Volume 4
Number 1

Spring 1999

The Journal of Construction Education

K. C. Williamson III, Ph.D., ***Editor/Publisher***

Thomas H. Mills, ***Associate Editor***

A Tri-Annual Publication of
The
Associated Schools
of
Construction

ISSN 1522 8150

The *Journal of Construction Education* (ISSN 1522 8150) was founded in 1996 by the Associated Schools of Construction, an association of 92 international colleges and universities with construction education programs. The purpose of the *Journal* is to provide an important process necessary for the preservation and dissemination of manuscripts that report, synthesize, review, or analyze scholarly inquiry. The *Journal* is an important way of our focusing international attention on and contributing to the understanding of the issues, problems, and research associated with construction education and training. The recognition of scholarly work within the realms of curriculum information, contemporary educational practices, educational research and instructional application development within construction departments, schools and colleges, and industry are the reasons for the *Journal's* existence. The *Journal's* mission is to provide construction educators and practitioners with access to information, ideas, and materials for improving and updating their understanding of construction education and training. It is also intended to help its constituency become more effective in developing the talents of learners within construction programs. This *Journal* is not only a living textbook of construction education, but also a perpetual and dependable learning source for construction professionals whether they are within academia or within industry. The *Journal* will be published tri-annually (Spring, Summer, and Fall issues). The divisions of the *Journal* include invited and editorially reviewed Book Reviews and Teaching Profiles, and blind peer reviewed Educational Practice and Research Manuscripts.

Editor/Publisher
Kenneth C. Williamson III, Ph.D.
Langford Building A, Room 427
College Station, TX, 77843-3137
Tel: 979.845.7052
E-mail: jce@taz.tamu.edu

Author Instructions for Submitting

Submission to the *Journal* implies the manuscript is original and is not being considered nor has been published in whole or part within another journal. It is encouraged that author(s) present their works at annual conferences and other conferences. In that papers submitted, reviewed, presented or published within conference proceedings are considered a "work-in-progress," it is expected that manuscripts submitted to the *Journal* will reflect changes resulting from that presentation process. Manuscripts not modified in part by this process will not be considered to represent an original work and the *Journal* will not consider the manuscript publishable. Manuscripts accepted for publication will require authors to sign the Assignment of Copyright Agreement. This agreement must be signed and submitted with the manuscript's review documentation.

Authors should prepare manuscripts according to the Publication Style Guide, which conforms to the Publication Manual of the American Psychological Association (4th ed). All manuscripts must include an abstract, which is limited to one paragraph, containing a maximum of 200 words. Immediately following the abstract, a maximum of five key words must be included. Typing instructions and instructions on preparing headings, paragraphs, text body citations, tables, figures, references, appendices, and abstracts appear in the Publication Style Guide. All manuscripts are subject to editing for personal, university, program and sexist language. Manuscript length per se is not an issue, although length should be relate to the manuscript's "information value."

The *Journal* considers it unethical for authors to withhold the data on which their conclusions are based from other competent professionals who seek to verify the substantive claims through reanalysis and who intend to use such data only for that purpose, provided that the confidentiality of the participants can be protected and unless the legal rights concerning proprietary data preclude their release. JCE expects authors submitting to the *Journal* are expected to have available their data throughout the editorial review process and for at least five years after the date of publication.

Manuscripts being submitted for review by the JCE Board of Reviewers must be submitted electronically from the JCE Website. The work submitted by authors will be circulated to review board members electronically and all correspondence with the authors, editors, and review board members will also be handled in this manner. The Editor and Associate Editor are responsible for managing the electronic review process.

Educational Practice and Research Manuscripts that appear in the *Journal* are subjected to a blind review by a minimum of three members of the JCE Board of Reviewers. All contributions, whether invited or unsolicited, are critically reviewed. Manuscripts must demonstrate clear communication and authority of knowledge of the topic to ensure acceptance. Authors are encouraged to make liberal use of multimedia to visually present data and ideas. Reviewers are selected from those having content knowledge concerning the manuscript's topic. This review process generally takes from four to six weeks. Authors are notified upon receipt and completion of the review process.

The Journal of Construction Education

Spring 1999

Volume 4
Number 1
pp. 1 – 102

Educational Practice Manuscripts

General Manuscripts

Other

Journal of Construction Education
Spring 1999, Vol. 4, No. 1, pp. 6-16

1522-8150/99/$3.00/Educational Practice Manuscript

Teaching Application-Based Estimating: Integrating the Workplace and the Classroom

W. Max Kirk
University of Nebraska – Lincoln
Lincoln, Nebraska

Estimating in construction is often considered an art, which takes time and experience to cultivate. However, estimating can be taught effectively in a construction management program by integrating the workplace and the classroom to better prepare students for what they will face upon graduation. Described in this paper are several successful application-based teaching methods which I have developed over eleven years of teaching estimating. These methods allow students to develop the skills and insights necessary to successfully perform an estimate.

Key Words: Estimating, Construction Management, Application-Based Teaching

Introduction

Estimating in the construction industry can be defined as a compilation of material and labor prices submitted as a competitive bid for the cost of a building a particular project. Yet, as simple as this sounds, estimating goes far beyond punching out numbers to come up with the lowest possible bid. There is an art to estimating which takes time and experience to cultivate.

Many contractors have stated that graduates will learn more about the construction industry as a whole from performing estimates during their first two years on the job, than their counterparts who are hired as project managers or assistant superintendents. The reasons are obvious – estimators will read more specifications, examine a wider variety of working drawings, and gain more knowledge on materials and methods than those who only work on one or two projects in the same time span. I definitely agree with this statement from my previous professional experience as an estimator and project manager and currently as a consultant in the area of estimating. The importance of estimating to a construction firm cannot be overemphasized.

Regrettably, estimating isn't always given the status or importance that it deserves when compared to other subjects taught in construction curriculums. One reason is that many educators teaching construction courses are trained in areas other than construction, such as architecture or engineering disciplines, where estimating is mentioned, but not covered in depth. Additionally, some educators believe that estimating cannot be effectively taught in the classroom, but must be learned on the job. However, construction firms are looking for graduates who not only have the basic skills needed to compile an estimate, but also have the ability to think critically and independently.

How, then, can we teach estimating effectively given the small amount of time that most curriculums devote to the subject? The solution is relatively simple. Teach estimating in an application-based format. Break away from prevalent traditional teaching methods, which are based on assimilating theoretical concepts in isolation (Rosenbaum, 1996). Many methods used to teach estimating are very abstract, sequential and linear in application -- a paint-by-numbers approach (Kirk & Wentz, 1996). Over eleven years of teaching estimating, I have developed several methods where students learn to apply previous knowledge, build on that knowledge and develop independent thinking skills, which will enable them to perform successful estimates and, hopefully, encourage them to be lifelong learners.

Why Application-Based Methods are Needed

In 1955, a landmark report was published titled the Grinter Report, which called for greater emphasis on incorporating scientific principles in education. The subsequent launching of a series of unmanned satellites by the Soviet Union called “Sputniks” gave the Grinter Report validity; since our country seemed to be falling behind when it came to scientific principles. Prior to the report, many post-secondary engineering curriculums were based on an underlying tenet which was job-oriented, very practical, not too rigidly science-based, more of a gild, crafts approach (Rosenbaum, 1996). Construction education programs began evolving (usually from colleges of engineering or architecture) soon after the Grinter Report was issued and the cold war began, consequently falling under the influence of theoretically- and scientifically-based teaching philosophies.

More recently, the education pendulum has been returning to the application-based position. There has been an outcry for application-based education, especially in schools of engineering. This outcry is due in part to the overwhelming amount of information and technology now bombarding not only students, but to citizens in general. This point is illustrated by Rick Grigsby, President and CEO of Grigsby Construction, in Precision Vantage Point Newsletter where he states some staggering figures:

> If you don’t believe the world is changing consider this: Forbes Magazine recently said that the industrial revolution increased productivity approximately 100 times. The electronic revolution has increased productivity of information 1 million times. It is expected to increase another 10 thousand times in just the next few years. It took 200 years for information to double in this country the first time. The last time it doubled, it did it in 18 months. Experts are predicting that within the next few years it will double every 2 months.

One may agree or disagree with Mr. Grigsby’s figures, yet the fact cannot be argued that information and technology are increasingly flooding our environment. No longer can educators teach theoretical principles without teaching the application of those principles. At the same time, students must “learn to learn and, more importantly, learn to think”, (Hendley, 1996) in order to apply knowledge in a meaningful way.

As educators, we must break away from traditional, linear teaching methods based on assimilating theoretical concepts in isolation, i.e. the classroom. This teaching philosophy is based on an outdated theory called “objectivism”, which holds that knowledge exists independently of the mind and can be transferred to a student, as if the information is poured from a pitcher of knowledge into an empty vessel of the student’s mind (Rosenbaum, 1996). Changing our teaching philosophy might be difficult since most of us in higher education have held this theory as gospel because it is the way we were taught. Yet, we cannot continue to teach in this way and send graduating students off into a world where information is changing every two months.

The bottom line is, students need to learn how to teach themselves by applying knowledge and reinventing the world around them. Many courses in construction lend themselves to this application of knowledge. And, since estimating is vital to any construction company, estimating should be taught in an application-based, realistic approach and away from the objectivism approach, which is prevalent in many construction curriculums.

Key Elements in Application-Based Estimating

A majority of U.S. contractors are classified as small to middle size, thus many construction management graduates will at some time in their careers be required to perform estimating tasks along with scheduling and project management. Therefore, graduates of construction curriculums must have comprehensive instruction in estimating, including bidding, to be successful in the workplace.

Estimating is generally categorized into three areas: quantity survey, pricing, and bidding. To adequately cover each of these areas, a construction curriculum should offer a minimum of two estimating courses, 3 credits (semester credit hours) each, with a possible third elective course. Within the two courses, four application-based methods should be covered: *quantity survey, pricing activities, bidding strategies,* and *simulated bid exercises.* These methods culminate in having the students perform *actual bid projects*.

Through these application-based methods, the workplace and the classroom can come together to provide a realistic learning environment, which prepares students for what they will encounter in their profession.

Quantity Survey

To truly teach the concepts of quantity survey, or take off, it needs to be completed by hand in lieu of computer take off. That may be counter to the advancement of computer applications, however, computer applications are designed as a tool to aid estimators in producing estimates faster, and hopefully more accurately, not as a learning tool to teach the art of quantity survey. Students need to first gain an understanding of what is involved when creating an estimate by being able to read a set of drawings and see the relationships of the various parts within the project. Students must be brought along a developmental curve of understanding and apply previously learned knowledge in order to acquire the critical thinking skills needed to comprehend the complexity of any given project.

> Critical thinking in estimating includes the ability to visualize a project in its totality. This requires the ability to study a two-dimensional plan and "see" a three-dimensional product. Further, the estimator must view the project as a series of interrelated systems, each dependent on the other. Finally, the estimator must have the ability to identify areas that represent future pitfalls and conflicts, and which must be accounted for within the estimate (Kirk & Wentz, 1996).

I find that when students use a keyboard or digitizer, they see estimating not as an art and a relationship of the various parts, but a means to quickly create a take-off. Students learn that they must walk before they can run. And, although many contractors now have computers, they want graduates who can grasp these complex relationships. This sentiment is echoed in a recent Engineering News Record (ENR) article titled, "Preparing for a New Generation" by Tim Grogan where he interviewed Don Greenland, president of Nabholz Construction:

> Good estimating requires the ability to apply construction expertise to the numbers. One of the most troubling trends is the growing number of applicants for estimating jobs who are computer literate, but who know little about construction. We see kids who are computer whizzes, but couldn't build a dog house.

Thus, with pencil in hand, teach the students in an application format the art of quantity survey. Once the fundamentals have been acquired, the computer can then be introduced as a tool of expediency.

Pricing Activities

In the pricing portion of an estimating course, one of the goals is to obtain current and representative costs through rapport with the local industry. As an art, estimating is more than pulling numbers from references such as Means Cost Estimating Guide or Walkers. Students need to know the meaning of these numbers, or, as we say, make the numbers "talk".

Students should perform several classroom activities in unit costs preparation. I like to refer to these as "work-up sheets". On work-up sheets students create unit costs for various parts of a project, such as a monolithic, one-way slab pour. Students learn about the materials and labor involved and how they relate to other factors, such as time and function of the project. They learn how to obtain current prices from the industry by actually calling local material suppliers and subcontractors. This is difficult for most students at first, yet it is important that they learn to communicate in a professional manner with people in the industry and to apply the information obtained.

Occasionally some subcontractors and suppliers are reluctant to work with the students. When this happens, I contact the subcontractor or supplier and explain the classroom exercise. In eleven years, I have had only one contractor who refused to participate. Indeed, most companies actually want to do more by providing material samples, personal consultation, and even guest speakers. This contributes to building a positive relationship between our program and the local industry.

As they do work-up on various projects, the students record the prices on “quotation sheets”. They learn to fill out these sheets including details like time, date, phone number, material description, etc., which is needed for ethical and legal considerations, learned later.

Students must review and thoroughly understand the specifications given in order to determine appropriate unit costs and construction activity scheduling. For example, if the project given starts in late fall or winter, they must adjust unit costs for concrete pours, etc. that may be affected by adverse weather conditions.

When pricing out labor, have the students develop visualization skills. In other words, based on the their prior knowledge, or there ability to seek new knowledge, have them develop labor figures based on productivity that they create without the aid of a Means Cost estimating guide. One example of an exercise that I use to promote critical thinking in creating a unit cost is the curved wall exercise. (Note: This is one of many. Try to develop a number of these so they don’t get passed along to the next student class.) In the curved wall exercise, the object is to develop the line item unit cost for material, labor and equipment for a concrete wall with a described radius. At first students resent performing such exercises because they find that thinking critically is difficult. Also, they have a tendency to want to look up items instead of creating the needed information. The point that I attempt to get across is that the solution is not found in Means or other publications.

In the past eleven years of performing such exercises, I have found that 80% of the students will be within 5% of each other and the actual unit cost. These application-based exercises build the students’ confidence and show them that they can estimate when they apply knowledge or create new knowledge independent of outside sources.

Keep in mind; it is not important to cover <u>all</u> aspects of any given project when teaching students to think critically. It is more important to teach them to think *independently*, based on a philosophy that estimating is an art, which is cultivated by applying and building upon knowledge. If one attempts to address every aspect of estimating, the students are merely having information poured into their heads, without being given the needed tools to teach and develop themselves as estimators. Also, these exercises can just as easily be performed by hand or on the computer.

Bidding Strategies

Once students develop the skills (and probably more importantly, the confidence) in creating unit costs, they are ready to be introduced to bid strategies. The two general types of construction bids, negotiated and hard bids should be covered separately. Negotiated bids can be covered in senior capstone courses, for they involve many other aspects than merely creating an estimate. For example, skills in communication -- writing, speaking and presentation – should be addressed. The focus in the estimating courses should be on the hard bids. Graduates as well as contractors have informed us that students should learn hard bid strategies to adequately prepare them for the real world, since most graduates will be placed in hard bid situations. Negotiated bids have a much different process and are usually performed by senior level estimators.

Bidding is probably the most critical portion of an estimate. The major reason is the pressure placed upon bidders on bid day. The bidder's reaction to this pressure can directly affect the success of the bid, and ultimately the success of the company. As Paul J. Cook relates in *Bidding for the General Contractor.*

> Bidding deals with a multiplicity of variables, i.e., the bidder makes a series of many choices. The bidder makes these choices guided by convention, experience, personal preferences and values. The bidder's personality greatly affects the bid, by such traits as idealism, aggressiveness, or conservatism. These influences, however, tend to dissipate as a bidder accumulates experience. …many inexperienced bidders are active in the industry, learning the hard way and 'winning' a great number of contracts at unnecessarily low prices. Evidence points to the probability that organizations can and often do fail because of poor bidding.

Strategies in successful competitive bidding not only include a solid understanding of the elements that make up a bid, but how to effectively formulate and execute the bid under intense pressure. In my second semester estimating course, this pressure is simulated in a series of exercises that the students have coined "hot-seats".

Hot seats are unannounced and the students must be prepared to perform them at any time. This anticipation adds to the pressure atmosphere of the exercise. Each hot-seat lasts from 45 minutes to 1 ½ hours depending on the topic, and generally involves coming up with a bid number from analyzing a list of subcontractor prices, or breaking matrixes, or dealing with alternates, and so on. During the exercise, I do all sorts of outlandish things, including yelling and pounding on desks, to distract the students from their task. One might compare it to a drill sergeant hammering on a new recruit. Indeed, I try to make it as difficult as possible for them to concentrate on the task. The students really get competitive when I mention that in eleven years only five students have ever come up with an accurate number. The object is not for the students to achieve an accurate number, or as a means for a grade, but to teach students to overcome pressure and have confidence in their ability to make difficult estimating judgments under immense tension.

Now, this is not how we teach human factors in construction. Nor do estimators act like drill sergeants on bid day to add to the pressure of bidding. If you have ever been active in bidding projects, it is one of the most stressful situations one can find themselves in and truly the object in real life is for cool heads to prevail. However, the ability to stay cool under pressure is a learned trait. Therefore, hot-seats serve four important purposes: 1) they teach students to focus on the task at hand; 2) they prepare students for pressure situations in the live bid exercises and the real world; 3) students learn how they personally react to this pressure; and 4) I can evaluate each student's pressure tolerance and help them accordingly.

Simulated Bid Exercises

Once the groundwork has been accomplished with these preliminary exercises, simulated bid exercises can then be introduced. Again, the goal is for each exercise to simulate a real bid situation so that the students can acquire necessary estimating skills, along with an ability to make quick, accurate and ethical decisions to successfully bid a project.

Two simulated bid exercises can be performed during the second semester of estimating. I must emphasize one point here – new projects must be used each time with plans and specifications as complete as possible. Do not repeat exercises. They only create files for students to access and increase the temptation to cheat. When students see that new projects are continually being added, they have a tendency to respect the class and the instruction more by the dedication placed on the subject. I know the difficulty here is having the time to estimate a new project, let alone two of them, per semester, however it is essential in order to maintain the integrity of the exercises. I use projects that I have estimated for various contractors through my consulting, or have found contractors who are more than willing to share their estimates.

An important point to mention here is that the second semester should have an attached lab of preferably three hours per week in order to successfully accomplish these exercises. I believe that an estimating class must have designated lab hours to give this subject the true dedication that it needs.

The first bid exercise should be a fairly simple project, such as a commercial project stick frame, slab on grade, or a sub level with a price range of $200,000 to $500,000. The specifications and drawings should be as complete as possible. One reason I keep it simple is that the students are required to do the first exercise entirely by hand with no computer work. This gives the students a better feel for how the numbers are determined. They can then transfer this knowledge to the computer, which is used in subsequent exercises.

Students are divided up into construction “companies” in groups of three. I designate the members of each company to achieve a mix of personalities, talents and strengths for a realistic balance. Each company selects its own name, and creates its own overhead costs based on information (salary, personnel, office rent, etc.), which I provide. The students then obtain costs to formulate their unit pricing as they prepare for bid day.

Another key element in bidding is securing a bid bond. I find that local bonding companies are delighted to work with students, treating them as semi-real contractors in creating bonds for them. The students present their bond application to the bonding company, have the company scrutinize it, and, when everything is in order, are given a bid bond. The students learn that to bid a project, one must have the proper financial backing -- which they create when they form their companies, utilizing their business management course work. Also, they have the responsibility of doing this as soon as possible, for the bond must be secured and included in their packet for bid day.

The simulated bid process usually takes about four weeks, which closely parallels an actual bid process. During this time I prepare at least 75 sub quotations and recruit as many as 30 volunteer callers to act as subcontractors for bid day. The volunteer callers read from sub quotation sheets, which I have scripted to reflect a real sub bid. This takes a lot of orchestration to put this all together, but if planned well, everything should go smoothly.

Bid day is usually scheduled on a Wednesday with a bid opening time of 5:00 p.m. Each student company picks up a packet from me at noon that day containing some early prices. Then they go to their homes or apartments and begin preparing their bids. Around 1:00, their phones start to ring as the volunteer subs call in their prices. During the four hours each student company may get about 40 phone calls. In addition, they can call me (as a sub) to clarify or question certain prices. This produces a pressure-filled atmosphere similar to what they will encounter on the job. The students must be able to think quickly, analyze quickly, act professionally, and compile a reasonable, competitive bid.

About 30 minutes before bid time, a "runner" from each student company reports to the bid-opening site. The site can be either on or off campus. Runners are still receiving updates from their companies up to the last minute when they must write down their final number and seal it in the envelope with their bid bond. The envelopes are submitted to the actual architect of the project who then reads the bid aloud.

The second bid exercise follows the same procedure as the first, but is done with the computer. This simulated bid exercise is much more dynamic than the first one. It includes alternates, Disadvantaged Business Enterprise (DBE) requirements, cross-reference prices requiring matrix analysis, and ethical dilemmas such as incomplete or unrealistic prices, or quotes that do not comply with the plans and specifications. Sometimes students do not receive complete coverage from subcontractors, so they must come up with their own numbers on very short notice. The project is usually more complex, including steel and other quantities not covered in the first exercise, and has a price range of $1 million to $3 million.

Actual Bid Projects

Actual bid projects can be included in the second semester estimating class in place of the second bid exercise, or in a separate elective course. Again, as with the simulated bids, students work in groups of three, forming construction "companies" and registering these companies with the Nebraska Department of Roads. Working in conjunction with the Department of Roads over a period of three weeks, the students compile their estimates and proceed to bid under actual conditions utilizing real specialty contractor quotations. Their bids are read aloud along with other actual contractor bids. The only difference is that the student companies are not legally bound to enter into contract under orders of the state attorney general's office. These projects are usually bridge projects, but can be buildings, such as office remodels, or rest areas that the state has issued.

The reason for the bidding state work is threefold. One, it offers students who desire to learn the estimating methods and procedures found in heavy estimating a means to do so. Estimating commercial construction projects is in many respects different than estimating and bidding heavy construction projects. Second, the professor only needs to work out the legal parameters and relationship with a single owner. It is much easier to go through the owner permission process one time with the state, than many different times with various other owners in subsequent semesters and projects. And third, through successful exercises, you can establish a positive reputation and rapport with the many specialty contractors who will be submitting quotations to the students as well as the actual contractors who will bid along with your students.

The dollar size of these projects is very important. They must be large enough to challenge the thought process and to test the students' ability to estimate, yet small enough so they can comprehend the projects. I have found that for the first project, a county bridge between $300,000 to $500,000 is ideal. Usually included in this bid is the demolition of an existing bridge and the re-routing of traffic. In an elective class where the students have participated in bidding actual projects before, I have had some of them successfully bidding projects as large as $5 million.

Preparing these actual bid projects is not as complicated as it may seem. Here is an overview of the steps required to establish this application-based method:

1. First, contact your local department of transportation or department of roads and explain the objectives of the exercise. Gain their approval to continue.

2. In conjunction with the department, contact your state attorney general's office to work out the legalities of the student bid process. This was not as complicated as it sounds. The main reason for this cautious step is to protect your department and students. What if a student company is the low bidder? Are they obligated to enter into the contract? Our state attorney general's office requires the readers of the bids to announce a disclaimer statement when the bids are read aloud that the university labeled group cannot be considered to construct the project if low. This is the only difference and special consideration given to the students on reading their bids. Interestingly, because we have now bid on numerous projects over the past four years, they sometimes do not read the statement when the student bids are read as directed, for it is understood.

3. The next step is to have the student companies registered with the state as viable contractors. Before they can obtain drawings, they must become qualified bidders by preparing state approved financial reports. These reports are again created using fictitious dollars from their made-up companies. However, because the state audits these reports, the dollar amounts represent factual numbers. Obviously, the state understands these are student companies. However, if the paperwork is not completed correctly, they do not receive drawings.

4. Next, notify your local contractor associations and advertise in their local and state publications so that the contracting industry understands what you are doing. Communication cannot be stressed more if you are to gain the respect and trust of the contractors. The student companies must also get on the proper bid list. The local AGC and ABC can be of valuable assistance here. Our local heavy AGC organization has been very cooperative in listing the student companies right along with the other actual contractors. In fact, many times there is no way to differentiate the student companies from the actual contractors. However, I do require that the student groups identify

themselves by providing the initials of the university after their company names. Other than that, there is no other distinction.

5. Then we find a contractor to “sponsor” a student company. Not for monetary support, but to help cost line items which would be difficult for me -- and especially the students -- to create, such as a batch plant for concrete in remote locations, or other unknown factors.

6. The next step is to establish student company telephone numbers, addresses and fax numbers so that they can receive specialty bid prices from contractors. The student companies set up in either our computer lab utilizing our department’s fax, or at their homes with an answering service using their personal addresses and obtaining their own fax machine. Both of these company setups have been successful.

7. The final step is, of course, having the students formulate their estimate and prepare for bid day. Usually this occurs over a 3-week period for each bid they perform.

Note: If it is difficult in your location to travel to your state’s Department of Transportation or Department of Roads, check into electronic communication. Many state departments now utilize the computer to not only download plans to remote locations, but also perform bids electronically.

These actual bid projects have been very successful. On the very first bid project, one student group came in second out of nine bidders on a large bridge project. At least three times they have been low with very respectable numbers as well placing second and third countless times. Many student groups are in the middle of the pack of bidders with very competitive bids.

However, being low, or second, or even third is not the goal. Our goal is to have the students acquire worthwhile experience by participating in an actual bid where they can see that their numbers really mean something, and allow them to gain experience based on applying pervious knowledge from an application-based method. In doing so, the students gain the respect of the contractors by integrating the classroom with the real world. Personally, there is nothing more gratifying to me than to see the students’ faces when they are publicly acknowledged and praised by professionals in the industry.

Conclusion

As you may have concluded, setting up these application-based methods takes an enormous amount of time and dedication. However, they require no more time than any other new course. Also, one might think that these methods can only be effective with small class sizes. Of course we would all like to teach to small classes, but I have consistently taught these methods to classes of as many as 36 individuals without difficulty.

To effectively teach construction estimating, we must teach with realism in mind. The simulated and actual bid exercises described in this paper have benefited the students, local construction industry and our construction program. Students learn in a realistic environment what they will encounter on the job, develop specific estimating skills, gain practice in professional conduct, and discover how they deal with the stress involved. Some may decide that estimating is not for them, and choose jobs in scheduling, field engineering, or other areas not directly related to estimating. Local industry people can observe and participate in the students' learning process, contribute useful knowledge on current prices and industry practices, and provide valuable feedback on their expectations of graduates. This enhances communication and rapport between industry and academia, which in turn assists us in designing effective course work in construction education.

References

Cook, P. J. (1985). *Bidding for the general contractor.* R. S. Means Co.

Grigsby, R. (1995, third quarter). Competitive strategies for estimators in small and medium firms. *Precision Vantage Point Newsletter* , pp. 1-2.

Grogan, T. (1996, May 27). Preparing for a new generation. *Engineering News Record,* pp. 31-32.

