teach and crystallize students' understanding of the CSI specification format method. The original specifications do not utilize CSI *MasterFormat* (see Figure 2). The objective of Part I of the project is to reorganize the original house specifications into a set formatted using the *CSI MasterFormat*. After presenting the *MasterFormat's* level I numbering scheme and titles to the students, the project is introduced. The first phase of this project requires the students to rename and replace the project headings used in the original specifications with the proper *MasterFormat* level one heading and its accompanying level one number. However, the original specification set uses category headings, in some instances, that do not directly coincide to level one titles used in the CSI format. Thus, the student is also required to read through the entire specifications to determine the *MasterFormat* level one category that best fits the information contained in the original specification. Reading the entire specification also reinforces the point that all specifications should be read in order to gain a thorough understanding of project requirements prior to soliciting for and/or beginning any work on it.

The second phase of this project begins shortly after the first phase and then runs concurrently with it. As previously mentioned, the Level Two/Level Three titles and the accompanying numbering scheme is presented to the students in week one. At this point in the course, emphasis is placed on the "Level" scheme providing (1) the system's uniform organizational methodology for all projects utilizing this system and, as a result, how it provides a consistent means for finding project information regardless of project type and/or location; and (2) the provisions that allow for adaptability within the system's uniform scheme and structure, and how this provides the means for customizing elements of the *MasterFormat* to meet individual project needs. Content in each section of the original specification (i.e., each item, sentence and/ or listing in the original specification) is evaluated to determine the

Division 2: Concrete(D3)

Sec. 1. Scope. This division includes all concrete and related items required to complete the work indicated on the drawings and/or specified. ***(03050)*****(Part 1: Summary)**

Sec. 2. Materials. ***(03050)*** **(Part 2: Materials)**

(a.) Portland cement shall meet the requirements for Type 1.

(b.) Aggregates.

(1) Fine aggregates shall be natural sand, or sand prepared from inert materials having similar characteristics, if approved by the architect.

(2) Coarse aggregates shall be crushed stone, ground clean and free from foreign matter. Size range for walls shall be designated, as "no. 4 to 3/4".

(c.) Water. Water used for concrete work shall be clean and free from injurious amounts of oils, acids, alkalies, organic, or other deleterious substances.

(d.) Metal reinforcement. Wire mesh reinforcing shall conform to A.S.T.M. Designation A82-34 and shall be free from excessive scale, rust, or coatings, which reduce bond to the concrete. ***(03050, 03200, or 03220)***

Sec. 3. Depositing Concrete. ***(03050)*** **(Part 3: E/I/A)**

(a.) Deposit concrete as nearly as practicable in its final position to avoid segregation due to rehandling or flowing.

(b.) Retempering. No concrete that has partially hardened or has been retempered shall be used.

(c.) Compaction. Concrete shall be thoroughly compacted by vibrating during placement.

Sec. 4. Curing. All concrete shall be covered with a polyethylene plastic, airtight cover for three days at 70^{o} F or five days at 50^{o} F. ***(03050)*** **(Part 3: E/I/A)**

Sec. 5. Cleaning. Clean all exposed concrete surfaces and all adjoining work which has been stained by the leakage of concrete. ***(03050)*** **(Part 3: E/I/A)**

Figure 2: Example of specification in its original form with CSI Three Part Format components identified for content (Spence, 1991). Used with permission from Glencoe, MacMillian/McGraw-Hill Inc.

correct or most appropriate level two/level number and category heading for it. Thus, at the end of this phases I and II of the project, the students have placed the contents of the original specification with its proper CSI level one number and category, and with its proper level two or level three number and category (see Figure 2).

The third phase of this project begins after completion of phase I and II. In this phase, students are required to reformat the contents of the original specifications into a specification formatted using the CSI Three Part Format methodology. Students must first identify the Three Part Format category for each entry of the original specification (see Figure 2). Next, they reformat the content into a CSI *MasterFormat* specification (see Figure 3). Each specification developed includes a "Part I Summary – Scope Includes" section and a statement from the original specification content which describes the scope for it. Students are instructed to develop a statement when one does not exist within and/or for the contents of the original specification. The remaining Three Part Format categories

03050 Basic Concrete Materials and Methods

Part 1 General

1.01 SUMMARY

A. **Section Includes:** This division includes all concrete and related items required to complete the work indicated on the drawings and/or specified.