Hendley, V. (1997, January). Engineering advocate: Woodie Flowers, *ASEE Prism*, pp. 14-15.

Kirk, W. M. and Wentz, T. (1996, third quarter). Teaching critical thinking in an estimating course. *Estimator,* pp. 2-8.

Rosenbaum, D. (1996, September 2). Schools erase chalk-and talk: Just-in-time learning, popsicle-stick bridges and ping-pong catapults change old methods. *Engineering News Record,* pp. 24-30.

Journal of Construction Education
Spring 1999, Vol. 4, No. 1, pp. 17-25

1522-8150/99/$3.00/Educational Practice Manuscript

Service-Learning: A Win-Win Resource for Construction Education

Bolivar A. Senior
Colorado State University
Fort Collins, Colorado

Service-learning is a form of experiential education that uses the context of a service project to practice academic skills, solve a real project, and learn from the project in a reflective manner. This paper discusses the elements and need for this educational tool, and provides an example of how it was applied to a scheduling course at Colorado State University. The challenges to the adoption of service learning are considered, and a Conclusion section summarizes the discussion and reflects on the future of this approach.

Key Words: Service-learning, Experiential education, Undergraduate education

Introduction

The nature of construction education should require as much emphasis in forming a student's character as in providing the formal knowledge required for planning and managing a project. The hiring policies for new graduates of the vast majority of the construction industry reflect this fact. Although a good academic record is part of the stated requisites, what really makes a difference is the character of a job applicant. Despite its importance, very few pedagogical tools are commonly used to foster a student's character formation.

This paper describes a relatively new pedagogical resource called service-learning. It is a form of experiential education in which the student is guided through a service-oriented project. By offering a high level of autonomy and reflection, it helps significantly in buttressing character along with traditional learning objectives. The philosophy and elements of this tool are discussed here, along with some of the implementation issues found while integrating it into a construction course at Colorado State University. Finally, the challenges of this new pedagogical tool are discussed, followed by a Conclusion section.

Basics of Service-Learning

The National Society for Experiential Education has defined service-learning as "any carefully monitored service experience in which a student has intentional learning goals and reflects actively on what he or she is learning throughout the experience." (Furco, 1994). This definition requires some further discussion, since the term "service-learning" has been applied to many forms of experiential education.

Figure 1 shows the distinctions among experiential programs in a graphical format.

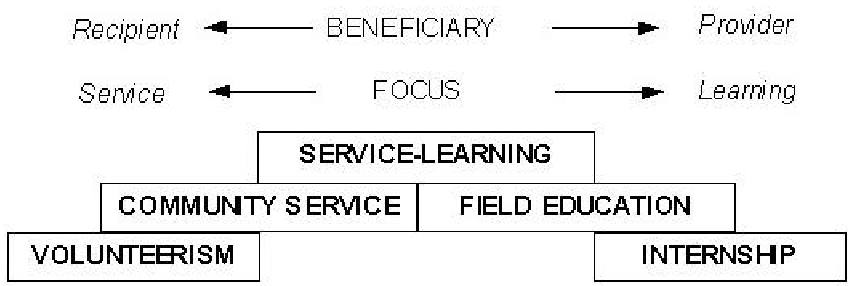


Figure 1. Distinctions Among Service Programs (Furco, 1996)

Figure 1 shows how service-learning requires that both the recipient and the provider benefit from the experience. This is a fundamental distinction between service-learning and community service or volunteerism, where the provider of the service does not intend to realize any personal gain. On the other hand, an internship makes the service component accessory to the technical training, or absent altogether. A mutually beneficial situation could result, for instance, from engaging a class in building a house *for Habitat for Humanity* ™. While *Habitat* will benefit from the finished house, the students will also benefit from the experience.

An important element of service-learning is the need for a deliberate learning goal. In the *Habitat for Humanity* example, if students would simply show up to work without any programmatic design from the class instructor, the experience would qualify as volunteerism, but not as service-learning.

Perhaps the most difficult component of service-learning is the need to introduce reflection into the learning experience. However, it is a well established fact that "we learn through combinations of thought and action, reflection and practice, theory and application." (Kendall, 1988). This implies discussing "intellectual, civic, ethical, moral, cross-cultural, career, or personal [goals]." (Kendall, 1990). Using the *Habitat for Humanity* setting again, some valid topics could be: why should homeless people be given a subsidized or free home? How do other countries deal with the problem of homeless people? How could the cost of the house built be lower? Should the code regulations be different for this type of construction? It is part of the instructor's duties to think in advance and discuss such topics with the students. Reflection should not be postponed to the end of the experience, but be part of it as it unfolds.

Need for Service-Learning

In order to appreciate the need and advantages of service-learning, it is necessary to locate it in the big picture of today's higher education. Many recent articles have criticized the current environment in institutions of higher education for their "indifferent undergraduate teaching, overemphasis on esoteric research, failure to promote moral character and civic consciousness, and narrow focus on preparing graduates for the job market" (Jacoby, 1996). This failure to nurture civic character was revealed even more dramatically in a 1993 survey (Levine, 1994), which found that 64 percent of college students were involved in some type of volunteer activity.

This figure was consistent regardless of the type of higher education institution, gender, race or region. For example, it was 68 percent for universities, 67 percent for four-year colleges, and 59 percent for community colleges. Since very few institutions or programs include service as part of their formal goals, it appears that students have undertaken this part of their education on their own.

As service-learning is a form of experiential learning, it offers all the advantages of expanding knowledge acquisition with practical exposure. In virtually all-modern learning theories, the need for such hands-on opportunities is a central component. For example, Bloom's Taxonomy (Bloom et al., 1956) identifies six major divisions of cognitive domain: knowledge, comprehension, application, analysis, synthesis, and evaluation. Service-learning applied to construction does not address directly the knowledge domain (i.e., the technical facts required to solve a problem), but fits very well into the others. Solving a typical service-learning problem requires a deeper understanding of the meaning of technical alternatives than the simple aggregation of technical facts (comprehension domain). It also requires the application of these facts in a particular concrete situation (application domain); the breaking down of a relatively complex problem into manageable pieces, and then finding a wholistic solution to these pieces (analysis and synthesis domains). A reflective assessment of the problem and the applied solution (evaluation domain) is a central element of service learning. A similar coherence can be found between service-learning and other learning theories such as Perry's Theory of Development of College Students (Perry, 1970; Culver, 1985) and Kolb's Learning Cycle (Kolb, 1984).

The strengthening of character through service is less discussed in the literature, and here the construction industry can offer excellent testimonies of improvement and even dramatic change in the character of many participants in internships and similar practical experiences. Time Magazine conducted a survey of 608 middle and high school students with some previous exposure to community service. It found that 75 percent of the students said that they "learned more during community service than in a typical class." (Cloud, 1997). Although some judgement must be exerted to extrapolate these results to construction students engaged in service-learning, they show that Bloom's taxonomy (Bloom et al., 1956) seems to hold true insofar as the educational value of service in general.

Implementing Service-Learning at Colorado State University

Colorado State University (CSU) has had many successful cases with service-learning integration. For instance, a business management course was recently modified to include service-learning. Students in the class volunteer in elementary schools to introduce principles of economics to first to sixth graders, using a variety of teaching techniques. It was reported "college students that participate in this program walk away with greater self-confidence and a better understanding of not only what they learn in class, but how they can make a difference in the community" (CSU, 1997).

There have been few attempts to integrate service-learning in the construction curriculum. This section discusses how IS-461, *Construction Project Scheduling and Cost Control* (now designated as MC-461) was modified to integrate a module of service-learning. A more complete review has been presented elsewhere (Senior, 1998). IS-461 is a required senior course in the Construction Management curriculum at CSU. It is offered in all regular semesters, and has an average enrollment of 28 students for each section, who typically have taken courses on estimating (a prerequisite), safety, and can take construction administration concurrently. A traditional lecture/laboratory format, slightly adjusted to accommodate each instructor's teaching style, had been used for many years to deliver its contents. Although service-learning can be introduced in other courses such as in a capstone experience, the circumstance of the author being the instructor for IS-461 for the 1997 spring semester (when this module was introduced) was the primary reason to choose this course.

A local service agency called Neighbor-to-Neighbor (N2N) was offered a relatively old house that was going to be demolished to make space for a subdivision development project. N2N was interested in converting the house into a two-family condominium that could be sold at a profit. The house was in good condition. However, N2N had no in-house expertise to develop such a project. The role of the IS-461 students was to provide a design of the remodeled project, and a total, although preliminary, report to N2N of its technical and financial implications. CSU has a Service Integration Project, which operates as an independently staffed unit of the Office of Community Services. This office was instrumental in obtaining the N2N project.

The original house owner, N2N's executive director, a financial agent, and a contractor specializing in total house relocations participated in a brainstorming session with the IS-461 students to develop the project scope. After discussing what was required to help N2N, the tasks shown in Table 1 emerged.

Table 1

Tasks for the N2N Project

1. Proposed new layouts.
2. Technical and resource requirements.
    a. Moving.
    b. Renovation alternatives.
3. Administrative requirements.
    a. Regulations.
    b. Risk avoidance.
4. Preliminary estimate.
5. Preliminary schedule.
6. Final report.

The class was divided into groups of three to four students, each in charge of one of the tasks presented in Table 1. The Construction Management program at CSU tends to include non-traditional, older students, who have had construction experience. In this particular case, the class included an architect; the owner of a restaurant with the consequent business experience; several students with prior construction experience, and several officers of the program's professional student chapters. However, more than 15 of the 30 students registered for the class had no prior business or construction experience. Unfortunately, good students and leaders tended to team up with other good students and leaders. This fact resulted in a disparity in the quality of the teams. A solution to this could have been forcing the team composition, but it was felt that doing so would have made the experience feel like an imposition. It was decided to leave the teams, as they were naturally composed. The solution to this dilemma of quality control was to designate two non-traditional, experienced students to control the overall quality of the effort. The instructor confirmed any problem reported by the "QC inspectors," and helped in solving it.

The next step was a field trip to the house. It gave a much more concrete sense of the project to the students, and began the actual work in the project. The contractor specializing in house relocation provided a tour of a house nearby that was being moved. This provided a better understanding of the relocation requirements, and by the unusual nature of the operation, gave students a sense that there were technical lessons to learn from the project.

A total of four weeks were allocated to actual work, including writing the final report. This relatively tight schedule was due to the need of N2N to meet a deadline to compete for government funds. During this period, the student groups met with outside consultants, authorities and N2N executives. The level of cooperation from these external sources was, in general, remarkably good.

After the report was delivered, a lecture session was devoted to reflecting about what was learned from the project. This reflective analysis proved to be crucial for the internalization of the experience, and to put its importance in perspective.

The reflection session had the structure recommended by CSU's Service Integration Project (more information can be requested at ccleary@vines.colostate.edu) and others. It began with an objective description of what was done, then an assessment of what the experience meant at the student's personal level, and finally, some discussion of what should be done next. In general, several reflective sessions are recommended for a service-learning experience. The fact that only one was conducted in this case reflects more the instructor's inexperience in this field than any deliberate decision.

Overall, the service-learning experience was very positive for the majority of the students in the class. In the student evaluation of the course at the end of the semester, service-learning was consistently considered to have enhanced the learning of the course contents.

Challenges to Service-Learning

Although the previous sections have shown that service-learning is a powerful pedagogical resource, its challenges and limitations must also be discussed.

The first challenge to service-learning comes from the recentness of its application to technical fields such as construction management. In areas of study such as social work, students are expected to gain a deep understanding of their community. There is an evident link between service-learning and their educational goals. This is not the case in construction education. An instructor trying to implement service-learning in a course has the burden of the proof to convince others of the merits of this approach. An extensive literature search was conducted before implementing this project, and it became apparent that another consequence of this absence of precedent is that there is no “little black book” of lessons learned specifically for construction education. In contrast, there is a sizable body of literature offering insights about experience gained from implementing service-learning in the social areas. However, even though this literature has been developed by social scientists, they can be valuable tools to guide the construction educator.

Another challenging area for an instructor implementing service-learning is the nature of the subjects typically emphasized in the reflection component of the experience. A few possible topics were mentioned in the *Habitat for Humanity* example. Some of these topics may seem too ideological to many construction instructors, and distant from the typical scope of construction education. Discussing such subjects is an important component of service-learning, and perhaps the awkwardness of the typical construction instructor when dealing with social issues is the best testimony of the chronic deficiency of the construction education system to address this important area.

Many specific implementation problems were exposed during the integration of service-learning to IS-461 described in the previous section. For example, coordinating efforts with N2N was particularly demanding. Its executive director was difficult to contact, and shifted his own objectives with respect to the project several times. At the end, N2N obtained financing for the project, but decided to abandon the idea and proceed with a more traditional building approach. (This happened after the end of the semester. The students were never aware of this outcome).

A challenging aspect in the IS-461 case was dealing with students not willing to cooperate with the project. Although only a few, these students jeopardized the quality of the project by delaying their part until the last possible moment, and then providing a mediocre contribution to the final report. Parallel to this topic was the question of grading: how much effort should be required from students? How can an instructor assign a fair grade? At CSU, the Service Integration Project recommends 5 hours of work for each course credit. This level of effort seemed satisfactory for the IS-461 project. A basic grade was assigned to each group, which was then re-distributed among the participants. Feigenbaum and Holland (1997) discuss this process in detail.

A willing instructor can control the above aspects. However, other issues are generally outside the control of anyone in particular. Such an issue is getting an appropriate project in the first place. In this case, the Service Integration Project at CSU provided the appropriate contact. It was not the first or only contact. Other contacts led to uninteresting projects, which were discarded after interviewing representatives from the involved agencies. Even when an appropriate project is found, it has to be at the right point to be workable into the semester. For instance, if the present project had been developed for the following semester, it would have been useless for any practical purpose. Finally, the reflective session (reflecting about what was learned from the experience) proved difficult to implement. The session strayed at times into arguments about the lack of cooperation from some students. Keeping focus in such situations requires substantial effort from the instructor as mediator.

Conclusion

Help in implementing service-learning is readily available in many campuses. Most instructors are likely to have access to some level of institutional support through their office of community services (or similar name). There, they can usually find literature and get help in procuring suitable service projects, modifying the course syllabus, and other initial tasks. CSU even offers grants to help in the start-up of such efforts. Unfortunately, these grants come with many strings attached (such as the number of required hours of service, reflection components, etc.) that discourage their use. In general, service integration seems to have political momentum. The State of Maryland now requires 75 hours of community service from all high-school students. Miami began requiring 75 hours in 1996, and Chicago will demand 40 hours starting in 1998 (Cloud, 1997). Although revolutionary by American standards, these requirements are still shy of the much stricter service system in place for decades in Germany, Austria and other European nations. Furthermore, the current administration is pushing for service-learning as a requisite for federal grants and local service programs (Cloud, 1997).

Such momentum does not guarantee ultimate success. Time Magazine entitles "involuntary volunteers" an article dealing with community service, and explains that even though 91 percent of students polled agreed that they should be "encouraged" to participate in community service, only 36 percent think that they should be required to participate (Cloud, 1997).

At the more immediate level, untenured construction instructors may face the dilemma of keeping their teaching within the comfortable realm of traditional lecturing, or entering into relatively uncharted territory with service-learning. As Morton notes, "the growth of service-learning will require that executive officers, from department chairs to presidents, find ways to recognize and reward different teaching styles, assign equitable teaching loads, […] and otherwise protect and promote the careers of faculty who wish to commit to the integration of service and learning." (Morton, 1996). Is construction education there yet?

It is the author's opinion that service-learning presents a uniquely positive opportunity for construction students and their community. This paper has not attempted to offer statistical proof of the benefits of service learning. However, anecdotal evidence suggests that solving a complete problem, reflecting on the experience and enjoying a high level of autonomy tends to foster the creation of character while improving the technical skills of the participants. The informal comments of most prospective employers interviewing at CSU are that this combination is fundamental for a successful construction career. This case study shows how the implementation of service-learning in construction education requires attention to detail. After an exhaustive search, it appears that service-learning does not enjoy the literature support found in the social sciences. A basic question is that of an adequate reward system for the faculty willing to integrate service-learning into their programs. In the author's opinion, everyone needs to feel that this is a win-win resource to assure its success.

It is the author's opinion that an essential element to the adoption of service-learning for construction education is the creation of a body of literature specific to this discipline. The publication of new case studies should be encouraged to achieve this objective. This case study shows encouraging, but informal, indications that the students in IS-461 benefited from the experience. Formal research should examine the hypothesis that service-learning indeed improves the education of construction students.

References

Bloom, B. S., Engelhart, M., Furst, E., Hill, W. and Krathwohl, D. (1956). *Taxonomy of educational objectives. Book I: cognitive domain*. New York, NY: David McKay.

Cloud, J. (1997). Involuntary volunteers. *Time Magazine*, December 1, 1997, 76.

Colorado State University (1997): CSU News Release, April 2, 1997. http://www.colostate.edu/Depts/PR/releases/news/share100.htm

Culver, R. S. (1985). Applying the Perry model of intellectual development to engineering education. *Proceedings, ASEE/IEEE Frontiers in Engineering Education Conference,* New York, NY, 95-99.

Feigenbaum, L. and Holland, N. (1997). Using peer evaluations to assign grades on group projects. *Proceedings of the 33rd Annual Conference, ASC,* D. Koehler, ed. Seattle, WA., 75-80.

Furco, A. (1994). *Partial list of experiential learning terms and their definitions*. Raleigh, NC: National Society for Experiential Education.

Furco, A. (1996). Service-learning: a balanced approach to experiential education. *Expanding boundaries: serving and learning*, Vol 1. New York, NY: The Corporation for national service learn and serve America: higher education.

Jacoby, B. (1996). Service learning in today's higher education. *Service-learning in higher education: concepts and practices*. B. Jacoby et. al, ed. San Francisco, CA: Jossey-Bass, Inc.

Kendall, J. C. (1988). From youth service to service-learning. *Facts and faith: A status report on youth service,* A. C. Lewis, ed. Washington, DC: William T. Grant Foundation.

Kendall, J. C. (1990). Combining service and learning: an introduction. *Combining service and learning: a resource book for community and public service*, Vol1. Raleigh, NC: National Society for Experiential Education.

Kolb, D. A. (1984). *Experiential learning: experience as a source of learning and development.* Englewood Cliffs, NJ: Prentice Hall.

Levine, A. (1994). Service on campus. *Change*, July / August 1994, 4-5.

Morton, K. (1996). Issues related to integrating service-learning into the curriculum. *Service-learning in higher education: concepts and practices*. B. Jacoby et. al, ed. San Francisco, CA: Jossey-Bass, Inc.

Perry, W. G., Jr. (1970). *Forms of Intellectual and Ethical Development in the College Years: A Scheme.* New York, NY: Holt, Rinehart and Winston.

Senior, Bolivar A. (1998*). Incorporating service-learning into a construction-planning course*. Proceedings of the 1998 ASC Region IV annual meeting, Kansas City, MO.

Journal of Construction Education
Spring 1999, Vol. 4, No. 1, pp. 26-37

1522-8150/99/$3.00/Educational Practice Manuscript

Practical Business Application of Break Even Analysis in Graduate Construction Education

Charles W. Berryman, Ph.D.
University of Nebraska – Lincoln
Lincoln, Nebraska

Michael D. Nobe, Ph.D.
University of Nebraska - Kearney
Kearney, Nebraska

The recent trends in the competitive global market dictate that construction management students must manage at higher levels of sophistication. This is especially important at the graduate level where the focus of education is on "management". One potential discipline, which can aid in producing more sophisticated managers, is economics. However, many of the economic tools are unfamiliar to the construction graduate because agriculture and business disciplines traditionally dominate economic analysis. As a result, construction students who enroll in economics courses are taught agricultural or business terms with no application being germane to construction. In an attempted to supplement the traditional disciplines, this paper will examine and demonstrate one of the typical economic analytical tools, Break-even Analysis, in a construction business context. This is to provide the graduate educator with a teaching tool that can be used to assist future construction professionals in the nuances of operating a construction business. Included are the theoretical underpinnings of break-even analysis and a hypothetical case study, which applies this economic concept to the business operations of road construction firm.

Key Words: Break-even Analysis, Profit Contribution Analysis, Economics, Construction Management, and Construction Graduate Education

Introduction

The cornerstone of financial decision-making is economic analysis. There are several evaluation tools currently available to construction managers, including present worth analyses, benefit/cost analysis, equivalent annualized costs, rate of return on investment, cash flow analysis, and break-even (Barrie and Paulson, 1978). At the undergraduate level, the typical student will probably not be expected to produce these sophisticated economic analysis as a part of their initial job responsibilities. However, the graduate student is likely to be initially employed in a position which does require sophistication of management methods, including economic analysis. While most graduates may have heard of some of these tools, they probably could not effectively utilize them within a construction firm's analytical framework.

Why is this? One possible answer -- predominant disciplines utilizing these decision making tools are agriculture and business colleges. Cows and widgets are used as the units for evaluation -- not square feet, board feet, or cubic yards. In most cases, if students take a business course outside of their respective construction department, they are not exposed to economic decision making scenarios or case studies involving construction. Construction is a relative newcomer to economic analysis and a review of the literature confirms this, with very few references being made toward economic analysis as a function of construction.

To help make economic analysis a part of the construction manager's knowledge base, one economic tool, Break-even Analysis, is scrutinized for the construction instructor and student.

This article evaluates an agriculture/business economic tool and places it in a construction business context by outlining the fundamental components, steps, and limitations of break-even analysis. The evaluation is followed by a hypothetical case study, which demonstrates how break-even analysis can be utilized as a useful managerial tool for the construction graduate.

Break-Even Fundamentals

Traditional break-even analysis is a relatively common managerial tool used in a wide variety of purposes for nearly all types of decision-making. Break-even analysis (sometimes called profit contribution analysis) is an important tool, which allows comparative studies between costs, revenues, and profits (Pappas and Brigham, 1981). This analytical technique facilitates the evaluation of potential prices, the impact of price changes and fixed/variable costs on profitability (Powers, 1987). This analysis can also be used to expedite decisions on investment return criteria, required market shares, and distribution alternatives (Kotler, 1984)

Break-even is the sales volume at which revenue and total cost are equal, resulting in no net income or loss. It is typical to graphically depict break-even as the point where a firm's total cost and total revenue curves intersect. This is the sales point where both variable and fixed costs are covered by the sales volume for the relevant range. If the break-even point is not achieved, that business will (or should) eventually go out of business (Casavant et. al, 1984).

Break-even Components

To fully appreciate the break-even theory and related graphical depictions, it is necessary to have a basic understanding of the concepts related to cost, revenue and profit. In order to facilitate this, one must first know the following components of break-even:

- Total Cost
- Total Revenue
- Net Profit
- Fixed Cost
- Variable Cost
- Semi variable Cost
- Contribution Margin
- Relative Range

Total cost is the sum of fixed cost and variable costs. *Total revenue* is that amount of gross income received from product sales or a service rendered, and is equal to the price of a unit times the number of units sold. *Net profit* results when total revenue exceeds total cost.

Fixed and *variable costs* represent the expenses incurred in making and selling the goods or services. Fixed costs are invariant costs that are not affected by production level or output. Such costs include interest on borrowed capital, rental expense, employee salaries, etc. In contrast, variable costs change with each marginal unit of production or output levels. Included are such costs as materials expense, depreciation associated with the use of equipment, utility charges, some labor costs, sales commissions, etc. (Pappas et. al, 1981). The easiest way to determine variable or fixed costs is to evaluate the expense versus the production level. For example, a project manager received a monthly salary. His salary expense to the company would be the same, regardless of the dollar amount of work completed by him, and therefore is a fixed cost.

Consider a framing carpenter who is paid per square foot of building. If no buildings are constructed, his cost to the company is zero. His cost varies as a function of the building size and number of buildings completed during a relevant time frame; therefore, this is a variable cost.

Semivariable costs often stay constant for a certain time period during production increases, then “step up” to a higher cost level at specific points of increased volume. An example of this is an insurance premium, which covers production to a certain level, which if exceeded, is changed to a new fixed level. To simplify the analysis process, semivariable costs are generally calculated and split into appropriate fixed and variable costs.

Contribution margin is that amount which contributes to the fixed costs of the company and to its profits, after deducting the variable costs. Total variable costs are subtracted from total revenue to yield the contribution margin. The contribution margin can be expressed in total dollars, in dollars per unit, or as a percentage.

Relative range is the limit of production or output levels over which fixed costs remain constant. Above the relative range cost evaluations and respective relationships are no longer applicable. For instance, if a construction firm’s work doubled or tripled, the company would have to hire more people, rent more office space, and acquire more equipment -- thus increasing fixed costs and altering the entire break-even cost and revenue structure.

Basic Analysis Steps

Once the definitions and their respective applications are mastered, it is then matter of performing the three basic steps of the break-even analysis:

1. Conduct a cost/income analysis of the construction firm to determine:
    1. Fixed costs
    2. Variable costs
    3. Total costs
    4. Total revenue

2. Calculate contribution margin and perform break-even analysis (Powers, 1987):

$$CM = P - V \qquad\qquad Q = F / CM$$

whereas:

CM = Contribution Margin
Q = Break-even point in units
P = Price per unit sold
V = Variable cost per unit (total)
F = Fixed cost per unit (total)

There are variations of the traditional break-even formula that calculate the market share required to break-even alone or to break-even and cover a profit requirement. This can be seen as follows:

Variations of break-even:

$$Breakeven\ with\ Profit\ Requirement = \frac{F + Profit\ Requirement}{Contribution\ Margin}$$

$$Market\ Share\ Required\ to\ Breakeven = \frac{Breakeven\ Point}{Market\ Size}$$

In all of these formulas, any type of appropriate unit can be used. Units in total dollars, dollars per unit, and percentages are commonly used. An example could be the market size of residential home construction -- units could be in total market dollars or in the total number of homes being built.

3. Create chart (optional)

A break-even chart is constructed using the above data. The break-even components are graphically depicted in Figure 1. Graph A illustrates fixed costs and graph B illustrates variable costs along with semivariable costs. Graph C combines both fixed and variable costs to equal total costs. Note that variable costs have to be considered in addition to fixed cost and are represented by beginning at the origin of the fixed cost at the y axis. Also, note that the semivariable costs have been reclassified into appropriate fixed and variable cost components for Graph C. Graph D illustrates sales revenue proportionate to the units sold. In Figure 2, all of the break-even components are synthesized to demonstrate the overall cost and revenue relationships. The difference between total sales and total costs to the left of the break-even point is loss and to the right is profit.

Limitations

The power of this tool to accurately reflect useable results can be limited due largely to the definition of fixed and variable costs. It is difficult to determine and categorize costs as fixed or variable. Most businesses have a combination of the two resulting in semivariable costs. Other costs are questionable and cannot be easily classified (Sinclair and Talbott, 1986). As a consequence, the usable results are limited by the structure of the formula, which defines all cost as either fixed or variable (Powers, 1987). Also, along with this cost analysis is a certain degree of difficulty in determining relevant ranges. Most companies that have been in operation for just few years have not yet experienced their maximum operating capacity. Difficulty arises when a company has never reached their maximum output and are uncertain of their limits as a function of their relevant range.

Management is sometimes deterred from using break-even analysis because of these complexities and the inherent imprecision to exact measurements. However, it is important to remember that break-even analysis is often used as a measure to determine <u>general</u> guidelines for business decision making (Pollack, 1995).

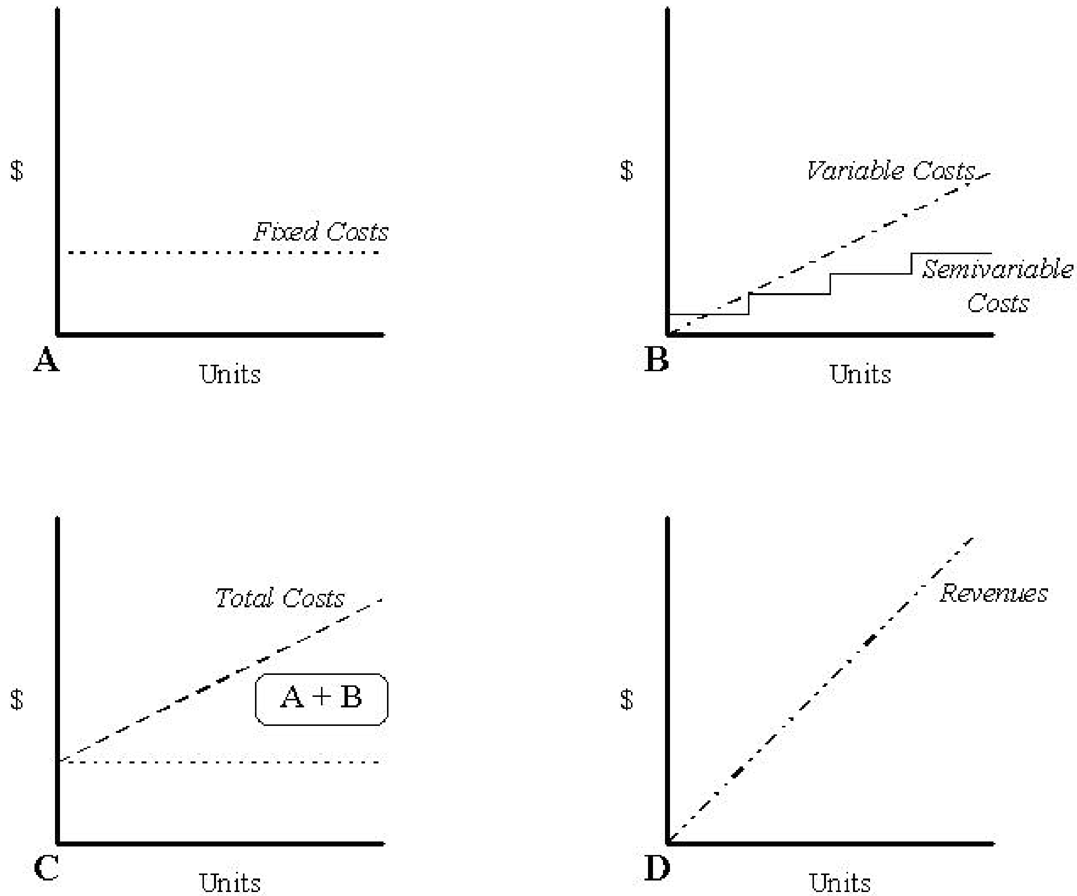


Figure 1. Break-even Components

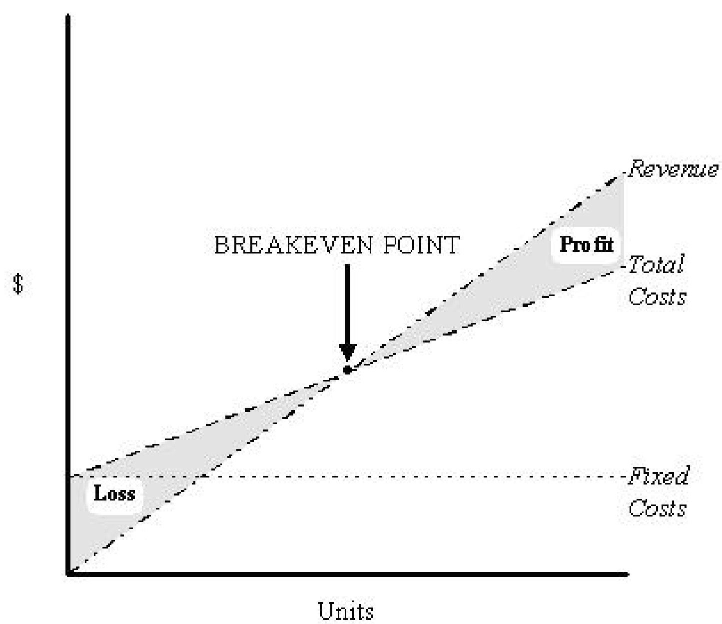


Figure 2. Graphical Break-even Analysis with Break-even Point

Practical Application of Construction Break-Even Analysis

The following hypothetical case study is presented to demonstrate the practical application of economic break-even analysis to the discipline of construction management. The information provided can be used by educators as a lecture/discussion aid. As an alternate, the instructor can give the student only the hypothetical background information (presented below) along with the expense/income sheet (Appendix A) and request that the students generate their own economic break-even analysis. Another option is to utilize the tutorial (web site still under construction) on the Internet as part of the classroom instruction (see Figure 3).

Hypothetical Case Background

Jack Lignite, president of Smooth Roads, Inc., is contemplating whether or not to place his bid on a large State construction contract, which involves approximately 6000 tons of hot mix asphalt. To competitively bid such a large volume, Jack would have to lower his standard construction price of $50 a ton to $45 a ton. This price includes labor, materials, and equipment for a turnkey asphaltic road system. Jack's main concern is that if he is awarded the contract, he won't make a profit. If this happened, Smooth Roads, Inc. could be out of business. Jack decides he can run a break-even analysis to answer his questions.

Currently, Smooth Roads, Inc. has a maximum construction capacity of 200,000 tons. Increasing the highway construction volume above this number results in increased fixed costs to the company. This 200,000-ton limit is the top of Jack's relevant range. It is a ceiling limit on the amount of roads the company can build without requiring more equipment and manpower.

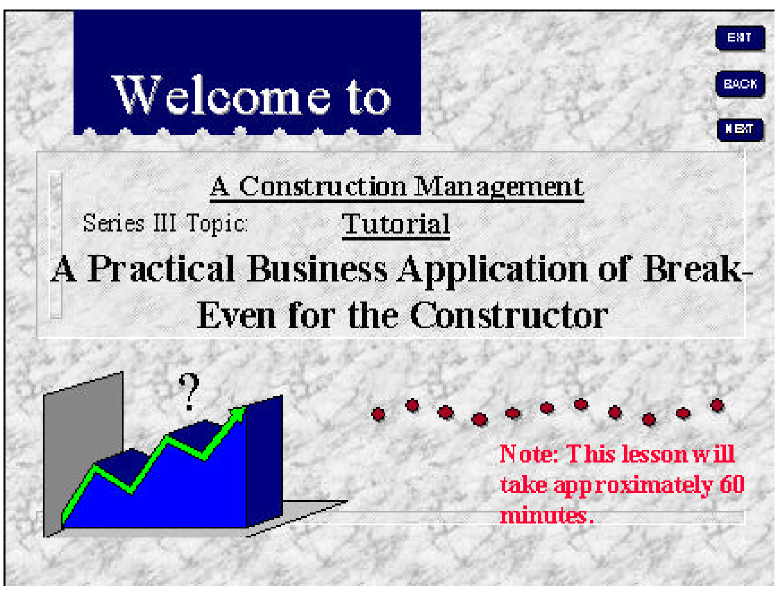


Figure 3. Introduction for Internet Tutorial

Analysis of Fixed and Variable Costs

Jack performed a detailed analysis of his fixed and variable costs. The semi-variable costs were computed using the "high/low" method to estimate individual cost components.

The “high/low” method (Powers, 1987) simply calculates the change in 1) a semivariable cost item and 2) volume of sales from one year to the next. The change in the cost (? C) is then divided by the change in volume of construction or sales (? V) from one year to the next to find the variable cost per unit. This result leads to the estimation of the variable component of the semivariable cost unit as follows:

Jack’s repair and maintenance expenses were $25,200 in 1994 and $25,100 in 1993.

$$\Delta C = \$25,200 - \$24,100 = \$1,100$$

Jack’s construction volume was 172,000 tons in 1994 and was 155,000 tons in 1993.

$$\Delta V = 172,000 - 155,000 = 17,000 \text{ tons}$$

To find variable cost per ton of hot mix asphalt from the semivariable repair and maintenance:

$$\Delta C / \Delta V = \$1,100 / 17,000 = \$0.0647 \text{ variable cost per ton}$$

To find the current variable portion of repair and maintenance, multiply the 1994 construction volume by the variable cost per ton:

$$172,000 \times \$0.0647 = \$11,130 \text{ variable cost}$$

The fixed and variable portion equal the total expense of repair and maintenance, therefore total cost less variable cost equal the fixed cost:

$$\$25,200 - 11,130 = \$14,071 \text{ fixed cost}$$

Jack applied this technique to all his semivariable costs. Once completed, he had successfully divided his expenses into fixed and variable (summarized in Appendix A). With a production level of 172,000 tons of hot mix asphalt, Jack found his total fixed expenses to be $1,278,110 and his total variable expenses to be $6,956,500.

Calculating Contribution Margin

Jack took the total variable costs and subtracted them from total revenue to acquire the contribution margin for the company as a whole (see figure 4). Jack discovered that he has $1,643,500 (contribution margin) towards his fixed cost. Subtracting the fixed cost from this number, indicates his profit, before taxes, of $365,390. Converting to a contribution ratio of 0.191 (by dividing contribution margin by total revenue) indicates to Jack that approximately 19% of every dollar of revenue will contribute to the fixed costs up to break-even, after that point, it will contribute to profit.

	$8,600,000	*Total Revenue*
−	6,956,500	*Variable Costs*
	$1,643,500	***Contribution Margin ($)***
−	1,278,110	*Fixed Costs*
	$ 365,390	***Profit Before Taxes***

$$\frac{\text{Contribution Margin} \quad \$1,643,500}{\text{Total Revenue} \quad \$8,600,000} = \mathbf{19.1\%} \ \textit{Contribution Margin (\%)}$$

Figure 4. Analysis of Contribution Margin

Break-even Analysis

Before Jack would turn his bid into the State, he needed to reassure himself that he could construct additional road systems at his current volume, and that his lower bid price covered both his fixed and variable costs (break-even point). To find the volume of construction (in tons) needed to break even, Jack divided the total fixed costs by the average contribution margin per ton (see Figure 5 for summary):

$$\text{Breakeven Point in Units} = \frac{\text{Total Fixed Costs}}{\text{Avg. Contribution Margin per Unit}}$$

Jack discovered that his break-even point was 141,228 tons. Multiplying this number by average price per ton gave Jack his break-even point in dollars -- $7,061,381. This meant that the company had to place 141,228 tons of hot mix and collect the respective construction revenues of $7,061,381 in order to cover total cost and yield a profit of zero. Construction in excess of this point will yield a profit because the contribution margin covers the fixed costs. Conversely, any amount below this point will result in a loss because the fixed costs cannot be covered by the contribution margin.

Charting for Visual Representation

From the break-even calculations, Jack constructed a chart to demonstrate the newly identified relationships. Using graph paper, Jack accurately plotted the values and located the break-even point (see Figure 6).

Break-even Point in Units (tons) = *Total Fixed Cost* ⇒ \$1,278,110 / *Avg. Contribution Margin per ton* ⇒ average construction price per ton minus average variable cost per ton

$$\Rightarrow \$50 - \frac{\$6{,}956{,}500}{172{,}000 \text{ tons}}$$

$$\Rightarrow \$50 - \$40.5$$

$$\Rightarrow \$9.50 \text{ per ton}$$

$$\therefore \textbf{ Break-even points in tons} = \frac{\$1{,}278{,}110}{\$9.05} = \textbf{141,228 tons}$$

$$\therefore \textbf{ Break-even points in dollars} = 141{,}228 \times \$50 = \textbf{\$7,061,381}$$

Figure 5.Summary of Break-even Calculation

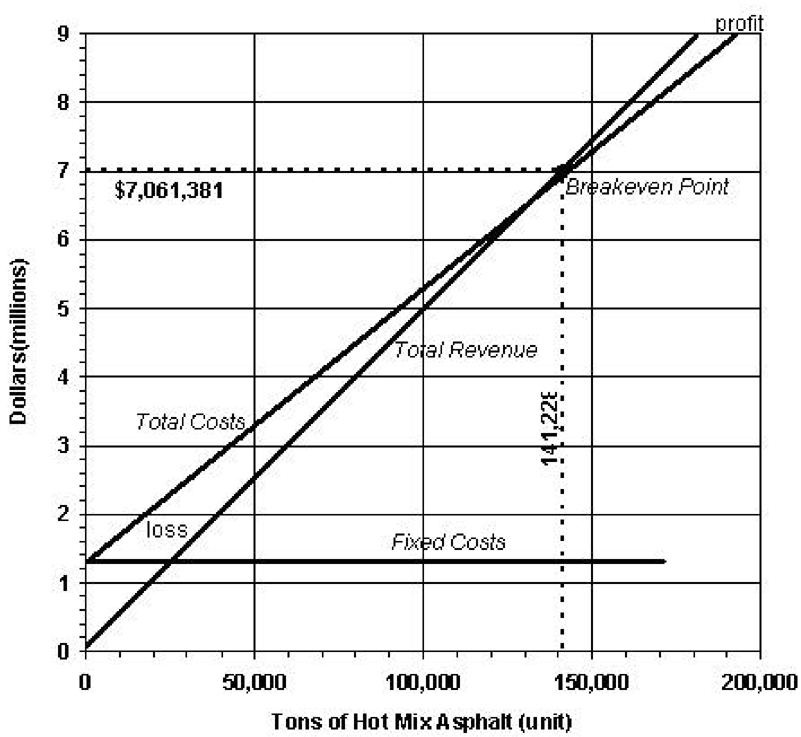


Figure 6. Smooth Road, Inc. -- Break-even Chart

Management Decisions

Jack has completed the break-even analysis and can now determine whether the company should take on the State's extra work at a lower competitive price. At this point, Jack believes that the company is able to construct the State road system without losing money. Further assessment is needed however before a final decision can be made:

1. Can Smooth Roads, Inc. places the additional 6000 tons without increases in the fixed costs (relevant range)?
2. Is each ton's (unit) variable cost covered by the reduced price?
3. Is the increased work beneficial and profitable?
4. Should Smooth Roads, Inc. definitely bid the project?

From experience, Jack had previously determined that Smooth Roads, Inc. can place a maximum of 200,000 tons of hot mix asphalt without purchasing more equipment and acquiring more manpower. He would not incur additional fixed costs -- only variable costs such as labor, materials, and job related overhead. Smooth Roads current rate is 172,000 tons. An additional 6000 tons of hot mix asphalt can be placed without increasing the fixed costs. This indicates that the proposed level of production is within the company's relevant range.

Jack calculated earlier that $40.50 was the average variable cost per ton (unit). The reduced rate of $45.00 covered the variable costs by the contribution margin of $4.50 ($45.00 less $40.50). Since Smooth Roads, Inc. would already be operating past the break-even point, Jack concludes that the increased work would profit the company $27,000 (6,000 x $4.50). Jack realizes that his actual profits might be lower if the company has to put in overtime to complete the State contract. He is also aware that this would be a great opportunity for the company to acquire another client. Jack concludes that each ton's variable cost is covered by $4.50 and the work would be profitable and apparently beneficial.

Should Jack proceed with the bidding process and submit a Smooth Roads, Inc. proposal to the State? Based strictly on the economic issues of cost, revenue and profit, the answer would be.…Yes.

Discussion

This case study introduced construction to the business basics of economic break-even analysis. There are two primary beneficial uses for break-even analysis. These include techniques in company evaluation of desired profit levels and cost reduction impact analysis. Also, the decision making process can be enhanced by using break-even analysis in combination with other analytical tools such as Break-even Default Ratios (a sensitivity analysis on the limit of decreasing unit prices) and Degree of Operating Leverage (analysis on how a change in volume affects profits).

Inclusion of these tools to the graduate students' arsenal of analytical techniques assist in enhancing the critical thinking process. It also provides these future managers of construction with another tool to produce safe and sound managerial decisions, a typical requirement of graduate level students entering the workforce. Needed in the classroom is the connection between economics and construction. Once the association is complete, one can then teach the construction graduate students these simple managerial tools in *terms of construction* -- not in cows or widgets.

References

Barrie, D. and Paulson, B. (1978). Cost engineering. *Professional Construction Management* (pp. 248-271). McGraw-Hill Book Company: New York, NY.

Casavant, K. and Infanger, C. (1984). Management decisions: How much to produce? *Economics and Agricultural Management: An Introduction* (pp. 24-61). Reston Publishing Company, Inc.: Reston, VA.

Kotler, P. (1984). *Marketing Decision Making: A Model Building Approach*. Rinehart and Winston: New York, NY.

Pappas, J. and Brigham, E. (1981). Cost theory. *Fundamentals of Managerial Economics* (pp. 240-295). CBS College Publishing: New York, NY.

Pollack, B. (1995, Summer). Break-even analysis: the third leg of the underwriting stool. *Real Estate Review, 25*, 43-46.

Powers, L. (1987). Break-even analysis with semifixed costs. *Industrial Marketing Management*, *67*, 35-41.

Sinclair, K. and Talbott, J. (1986, July). Using break-even analysis when cost behavior is unknown. *Management Accounting, 68*, 52-55.

Appendix A

Summary of Fixed and Variable Cost for Smooth Roads, Inc.

As Per Income Statement December 31. 1994					FIXED	VARIABLE
Revenue:						
172,000	@	$50.00		**$8,600,000**		
Cost of Construction						
Material			3,324,180			3,324,180
Labor - Main Office			1,830,500			1,830,500
Labor - Branch Office			827,350			827,350
Payroll Taxes			212,300			212,300
Equip. Depreciation			443,500		443,500	
Insurance			160,000			160,000
Bonding			412,000			412,000
Repair and Maintenance			25,200		14,070	11,130
Equipment Rentals			32,460		32,460	
Total Cost of Const.				**$7,267,490**		
Plant Expenses						
Auto expenses			14,000		10500	3,500
Depreciation			32,200		32,200	
Electricity			8,300		7,100	1,200
Insurance			15,680		15,680	
Misc. Expenses			65,200		58,200	7,000
Telephone			13,290		12,000	1,290
Plant Labor			102,550			102,550
Property Taxes			12,500		12,500	
Total Plant Overhead				**$263,720**		
General and Administrative						
Advertising			110,000		110,000	
Association Dues			15,000		15,000	
Bad Debts			18,000		18,000	
Computer Service			14,200		14,200	
Commissions			9,800			9,800
Interest expense			130,000		88,000	42,000
Legal and accounting			28,200		21,000	7,200
Salaries – Office			80,000		80,000	
Salaries – Field			145,000		145,000	
Stationary and Supplies			12,400		12,400	
Payroll taxes			30,100		30,100	
Telephone			22,500		18,000	4,500
Travel and expenses			88,200		88,200	
Total G & A				**$703,400**		
Total Costs				**$8,234,610**	**1,278,110**	**6,956,500**
Profit before Taxes				**$365,390**		

Journal of Construction Education
Spring 1999, Vol. 4, No. 1, pp. 38-49

1522-8150/99/$3.00/Educational Practice Manuscript

A Critical Analysis of an Introductory Computer Course for Constructors

Avi Wiezel, Ken Walsh, and Jose Breña
Arizona State University
Tempe, Arizona

The course Microcomputer Applications in Construction (CON 251) was originally developed to teach computer literacy to undergraduate students. Basic computer skills were taught, which included certain functions in spreadsheets, word processors, and databases. Beginning in the Fall of 1995, a section on multimedia application development was added. Based on the experience gained through teaching CON 251, as well as on the results of surveys of industry needs and student opinions, a new syllabus was devised for the course. The methodology used to create the new syllabus, results of the research, and recommendations for continuous monitoring of the course and adaptation to change are presented in this paper

Key Words Computer Education, Multimedia, Computing in Construction, Undergraduate Education.

Introduction

The course Microcomputer Applications in Construction (CON 251) was originally developed to teach computer literacy to undergraduate students. Basic computer skills were taught, which included certain functions in spreadsheets, word processors, and databases. The competency of the students entering this course has increased during the years due to modifications of the perquisite engineering core class, Introduction to Engineering (ECE 100), wider spread of ownership of personal computers among the incoming students, and increases in preparation in grades K-12.

During the 1994 academic year, the skill level of students at the beginning of the class was checked through a series of interviews and a survey that asked the students to self-select their competency level in a number of software applications. This evaluation indicated that the student entering CON 251 in 1994 was relatively capable in word processing and spreadsheets but not as capable in database management and graphics (Walsh and Breña, 1996). Newer ways of information storage and manipulation, such as multimedia or hypertext, were found to be practically beyond the limits of construction students.

Beginning in the fall semester of 1995 the CON 251 course was changed to incorporate the use of World Wide Web (www) and multimedia programming (Walsh and Breña, 1996). This change was undertaken to maintain a cutting edge position in the course and to expose students to many advanced topics in order to reduce computer anxiety. Additionally, the instructors believed that in the relatively near future construction companies would be requiring an even more advanced knowledge of computer applications from their new employees. It is anticipated that the use of multimedia and intranets as a means of information management will increase (Aminmansour, 1994).

After three semesters of teaching according to the modified syllabus, an analysis was performed to evaluate the performance of the course (how well it serves the students and the construction industry). A broader analysis was also performed to establish the optimal balance between the different components of the course. This paper presents the methodology applied for the analysis and the results obtained.

Background

One of the major changes to CON 251 in the fall of 1995 was the introduction of a final project. The project consisted of the development of a multimedia application that would illustrate a construction-related topic. This project was to be developed in teams of three to four students. The time spent by each of the teams prior to their presentation varied significantly, from a couple of days up to several weeks.

The presentations proved to be very interesting. Some teams made their presentations unidirectional, just as they would create a slide show with presentation software. Other teams made their presentations similar to the World Wide Web with hypertext links. One team linked its presentation to an external spreadsheet, where the main part of the application was located. Another team linked their application to a spreadsheet that created a database, keeping records of the users.

After the course was concluded in the fall of 1996, each team was asked, "What did your team get out of the creation of this application?" The following list shows a summary of the responses.

- Students gained self-confidence in using many computer applications.
- The teams found that developing a multimedia application was well within their grasp.
- The teams visualized a future step in construction computer technology.
- The teams saw multimedia as a high-tech method for teaching and learning. Several felt that the major benefit would be to educators.
- Several teams indicated that construction companies might be interested in using multimedia to educate employees who are not familiar with field operations or to us in place of traditional seminars.
- The main benefits of the multimedia package occur when it is linked to external programs. Multimedia by itself is not as useful as other programs such as spreadsheets.
- The programmer of any application has to learn to keep the user in mind. A lot of teamwork is needed to develop these applications. When developing a new application it is necessary to keep complete documentation of all the steps as it is “easy to get lost” in the middle of the application.
- Students learned to appreciate user-friendly programs.

Although the answers were interesting and proved again that there is some use in every learning experience, the most important question generated was for the instructor: "What should an introductory computer course for constructors include?"

Methodology

A literature review was conducted to answer the above question and to learn from the experience of other universities. At the same time, a survey was conducted among the CON 251 students and representatives of construction companies. The purpose of the survey was to perceive the current expectations from the graduating students and to assess the expected computer application skills in 10 to 15 years. Once this information was compiled, recommendations for a revised syllabus were made, based on an analysis of the available time and required effort.

Figure 1 outlines the process that was followed to accomplish the objectives of this research.

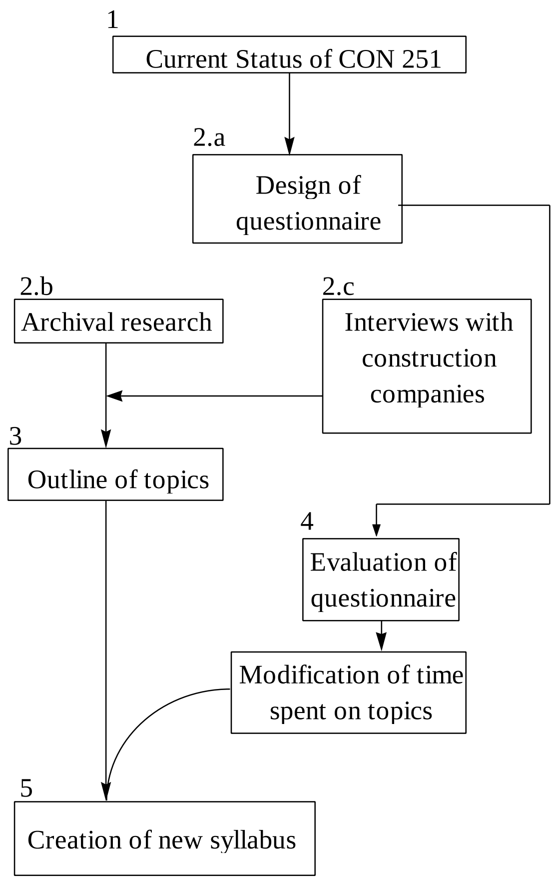


Figure 1: Analytical framework for assessment of CON 251.

The individual steps included:

1. The initial status of the course. A description of the topics taught currently in the course and the time spent on each one of them is shown in Table 2.
2. The second step was divided into three different parts:

   a. The development of a questionnaire to evaluate the perceived effectiveness of the course in particular topics and the students' perception of the importance of those topics.
   b. Archival research to evaluate the degree to which some other universities are incorporating multimedia.
3. Interviews with representatives from construction companies to determine the computer tools they expect their future employees to know.
4. The creation of an outline that combines industry expectation and curricula from other universities.
5. Student questionnaires were evaluated. Depending on the apparent effectiveness of each topic and the results of step 3, the time spent on each topic was modified.
6. A proposed syllabus was created to be taught in the course CON 251. The syllabus was based on 28 classes (75 minutes/class) during a semester.

The remainder of this paper describes the major steps and results of the research.