Part 2 Products

2.01 MATERIALS

A. Portland cement shall meet the requirements for Type 1.
B. Fine aggregates shall be natural sand, or sand prepared from inert materials having similar characteristics, if approved by the architect.
C. Coarse aggregates shall be crushed stone, ground clean and free from foreign matter. Size range for walls shall be designated, as "no. 4 to 3/4".
D. Water used for concrete work shall be clean and free from injurious amounts of oils, acids, alkalies, organic, or other deleterious substances.
E. Metal reinforcement: Wire mesh reinforcing shall conform to A.S.T.M. Designation A82-34 and shall be free from excessive scale, rust, or coatings, which reduce bond to the concrete.

Part 3 Execution

3.01 ERECTION/INSTALLATION/APPLICATION

A. Depositing Concrete: Deposit concrete as nearly as practicable in its final position to avoid segregation due to rehandling or flowing.
    1. Retempering: No concrete that has partially hardened or has been retempered shall be used.
    2. Compaction: Concrete shall be thoroughly compacted by vibrating during placement.
B. Curing: All concrete shall be covered with a polyethylene plastic, airtight cover for three days at 70^{o} F or five days at 50^{o} F.

3.02 ADJUSTING/CLEANING

A. Cleaning: Clean all exposed concrete surfaces and all adjoining work which has been stained by the leakage of concrete.

Figure 3: Example of concrete specification content reformatted using the CSI ***MasterFormat*** Three Part Format. Original specification content from Spence (Spence, 1991).

titles and their accompanying sub-category titles are utilized as necessary by the students to present the information contained in the specification in the most efficient, practical, and effective manner that they can develop. Students are encouraged to make use of references to other specifications developed by them in this exercise, use the subcategories such as "items provided but not installed under this specification" and "items installed but not provided under this specification," and make use of reference standards in order to learn their proper use. They are also given the leeway to break out and/or separate the original specification content as discretely as they see fit as long as a CSI category and level two, level three, or level four title exists for the entry. This also discourages duplication of effort between students while still allowing collaboration and peer-learning (i.e., it's very easy to spot duplicate efforts).