Student Opinion

The modified course CON 251 was delivered during three consecutive semesters to approximately thirty-five students and had a very ambitious syllabus covering the following areas (in chronological order):

1. **Microcomputers and Information**: terminology, hardware, software.
2. **Internet**: surfing, searching, style, HTML.
3. **Presentation software**: advanced techniques, presentation style, and timing.
4. **Word processing**: advanced features, office automation.
5. **Multimedia applications** (team project): editing of photographic images, recording of sounds, multimedia programming. Students were asked to develop a multimedia application that described a construction-related topic. Each team selected a topic approved by the professor.
6. **Spreadsheets** (individual and team assignments): creating a macro-driven spreadsheet. Advanced topics were built around the crane selection problem presented by Paulson (1995).
7. **Databases**: creation of relational databases, queries, input forms and reports, choosing between databases and spreadsheets.

At the end of the fall of 1996 an extensive questionnaire was administered to the students to measure the knowledge gained in all the areas taught during the course. The questionnaire was designed to allow the researchers to evaluate if the time spent in the different areas was appropriate. It was divided into several sections for each of the topics, as shown in Table 1. Each section was further divided into detailed questions regarding specific skills. The participation of the students was voluntary and anonymous. Of the thirty-five students in the course, 18 answered the questionnaire.

Table 1

Sections Of CON251 Performance Evaluation Questionnaire

Internet Surfing	Web page creation
Microsoft PowerPoint	Basic skills Slide layout Effects and animation Printing
Microsoft Word	Basic skills Formatting Page setup Graphics Indexes and tables Edition and revision
Microsoft Excel	Basic skills Cells and ranges Functions Databases Charts Macros and dialog boxes
Multimedia	Basic skills Programming
Microsoft Access	Tables Forms Queries Reports

For each concept or skill, the students were given three options regarding their knowledge:

1. Concept was known before entering the course.
2. Concept was learned during the course.
3. The concept is unknown and the student did not learn it during the course.

The results for each subject were counted. When the results indicated that more than 50% of the students already knew a concept that was taught in the course, we concluded that it was of general knowledge and the time spent in teaching that concept could be reallocated. The following topics fell into this category:

1. The general use of the Internet (Surfing). More than 50% of the students believed themselves highly competent in all skills except assessing the value of a Web page.
2. The basic skills of Microsoft PowerPoint except how to add sound to a slide.
3. In Microsoft Word, the basic skills of formatting, page setup, graphics, editing, and revisions. The use of graphics and images was less clear.
4. In Microsoft Excel, the basic skills, including the use of cells and ranges. The use of functions and charts was less clear.

When the results indicated that more than 50% of the students learned the concept during the course, we concluded that the time spent for that concept was appropriate and it should be taught using the same method used during the semester. This category included the following topics:

1. Assessing the value of a Web page. The concepts also related to the creation of a Web page, except for the part that related to Java scripts.
2. Microsoft PowerPoint slide layout, effects, and animation.
3. Microsoft Excel functions, macros, and dialog boxes.
4. Multimedia programming skills and component (sound, images, etc.) input.
5. Microsoft Access, essentially all skills.

When the results indicated that more than 50% of the students did not know the concept before and did they learn the concept during the course, we concluded that the concept required more time and should be approached on a more basic level. The following concepts were included in this category:

1. The use of Java for the Internet.
2. The use of indexes and tables in Microsoft Word
3. Some concepts in Microsoft Access.

The final part of the questionnaire gave the students the opportunity to evaluate the importance of the course content by ranking each concept and each subject area on a scale of 1-5 (least important to most important). This evaluation gave us a way to consider the students' perspective on the importance of course topics. Figure 2 shows the results of the subject area evaluations.

Literature Review

A limited program of identifying multimedia educational experiences in use in engineering and construction programs was conducted to obtain a flavor of available programs. A number of examples of multimedia used in education were found. Echeverry (1996) has developed multimedia applications covering several building methods topics. Aminmansour (1996) has developed applications for teaching structural steel design. Dymond (1996) describes a course that includes the development of multimedia applications in environmental engineering. Furthermore, there is rising evidence of the use of multimedia in industry as well (for example Abudayyeh, 1996; Wang, 1996).

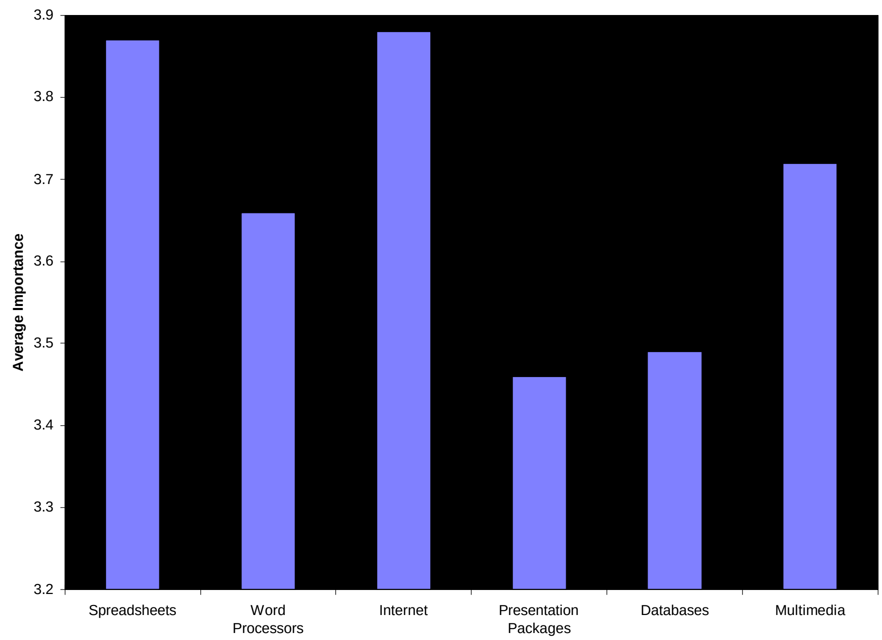


Figure 2: Perceived Importance of Topics by Construction Students

Industry Opinions

After identifying skill areas important to students, we conducted interviews with representatives from several construction companies to evaluate the current usage of computer technology and expectations of graduating students. The representatives were selected by the management of the respective companies and were the persons responsible for the development of "computing policy."

Seven companies of different sizes and involved with different types of construction were selected for interviews. Because of the small number of companies interviewed, special care was taken when drawing the final conclusions. The trends that were clearly common among the interviewed companies were further analyzed and accepted only if a clear value was perceived for CON 251. The names of the companies, by their request, are confidential.

Company A did not rely heavily on computers for information transfer. They are comfortable using common systems such as the fax, telephone, and film-based photographs. The representative of this company stated, "We are in the process of incorporating e-mail in our offices and we don't see a near future of using computers to transmit all of our information. I think that if computers would offer a higher resolution to show images, multimedia would be a valuable tool for us." This company does use spreadsheets and word processors. They also use a package that allows them to combine contract documents such as specifications, change orders, project schedule, estimates, and any other documents that are relevant for a project.

Company B thought that teaching the development of multimedia applications would be appreciated in the industry. New employees need to know how to use spreadsheets, word processors, estimating software, and scheduling software. The company has recently bought one digital camera for their office in Arizona so that they can evaluate the potential advantages of this technology. Their comments included, "We expect the use of multimedia in the future; however, we don’t know when this might occur within our company. We are not looking for a graduate who knows how develop a computer application. If we needed to develop an application, we might subcontract it from a company that specializes in that field."

Company C does not use multimedia at this time. However, they think that in the near future (2 to 3 years) most of their information is going to be managed through computer systems. "We use e-mail to transfer many files from the office to the field and vice versa. We also have to use video cameras sometimes to understand how a certain process is being realized in the field." This company would prefer graduates who know how to use digital cameras, can create reports using those images, and who are, in general, competent in the use of computer applications, including spreadsheets and word processors.

Company D does not use multimedia and does not think that they will be using it in the future. They expect graduates to have knowledge in the use of spreadsheets. The company uses e-mail to send messages from the field to the office. The company does not consider the knowledge of programming multimedia applications to be an asset for new employees.

Company E does not hire construction graduates to create multimedia applications. However, they do consider a student’s computer proficiency to be a valuable asset. They have e-mail at every job site at which they can install it. Computer emphasis is on spreadsheets, which are in daily use. This company has its own department of research and development and they have been studying multimedia applications created by other companies. They think that multimedia applications are very helpful for learning certain processes. They have a digital library for which they in the process of incorporating these tools for their employees.

Company F does not use multimedia applications. They do not like to spend a lot of time trying to figure how to insert an image into a word document. The company uses e-mail to send messages; however, extensive information is sent through messenger services. Spreadsheets and word processors are in daily use.

Company G does not seem to be advanced in the use of technology. The information received on the day of the interview (December 3, 1996) was that they were in the process of switching their operating system to Windows 95. They use e-mail to send messages and the most common computer tools that they use are spreadsheets. The company does not consider the knowledge of multimedia programming to be an asset for their new employees.

All the companies were asked to rate the importance of several classes of programs, again on a scale of 1 to 5 (from the least important to the most important. The question was, "How important is it for students to learn the following packages: 1.Spreadsheets, 2. Word processors, 3.Databases, 4.Presentation packages, 5.Multimedia, 6.Internet?” The average results and the student evaluations are shown on Figure 3. The agreement between the two groups is striking, excepting multimedia applications (with which the students are much more familiar).

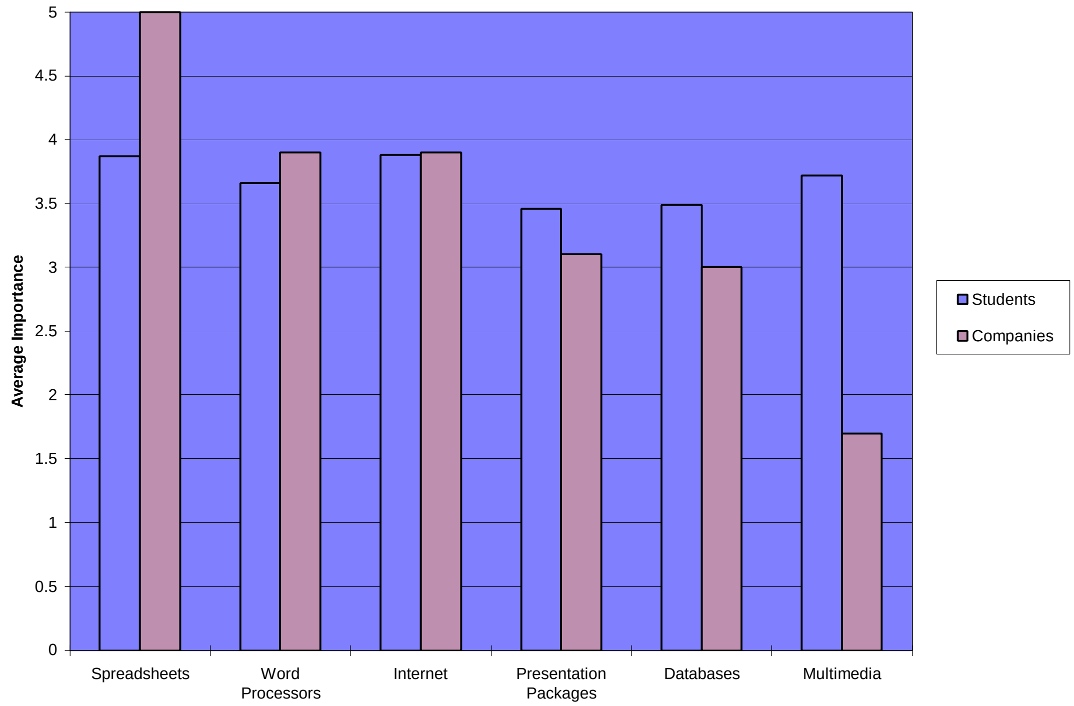


Figure 3: Perceived Importance of Topics by Construction Companies Compared to Construction Students

Proposed Applications

From the results obtained in the interviews with the construction companies and the archival research, as well as forecasts made by the members of the research team, the following applications were proposed for CON 251:

1. Spreadsheets
2. Word processors
3. Presentation packages
4. Databases
5. Use of the Internet (e-mail, and the World Wide Web)

Multimedia use and development will continue to be incorporated into the course, but in a greatly modified version. Even though the construction companies interviewed expressed the viewpoint that multimedia development skills are not needed, we have observed during three semesters that learning some multimedia increases self-confidence and computer literacy dramatically. Therefore, for the next several semesters we will include input and capture of multimedia as part of the class. The students will then learn how to include these components into the application areas listed above. A detailed analysis of the proposed syllabus follows.

Proposed Syllabus

From the effectiveness of the teaching delivery inferred from the student responses, industry evaluations of the importance of each topic, and the experience of the instructors, we developed a revised breakdown of class time per topic. The breakdown is presented in Table 2, along with a summary of the syllabus used in the last three semesters.

Table 2

Proposed Syllabus Changes Based on This Study

Topic	Number of Classes Last Three Semesters	Proposed Number of Classes
Computers	2	1
World Wide Web and HTML	3	3
Presentations	2	2
Word Processors	2	1
Multimedia	10	7
Spreadsheets	5	7
Databases	4	7
TOTAL	**28**	**28**

The first class must continue to be an **introduction to computers**. Students must learn how to evaluate different systems and be capable of deciding which system is the most appropriate for specific needs.

The coverage of **multimedia** will change drastically, with seven lectures instead of ten. The focus will change from programming to acquiring the components, including images, video, and sound. The first class will show students how to acquire still images via scanning, digital photography, and video snapshots, as well as criteria for selecting a resolution. The second class will cover editing the images. The third class will cover capturing movies with a video card and an application for creating animation. In the fourth class students will learn how to record sound using CDs, the microphone, or an external device. An additional three lectures will be spent on application development. These lectures will be distributed over the semester as an all-class project to design an application that will teach a specific construction topic previously chosen. Although the instructor will program the application, all the components required to complete the application will be provided by the students in the class. The students will view the application several times during its creation. This project will be less time-intensive than projects of previous semesters.

Three lectures will be used for the **Internet**. One lecture will explore the World Wide Web and search engines. The second lecture will demonstrate how to use e-mail (including attached files). The instructor should also encourage students to use e-mail for almost all communication outside the computer lab. The creation of a home page will be introduced.. The third meeting will be a workshop in which each student will create his/her personal home page and publish it in the university’s server. This personal assignment has been an effective learning tool.

Two classes will be spent on **presentation software**. The first class will include a brief introduction to PowerPoint, since the students generally are familiar with this program. It will also include the use of the slide master and the general organization of a slide layout. The second class will focus on effects and animation, along with use of speaker notes and presentation rehearsal.

The coverage of **word processors** was found to require a complete overhaul. Students are very familiar with this application. One class only will introduce advanced concepts such as the use of styles, inserting images, and creating a table of contents or indexes.

Spreadsheets will be expanded from five lectures to seven. A team project similar to the one that was used in the previous semesters will be assigned. The first class will be a general overview of such concepts as inputting data, cells and ranges, and simple functions. The second class will cover creating use lookup functions and conditional functions. The third class will teach creating and editing charts. Macros and dialog boxes will be covered in the fourth lecture. The next two classes will be workshops in which student teams can work on their projects. The final class will cover using the database functions of a spreadsheet. This class will also serve as a transition between spreadsheets and relational databases.

Databases will be the final topic of this course, with coverage expanding from four classes to seven. The first class will be an introduction of relational databases. The second class will teach how to create tables. The third class will cover single- and multiple-table queries. Forms and data input will be covered in the fourth class. The fifth class will cover creating and printing useful reports. The two remaining classes will be workshops in which students will work on another team project, the creation of a database for a construction company. For example, a database may be created to track materials delivered to several sites, the personnel involved in delivery, as well as data from the projects to which the materials are delivered.

Conclusions and Recommendations

The limited interviews clearly reveal that construction companies are not looking for graduates who are proficient in developing multimedia applications. Furthermore, as currently taught, multimedia programming consumes an unduly large amount of student time. As a result, we have recommended modifications to the treatment of multimedia in the course. Databases and spreadsheets will be taught in more depth, as those applications appear to be the primary computer tools that students will use during their professional experience.

Obviously, construction companies need time to incorporate new software technologies. Their lack of doing so up to now may be because of the capital or training costs, resistance to change, the current level of construction activity, or simply because of fear. We believe that companies will persist in not having the latest software technology, and that graduates will usually have more knowledge in the use of computers than the company that hires them.

Furthermore, even though multimedia was not highly ranked by the companies we interviewed, students gained computer confidence after being exposed to multimedia. It was a useful application that showed students that they are capable of doing anything they want with a computer. It encouraged them to explore several applications and learn new things. The final products were engaging and exciting to the students.

Computer technologies (including hardware and software) change dramatically and rapidly. Through the evaluation of the course we have developed a process for maintaining currency and applicability of CON 251. We believe that change must become an integral part of the class and recommend that at the beginning of each semester the questionnaire developed for this research be administered to the students to evaluate their entrance competency. Further, the process of investigating industry needs, peer institution offerings, and delivery effectiveness must be periodically repeated.

References

Abudayyeh, O. (1996). A Multi-Media Information System for Construction Delay Management, *Proceedings, Computing in Civil Engineering.* Anaheim, CA. 593-599.

Aminmansour, Abbas. (1994, December). “Can Interactive Multimedia Technology Help the Construction Industry?” *Concrete International*, *16,* 30-31.

Aminmansour, A. (1996). Utilizing Information Technologies To Better Educate Engineers Of Tomorrow, *Proceedings, Computing in Civil Engineering.* Anaheim, CA. 965-971.

Echeverry, D. (1996). Multimedia-Based Instruction Of Building Construction, *Proceedings, Computing in Civil Engineering.* Anaheim, CA. 9 72-977.

Dymond, R. (1996). WWW And Multimedia In Undergraduate Civil Engineering, *Proceedings, Computing in Civil Engineering.* Anaheim, CA. 341-347.

Walsh, K.D., and Breña, J. (1996, April 16-19). The World Wide Web and Multimedia in Undergraduate Construction Education, *Proceedings, 1996 Associated Schools of Construction Annual Conference,* College Station, Texas, 55-64.

Wang, K., and Li, X.. (1996). Multimedia Data Management in a Highway Information System, *Proceedings, Computing in Civil Engineering.* Anaheim, CA 607-612.

Journal of Construction Education
Spring 1999, Vol. 4, No. 1, pp. 50-58

1522-8150/99/$3.00/Educational Practice Manuscript

An Approach for Developing and Implementing Writing Skills in Construction Project Administration: The Purdue University Model

Christopher S. Ray
Purdue University
West Lafayette, Indiana

This paper explains how the Purdue University Department of Building Construction Management is attempting to develop and implement general writing skills into its Construction Project Administration course. By requiring students to practice writing skills relevant to entry-level skills expected upon entry into the construction market, students' writing skills should improve, and students should actively seek ways to enhance their knowledge of Construction Project Administration.

Key Words: Writing Skills, Project Administration, Entry Level Skills

Introduction

A widely accepted premise that construction education graduates possess inadequate writing skills for entry into the business community was noted by Wright in 1987. Improving communication skills, particularly writing skills, is paramount to success in the industry. As indicated in the Associated General Contractors Construction (AGC) Education Committee Academic Competencies Task Force Report Executive Summary, *The realities of the construction profession are that reading and writing are foundations of performance*. (AGC, 1995) Without adequate performance in this basic competency, graduates entering the job market will be at a significant disadvantage.

Reading and writing skills need more emphasis in the Building Construction Management curriculum. In order to enhance writing skills, students need to practice writing. Not only do students need to practice writing, they need to practice writing within the subject matter being taught. It is imperative that students realize writing is critical to successful project management, and the ability to write clearly, completely, concisely, and accurately is a skill requiring significant practice.

Background

The Construction Project Administration course is one of the required courses within the Building Construction Management curriculum at Purdue University. Students taking this course are normally at the 7th- or 8th- semester level. The course is currently taught on a semester basis, with classes being held twice per week for 75 minutes per session.

The course objectives are to present to the student a study and analysis of construction procedures and administrative functions common in the commercial construction industry. Students are required to become familiar with the basic industry administrative functions and practices as delineated and required by standard contract documents

Based on the AGC Construction Education Committee Academic Competencies Task Force Report, it was decided this Construction Project Administration course would be studied and modified to incorporate written communications.

Problem Statement

Understanding that writing skill can be developed through instruction and practice, how do we improve student-writing skills within the Building Construction Management program at Purdue University?

Strategy of Approach

The strategy used to improve student-writing skills will be to incorporate the following into the Construction Project Administration course currently offered within the department:

1. Provide guidance and instruction in basic writing and grammar skills,
2. Require the students to write,
3. Integrate writing material relevant to course content and student interest.

Provide Guidance and Instruction in Basic Writing and Grammar Skills

An integral part of written communications is the understanding and application of grammar and usage. By incorporating the use of the Purdue University Writing Lab and the On-line Writing Lab with the written requirements of the course, students will be able to enhance their writing abilities. The primary use of the Writing Lab will be to develop and assist the students in developing those writing and grammar skills suggested by Harris (1997). The Harris writing and grammar skills to be developed are as follows:

- The Writing Process,
- Sentence development,
- Parts of Sentences
- Punctuation,
- Mechanics and Spelling.

Require the Students to Write

In order to improve writing, the students need to practice writing. Within the Construction Project Administration course, the students will be required to write several types of documents. Four primary written documents will be required. These are as follows:

- Request for Information (RFI)
- Technical Letters
- Project Meeting Minutes
- Technical Topic Summary Report

Integrate Writing Material Relevant to Course Content and Student Interest

As indicated by Maher (1990), within the contract are numerous content areas for writing assignments. As an example, the roles and obligations of the contractor pursuant to AIA Document A201 account for approximately 90 various issues that need to be addressed by the contractor. Requiring written assignments on several of these issues will allow the students the opportunity to become familiar with the AIA documents as well as to improve writing about the relevant material contained in the contract documents.

Another excellent source of construction-related issues and problems is *The Construction Contractor* published by Federal Publications, Inc. This publication provides construction contract decisions issued by the federal court system, state courts, administrative boards, and several governmental authorities. By offering summaries of these cases from the plaintiff and defendant positions, each case is presented as a real-world situation to the students. During this exercise, the students are required to *take a stance and defend it* in writing. During this exercise, the students begin to understand the very real necessity of being able to communicate clearly, concisely, completely, and accurately.

Procedures and Conditions

The following procedure will be implemented and incorporated into the Construction Project Administration course at Purdue University. These procedures and conditions are to be used as guidelines for enhancing the students' writing skills.

Providing Guidance and Instruction in Basic Writing and Grammar Skills

During the first three weeks of class, the Purdue University Writing Lab will conduct five help sessions within the classroom on grammar and writing skills. In general, these help sessions will be review periods for the students. In many instances, the students have not been exposed to formal grammar and usage for many years, and providing a quick review allows them the opportunity to re-familiarize themselves with the material in a short time.

During these in-class sessions, basic instruction will be provided regarding the writing process, sentence development, and parts of sentences, punctuation, mechanics, and spelling.

During these five sessions, ten-minute quizzes will be administered to the students. Once the class has completed the quiz (see Appendix A), the writing lab instructor discusses the correct answers for immediate feedback and provides examples of how the material covered is applied to basic writing development and usage.

Requiring the Student to Write

Requiring the students to write critically about information relevant to the course content is essential to improving writing skills and learning the subject matter. As mentioned earlier, four primary vehicles by which the students are required to write within the Construction Project Administration course are requests for information, technical letters, project meeting minutes, and technical topic summary reports.

Request for Information

The Request for Information (RFI) is a typical construction document normally issued by the general contractor to the architect and engineer requesting clarification or additional instruction on some issue about the specific project. (See Appendix B)

Each student will be required to prepare a Request for Information based on material read for the particular class session. By requiring the student to prepare an RFI, basic writing skills are being developed. Writing the RFI also requires the students to think about the material within the assigned reading.

An additional significant benefit to the student RFI assignment is that it allows the instructor the opportunity to initiate the discussion method in class based on questions presented in the RFIs. In a sense, the student will be participating and contributing to the development of the discussion for the day.

Technical Letters

During the semester, the students will be required to write several two-page technical letters based on a topic developed by the instructor. These letters provide the students the opportunity to critically think about specific issues related to the course content. A sample of the Technical Letter Topic is in Appendix C.

Technical letters will be developed over four consecutive class periods.

During the first class session, the technical letter topic is provided to the students. At this time, the instructor will provide a brief overview of the situation.

By the beginning of the second-class session, the students are required to turn in an outline of their technical letter. By preparing an outline, the students are starting to develop the thought process for solving the problem, as well as developing the process for writing the actual letter.

Additionally during this session, the instructor will provide further clarification on the technical letter topic allowing the students the opportunity to confirm or question the topic.

By the beginning of the third class session, the students will be required to provide a rough draft of the letter to the course instructor.

Prior to turning in the final letter at the beginning of the fourth class session, the students will be required to take their rough drafts to the Writing Lab in teams of three for a peer review session, and for additional guidance by the Writing Lab instructors when needed. In the writing lab, rough drafts are exchanged among the peer group for review and discussion.

The peer review provides the students the opportunity to critically review each other's letters, both for content and grammar. Since the students generally possess the same construction knowledge base, many of the questions the students ask concern the content. This relationship and peer review session allows the students to ask the *What are you really trying to say?* questions without the fear of looking incompetent to the instructor or other students.

As a service offered by the Purdue University Writing Lab, a form is prepared by the Writing Lab instructor indicating when the students were in the lab and the instruction provided, and a copy is provided to the instructor. By reviewing these forms, the instructor can identify any common problems students are having, and provide additional instruction to remedy the problem area.

At the beginning of the fourth class session, the student will be required to turn in the final letter, the original outline, and any markup copies of the letter drafted during the previous three class sessions. At this time, the instructor will review the documents and provide written feedback to the students.

Project Meeting Minutes

Each student will be required to prepare formal meeting minutes based on guidelines provided by the instructor at the beginning of the semester. The students will be required to record (in writing) minutes of two class lecture sessions, prepare formal minutes, and provide a copy of the formal meeting minutes to the instructor by the beginning of the next class session. The instructor then provides copies for distribution to the entire class during the following class session.

The primary objectives of this writing assignment are for the students to develop note-taking and critical-listening skills, and skill in developing procedures for presenting minutes in a clear and concise manner.

While the student is recording the class minutes, the instructor will ask for occasional readings of a prior discussion the student has recorded in the previous few minutes of that meeting. This will ensure that the student is following the prescribed guidelines and is attempting to complete the assignment.

Technical Topic Summary Report

Each student will be required to prepare a three- to five-page Summary Report based on a technical topic of interest selected by the student. This writing assignment takes the format of an executive summary report.

The objective of this writing assignment will be to allow the students to practice summarizing a significant amount of information into a clear, complete, concise, and accurate document to be presented to senior management.

Prior to beginning this assignment, the students will be required to write a letter requesting authorization to use a specific topic for the executive summary. Upon approval by the instructor, the students will be provided a general guideline for the executive summary. As with the technical letters, the student will be encouraged to utilize the services of the Writing Lab.

Integrating Writing Material Relevant to Course Content and Student Interest

As indicated by Maher (1990), having the students write *on* the terms, conditions, roles and obligation of the contractor under AIA Document A201 presents many applications for writing. In many instances, the student may need to document specific requirements pursuant to the contract documents. At other times, terms and conditions of the contract document may need to be clarified or discussed. Both of these *writings* may be relevant and necessary for completion of the contract conditions.

The use of legal cases presents another opportunity for the students to write about material relevant to the class. *The Construction Contractor* by Federal Publications, Inc., presents cases decided by various courts and boards. By the instructor modifying these cases to present a specific view being presented in class, the students have the opportunity to critically think and write about the topic. Additionally, once the students have completed the assignment, the actual case may be discussed in class for immediate feedback to the students.

Expectations

Knowing that students' writing skills need improvement and acknowledging that these skills can be improved are the first steps towards resolving the problem. Requiring students to write and to write on relevant material are further steps towards improving writing skills.

Once the students realize that significant writing will be required in the course and that significant effort on their part will be required to become more competent writers, the instructor will be better able to guide the students to proper writing. By reviewing and editing the students' writing assignments through a peer review process, a Writing Lab process, and a final instructor review, it is expected that the students will write more successfully.

By utilizing the services of the Writing Lab for review of grammar and syntax, the faculty member will not be expected to critically review and grade these issues. The instructor's time can be concentrated on reviewing content and teaching the subject matter.

By (1) attempting to develop and implement general writing skills requirements into the Construction Project Administration course, (2) requiring students to practice writing skills relevant to the entry-level skills expected upon entry into the construction market, (3) allowing students the opportunity to interact with other students confronted with the same writing problems, and (4) interacting with Writing Lab personnel, students should improve overall awareness of the importance of quality writing.

Summary

The importance of possessing competent writing skills for the successful completion of projects is paramount to the construction industry. Employers demand that entry-level employees effectively write as topics relate to specific conditions of the contract. By integrating this writing emphasis into specific application courses in the university setting, the student will not only become a better writer, but also will be a more informed construction professional.

By providing guidance in basic writing and grammar skills, requiring the students to write, and requiring them to write on topics relevant to the course content and student interest, the students are provided the opportunity to improve and enhance their writing ability. However, it is the individual student who must make the effort to become proficient in construction writing and documentation.

References

Associated General Contractors of America Final Report. *Academic Competencies Task Force. AGC Construction Education Committee*, 1995.

Elliott, R. (1997), *Painless Grammar.* New York: Barron's Educational Series, Inc.

Harris, M. (1997), *Prentice Hall Reference Guide to Grammar and Usage* (3rd Ed.). New Jersey: Simon & Schuster.

Maher, R.P. (1990). *A Need for Teaching Writing Skills in Construction Education.* Proceedings of he 26th Annual Conference of the Associated Schools of Construction. Pp. 41-43.

Wright, E.H. (1987). *Total Integrated Across Curriculum Writing.* Proceedings of the 23rd Annual Conference of the Associated Schools of Construction. Pp.91-94.

Appendix A

Sample Grammar Quiz (Elliott, 1997)

Find the mistakes in these sentences and correct them.

1. Don't even think of trying to buy beer (It's against the law.) before you're 21 years old.
2. It is dangerous (potentially deadly)! to drink and drive.
3. There is only one thing I need to be happy (or I should say really happy:) cash.
4. I am excited (really excited!) about the project.
5. I want three things on this project, productivity, safety, and positive cash flow.

Appendix B

Sample Request for Information

Dear Mr. Ray: D.A. Roberts, Inc.
400 Northwestern Avenue. West Lafayette, IN 47906

February 24, 1998

C.S. Ray & Associates, Inc.
1414 Knoy Hall of Technology
Suite 435
West Lafayette, IN 47907

Re: Request for Information #13
Substitution of Securities for Retainage

Our company is experiencing difficulty understanding the concept in Section 3.10.6 of the text. It discusses exchanging retainage for securities.

The text discussed this topic in minor detail. However, after reading this section we are still unsure of this term. Our main question is if the security is in the possession of the owner, can the actual security holder reinvest the money into another security of equal or greater value?

At our next meeting, would you please debrief our staff in further detail concerning this concept. If you have any questions, please feel free to contact me at your earliest convenience.

Sincerely,

Dave A. Roberts
President

Appendix C

Technical Letter Topic and Description

Technical Letter #5

The soil on which the contractor built the owner's warehouse was not stable enough to support the weight of the building, which began to sink during construction. The Contractor attempted to fix the problem by jacking it up and trying to stabilize its pier supports, but the house continued to sink. Thereafter, portions of the walls and floors buckled, and a pipe burst, causing extensive water damage to the interior.

State law provides that an architect or contractor is liable to the owner of the building if the building "should fall to ruin" because of bad workmanship within 10 years after construction. Although soil defects are not mentioned in the statute, the courts have extended it to cover defects that were or should have been apparent to the architect or contractor.

Who should pay for the damaged building? Defend and explain your answer.

This letter is due by 5:00 PM, Thursday, March 26, 1998.

The inside heading is addressed to Mr. Christopher S. Ray at the address noted on the technical letter format originally handed out in class. Line spacing of the letter shall be 1-1/2 spacing.

Provide the following:
1. Introductory paragraph.
2. A paragraph describing the situation.
3. One or two paragraphs defending and explaining your position.
4. A brief summary paragraph.

Journal of Construction Education
Spring 1999, Vol. 4, No. 1, pp. 59-68

1522-8150/99/$3.00/General Manuscript

Major Changes in AIA 201 (1997 version)

Nancy J. White
Texas A & M University
College Station, Texas

This paper discusses six major changes in AIA 201 (1997 version). These changes include: 1) Increased design delegation to the Contractor, 2) Mutual Waiver of Consequential Damages 3) Change in Indemnity Provision 4) Broader definition of Hazardous Materials 5) Requirement of Mediation and 6) Changes to Insurance.

Key words: General Conditions, AIA 201

Introduction

The American Institute of Architects (AIA) has revised many of their standard form contracts effective late 1997. Among them is AIA 201- General Conditions of the Contract for Construction. This document is the basis for much of the construction documentation in the industry. In addition to its widespread use, it is often a model used by others when drafting general conditions. It reflects the current trends in both industry and the law.

The new AIA 201-1997 version contains many major and minor changes from the 1987 version. Six major changes are: 1) increased design delegation to the contractor and the subcontractor, 2) mutual waiver of consequential damages between owner and contractor, 3) contractor indemnification of owner is limited to the extent of the contractor's own negligent acts; 4) a broader definition of the term "hazardous materials; 5) the requirement of mediation before arbitration is filed and 6) increased insurance requirements. These changes are discussed in this article.

Increased Design Delegation to the Contractor and Subcontractor

AIA 201, §3.12.10 (1997 Version) states:

> *The Contractor shall not be required to provide professional services which constitute the practice of architecture or engineering unless such services are specifically required by the Contract Documents for a portion of the Work or unless the Contractor needs to provide such services in order to carry out the Contractor's responsibilities for construction means, methods, techniques, sequences and procedures. The Contractor shall not be required to provide professional services in violation of applicable law. If professional design services or certifications by a design professional related to systems, materials*

or equipment are specifically required of the Contractor by the Contract Documents, the Owner and the Architect will specify all performance and design criteria that such services must satisfy. The Contractor shall cause such services or certifications to be provided by a properly licensed design professional, whose signature and seal shall appear on all drawings, calculations, specifications, certifications. Shop Drawings and the submittals prepared by such professional. Shop Drawings and other submittals related to the Work designed or certified by such professional, if prepared by others, shall bear such professional's approval when submitted to the Architect. The owner and the Architect shall be entitled to rely upon the adequacy, accuracy and completeness of the services, certifications or approvals performed by such design professional, provided the Owner and the Architect have specified to the Contractor all performance and design criteria that such services must satisfy. Pursuant to the Subparagraph 3.12.10, the Architect will review, approve or take other appropriate action on submittals only for the limited purpose of checking for conformance with information given and the design concept expressed in the Contract Documents. The Contractor shall not be responsible for the adequacy of the performance or design criteria required by the Contract Documents.

Consistent with recent trends, this section of AIA 201 delegates design, and therefore the cost of design, of certain elements of the construction to the contractor and subcontractor. Prudent contractors will want to clarify exactly what design elements they are undertaking in a particular project, and to be aware they may be required to expend large sums for design of certain portions of the work.

The amount of design delegation to the contractor and subcontractors is getting so great there is some fear the contractor may come into conflict with State architect and engineering licensing laws. Certainly AIA 201 tries to prevent any conflict with state licensing laws by stating in section 3.12.10 "The Contractor shall not be required to provide professional services which constitute the practice of architecture or engineering unless … The Contractor shall not be required to provide professional services in violation of law. If professional design services or certifications by a design professional … The Contractor shall cause such services or certifications to be provided by a properly licensed design professional...". This provision merely says the Contractor cannot do the design itself, but must pay licensed design professionals to perform the work necessary to comply with the contract documents.

A problem with the increased design delegation is the responsibility for design placed on unlicensed and untrained individuals, rather than those who possess state licenses. An example of what can go wrong is the Hyatt Regency Hotel walkway collapse in Kansas City, Mo. In 1981 114 people lost their lives and many were injured when the second and forth floor walkways of the hotel collapsed. The original structural supports for the walkways had been changed at the suggestion of the steel fabricator. If the design in that case was the responsibility of the Architect, then the Owner would be responsible for it. However, if the design was the responsibility of the Contractor, the Owner would be shielded from liability unless an injured plaintiff could prove the Owner negligently hired the Contractor – not an easy task. This new document makes it clear that much of the design work is the responsibility of the Contractor, and the Contractor must be aware of the risks it is undertaking when it is responsible for design.

Prudent contractors will carefully check their insurance. It is unlikely a Builder's Risk or Umbrella policy will cover claims and damages related to design work. Contractors may need to obtain errors and omissions insurance, similar to that purchased by architects and engineers. These policies will protect them from lawsuits related to defective design claims, claims which may arise years after the construction is completed.

Section 3.12.10 potentially requires the Contractor to provide and pay for design work in three different areas: 1) Design necessary "to carry out the Contractor's responsibilities for construction means, methods, techniques, sequences and procedures"; 2) Design "specifically required by the Contract Documents for a portion of the Work" AND related to systems, materials or equipment; and 3) Design "specifically required by the Contract Documents for a portion of the Work" and NOT related to systems, materials or equipment. While it is true the "Contractor shall not be required to provide professional services which constitute the practice of architecture or engineering" or "to provide professionals services in violation of applicable law" the provision requires the Contractor to pay for professional design services in the specified instances. This provision potentially requires the Contractor to incur large expenses for professional design services and to comply with all local law regulating design services.

The first category of design elements to be paid for by the Contractor are those necessary to carry out the Contractor's responsibilities for construction means, methods, techniques, sequences and procedures. This is not new, and contractors have historically been responsible for design costs associated with means and methods. None of these design elements need be reviewed by the Architect, though they, like all design elements, could be submitted to the architect for "the limited purpose of checking for conformance with information given and the design concept expressed in the Contract Documents". The wording does not specifically require the Contractor to have such design elements prepared by a licensed design professional, though a prudent contractor certainly would comply with all local law regulating design services.

The second category of design elements to be paid for by the Contractor are, "Design elements that are specifically required by the Contract Documents for a portion of the Work" AND related to systems, materials or equipment. This is the category of design discussed most extensively in the provision. For this category of design, and this category only, the Owner and the Architect will specify ALL performance and design criteria that such design services must satisfy. The contractor must have this work done by properly licensed design professionals, and the Owner and Architect shall have the right to rely upon the adequacy, accuracy and completeness of those services. While it is true the Owner and Architect must provide ALL performance and design criteria for this category of design expense, a broadly worded performance specification will require extensive detailed design, all at the contractor's expense.

The third category of design elements to be paid for by Contractor are design elements "specifically required by the Contract Documents for a portion of the Work" and NOT related to systems, materials or equipment. Exactly what design elements are in this category are not clear.

However, it appears that the provision envisions something here. If not, this provision could have been worded as follows:

> "The Contractor shall not be required to provide professional services which constitute the practice of architecture or engineering unless such services are specifically required by the Contract Documents for a portion of the Work … If professional design services or certifications by a design professional are specifically required of the Contractor by the Contract Documents for a portion of the Work, the Owner and the Architect will specify all performance and design criteria that such services must satisfy."

However, the provision does NOT say this, instead it says:

> "The Contractor shall not be required to provide professional services which constitute the practice of architecture or engineering unless such services are specifically required by the Contract Documents for a portion of the Work … If professional design services or certifications by a design professional ***related to systems, materials or equipment*** are specifically required of the Contractor by the Contract Documents, the Owner and the Architect will specify all performance and design criteria that such services must satisfy. (emphasis added)."

Since courts are likely to favor an interpretation, which gives meaning to all provisions, instead of one that renders any provision meaningless, it is conceivable items that are not specifically related to systems, materials or equipment could be covered differently. [See *U.S. v. Lennox Metal Mfg. Co.,* 225 F.2d at 309), *Blake Constr. Co. v. U.S.*, 597 F.2d 1357 (Ct.Cl. 1979)].

Contractors must be aware they are accepting not only the costs of design, but the liability and risk the design will be adequate to perform the job. Should the design prove inadequate, the Contractor will be liable for damages associated with the inadequate design, including potential damage to third parties. Contractors need to be aware that they may need to purchase errors and omissions insurance, similar to that purchased by architects and engineers, to cover potential lawsuits which may not arise for years after construction has ended.

Contractors may think they are not responsible for damages related to inadequate design under the last sentence of the provision. This sentence reads the "Contractor shall not be responsible for the adequacy of the performance or design criteria required by the Contract Documents". A court is likely to interpret this sentence as meaning the Contractor will not be responsible for those designs as being adequate to the overall purpose and construction of the project. If the contractor can show it built exactly according to the performance or design criteria outlined in the contract, and those criteria prove to be inadequate, then the Contractor bears no responsibility.

However, the Contractor will be responsible for performing all requirements of the contract adequately, including design work it is responsible for under the terms of the contract. If the design prepared by the Contractor (or the architect, engineer hired by the Contractor) is inadequate or fails, the Contractor will have breached the duties it assumed under the contract and be liable for damages. Also, since many design criteria may be broadly worded performance specifications, the Contractor will be assuming the liability for the adequacy of its design to fit that broadly worded performance specification. The courts have historically found Contractor's liable for the costs and risks associated with broadly worded performance specifications.

For example the court in *Stuyvesant Dredging* said, " Design specifications explicitly state how the contract is to be performed and permit no deviations. Performance specifications, on the other hand, specify the results to be obtained, and leave it to the contractor to determine how the achieve those results." *Stuyvesant Dredging Co. v. U.S.*, 834 F.2d 1576 (Fed. Cir. 1987).

The extent a Contractor in a particular project must pay for design services will depend on the detail of the plans and specifications. Plans and specifications lacking detail or containing broad performance specifications will require the Contractor to expend large sums for design, and the Contractor will be accepting the risk of those designs. The architect or engineer hired by the Owner does not bear the risk of those designs. If the contract contains broadly worded performance specifications, the contractor will be responsible for preparing the design to comply with that specification. Performance specifications are those, which contain broad language stating merely how a particular project or part of a project is to perform. For example, a performance specification may state something like: Provide air conditioning systems to cool a particular area to 72° when the outside temperature is 102° degrees and 80% humidity". This type of specification would require the contractor to determine what type of system to install. In the event the system designed by or for the contractor proved inadequate to cool to the required temperature, the Contractor would be responsible for damages.

Another area of potential conflict between the Owner/Architect and the Contractor may be the extent to which the Contractor responsible for design that may only be inferable from the Contract Documents. For example, assume the contract contains the following provision, a provision common in AIA contracts:

> "The intent of the Contract Documents is to include all items necessary for the proper execution and completion of the Work by the Contractor…performance by the Contractor shall be required to the extent consist with the Contract Documents and reasonably inferable from them as being necessary to produce the indicated results."

Is this paragraph specific enough to engage 3.12.10? Does this mean the contractor is financially and legally responsible for all design "reasonably inferable... as being necessary to produce the indicated results"? Depending on the precedence given to the documents, it could be argued this is so. However, a better interpretation would be the Contractor is liable for all design specifically enumerated in the contract some place, even if in the form of a broadly worded performance specification.

The line of 3.12.10 which says, "If professional design services or certifications by a design professional related to systems, materials or equipment are specifically required of the Contractor by the Contract Documents, the Owner and the Architect will specify all performance and design criteria that such services must satisfy", bolsters the Contractors argument that it is not responsible for "inferable" design. Exactly what, if any, design may be required under a broadly worded performance specification as versus design that is merely inferable from the Contracts Documents is not clear and will hopefully not prove to be a problem.

Mutual Waiver of Consequential Damages

The second major change in AIA 201 (1997 version) is the waiver of consequential damages. Though the law relating to damages varies with state law, some general principles have emerged. In a broad sense, "damages" are what the losing party to a lawsuit will pay to the winning party. Several categories of damages are recognized.

The most common form of contract damages awarded is "general" damages. Other terms for general damages include "direct" or "actual" damages. The term "actual damages" is more often used in connection with tort liability, rather than contract liability. General damages are the immediate costs associated with breach of the contract or those, which arise naturally from the breach. General damages include items the parties could have reasonably foreseen when the contract was entered into. For example, should the Owner delay the construction, it is foreseeable the Contractor will have increased rental payments for the job shack located on the site. That rental would be an actual damage.

"Consequential" or "special" damages are those damages that are more remote than actual damages, or damages that may not naturally flow from the breach. A consequential or special damage may be one that arises because of some unique characteristic of the damaged party, rather than some general characteristic of all similarly damaged owners. For example an Owner may cause a delay in the construction, and during that delay the project manager dies in an unrelated car accident. The Contractor is forced to obtain the services of another project manager, but at a cost greatly in excess of the deceased project manager's salary. This would likely be a consequential damage as it was not reasonably foreseeable that the first project manager would die and it would be difficult to obtain the services of another because of an overly tight market for professionals in the industry.

Of great concern to contractors was the case of *Perini Corporation v. Greate Bay Hotel & Casino, Inc.*, 129 N.J. 479, 610 A.2d 364 (1992). In this case the owner was awarded consequential damages in excess of $14.5 million dollars for lost profit when a casino was not completed on-time. While lost profit might be an actual or direct damage, the unusually large amount in this cases is considered a consequential damage because of the unique characteristic of this owner, rather than owners in general.

The exact line between and direct and consequential damages is not clear and may vary with state law, and certainly depends on the specific facts of the case and the characteristics of damage. AIA 201 (1997 version) does provide some guidance. The provision specifically states the owner waives the following damages: rental expense, loss of use, income, profit, financing, business and reputation, and for loss of management or employee productivity or of the services of such persons. Damages waived by the contractor include: principal office expenses including the compensation of personnel stationed there, for losses of financing, business and reputation, and for loss of profit except anticipated profit arising directly from the Work.

Notice this provision does waive much of the damage and risk the contractor is accepting should its design work performed prove to be faulty. For example, assume a stairwell or walkway designed by the Contractor's licensed engineer employee proves to be faulty, collapses and kills the Owner. This would likely be a consequential damage waived by the provision. Note, however, this provision cannot waive the liability of third parties who may be injured. Should patrons of the Owner's establishment be injured, the Contractor will retain liability to those patrons. A Contractor should obtain insurance to protect it form such lawsuits.

The provision specifically retains the possibility of "direct liquidated damages". The term "direct liquidated damages" is not know in the case law and will hopefully not cause confusion to judges unfamiliar with the construction industry practice. In this sentence the term means that the liquidated damage provision must be an estimate of the direct damages only, no consequential damages.

The contractor must be careful the owner does not try to "hide" consequential damages in the direct liquidated damage clause. The direct liquidated damage clause must reflect an estimation of direct damages only, and should not contain any provisions for consequential damages.

The problem could arise because Judge-made law normally enforces liquidated damage clauses and makes no distinction between "direct" or "consequential" damages included in the provision. If the provision is an estimation of the *actual* damages, are not designed as a penalty, and are understood by the parties to be a provision for liquidated damages, the provision will be enforced. However, actual damages could include consequential damages. The inclusion of the term "direct" will hopefully prevent this from happening. Should the court or jury determine the liquidated damage provision contains consequential damages, the provision should not be enforced.

Enforcing a liquidated damage provision that contains consequential damages would be contrary to the spirit of the document. However, realistically, it is unlikely the contractor will dissect the direct liquidated damage provision at the time the contract is entered into, and judges may be unwilling to do so at the time of trial. Judges may be of the opinion the contractor should have negotiated the direct liquidated damage clause at the time the contract was signed, if it thought the direct liquidated damage clause actually contained hidden consequential damages.

Changed Indemnity Provision

The third major change involves a change in the indemnity provision. Indemnity provisions have been the subjects of much dispute and negotiation. Historically the indemnity provision in AIA 201 stated "3.18.1..Contractor shall indemnify…the Owner, Architect…from and against claims, damages…arising out of our resulting from performance of the Work….***but only to the extent caused in whole or in party by negligent acts or omissions of the Contractor***…". This meant if the Contractor was 1% responsible for the claim or damage, the Contractor was 100% responsible for the damage.

The present provision reads "Contractor shall indemnify…the Owner, Architect…from and against claims, damages…arising out of our resulting from performance of the Work…***. but only to the extent caused by the negligent acts or omissions of the Contractor***…". This modified provision states the Contractor will only be responsible for its own damages and the Owner and/or Architect will be responsible for their own damages. For example, if the Contractor is 1% responsible for the claim or injury, it will be responsible to pay for only 1% of the damage.

Broader Definition of Hazardous Materials

The forth-major change in AIA 201 is a broader definition of hazardous materials. This provision was first introduced in 1987 and protected the Contractor from costs associated with the removal and containment of asbestos and PCB. Under the 1997 version, a hazardous material is more broadly defined as "a material or substance, including but not limited to asbestos and polychlorinated biphenyl (PCB), encountered on the site by the Contractor that presents the risk of bodily injury or death." Under this definition any substance, which presents a risk of bodily injury or death, is a hazardous substance.

In the event hazardous materials are found the owner is required to indemnify the Contractor, Architect or subcontractor for claims or damages related to the hazardous substance, including removal, containment, and injury. This in effect puts the cost of alleviating the condition caused by hazardous material upon the Owner.

As with all risks and liabilities of the parities using AIA 201 (1997 version) the damages are limited by the Mutual Waiver of Consequential damages. Therefore, should the Contractor uncover a hazardous material and be delayed in the project, it is not likely it will be able to recover home office overhead or other consequential damages.

This is an area where Owners need to check their insurance coverage. Many property and liability policies do not contain provisions for removal, containment or damage related to pollution or pollutants. Pollutants are likely to include hazardous materials. Therefore a provision denying coverage for pollution is likely to deny coverage for anything related to hazardous wastes.

Requirement of Mediation

The construction industry has long recognized the inefficiency of litigating disputes. Construction contracts have for some years contained mandatory arbitration clauses. These mandatory arbitration clauses have consistently been upheld in most jurisdictions. Upholding a mandatory arbitration clause prevents the parties from proceeding with litigation in a matter.

In a further attempt to reduce the cost of claims and conflict disputes, mediation is now required before arbitration or litigation is filed. Mediation is the use of a third party to help the parties voluntarily comes to a settlement of their dispute. The mediator does not decide if one party is right or wrong, but merely assists the parties in negotiating a settlement. In mediation the parties retain more control over the outcome of the settlement and can fashion unique and appropriate remedies to conflicts. Arbitrators and judges are generally limited to damages.

Arbitrators, on the other hand, operate similar to judges and actually decide the case after evidence is presented. While it is true an arbitration is less formal than a court trial, the parties still give up a great deal of control over the outcome once the matter is placed in the arbitrators' hands. In addition the arbitrators are generally limited as to the scope and type of remedies they can employ. As with judges they are generally limited to monetary damages.

Changes to Insurance

The types of insurance the Contractor needs to obtain has been increased. The builder's risk policy must now include "earthquake, flood, windstorm, test and start up."

In addition, a new type of insurance, "Project Management Protective Liability," (PMPL) is an optional insurance the Contractor can obtain. The Owner will pay for this insurance. This policy provides "primary protection of the Owner's, Contractor's and Architect's vicarious liability for construction operations under the Contract."

In other words, this policy provides insurance if a party is found to be vicariously liable for the acts of others. In general, a party with control over a person will be vicariously liable for all damages caused by that person. An employer is generally vicariously liable for the breaches of tort or contract committed by its employee in the course and scope of employment. The Owner will be vicariously liable for the breaches of the Architect, and the Contractor will be vicariously liable for the breaches of subcontractors.

There are two major advantages for the Contractor obtaining this policy. First, to the extent the policy covers a claim or damage, indemnity and subrogation are waived. Secondly, the Contractor will not be required to name the Owner as additional insured on its general liability coverage. Because the PMPL policy is separate from the Contractor's other insurance, conflicts between the Owner, Contractor and Insurance Company over coverage can be expected to decrease. Since this is a new form of policy however, Contractors and Owners will want to understand the exact scope of coverage before deciding the Owner should not be added as an additional named insured on the Contractor's Builders Risk or other insurance.

Summary

This article has discussed some of the major changes in AIA 201 (1997 version). Many other changes have also been incorporated into it, changes not discussed here. It is likely specific state law will affect any interpretation of the document. Anyone using AIA 201 (1997 version) should have the document carefully reviewed by counsel to determine the exact nature of their rights and liabilities under this new form, as compared to the prior form, and in connection with a particular project.

References

Clough, R.H., & Sears, G.A., (1994), *Construction Contracting*, New York, John Wiley & Sons, Inc.

Ernstrom, Esq.**,** J. William, (1998), A-201 It is Not What it Used to Be, *Proceedings of the 11 Annual Construction law Conference, Texas State Bar.*

Stein, Esq., Steven, (Ed.) *Construction Law,* (1997 Edition), Matthew Bender.

Journal of Construction Education
Spring 1999, Vol. 4, No. 1, pp. 69-82

1522-8150/99/$3.00/General Manuscript

Managing Specification Information Flow Through the Residential Construction Process

Jay P. Christofferson
Brigham Young University
Provo, Utah

To increase their profitability in a market that continually is becoming more competitive, builders must find ways to use technology to improve the effectiveness of their communication. The problem is that residential contractors lose profits as a result of inefficiencies and mistakes that are made because of poor communication of specification information through the construction process. The purpose of the study was to develop a specification information flow model and computer program which could provide a framework to convert large amounts of construction specification data into useful information for builders, suppliers and subcontractors, thereby increasing production efficiency and effectiveness. A series of interviews with residential builders was used to develop a specification information flow model. The information flow model was evaluated for conceptual correctness and completeness. Implementation of the model was accomplished through the development of a computer application to control and organize customer specification information. The builders' assessment of the software confirmed that the model greatly facilitated the organization and management of specification information and would improve communication efficiency and effectiveness. It was found that a communication system based on a project's schedule was an effective method of managing residential specification information.