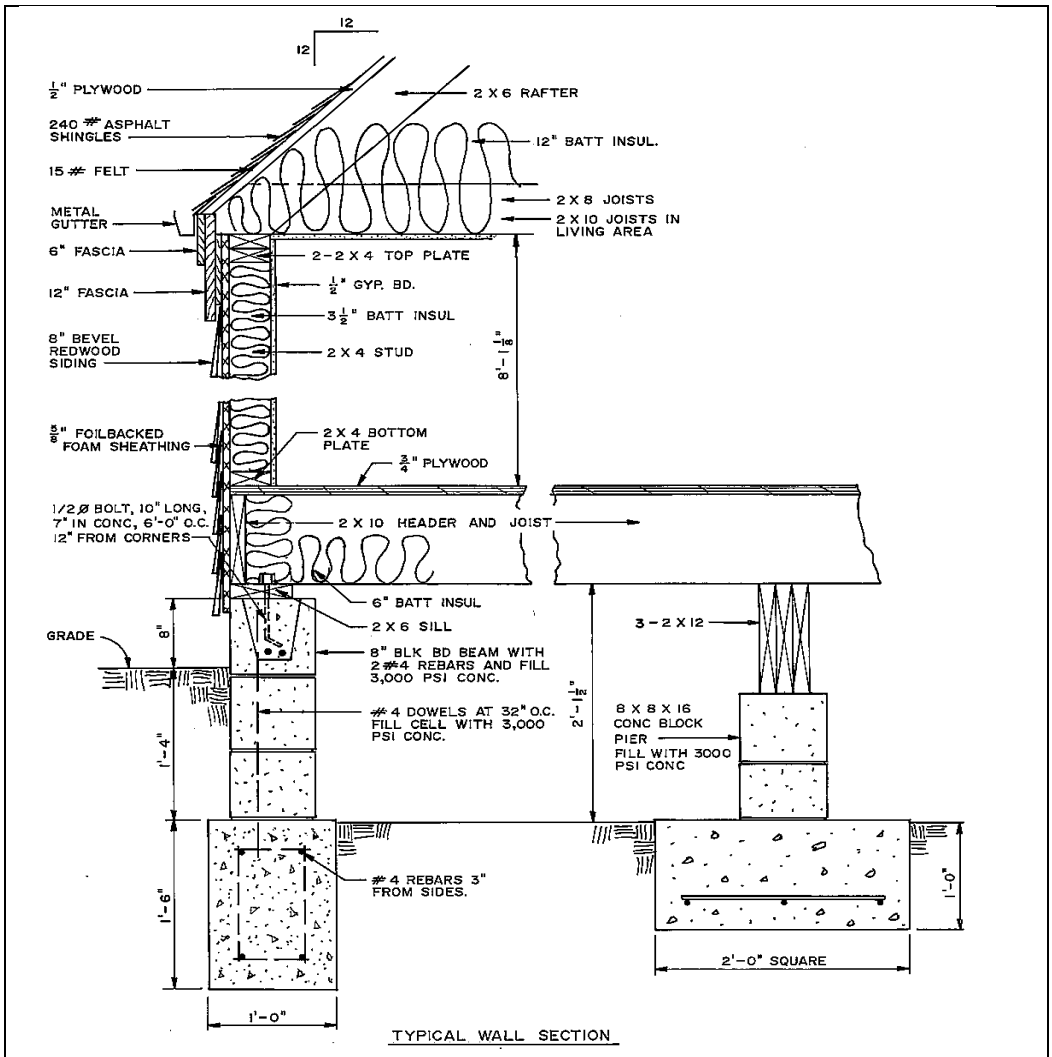

Figure 4: Wall section used for part 2 of the project (Spence, 1991). Drawing Designation: A-4. Used with permission from Glencoe, MacMillian/McGraw-Hill Inc.

Students are also required to develop a table of contents listing the specification number, its title, and the page number where the specification can be found. Additionally, formats for General Conditions and General Requirements are covered in the class and included in the original specification contents. Students are required to developed CSI *MasterFormat* specifications for this content also and include it. The entire set of specifications developed is submitted in a binder with a cover sheet.

At this point, students have created a re-ordered set of specifications in the CSI *MasterFormat.* The project has crystallize the following objectives; (1) learning the CSI level 1 and level 2/level 3 numbering system, (2) learning the CSI level 1 and level2/levl 3 category titles and subtitles, and (3) learning the CSI Three-Part format, how its organize, the categories and sub-categories utilized in the Three-Part format, and how to make use of the categories and organization of them to create specifications that can be used to effectively convey information. By doing this, the student learns the structure of the CSI format, and thus, learns how to efficiently find and retrieve information in the CSI specification system, the ultimate goal for the end user approach methodology, and a fundamental and important learning component key to the overall objective for this approach to teaching specifications and estimating.

Table 1: Estimate Detail Sheet Developed For Concrete Foundation for Foundation Wall

Description	Comments/ Calculations	Dwg. No.	Spec.	# Of Items	L	W	H	TO. Unit	Est. Unit	Qty.
House Foundation										
(A) North Foundation Wall	32' Long Wall	S-1								
(i)Grade Beam: Cast In Place Concrete										
(1) Concrete Footing, 3000 psi Concrete	Footing Trenches to be excavated; forms to be omitted. Consolidation by Vibration only.	S-1, A-5, A-6, A-7, A-4, S-3	02300 – 3.02.A.3; 03050 - 2.01.(A - D)		32	1	1.5	Ft.	Ft^3	48
(2) #4 Rebars	Placed 3" from sides	A-4, S-3								
(3) Curing Material	Polyethylene Plastic - Airtight cover - 3 days at 70F or 5 days at 50F	S-1	03050-3.01B		32	1		Ft.	Sq Ft	32
(5) Stirrups	6" on center	A-4			32			Ft.	Each	63

First Project – Part II

The objectives of this part of the project are twofold. First, it continues the process of developing the student's ability to connect information contained on a drawing to those *MasterFormat* formatted specifications where supplemental information required for it can be found. Additionally, it aids in the goal of reinforcing the importance of presenting all of the information gleamed and extracted from all of the construction documents into job activity details with descriptions that convey a clear construction management plan of execution, a central goal of the class. Students are required to develop the job details for five systems contained in the project.