Key Words: Specification Information Flow, Residential Construction Management, Computer Integration

Introduction

The demand to improve performance in construction is driven by increasing competition and declining productivity (Brown, 1983; Donohue, 1995; Rouda, 1993). To improve construction productivity, builders must focus on specific areas where daily operational and management tasks and procedures may be streamlined to be made more efficient.

Construction has been described as the process of converting inputs such as capital, labor, material, and technology, into outputs such as products and services. Koontz, O'Donnell and Weihrich (1984) described the construction operation as being a transformation process. Through planning, organizing, staffing, leading, and controlling, inputs from the environment are transformed into outputs (products) for use by consumers. Their approach demonstrates that the successful transformation process depends upon an effective communication system.

The primary role of a contractor is to process and communicate information. "In order to successfully plan and subsequently control the building process, the construction firm must collect, process, and interpret vast amounts of information and data. In fact, one might define a contractor as a ‘manager of information’” (Adrian, 1985, p. 5). Adrian pointed out the importance of information management in the building process; “One can state that contractor financial failure can be traced to data collection/processing functions more often than marketing or production causes” (Adrian, 1985, p. 5). For building companies to be successful, they must be able to keep accurate and current information in not only the accounting areas but also in all areas of the business (Donohue, 1995; Schleifer, 1990; Shinn, 1993).

One aspect of construction communication deals with the communication link between the customer, the construction manager/superintendent, and the subcontractors and suppliers. According to T. Clydesdale (1993) from Home Builder’s Institute, the National Association of Home Builders estimated that there are approximately 29,000 items that must be accounted for during the construction of a new home. Building specifications and customer selections describe the colors, models, sizes, and delivery requirements for these items. These items are part of nearly 100 scheduled construction activities. Approximately 50-60 suppliers and subcontractors are involved with providing and installing materials for each new home. Construction managers must gather information from homebuyers about what they want their new homes to be like. This information must then be interpreted into construction terms, documented, organized and sorted, and communicated to the appropriate suppliers and subcontractors. The responsibility to communicate these specifications accurately and efficiently for each home is a demanding job. The concern is that when building 5, 50, 100 or more homes per year and combined with all of the other responsibilities related to managing a construction job, the communication task alone is very taxing.

The added and uncontrolled costs due to mistakes during the construction process are deducted directly from projected profits. For example, the roofing on a home represents one to two percent of the total cost of construction (Shinn, 1995). A seemingly small problem such as a miscommunication about the color of a home’s shingles could ultimately cost a builder 50 percent of the typical profit for the home (Ibid.). Even if the mistake were discovered before the shingles were installed, the builder would suffer the costs of restocking the shingles and a delay in construction time. Assuming that oftentimes there are several communication breakdowns during the construction of a home, it is understandable that these wasted expenses could consume much of a builder’s profit. If one were to multiply these costs by the number of homes the contractor builds in a year, the loss of revenue would be startling. The builder should not only be concerned with the monetary loss, but also with the loss of reputation that accompanies such mistakes.

The burden of organizing and communicating customer specifications through the residential construction process is very expensive in terms of the time needed for the process and the expenses due to errors in communication. Some residential contractors are experiencing expanding markets where the demand to build more homes is increasing. With this increase in workload, these contractors are required to organize and process more information. They can accomplish this either by hiring more people to help with the workload or they can find more efficient ways to use tools that are already available to accomplish the task. The apparent costs of hiring more employees may seem to be the same as the costs associated with implementing new technology; however, this may not be true. For example, payroll expenses carry the additional overhead burden of taxes, insurance, and other benefits that are paid to employees.

Training new employees is expensive in terms of time and money and new employees are prone to make more mistakes. Another problem with adding employees is that residential construction markets are cyclical. Many contractors avoid hiring during boom markets to avoid having to lay off employees during anticipated down cycles.

Problem Statement

To increase their profitability in a market that continually is becoming more competitive, builders must find ways to use the tools of technology to improve the effectiveness of their communication. The problem is that residential contractors are losing profits as a result of poor communication of specification information through the construction process.

Purpose of the Study

The purpose of the study was to develop a specification information flow model which would provide a framework to convert large amounts of construction specification data into useful information for builders, suppliers and subcontractors. The information flow model was used to develop a computer application that would facilitate the organization and control of specification information thereby improving communication efficiency and effectiveness.

Research Questions

Breaking the research problem into separate components facilitated the development and computer implementation of a model information flow system. The following research questions assisted in the development and implementation of the specification flow model.

1. What are the components of an effective specification communication system and how can they be applied to a residential specification information process flow model?
2. What components of the specification information process flow model can be integrated into a computer software application?
3. To what extent does the software computerization of the specification information process flow model impact efficiency and effectiveness in communicating specification information?
    a. To what degree is the software perceived to require more or less time?
    b. To what degree is the software computerization perceived to save or cost money?
    c. To what magnitude is the software computerization perceived to be more or less accurate?
4. What is the level of ease with which the user can operate the software?
5. To what extent is the software perceived to be able to accommodate the management of custom specification needs?

A review of literature and other research failed to produce any acceptable instruments which could suitably aid in answering the research questions. A questionnaire was developed to extract the information needed to answer the research questions. A distinct jury of six residential construction experts who evaluated each question based on its content determined the face validity of the survey instruments. Each jury member was asked to judge each question as to its appropriateness to the study, whether or not the statement led to a particular response, and whether or not each question was clearly written and avoided ambiguity. Jury members were allowed to make additional comments on each item

Specification Information Flow Model

An initial builder survey was conducted to find answers to the first research question. Custom homebuilders were categorized according to the number of homes each built per year. Builders were divided into small volume builders, those who built 5 to 19 homes per year, medium volume builders, 20 to 79 homes per year, and large volume builders, 80+ homes per year. An interview with each of six builders who participated in the study (two from each category) was conducted to learn what builders were presently doing to gather, organize, and communicate specification information and what elements were essential for a specification communication flow model. Builders were asked to evaluate the effectiveness and efficiency of their own systems and to provide recommendations that would improve their systems.

Although the responses varied between builders, many responses were similar. All used a written contract to validate the sale of the home, whether it was a standardized real-estate sales contract or a custom contract for their own company. Each builder had some system developed to handle specification information. Some systems were as simple as putting all notes into a file under the customer name. Other systems were more sophisticated; for example, one builder had an elaborate system to organize all the specification information before construction started. The process, however, took several hours to complete by hand for each house.

Most of the builders gathered specification information from their customers during personal interviews. The information was typically gathered during pre-construction conferences or during a series of customer meetings.

The builders thought that their information systems could be improved but were not sure exactly how. While only one of the builders was still doing business without a computer, all thought that computerizing their specification information would help them to become more efficient. Some thought that their greatest unforeseen costs were those created by mistakes from deficiencies in their communication systems.

Creation of a Specification Information Flow Model

A model of the specification information flow was created (Figure 1) that included databases for buyer information, lot information, custom options, subcontractor and supplier information, schedule information, and a plan database that included the allowances for each plan. A sales summary sheet was used to help with the selection of information to be included in the sales contract. An addendum sheet was used to select options and colors from the options, colors, and cost database. As options and colors were selected, costs for the upgrades or credits for less expensive choices would also be shown.

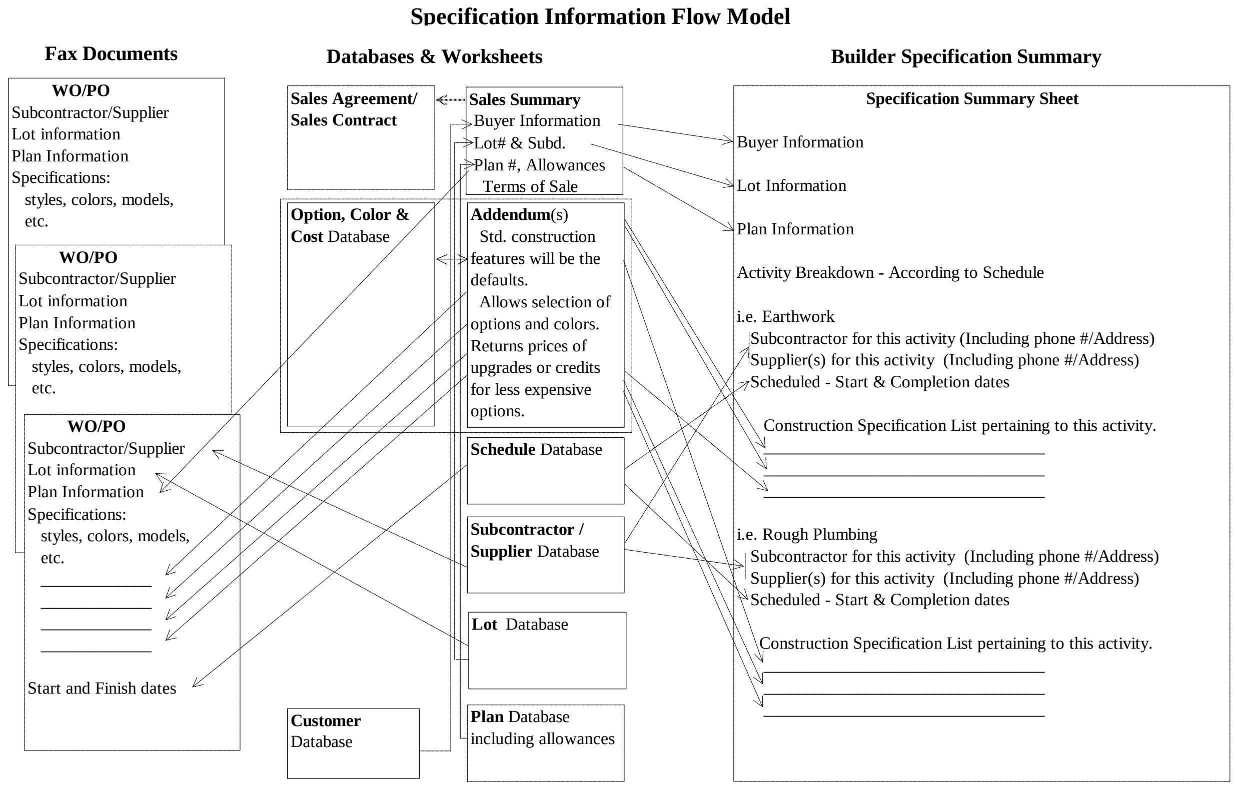


Figure 1. Specification Information Flow Model

The Builder Specification Summary report (Appendix A) is the main report for builders' use. It summarizes, according to the production schedule, all of the information needed to build the house. On it were recorded buyer, lot, and plan information. A list of construction activities including scheduled start and completion dates, the supplier/s and/or subcontractor/s associated with each activity, and any specification information pertaining to that activity.

Another important set of reports that are included in the information flow model are work orders and purchase orders to be mailed or faxed to the subcontractors and suppliers (Appendix B). These orders contain specification, lot, plan, and schedule information that the subcontractors and suppliers need to complete their jobs.

Validation of Specification Information Flow Model

The builders involved in the study were asked to judge the model for wholeness (completeness) and conceptual correctness (suitable for use) (Reingruber & Gregory, 1994). After reviewing the specification information flow model, the builders were asked to indicate their attitude relative to the completeness or wholeness and accuracy of the model.

The first survey question measured the wholeness of the model. The average response to this question, "Do the attributes of the model adequately describe the full scope of specification communication flow from the customer through a residential construction company to the subcontractors and suppliers?", was 6.0 (Seven was the maximum on the Likert scale). The second survey question measured the model's conceptual correctness. The average score for this question, "Does the model portray an accurate representation of the real world as it applies to specification information flow in residential construction companies?" was 6.3.

A Computer Application Of The Specification Flow Model

To answer the second research question, the flow model was used to develop a software application using Microsoft's Excel, Word, and Project. Microsoft products were chosen for two reasons; first, they are used by many builders (NAHB, 1994), and second, this software utilizes Object Linking and Embedding (OLE), a method of sharing information between programs. The procedural code was written using Visual Basic for Applications.

Application Walkthrough

The software application begins at the Sales Contract Summary sheet (Figure 2). This sheet allows the builder, with input form the homebuyer, to select pertinent information that will be used in the sales contract. The builder can retrieve information about the buyer if the salesperson has previously entered the buyer information into the database. The builder selects the customer by clicking the mouse over the correct name and clicking on OK. The associated customer information is automatically brought into the summary sheet.

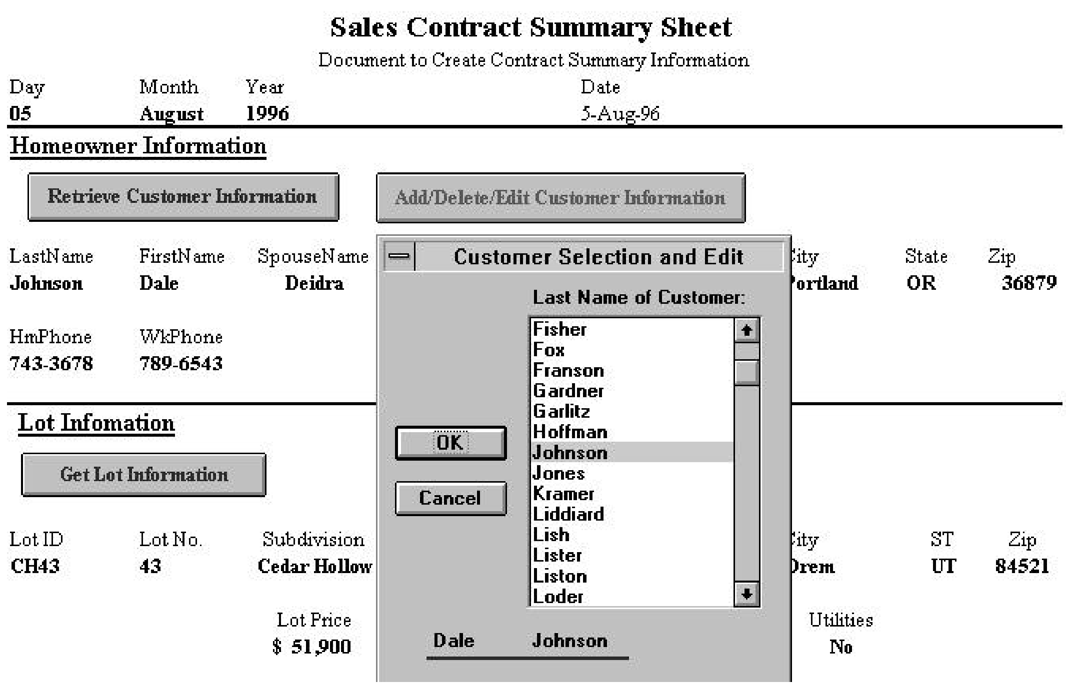


Figure 2. Retrieving Customer Information

Otherwise, the program allows the builder to enter the buyer information if the customer information is not yet in the database. Customer information can also be edited and deleted by clicking on the edit/add/delete button. Information about the lot and plan is handled in the same manner.

The plan information also contains the allowances included with specific plans (Figure 3). Adjustments to the allowances can be made. The base price of the plan and adjustments to the base price (adjustments to the allowances) is automatically added to the lot price to give the sum total of the contractual purchase price. If the buyer is in agreement, the Update Files button is clicked and a new work file for the lot (CH43 - Cedar Hollow lot 43 in this case) is created.

Plan Information

Retrieve Plan Information

Add/Delete/Edit Plan Information

Plan ID	Plan Name	Plan Style	Finished SF	Tot SF	Base Price	Architect
R-1825	**Riverton**	**Rambler**	**1825**	**3500**	**$ 136,875**	**Technigraphics**

Allowances		Adjust Allowance	Total Allowance
Hardware (installed by contractor)	**$ 1,200.00**		**$ 1,200.00**
Electrical & Lighting Fixtures	**$ 2,500.00**	($500.00)	**$ 2,000.00**
Floor Coverings	**$ 8,000.00**	$ 1,500.00	**$ 9,500.00**
Cost of Brick per Thousand	**$ 260.00**		**$ 260.00**
Cabinets & Countertops	**$ 9,500.00**	$ 2,500.00	**$ 12,000.00**
Mirrors and Medicine Cabinets	**$ 650.00**		**$ 650.00**
Appliances	**$ 2,400.00**		**$ 2,400.00**
Rain Gutters and Down Spouts	**$ 800.00**		**$ 800.00**
Other:			**$ -**
Total of Allowances (Included in Base Price)	**$ 25,310.00**	$ 3,500.00	(Tot. Adjustments to Allow.)
		$ 136,875	(Base Price)
		$ 140,375	(SubTotal)
		$ 51,900	(Lot Price)
		$ 192,275	(Total Contract Amount)
		$ 5,000	(Construction Deposit)

Update Files - (this will take a few minutes)

Figure 3. Working With Plan Information

The program then switches to Microsoft Word and the standard contract form is updated with all of the essential information from the Contract Summary sheet.

While the customer is with the builder, or at a later date, custom (or option) selections can be made using the Addendum sheet (Figure 4). The Addendum sheets summarizes the buyer, lot, and plan information and allows the customer to select from all options offered by the builder. By selecting the item to be changed and clicking on the bar on the left hand side, an option selection menu comes up which allows the user to add, delete, and select options from the database.

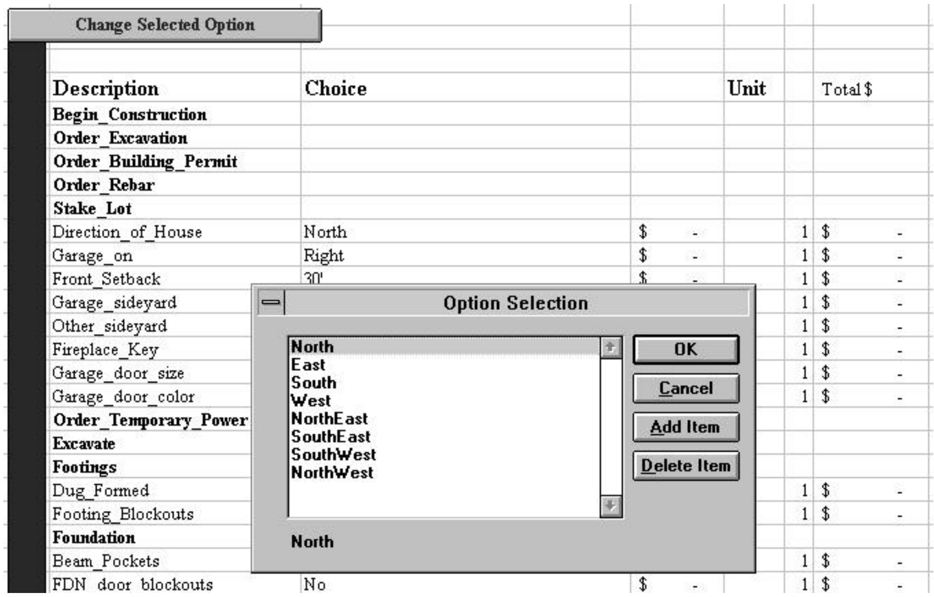


Figure 4. Selection of Options

Upgraded items will show an added cost and the upgrades will be totaled at the bottom of the addendum. Downgrades will be credited from the total. Once the buyer has selected all of the options (colors, styles, other specifications for the house), the total of the upgrades/downgrades is added to or subtracted from the original contract price of the house. The buyer/s then sign/s the addendum and it becomes part of the contract documents. The buyer is done and leaves the office.

The builder now begins to make selections of the subcontractors and suppliers who will be employed to complete the house. The Subselect sheet (Figure 5) is used to make the selection process faster.

Select Sub / Subcontractor

Activity	Index	BusinessName	Contact	Phone	Phone2	Work
Termite	111	Recto Pest Control	Nathan Backman	545-8488	354-5456	Termite
VA/FHA Inspector	42	FHA	Nathan Russel	658-8210	580-5698	VA/FHA Inspec
Lumber	18	BMC West	Eric Healey	252-3000	580-6632	Lumber
Exterior Doors	5	Ace Doors	Brian Pratt	848-9554	854-6543	Exterior Doors
Windows	68	Jones Paint and Glass	Russel Jones	496-5887	463-558	Windows
Grading Labor	72	Kendall Jackson	Kendall Jackson	368-5899	0	Grading Labor
S & W	100	Jenson's Plumbing	Mike Carter	848-5433	843-6461	S & W
General Labor	141	Walter Jennings	Walter Jennings	545-8545	848-5466	General Labor
Plumbing	142	Wasatch Plumbing	Bill Quincy	848-5456	526-4156	Plumbing
City Inspector	96	Provo City	Bergen Merrill	547-8547	0	City Inspector
Flatwork	64	Jerry Monson Construction	Jerry Monson	459-6894	480-6589	Flatwork
Framing	104	Quality Framing	Frank Tenison	845-9953	848-3546	Framing
Roofer	71	Kelly Roofing	Kelly Baker	844-5466	545-2316	Roofer
Roofing	139	Valley Roofing	Guy Reynolds	321-6554	632-5622	Roofing
HVAC	55	Heating Systems	Stan Letterman	848-8984	545-5221	HVAC
Electrical	148	Wire Co.	William Peterson	545-5845	545-8858	Electrical
Cabinets	101	Quality Cabinets	Frank Osmond	525-5588	0	Cabinets
Fireplace	44	Fireplace Inc.	Harry Oaks	545-5454	361-8462	Fireplace
Insulation	116	South Town Insulation	Sally Nelson	545-6545	545-9874	Insulation
Drywall	120	SheetRockers	David Roland	232-8844	545-8885	Drywall
Garage Door	83	Martin Doors	Jed Anderson	636-6955	362-5968	Garage Door
Finish Lumber	26	Cubco	Jared Wilson	378-6554	0	Finish Lumber

Figure 5. Subcontractor and Supplier Selection Sheet

If, for example, the builder wanted or needed to select a new framer for this job, he or she could do so by selecting the Framing trade box and then clicking on the selection bar on the left. All framers from the Subcontractor/Supplier database are selected and the builder clicks on the number of the framer that will be used (Figure 6). If a subcontractor or supplier does not appear on the list, they can be added. Existing information can easily be modified or edited.

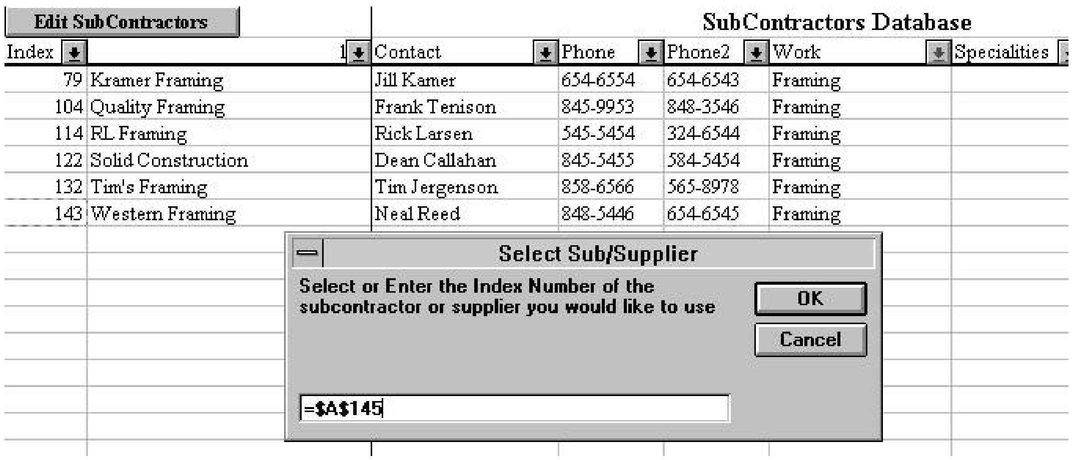


Figure 6. Selection of Individual Subcontractors and Suppliers

A baseline schedule was created in Microsoft Project as a standard for building the houses to a time scale. The baseline schedule can quickly and easily be modified and adjusted to meet existing requirements for specific houses. The construction start day can be changed as well as activity duration lengths. The new schedule is saved under the job identifier (CH43.mpp in this case).

The builder can now create the reports that will organize all of the specification and database details into useful information. The first of these reports is the Builder Specification Summary sheet (Appendix A). This report summarizes the buyer, lot, and plan information. It organizes all specification information according to the schedule. Schedule dates are given for each construction activity along with the subcontractor and or the supplier and all contact names, telephone, and mailing information. If the schedule needs to be adjusted during the course of construction, the dates on the Builder Specification Summary sheet can be updated by clicking the update button. Any changes of specifications, subcontractors, suppliers, etc. are automatically reflected in the appropriate place in the Specification Summary sheet.

The second major set of report documents are the mail-in or fax order sheets that will go to each of the subcontractors and suppliers involved in the construction of the house (Appendix B). These sheets act as work orders or purchase orders and detail all of the information required of the subcontractor or supplier to complete their part of the job including job address, lot number and subdivision, plan information, style, colors, model, special information, and dates for starting the work or delivering a product. These work orders and purchase orders can be faxed out all at one time or in batches to allow for changes and/or corrections to the schedule. Again, any changes to specifications, subcontractors, suppliers, or updates to the schedule are automatically reflected in these documents. The whole process of selecting and organizing information can take as little as 45 to 60 minutes depending on the amount of time the customer takes to decide on options.

Software Efficiency and Effectiveness

To answer the third research question, “To what extent does the software implementation of the specification flow model impact efficiency and effectiveness in communicating specification information”, the trial project was demonstrated to six residential builders. Each was allowed to interact with the program and ask questions about its operation. When the simulated exercise was completed, builders evaluated the program compared to their current method of communicating specification information.

The builders were asked to indicate the extent to which the software computerization would require their companies to spend more or less time. The average response was 6.2 (Seven was the maximum on the Likert scale). All thought that the software would require the builders to spend less time. They were asked how much time the software would cost or save each builder. The average hours expected to be saved per house, according to the responses of the six builders, was 16.

Comments from builders included; “set-up time would take some time, but once we are set up,” “the project would go 10 times better,” “the communication factor between the builder and the owner would increase 10-fold,” “it’s nice because once it’s done, it’s done,” “software is friendly, hopefully less mistakes are made because the software tells you your critical paths,” “looks like a great system, and depends on the skill level of your personnel”.

Another question asked the builders to indicate the extent to which the software computerization would require their companies to spend more or less money. The average response from the builders was 6.0. The average savings was estimated at $2,467.00 per house. This figure seemed to be a hard one for the builders to estimate. Part of the savings were estimated based on the amount of time saved, and part was based on estimated costs saved as a result of reducing errors during construction. Values ranged from $250.00 to $10,000.00 per house.

Comments from builders included, “The program would save on mistakes such as ordering the wrong countertop colors,” “Running-around time would be decreased and working with subs and owners would be a lot easier,” “Based on the controls of a builder’s current system, some could save thousands of dollars,” “The biggest savings comes as a result of items not missed -- where you have to go back and fix them, “ and “The time savings would be found in doing the job right the first time”.

The builders indicated the extent to which the software computerization would be more or less accurate than their current methods of management. The builders’ responses averaged 6.2. Comments from builders included; “It would always be only as accurate as the input but having this information always available and not relying on memory would save on mistakes,” “You have to think to input into the computer. The information, hopefully, is making it (the process) more accurate,” “It would save even on reconciliation and duplication and on items such as telephone time, work, and mistakes," "It would be a lot more accurate than what we are now doing," and "The only errors would be initial input errors".

Software Ease of Use

To answer the fourth research question question, were asked to rate the ease of use of the program. The builders indicated that the program would be easy to use. The average response was 6.5.

Software Customization

To answer the fifth research question builders rated the flexibility of the program and made comments about the software's ability to fit the custom needs of the company. The builders were asked to indicate the extent to which the software computerization could be customized to fit their own needs. The average response to this question was 5.8. Comments from builders included; "it looks adaptable to the way I use my computer now," "Short period of training," "It would take about two days to set it up, but once set up, it would save time and money," "The user would just have to add their own information to the system," "The only concern is the number of allowable changes or options with the software," and "The initial setup would be time consuming but it would be well worth it."

The builders were asked to indicate the extent to which they thought the program would be useful in managing their own company. All of the builders thought that the software program would be very useful to managing their companies. The average response was 6.7. Comments from builders included, "Would love to implement it. [Sales] agents could each have a laptop with the program. It would save tons of money," "We would like to look at using it in our company," "Any good scheduling software will allow you to mange your company better," "We look always to expediting the sales, contract, and expediting process," "Managing our company would be made a lot easier. Sub control is a big problem. It would greatly help - with scheduling also," and "Very much needed**!".

Conclusion

The development of the specification information flow model that was tested through software implementation and validated by experienced builders demonstrates that this schedule driven program does help solve the communication problem associated with customer specifications. The builders thought that this computer implementation of the specification information flow model would be very useful in helping them organize and control their specification information. Improving the flow of specification information through the construction process will be an area of greater focus and emphasis for builders as they continue to look for ways to build better quality homes in a more highly competitive market.

References

Adrian, J. J. (1985). *Microcomputers in the construction industry.* Reston: Prentice Hall.

Brown, C. D. (chairman), (1983, January). More construction for the money. *Summary Report of the Construction Industry Cost Effectiveness Project.*

Clydesdale, T. (1993). Personal communication, November 4, 1993. *Home Builder's Institute - Quick Management Systems*, Washington, D.C.

Donohue, G. (1995, January). Cost of doing business. *Builder: The Magazine of the National Association of Home Builders.*

Koontz, H., O'Donnell, C., & Weihrich, H. (1984). *Management*, 8th Rev. Ed., New York; McGraw-Hill.

NAHB (1994). 1994 Builder computer study. *National Association of Home Builders.* Home Builder Press, Washington D.C. Exhibit 35.

Reingruber, M. C. & Gregory, W. W. (1994). *The Data Modeling Handbook*. Wiley-QED, New York.

Rouda, M. B. (1993, July). Help for the Bottom Line. *Builder: The Magazine of the National Association of Home Builders*.

Schleifer, T. C. (1990). *Construction Contractor's Survival Guide*. Wiley-Interscience.

Shinn, C. C. (1995, July). Where Did My Profits Go? How Do I Get Them Back?, Part 1. *The Builder's Management Journal*, 9 (1).

Shinn, E. (1993) *Accounting and Financial Management for Builders, Remodelers, and Developers*, Home Builder Press.

Appendix A

Sample Builder Specification Summary Page

Builder Specification Summary Sheet

Lot ID	**Lot No.**	**Subdivision**		VA/FHA Case #			
CH43	**43**	**Cedar Hollow**					
		1465 E. 1940 N.		**Orem**	**UT**	**84521**	
Buyer(s)		Customer Last Name		First Name	Spouse Name		
		Johnson		**Dale**	**Deidra**		
		6881 Grand View		**Portland**	**OR**	**36879**	
		743-3678					
		789-6543					
Plan ID		**Riverton**		Fin SF	Tot SF	Architect	
R-1825		**Rambler**		**1825**	**3500**	**Technigraphics**	
		Original Contract Price		$ 192,275.00			
		Addendum 1		($370.00)			
		Total Contract Price		**$ 191,905.00**			
Update to Schedule							
Start Date	**Finish Date**	**Description**		**Selection or Company**	**Cost or Contact**	**Phone**	**Qty. or Phone2**
5/7/96	5/7/96	**Begin_Construction**					
5/7/96	5/7/96	**Order_Excavation**					
		Subcontractor	65	Jim's Excavating	Jim Holloway	444-2423	434-2344
5/7/96	5/13/96	**Order_Building_Permit**					
		Subcontractor	96	Provo City	Bergen Merrill	547-8547	0
5/7/96	5/7/96	**Order_Rebar**					
		Supplier	126	Superior Buck & Steel	Paul Murphy	561-5487	580-6531
5/7/96	5/7/96	**Stake_Lot**					
		Subcontractor	56	Nathan Black	Nathan Black	758-6985	580-6325
		Direction_of_House		North	$ 0.00	0	1
		Garage_on		Right	$ 0.00	0	1
		Front_Setback		30'	$ 0.00	0	1
		Garage_sideyard		8'	$ 0.00	0	1
		Other_sideyard		10'	$ 0.00	0	1
		Fireplace_Key		No	$ 0.00	0	1
		Garage_door_size		16 x 7	$ 0.00	0	1
5/7/96	5/24/96	**Order_Temporary_Power**					
		Subcontractor	148	Wire Co.	William Peterson	545-5845	545-8858
		Supplier	134	Utah Power & Light	Norm Shaw	265-6589	659-1254
		Temporary_Power		#N/A	#N/A	#N/A	
5/14/96	5/14/96	**Excavate**					
		Subcontractor	65	Jim's Excavating	Jim Holloway	444-2423	434-2344
5/15/96	5/15/96	**Footings**					
		Subcontractor	125	Summerville Construction	Ken Summmers	254-5441	580-3691
		Supplier	145	Westroc	Jenny Sorenson	368-7855	566-6537
		Dug_Formed		Formed	$ 0.00	0	1
		Footing_Blockouts		Yes	$ 0.00	0	1
5/16/96	5/17/96	**Foundation**					
		Subcontractor	125	Summerville Construction	Ken Summmers	254-5441	580-3691
		Supplier	145	Westroc	Jenny Sorenson	368-7855	566-6537
		Beam_Pockets		Yes	$ 0.00	0	1
		FDN_door_blockouts		No	$ 0.00	0	1
		Garage_Man_door_size		2' 8"	$ 0.00	0	1

Appendix B

Sample Subcontractor/Supplier Order Sheet

New Homes Construction Company
348 N. 800 E. Provo, UT 84209
(801) 354-7788

12/30/96

Subcontractor/Supplier Specification Checklist and Schedule

Earthwork

Company	30 Heartwood Dr.	Contact	Phone #'s
Jim's Excavating	Provo	Jim Holloway	444-2423
	UT		434-2344

Lot #	1465 E. 1940 N.
43	Orem
Subdivision	UT
Cedar Hollow	

Plan Identification
R-1825

Activity	Projected Start Date	
Excavation		5/7/96
Direction_of_House	North	
Garage_on	Right	
Backfill		5/29/96
Gravel	No Gravel Import	
Final Grading		7/15/96

Call Blue Stakes before excavating: 566-1245
2% grade minimum on final grade - 10' around foundation

Journal of Construction Education
Spring 1999, Vol. 4, No. 1, pp. 83-91

1522-8150/99/$3.00/General Manuscript

REDLINE - Real-time Documentation Linking Images and Notations Electronically

Thomas H. Mills
Virginia Tech
Blacksburg, Virginia

Real time archival of as-built documentation is currently possible and is being used during the construction process. Compilation and retrieval of accurate as-built documentation has always been a problem for designers, constructors, and owners. This problem can be overcome by utilizing the process described in this paper. Within the paper a strategy and appropriate technology for creating and tying electronic as-builts with computerized project scheduling is described. REDLINE assembles low cost portable video capture technology and Microsoft Project 4.0 software to record and link real time construction activities with manual and CADD (Computer Aided Design & Drafting) project drawings. Construction activities are video taped and visually linked to project drawings, details, and task activities through Microsoft Project. The digital information is "redlined" with text and graphics to convey as-built information and is retained for archival purposes. Video documentation is accomplished with minimally trained personnel as is linking video images to project task. CADD prepared drawings and details allow linking with an ability to "redline" as-built conditions. Digital conversion of manually prepared drawings remains a challenge as does disk storage capacity. Archived electronic as-built documentation implemented on a real time basis is achievable and effective. Easily retrievable archived information provides distinct benefits for designers, contractors, and owners. Each participant meets contractual obligations and can subsequently utilize the process to produce a peripheral database addressing their own unique situations

Key Words: CAD, CADD, As-built drawings, Record drawings, Scheduling, Digital image linking, Integrated database, Electronic data interchange

Introduction

Record drawing is the AIA recommended term for what contractors commonly call "as-builts." A record drawing or an "as-built" is a construction drawing that has been revised to reflect significant changes made during the construction process. Therefore it contains information not previously documented on the construction drawings. These record drawings take the form of marked up (redline) prints, or reproducibles that have the pertinent "as-built" information redlined on to them. Of particular importance to owners, who ultimately will be operating and maintaining a facility, is concealed conditions notably routing, depth, and location of underground utilities. These conditions become the major elements of acceptable deviations forming "as-built" drawing information. To maintain accurate as-builts, the record drawings must be noted on a daily basis as each activity occurs.

The term "as-built" is discouraged by professional organizations including the AIA. The reason for discouraging this term is concerns of professional liability regarding accountability in certifying the accuracy of completed construction. This appears a prudent mechanism in the absence of full time project surveillance by design professionals. The A/E/C industry fully embraces the concept of "as-built" documentation by endorsing standard General Conditions to construction contracts that makes the maintenance of "record documents" a contractual obligation. The concept of "record documents" is broadly defined to include all contract documents, in addition to, change directives, written interpretations, clarifications, approved samples and shop drawings. (AIA A-201, 1987) Typical contractual obligations make the maintenance of "as-builts" a contractor responsibility. The importance of "as-built" documentation cannot be overstated. Designers and owners stress the importance of maintaining "as-builts" by making their receipt a condition of receiving final payment.

This paper describes REDLINE (REal-time Documentation Linking Images and Notation Electronically) a process that can be used to record real-time construction activities and subsequently convert this record into electronic as-built drawings. REDLINE allows the user to interactively tie computerized project scheduling and digital as-built images. The model as developed uses Microsoft Project 4.0 for Windows as a self-contained archival source for digital images recording real-time construction progress. The data can further be archived in a read only CD-ROM, thus preserving the integrity of the archived database.

Electronic Record Documentation

Without continuous on-site observation and attentive field supervision the accuracy of "as-built" information suffers. Conditions or information is then redlined or transferred to reproducibles with a graphic quality that renders the information all but useless. This problem has given rise to many owners insisting that the record drawing process become a responsibility of the design professional. This puts a responsibility on the architect to document conditions that they may not have witnessed. This subsequently creates additional concerns on the reliability of "as-built" information.

There is much research being conducted on techniques of digital image processing to record and archive construction documentation. Efforts are being developed to achieve integrated project design and construction information capture within one database. (Vanegras, 1994) The benefit of this activity extends across all the participants and is creating a revolution in the way design/construction integration will occur in the future. On the construction side of the building enterprise project controls are of paramount importance. The most reliable way to implement effective project control is with accurate, reliable, and accessible information. Current strategy uses multimedia as the tool of choice for real-time capture, archival, and retrieval of needed construction process information. MULTROL, jointly developed by the US Army Corp of Engineers and the University of Illinois is a Windows based multimedia information system for documenting and retrieving as-built project information. (Liu, Stumpf, Kim, 1994) This system is directed at an all-inclusive approach to project documentation including text, sound, picture and video sources.

REDLINE follows the lead developed by MULTROL but approaches the process from a narrower perspective using existing scheduling software and low cost portable video capture technology to record, archive, and retrieve as-built conditions. The captured information, either graphical or visual is then tied back to scheduled activities and project drawings. As concluded by Liu, Stumpf, Kim, and Zbindnen in their 1994 survey, floor plans and as-built drawings were the two most helpful components of construction related information needed in day to day facilities operations. (Liu, Stumpf, Kim, and Zbindnen, 1994) The opportunity presented by REDLINE's narrow focus is the simplicity with which it can be implemented. Until the A/E/C industry is integrated with an Electronic Data Interchange (EDI) standard that is adopted and utilized by the multiple participants, full integration of design/construction data will remain lacking. Electronic as-built drawings are greatly simplified with the use of CADD. Less then 30% of surveyed companies maintain more than 25% of their as-built information in computerized format. (Liu, Stumpf, Kim, and Zbindnen, 1994) With the absence of originally produced digital information or CADD drawings the archiving of electronic as-builts remains cumbersome. Therefore the implementation of the system would only improve with improved exchanges of electronic drawings.

REDLINE -- Real-time Documentation Linking As-Built Images and Notation Electronically

Just as as-built schedules are being used to document deviations from as-planned schedules, as-built drawings can use computerized schedules to allow visual imaging tied to activity starts and finishes. This creates a real-time database for collecting visual images of as-built activities tied back to a digital plan, section, or detail that forms the construction design. This paper explores Microsoft Project 4.0 for Windows as the documentation and archival application for redlining the as-built process. Primavera P3 also has similar capabilities except that the "as-built" image placement is limited to within the Gantt chart or the CPM network.

In simple conceptual terms, REDLINE starts with a computerized project schedule, which list task activities and start dates. Once these dates are established and entered a project documentation schedule can be developed. The next step is to review the drawings and determine a mechanism for digitizing the "record drawings." As previously stated, access to CADD drawings for use as record drawings simplifies a major step in the process. Once drawings are digitized they are then object linked in electronic format to a task activity in Microsoft Project and are visible when viewing the project activity. The original captured image can be redlined and noted as required within its original application to reflect as-built conditions. Figure 1 represents a CADD drawn site plan that has been inserted into Microsoft Project as an "object."

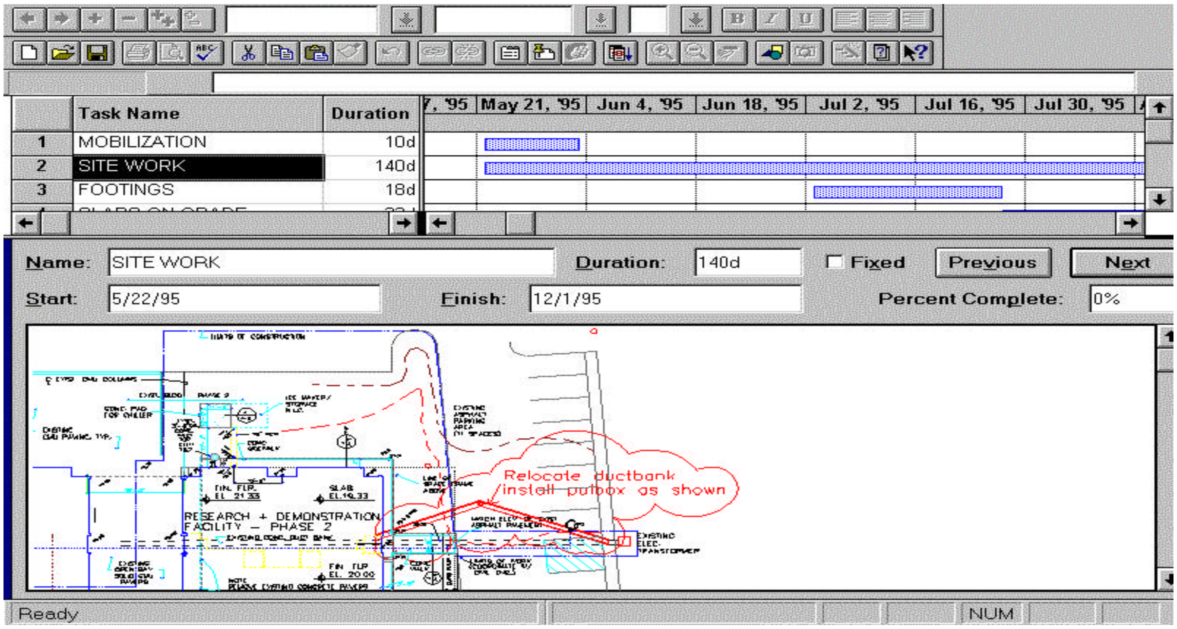


Figure 1. REDlined ductbank

The site plan is attached to the activity "site work" and the routing of the new ductbank is "redlined" within the clouded area. The last piece of REDLINE is actual visual images of the constructed activity captured in a digital format and linked to the same task activity. This is similar in concept to Liu's multi-media construction daily log (M-LOG). (Liu, Stumpf, Chin, Ganeshan, Hicks, 1995)

REDLINE is intended to be recorded and compiled on a daily basis, visually recording activity starts, completion, interruptions, and delays. In conjunction with a computerized project schedule REDLINE becomes an excellent tool for establishing a visualization linking the "as built" schedule to the "as planned" schedule. This application became immediately apparent when reviewing REDLINE with the contractor. The issue of claims analysis involving delay and the concept that REDLINE can be reverse engineered to visually document an as-built project in direct comparison to an as-planned schedule assumed great importance to the contractors who viewed the model. This was not the original intent of developing the model but is a credible and to some parties a desirable tool for delay analysis and dispute resolution. Figure 2 shows an actual screen image of the project schedule with digital images of completed work linked to a specific activity. The activity underground plumbing was video taped with a date stamp imprint, then electronically captured and redlined with a paint application before being inserted in Microsoft Project and linked to the desired activity.

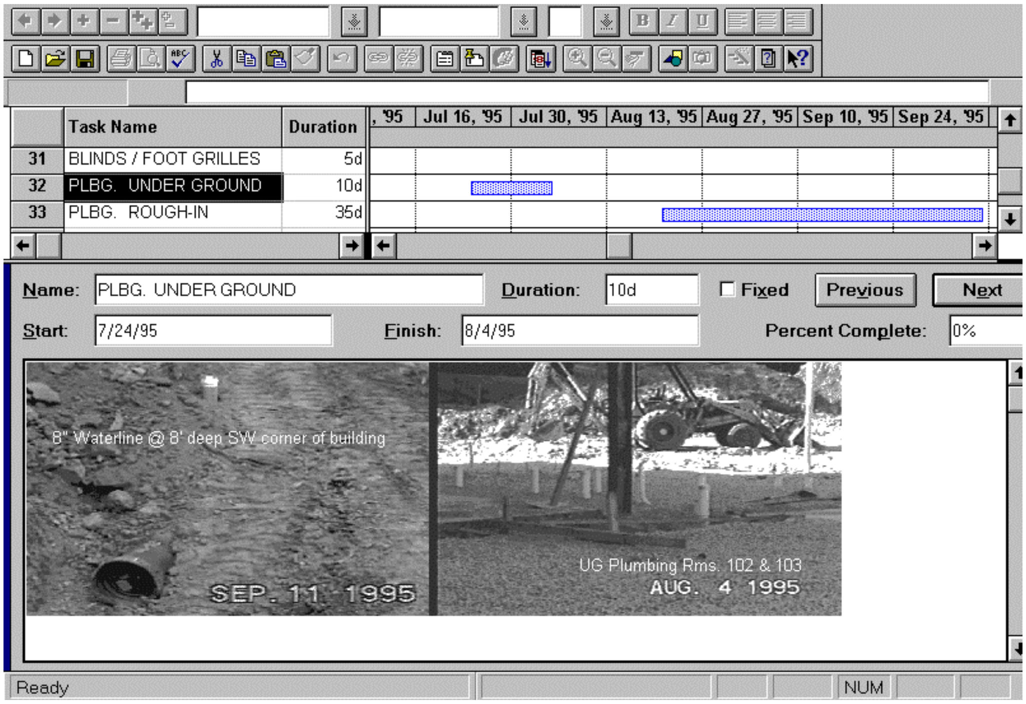


Figure 2. Linked activity

REDLINE Implementation

REDLINE was developed using a regional project as the vehicle for implementation. This project was a major expansion and renovation to an existing facility. It was chosen for convenience and access. The standard construction document package is a typical mix of part CADD, and part manual drawings. The goal of REDLINE was to provide accurate, effective and useful as-built information in a real-time archival environment. The utilization and linking of graphical (contract drawings), images (low cost portable video capture) and retrievable data (Microsoft Project) appears to have reached this goal.

The required project schedule was prepared in Microsoft Project 4.0 for Windows by the contractor's project manager. MS Project is the typical scheduling software used by this and other contractor's on much of their work. REDLINE uses a common 486 Windows based computer for operation, manipulation and file storage. A Sony Hi-8mm, 10x-zoom camcorder was used to record as-built conditions and to record manual drawings for digitizing and capture. The procedure of video taping manual drawn blueline reproductions produced a poor quality reproduction and has not been included in this paper. Manual drawings can be photographically reproduced at minimal cost and then digitally captured as a scanned document by the use of a video copystand. The scheduling software and the camcorder were standard tools used by the contractor during his field operations. A low cost ($180) portable video capture device known as "Snappy" by Play Incorporated was used to capture video snapshots of both as-built conditions and non-CADD drawings for creating the electronic as-built drawings. One additional piece of software Paintshop Pro was used to enhance poorly captured video that was linked to the as-built drawing.

Each discrete work activity is identified by the project manager and loaded into the schedule. Associated activities are identified and then video taped using the camcorder with a date stamp visible on the image. Once taped the video camera is connected to “Snappy” using a standard RCA patch cable, and “Snappy” is connected to the computer through the computer’s standard parallel port. The “Snappy” software is opened and a video image is previewed on the computer screen. Once an appropriate image is visible it is captured and saved in a format compatible with MS Project. Both the Windows clipboard and MS Project accept standard .bmp files.

After capture, the images are stored in .bmp format. This prevents degradation that occurs in transforming a stored .jpg file to a usable .bmp file. The principles of object embedding are similar to other Windows based applications. To embed a visual as-built image into the archival project schedule is relatively simple. MS Project is opened to the Gantt Chart window with a split screen also opened to Task Forms, with a link to Details/Objects. The images are then inserted from their file storage location through the Insert/Object routine. (Lowery, 1994)

MS Project only accepts objects in vertical sequence on the Task Form. To utilize the horizontal format shown in Figures 2 and 3 requires image manipulation by joining multiple images as one object prior to using the Insert/Object command. REDLINE used Paintshop Pro as a file manipulator for enhancements prior to embedding the “as-built” image. Once the images are ready for archiving they are then REDLINed with pertinent field information to provide future records. This information can consist of room locations, horizontal and vertical control information, concealed utility information, column locations or other notations linked to the construction and the construction drawings. Additional information particularly tape counter references can be added to the REDLINed image for later retrieval. Once electronic embedding is achieved access to the documentation is available by accessing the schedule and clicking on an activity and its associated image. The drawing sheet and/or visual image can be globally linked to the activity and its parent application, through Windows object linking and embedding (OLE) routine. This allows subsequent updates to the “as-built” with several clicks of the mouse, followed by an editing session then re-saving the document. Once saved the “as-built” is automatically updated in the master “as-built” schedule. Upon completion of the project, the “as-built” path can be archived on inexpensive optical media by downloading the schedule to a read only CD-ROM.

Challenges

The process of embedding is simple enough. The challenges are many but are surpassed by the benefits achieved by those involved in the process. Hardware and software compatibility are of a minor nature. Though a difficult challenge and minor inconvenience during the short term, these issues will ultimately be resolved. Snappy is able to handle image capture and storage under one of several graphical image standards including .bmp, .jpg, .gif. (Snappy Manual, 1994) Due to its compressible format .jpg is the preferred method of capture and archiving but at present neither the Windows clipboard nor MS Project supports the .jpg file format. An alternative strategy for “as-built” archives is the investigation of an indexing database that can handle graphics, CADD, and thumbnail imagery. For “as-built” archival purposes schedule linking is not necessary. In instances when claims may be an issue this application of tying activity start and finish dates to visual images that can easily be recalled has great potential. Some form of program structure similar to REDLINE that links activity to drawing to image to field modification will ultimately be developed. The necessity for CADD imagery becomes readily apparent when trying to capture a usable “digital snapshot” of a blueline drawing. To be successfully implemented on a business as usual basis, REDLINE requires original digital drawings as a base with which to construct the “as-built.” Other methods of capture such as digital cameras are being explored. (Liu, Stumpf, Chin, Ganeshan, Hicks, 1995)

Storage capacity did not present any problems. The manipulation of the image prior to archiving allowed the image to be reduced in file size through the elimination of unnecessary colors. The images in Figure 3 originally captured in 16 million colors were reduced to 16 colors with a corresponding ten-fold reduction in file size. (See Figure 3) A sixteen million-color image is not needed. A black and white background image is a better image choice for record drawings. This can be followed up with color added to depict deviations. In implementing a process like REDLINE, a defacto standard for as-built documentation becomes the challenge.

Toward this goal the CII (Construction Industry Institute) has initiated two threads of involvement that the A/E/C industry/profession is involving itself. CII’s strategy for “Achieving an Integrated Data Environment” is through concepts of “integrated database” and the development of “electronic data interchange.” (CII #20-3, 1993) The biggest barrier to implementation of this organizational change is from the industry itself. The A/E/C industry is a slowly changing culture that must learn to extend beyond a separate discipline. The life-cycle of information, and decision-making coupled with before and after construction user activity means that the design professional's drawings will be doing far more duty then previously observed.