The estimate details shown in Table 1 are for the concrete components of the north foundation wall. The "Descriptions" and "Comments/Calculations" entries are the columns that are used to fully describe the job detail and the plan/approach incorporated into the description for its execution. Additionally, the drawings and the specifications used to develop the detail are shown in "Dwg. No." and "Spec." columns of the tables as well. Entries in the "Spec" column provide the number of the specification where the content for the detail was obtained and the Three Part Format item number where the content is located within the specification. This ensures that students have reviewed both the specifications and drawings to develop the detail and it provides reviewers a means to check it. Also, this provides students with additional training in connecting drawings content to specification content, and it also provides additional training in connecting drawings to locations within the *MasterFormat* system where information to complete job detail requirements for the items displayed on them can be found. Lastly, note that since students use the CSI *MasterFormat* specifications that they developed previously for this exercise, no two students will have the exact same specification information listed in the column entitled "Spec."

In the examples shown, drawings are use to establish the direction needed to identify the location of the wall under consideration, the length of the wall, as well as other estimate/job details required for the wall's construction. For

example, Figure 4, designated as drawing A-4, shows dimensional information for the concrete details developed and shown in Table 1, and reinforcement requirements for it. However, the compressive strength of the concrete needed for the element is not shown on the illustration. Students have to go to another drawing, S-3, to find that information. The cross-sectional dimension of the element can also be obtained from A-4 (Figure 4); however, drawing S-1, the foundation plan, is needed to find the element's length. The north arrow needed to identify the wall is shown on the floor plan, a drawing labeled A-1 in the set. Thus, all of the aforementioned drawings, as well as others needed for development of this detail, are listed in the "Dwg. No." column. However, development of this detail is not complete. The student must also read the specifications to obtain information on curing requirements concrete mix ingredient requirements, concrete placement requirements (i.e., "consolidation by vibration only"). All of this information is necessary to complete the requirements of this project activity. However, the symbol for concrete on the aforementioned drawing (s) should trigger the thought "Division 3" in the student's mind: this is an example of the linkage this writer seeks to establish between drawings and CSI formatted specifications, and is one of the major objectives in this class. (Note: This class stops at job detail development as it relates to estimating. Pricing and estimating principles are taught in another course.)

All of the drawings and specifications used for job detail development are listed on the detail sheet. This reinforces the linkage between drawings and specifications, and additionally, provides a way to check student work and the completeness of the job details and takeoffs developed by them.

Finally, an entry from the earthwork specification, 02300, illustrates how information contained in specifications can be used to incorporate plan of execution aspects into scope development. Note item 3.02-A-3 in the specification, where the "3" connotes "Part Three - Execution." "It reads

"Footing trenches may be excavated to the exact dimensions of the concrete, and side forms may be omitted if concrete is poured in clean-cut trenches without caving. Place footing and foundations upon undisturbed and firm bottoms. The contractor shall not pour foundation footing until the architect inspects and approves the bearing."

Options for casting the grade beam include exaction to the exact dimensions of the concrete or using formwork if soil conditions do not allow. In the "Comments/Calculations" column of the detail sheet, the basis for execution for this detail is listed as "Footing Trenches to be excavated; forms to be omitted." This highlights that the basis for this work is no forms; an adjustment to the cost of this item must be made if formwork must be used. Thus, this entry's description provides an element of the execution plan included in the job details.

While it is not necessary to provide execution elements for each job detail, the elements should be provided for all entries that reflect execution decisions and/or for items that reflect an option chosen when multiple are options available. Additionally, execution elements and the entries accompanying them provide information that can be useful when making risk and unlisted/contingency assessments. And since they provide the basis for the method of execution assumed for the project, this information is useful and aids in quantifying the impacts of scope alterations that result from project changes.

Summary

This method of teaching specifications and estimating focuses on end users of the information and emphasizes the following key concepts: (1) understanding the CSI *MasterFormat's* numbering scheme for locating specifications and the organization scheme it uses to arrange information contained within them, (2) establishing a linkage between symbols and other information contained on drawings to the CSI number(s) and division(s) supplemental information for the item conveyed by the symbol can be found in, (3) using the drawings and specifications together to develop job details, and descriptions for them, which are complete and that incorporate an execution strategy. The details developed then provide the project's basis, and any changes, adjustments, deviations, or additions to the basis can be tracked, managed, and controlled. Getting the job details "right," which includes capturing execution methodology intent, approach, and/or strategy, is fundamental to successful project control, execution, and completion.

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