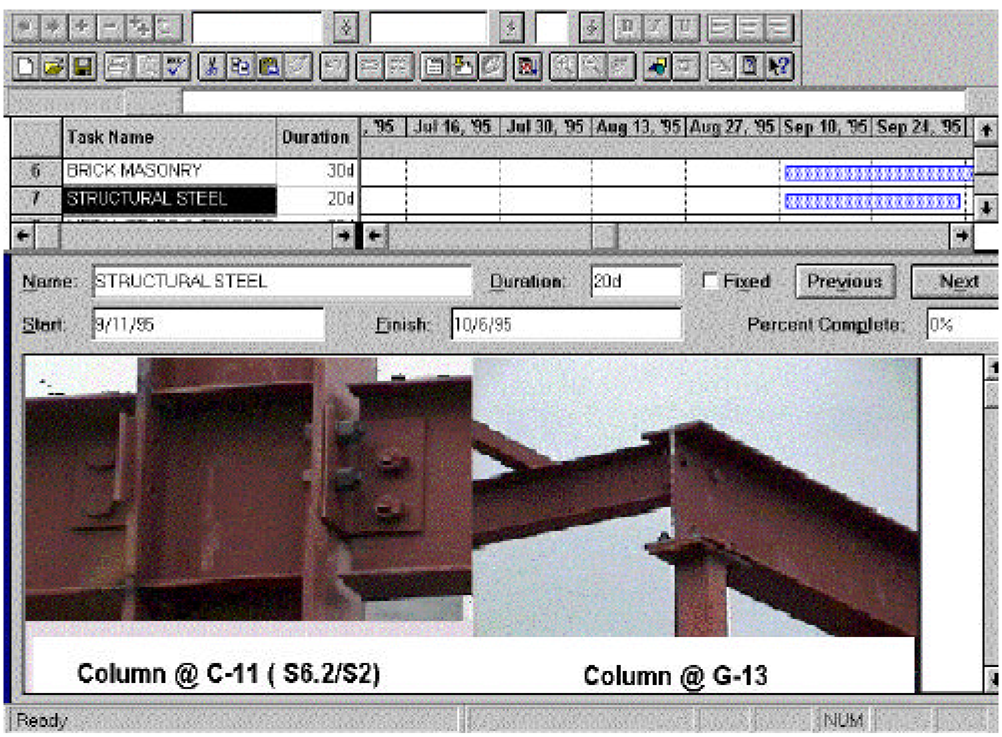


Figure 3. Sixteen color image

In creating an integrated database of standardized “as-built” documentation a cultural shift in organizational structure must occur. This cultural shift directed toward an integrated design construct profession must address issues regarding field implementation for data collection, disciplined life-cycle recording of data, purpose of recording the data, and developing drawings in electronic format. To accurately implement REDLINE the drawing package must be completed in a digital format and be provided as backgrounds for “record drawings.” Working from an electronic base sheet allows instant archiving, ease of manipulation, and quick retrieval, from which each participant in the design/construct profession benefits.

Conclusion

REDLINE a viable process that is being implemented into the design and construction industry. This is being done with electronic object attachment to project schedules or as a database linked to specific project activities or actions. Future areas of investigation opened by implementing REDLINE concern field personnel implementation, contractual relations in preparing “as-builts," and the multiple uses of electronic design drawings. As roles change in providing quality client services, these issues are creating new areas of exploration at each stage of the building life cycle. The future of “as-built” drawing documentation is a system of reusable base drawings, linked to a visual image electronically archived and easily retrievable. Which entity, owner, contractor, designer initiates the process and which entity demands implementation is still unknown. What is known, is that electronic as-built documentation is a proven process that is valuable in creating a building record.

References

AIA Document A-201. (1987). *General conditions of the contract for construction, Article 3.11.1* (14th ed.). Washington, DC: American Institute of Architects.

Construction Industry Institute. (1993). *Achieving an integrated data environment: a strategic initiative* (Publication 20-3). Austin TX: University of Texas, Bureau of Engineering Research.

Liu, L.Y., Stumpf, A.L., Chin, S.Y., Gansbar, R. & Hicks, D. (1995). Construction daily log management system using multimedia technology. *Computing in Civil Engineering, Proceedings of the Second Congress held in Conjunction with AEC Systems 95, American Society of Civil Engineers,* 1084-1089.

Liu, L.Y., Stumpf, A.L. & Kim, S.S. (1994). Applying multimedia technology to project control. *Computing in Civil Engineering, Proceedings of the First Congress held in Conjunction with AEC Systems 94, American Society of Civil Engineers,* 608-613.

Liu, L.Y., Stumpf, A.L., Kim, S.S. & Zbiden, F.M. (1994). Capturing as-built project information for facility management. *Computing in Civil Engineering, Proceedings of the First Congress held in Conjunction with AEC Systems 94, American Society of Civil Engineers,* 614-621.

Lowery, G. (1994). *Managing Projects with Microsoft Project 4.* Reinhold, NY: Van Nostrand.

Using the Snappy Video Snapshot. (1995). Rancho Cordova, CA: Play Incorporated.

Vanegas, J. (1994). Strengthening the design/construction interface using electronic imaging, document management and work flow technologies. *Computing in Civil Engineering, Proceedings of the First Congress held in Conjunction with AEC Systems 94, American Society of Civil Engineers,* 600-607.

Journal of Construction Education
Spring 1999, Vol. 4, No. 1, pp. 92-99

1522-8150/99/$3.00/General Manuscript

A Systems Approach to Residential Construction – Development of a Production Manual

Leon Rogers and **Jay Christofferson**
Brigham Young University
Provo, Utah

To remain competitive, residential builders must improve their organizations and systems to handle production more efficiently. The National Association of Home Builders (NAHB) Production Builders Committee realized the need for standardizing construction procedures among residential construction companies and commissioned the authors of this article to write a Production Manual for residential builders. In essence the manual addresses each phase of construction and outlines the construction standards that apply to each. The objective was to create, assemble, and edit a comprehensive manual of production standards which could be published in a loose-leaf format and be made available to individual builders on computer disks. This would allow builders to easily modify and customize these standards to meet their own requirements. Taking a systematized approach to the construction process has reaped abundant rewards for some builders and has generated some not-so-obvious advantages. As expected, systems became more efficient and better organized, and owners benefited because of more uniform production within their own companies. Some of the unexpected benefits resulting from the process of standardizing production procedures were greatly improved communication and understanding between employees within each of the companies. Also, the introspective self-evaluation function that each company went through helped the leadership to better define each company's mission and helped everyone in the organizations to more clearly focus on company goals. Other benefits were also recognized.

Key Words: Production Standards, Residential Construction Management, Communication, Production Manual

Introduction

Most residential builders start out as small volume builders and increase their volume of production as the market and company capabilities permit (Dasso, 1988; Music, 1985; and Schleifer, 1990). Due to improvements in management proficiency, builders are finding they cannot do business as usual and remain competitive. There is an increasing demand to improve performance in the face of increased competition (Brown, 1983; Donohue, 1995). As builders try to remain competitive, and especially as their volume increases, companies are being forced to improve their organizations and systems to handle production in a more efficient way.

Builders are feeling the need for greater standardization within their companies. Initializing a systematized approach to the construction process has reaped abundant rewards for some builders and has generated some not-so-obvious benefits.

Perceiving a need for standardizing their production and operation procedures, individual industry leaders in residential construction, have developed production and operational manuals to be written for their individual companies. The National Association of Home Builders (NAHB) Production Builders Committee realized the need for standardizing construction procedures among residential construction companies and commissioned the authors of this article to write a Production Manual for residential builders. In essence the manual addresses each phase of construction or activity performed and outlines the construction standards that apply to each. The objective was to create, assemble, and edit a comprehensive manual of production standards which could be published in a loose-leaf format and be made available to individual builders on computer disks. This would allow builders to easily modify and customize these standards to meet their own requirements. It would also result in great savings to builders who use the manual as some builders have spent over $30,000 to produce their own production and operation standards.

A customized version of the Production Manual was previously implemented by three companies. The three companies range in production from 450 to 850 homes per year. The results impressively validated the effectiveness of production standardization. The authors solicited input from builders from widely diverse geographic regions. Most of the builders had written their own production standards and were willing to allow the authors to incorporate portions of their standards in the Production Manual. The individual activities were divided into phases of construction according to the following chapters:

1. Excavation, Footing, Foundation through Backfill
2. Framing
3. Rough Mechanical
4. Exterior Finish
5. Interior Finish
6. Completion

An overview of each production activity was presented, and the procedures for completing each activity were outlined (Appendix A). Special attention was given to make sure that, as much as possible, construction methods representing the construction practices and various regions of the country were included. For example, builders in some areas of the country build basements while others build crawl spaces and still others use slab-on-grade techniques. All three methods were included in the manual. Some unique systems were deemed to be micro-geographic differences, such as the use of caissons for expansive soil in residential building in the Denver, Colorado region, and were intentionally left out. Special attention was given to safety concerns. In addition, chronic problems of clean up, compliance with building codes, and other issues were addressed for each trade.

In order to facilitate the implementation of the standards, quality control checklists (Appendix B) were also developed for each of the major trades to be used by superintendents and subcontractors to inspect completed work.

In addition to a text version of the production standards, line drawing graphic representations were also included to enhance the descriptions. Line drawings were included so that they could be easily reproduced by builders in their customized production manuals. Draft copies of the Production Manual were distributed to a review committee consisting of seven builders from throughout the U.S. They reviewed the manuscript and submitted suggestions on improvements. The final manuscript was then submitted to the NAHB for its approval.

Benefits Of Standardization

In studies done over the last five years, some interesting concepts have surfaced. Prior to the process of standardizing construction procedures for production and operations began, some of the benefits such as smoother, less confusing paper flows, and cleaner and more efficient methods of operation were expected. What were not anticipated, however, were the many other benefits resulting from the effort. Following is a summary of the major benefits gained through the process of standardizing the procedures for production and operations for various residential companies throughout the United States.

Self-Evaluation

The standardization process began with a thorough self-evaluation of all elements of the construction company. Each employee and many suppliers and subcontractors were interviewed. Employees discussed their own perceptions of the company, what practices worked and which ones should be changed. They described their roles in the company and how employees could more effectively contribute to the company. Companies discovered a lot about themselves. It was surprising to learn how little owners, presidents, and managers sometimes knew about the inner workings of their companies.

Enhanced Job Descriptions

Most employees are hired to do specific jobs. Over time, and as responsibilities and employee capabilities change, employees sometimes are not sure where their duties and responsibilities start and where they end. One benefit of the standardization process was that it helped to define the roles and responsibilities of employees within the company. Part of the outcome established current and more accurate job descriptions for all employees. The formal organizational structure was sometimes modified as a result of the findings. Sometimes, employee responsibilities were modified or restructured so that employees could focus on areas of greater need within the companies.

Improved Communication Within Companies

Another benefit came only because of the standardization process. As employees were interviewed individually and in groups, lines of communication were opened and employees gained greater insight into their own responsibilities and how they could better interact with others. The process itself initiated dialog within the company. Often, issues surfaced about problems of which others in the company were unaware. Employees found that many problems could be solved simply by discussing them with their co-workers.

Create Focus on Company Goals

As problems and solutions were considered in discussion groups, employees and employers began to gain a sense of where their companies were going. This inward evaluation process created a focus on real company goals and direction. Employers were more easily able to articulate their company's mission. Employees gained greater understanding of the direction and goals of the companies and began to take more ownership in their company's success.

Systems Organization and Efficiency

A major benefit of the standardization process was that company policies and procedures were thoroughly analyzed. Confusing or misunderstood practices such as how to handle Variance Purchase Orders or Measurement Purchase Orders were clarified. Procedures and policies were streamlined, making whole systems more efficient and effective.

Employee and Subcontractor Training

In companies where standardized practices and procedures are not written down, employees require more time to learn their roles, responsibilities, and privileges. Using company operation and production manuals helped employees and subcontractors learn their specific responsibilities and procedures more quickly. These manuals can be used for training new personnel and as references for long-time employees. Portions of the manual can also be included as part of subcontracts.

Uniformity throughout the Company

One problem of residential companies is that products don't always meet with customer expectations. Production builders, especially, encounter this difficulty. While selecting a builder, customers will visit various sites. The quality will vary between models and the workmanship will vary between different supervisors. A customer may see a high quality model in one area and buy in a different location. If the home they buy is not to their expected standards based on their previous experience, they will be very disappointed. Standardizing production creates uniformity throughout each company division. This greatly helps to keep customer expectations uniform for all production locations and helps subcontractors who work for more than one division.

Conclusion

Builders used the Production Manual to train new project supervisors. Although many new supervisors had previous experience in residential construction, they were not familiar with the construction methods and materials that were being used by the company doing the hiring. The Production Manual was used as a training guide for inexperienced supervisors and as a reference for seasoned employees.

Responses from the various participants demonstrated that the Production Manual was an advantageous tool for superintendents to standardize their production methods. One production manager explained that the Production Manual had been very beneficial in training new subcontractors. He gives all new subcontractors copies of the sections of the Production Manual and Quality Checklists which pertain to their particular sub-trades along with written subcontracts when he “sets up the subcontractors” to perform work. He reviews the copied sections of the Production Manual and Quality Checksheets in detail with the subcontractor at that point.

Superintendents used the Production Manual to train subcontractors as they visited the jobs on a daily basis and used the checklists to review and check the work of subcontractors prior to approving payment. One production manager indicated that the use of the Production Manual and Quality Checklists significantly reduced the cost of construction, because employees and subcontractors knew what was expected of each trade, thus, eliminating many mistakes and rework.

Another significant benefit of using the Production Manual was that the companies saw increased uniformity throughout all production lines and company divisions. Customers' expectations were the same across project locations. In each case, the builders that implemented a production manual were impressed with the process of self-improvement and communication that the approach initiated. They knew that the process would be a continual cycle of improvement within the company.

References

Brown, C. D. (chairman), (1983, January). More construction for the money. *Summary Report of the Construction Industry Cost Effectiveness Project.*

Dasso, H. A. (1988) Management Systems for Small Residential Construction Companies. Unpublished master’s thesis. The Pennsylvania State University Graduate School. Department of Civil Engineering, University Park, Pennsylvania.

Donohue, G. (1995, January). Cost of doing business. *Builder: The Magazine of the National Association of Home Builders.*

Feirer, John L., Gilbert R. Hutchings, and Mark D. Feirer. *Carpentry and Building Construction*; (New York:Glencoe / Mcgraw Hill, 1993, 29-9), 288.

Music, W. A. (1985) *Managerial Aspects of Residential Construction.* Unpublished master's thesis. The Pennsylvania State University Graduate School. Department of Civil Engineering, University Park, Pennsylvania.

Schleifer, T. C. (1990). *Construction Contractor’s Survival Guide*. Wiley-Interscience.

Appendix A

Floor Framing

Overview:
This activity includes the installation of the rough framing material including sill plates, bearing walls and beams, joists, subfloor, blocking, and other installations necessary to complete the floor structure of the house.

Procedures:
Duration: 1-2 days for average-size home.

To be completed before this activity begins:

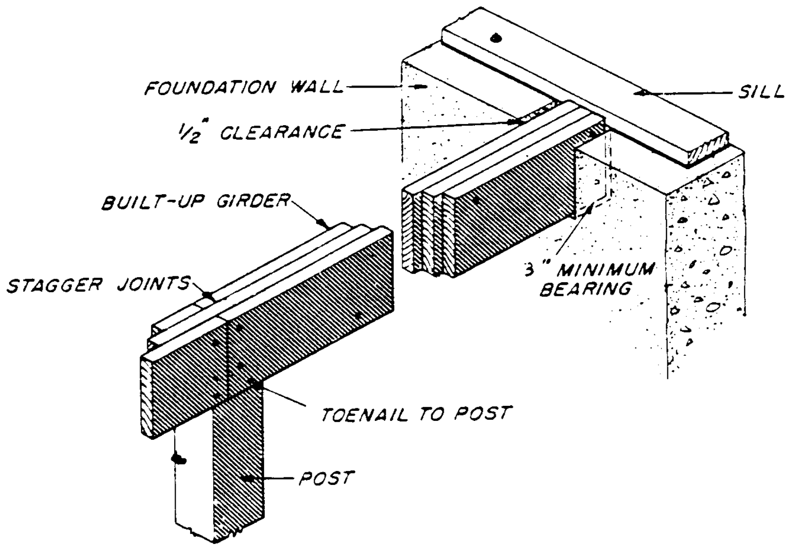
- Backfill complete.
- Temporary electric service available.
- Sewer, water, electric, and gas laterals complete (these could possibly be delayed until framing complete).
- Concrete - basement slab, garage, and front porch complete.
- Rough lumber delivered.
- Roof and floor trusses ordered.
- Doors ordered.
- Windows ordered.

1. The superintendent should meet the framer on the job and review the plans, specifications, and change orders. All changes should be reflected on the customized plans used for the job.
2. All work to be done according to local code regulations.
3. Check foundation for square and adjust sill plates as much as possible if the foundation is out.
4. Use treated plate material for sills resting on concrete or block.
5. Level sill plates starting at the high point of the foundation.
6. Sills should be set in from the outside of the foundation, the thickness of the sheathing except when using brick or stone.
7. Sills for concrete walls should be tightly secured with 1/2" washers and nuts or with anchor straps. 1/2" x 10" j-bolts are to be a maximum of 6' apart and all sill plates anchored within 12"of each end. Missing sill anchors should be replaced with 1/2" wedge anchors or Redheads. Mudsill anchor straps should be placed no more than 3' apart.
8. Sills for masonry walls require 1/2" x 16" j-bolts.
9. Splices in built-up-beams should occur directly over bearing posts. Proper nailing patterns and nail sizes should be used. Refer to the local code.
10. Glue-laminated beams are designed with a top and bottom side. The top has TOP written on it and has square edges. The bottom has rounded edges. The beam is designed with a slight camber which will straighten out when the beam is loaded.
11. Beams and girders should be straight and level to within ±1/8" in 10'.
12. Joist material should be checked for species, grade, and size against the required specification.
13. Joists are to have a minimum bearing of 1-1/2" and are to be installed with the crown up. Layout should be checked so that joists aren't placed under toilet installations.
14. Trimmer and header joists to be doubled when span of the header exceeds 4'.
15. The ends of header joists more than 6' long shall be supported by framing anchors or joist hangers unless bearing on a beam, partition or wall.
16. Tail joists over 12' long must be supported by framing anchors or 2" x 2" ledger strips.
17. Joist framing from opposite sides of a beam, girder, or partition should be lapped at least 3".
18. Solid blocking is required over all bearing points.
19. Subflooring ends should be staggered and all square edges should fall on the center of a joist or be blocked.
20. Subflooring should be glued with construction adhesive and 8d common nails should be spaced 6"O.C. on the edges and 12"O.C. in the field. Ring-shanked (deformed shank) nails or screws can be substituted to reduce floor squeaks.
21. Check nailing patterns for spacing and proper installation.
22. For seismic zones 3 & 4, 2 x 8's are not to be cantilevered without special engineering allowances.

Common Problems and Solutions:

1. Bouncy or spongy floors can be stiffened by using cross bridging at mid-span.
2. Use construction adhesive with subfloor to prevent squeaky floors.

Using Grabber screws instead of nails to secure the subfloor can help prevent squeaky floors.



Built-up Girder Set into Concrete Beam Pocket and Bearing on Wood Post (Feirer, 1993)

Appendix B

Layout and Footing Checklist

Subcontractor ______________________________ Job Name/No. _______________

_ All work must comply with local, state and the national codes, even in areas where no local inspection exists.

LOCATION/LAYOUT

_ Property lines surveyed by licensed surveyor or certified by the owner.
_ Property survey stakes in place.
_ Plot plan available.
_ Confirm that the layout is per owners agreement at the site meeting.
_ Correct front yard set back. Ft.
_ Parallel to the street to within 1 inch if applicable.
_ Correct side yard set back. Ft. Which side?
_ Rear yard set back. Ft.
_ Check for presence of ground water or soft spots in the soil.
_ Footing below the frost line after backfill is completed if applicable.
_ Check for proper elevation. Should provide for 5% grade away from building after backfill.

FOOTINGS

_ Inspector notified at least 24 hours ahead of time.
_ Inspection completed and inspection card signed.
_ Footings checked for position and proper grade. Double check layout.
_ Dirt thrown to the outside.
_ Soil under footing is undisturbed or compacted and adequate to support structure.
_ Sides of footings are cut square. Forms in place and properly braced.
_ Soil unfrozen, without snow or ice.
_ Check ALL dimensions.
_ The length is correct, all sides, to within +½" (BUT NOT SHORT!)
_ Square ± ¼" in 20'.
_ Diagonal measurements equal ± ½ inch.
_ Check for proper size location and elevation of blockouts.
_ Check offsets and jogs. Location Size.
_ Footing depth in inches 8" ± 1". Width in inches 18" ± 1".
_ Footing steps in 8" increments.
_ Metal rebar grade stakes 5' o.c. and set to grade with a builder's level.
_ Forms level ± ¼ in 10' and level ± ½ " overall.
_ Forms properly braced and backfilled.
_ Footings free of roots and topsoil.
_ Footings free of debris.

Contributing Reviewers

Dr. John W Adcox Jr., *University of North Florida*
Dr. Burcu H Akinci, *Stanford University*
Mr. Joseph O Arumala, *University of Maryland - East Shore*
Dr. Flynn L Auchey, *Virginia Polytechnic Institute and State University*
Dr. Gouranga C Banik, *Southern Polytechnic State University*
Dr. David L Batie, *East Carolina University*
Dr. Charles W Berryman, *University of Nebraska - Lincoln*
Mr. Keith Bisharat, *California State University - Sacramento*
Dr. S. Narayan Bodapati, *Southern Illinois University - Edwardsville*
Dr. Walter Boles, *Eastern Kentucky University*
Dr. Richard A Boser, *Illinois State University*
Dr. Hollis G Bray Jr., *University of Louisiana at Monroe*
Mr. Kevin L. Burr, *Brigham Young University*
Dr. Amaury A Caballero, *Florida International University - Timiami*
Mr. Jim K Carr Jr., *The Ohio State University - Wooster*
Dr. Abdol R Chini, *University of Florida*
Dr. John A Gambatese, *University of Nevada - Las Vegas*
Dr. Moussa T Gargari, *University of Cincinnati*
Mr. David W Goodloe, *Clemson University*
Dr. Douglas D Gransberg, *University of Oklahoma*
Mr. David Hanna, *Ferris State University*
Mr. Paul E Harmon, *University of Nebraska - Lincoln*
Dr. Allan J Hauck, *Colorado State University*
Dr. Toni Y Hynds, *Texas A&M University*
Dr. Donald A. Jensen, *University of North Florida*
Ms. Dianne H Kay, *Southern Illinois University - Edwardsville*
Dr. Mostafa M Khattab, *University of Nebraska - Lincoln*
Dr. Kraig Knutson, *Arizona State University*
Dr. Douglas W Kruger, *East Carolina University*
Mr. Jeffrey J Lew, *Purdue University - BCM*
Mr. Jon L Mason, *Boise State University*
Mr. Charles A Matrosic, *Ferris State University*
Mr. Bill W McManus Jr., *University of Oklahoma*
Mr. Thomas H Mills, *Virginia Polytechnic Institute and State University*
Mr. Donald E Mulligan, *Arizona State University*
Dr. John D Murphy Jr., *Auburn University*
Dr. Michael D Nobe, *University of Nebraska - Kearney*
Mr. Neil Opfer, *University of Nevada - Las Vegas*
Dr. Ray J Perreault Jr., *Central Connecticut State University*
Mr. Randy R Rapp, *Milwaukee School of Engineering*
Mr. Daniel R Rondinelli, *Colorado State University*
Dr. Anil Sawhney, *Arizona State University*
Dr. John E Schaufelberger, *University of Washington*
Dr. Bolivar A Senior, *Colorado State University*
Dr. Bradford L Sims, *University of Florida*
Ms. Linda B Swoboda, *University of Nebraska - Lincoln*
Ms. Audrey K Tinker, *University of Arkansas - Little Rock*
Dr. Zeljko M Torbica, *Florida International University - Timiami*
Mr. Tim G Wentz, *University of Nebraska - Lincoln*
Dr. Avi Wiezel, *Arizona State University*

Acknowledgement

The Editor wishes to thank the Department of Construction Science and the College of Architecture of Texas A&M University for their support of the *Journal* creation and operations. Thanks are also due to the Editorial Advisory Board whose names appear on the second page; and to those serving on the Review Board listed above.

Membership Applications

Inquiries should be send to: Associated Schools of Construction, Hendrick D. Mol., Executive Director, Building Science Department, 119 Dudley Hall, Auburn University, Auburn, AL 36849-5315, Tel: 334.844.4518, E-mail: molhend@mail.auburn.edu

Organizations eligible for membership may fill out one of the application forms at: (http://ascweb.org). Please read the following membership grouping information, pick or enter the hyperlink into your web browser for the type of membership that fits your organization and submit the completed form.

- Institutional Members: shall be those institutions having at least one baccalaureate or higher degree construction program. Annual member dues are $400.00.
- Associate Members: shall be institutions of higher education, including junior and community colleges, not meeting institutional member requirements (two year programs). Annual member dues are $250.00.
- Industrial Members: shall be industrial organizations demonstrating a constructive interest in construction education. Annual member dues are $400.00 base membership or $650, which includes $250 for advertising industry, positions on the ASC web site. This service (http://ascweb.org/internet/positions/industry/main.asp) includes full-time, part-time, summer internship, and co-op program listings.

National Office Staff

Executive Director
Mr. Hendrick D. Mol
Auburn University
Tel: 334.844.4518
E-mail: molhend@mail.auburn.edu

Webmaster
Dr. K. C. Williamson III
Texas A&M University
Tel: 979.845.7052
E-mail:asc@taz.tamu.edu

Journal Editor/Publisher
Dr. K. C. Williamson III
Texas A&M University
Tel: 979.845.7052
E-mail:asc@taz.tamu.edu

Journal Administrative Assistant
Ms. Kathy Tucker
Texas A&M University
Tel: 979.845.7052
E-mail:asc@taz.tamu.edu

Proceedings Editor/Publisher
Dr. Chuck Berryman
University of Nebraska – Lincoln
Tel: 402.472.0098
E-mail: ascedit@unlinfo.unl.edu

Officers 1998-1999

President
Dr. Howard Bashford
Brigham Young University
Tel: 801.378.2021
E-mail: bashford@caedm.et.byu.edu

First Vice President
Mr. Wesley G. Crawford
Purdue University – BCM
Tel: 317.494.2468
E-mail: wgcrawfo@tech.purdue.edu

First Past President
Mr. John Mouton
Auburn University
Tel: 334.844.4518
E-mail: moutojo@mail.auburn.edu

Secretary
Mr. Bill McManus
University of Oklahoma
Tel: 405.325.6404
E-mail: bill-mcmanus@ou.edu

Treasurer
Dr. John Murphy
Colorado State University
Tel: 970.491.7958
E-mail: drfire107@aol.com

Assistant Secretary Treasurer
Mr. F. Eugene Rebholz
Bradley University
Tel: 309.677.2942
E-mail: fer@bradley.edu

Directors 1998-1999

Northeast Director
Mr. Joseph F. Keuler
State University of New York/ESF
Tel: 315.470.6834
E-mail: jfkeuler@mailbox.syr.edu

Southeast Director
Dr. Arlan Toy
Southern Polytechnic State University
Tel: 770.528.7221
E-mail: gtoy@spsu.edu

Great Lakes Director
Mr. L. Travis Chapin
Bowling Green State University
Tel: 419.372.2837
E-mail: tchapin@bgnet.bgsu.edu

North Central Director
Mr. Eugene H. Wright
University of Nebraska – Lincoln
Tel: 402.472.3739
E-mail: ewright@unlinfo.unl.edu

South Central Director
Mr. Kenneth F. Robson
University of Oklahoma
Tel: 405.325.6404
E-mail: krobson@ou.edu

Far West Director
Dr. David F. Rogge
Oregon State University
Tel: 541.737.435
E-mail: rogged@ccmail.orst.edu