

CONSTRUCTABILITY REVIEWS — AN INTRODUCTION

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Overview

Construction Managers want jobs to be successful. One strategy for a successful job is to begin with a clear and complete set of bid documents. An important step to having a complete set of bid documents is to have them thoroughly vetted by a third party and then corrected before they are advertised for bid. Experienced Construction Managers (CMs) and seasoned inspectors can help with the vetting process by reviewing documents to determine if there are built-in problems, flaws that may impede construction or factors that may cause impacts to any stakeholder in terms of time, cost or quality. One of the many services Construction Management firms can offer clients during the design phase is to provide detailed reviews of draft construction plans and specifications. The review is commonly known in the industry as a *Constructability Review*.¹ There are many definitions² of Constructability Reviews, some of which are so complex they form narratives. But, to put it succinctly, a Constructability Review (hereinafter CR) can be defined as:

An independent and structured review of construction bid documents by construction professionals to make certain that the work requirements are clear, the documents are coordinated, and that they assist the contractor in bidding, construction and project administration to result in reduced impacts to the project.

A CR corrects documents from the viewpoint of the contractor, the inspector and the CM. If the contractor is able to complete the project without seeking many clarifications, if the project progresses smoothly and there are few disputes, then the CR has met its goal from the contractor's perspective. If the inspector knows where all building requirements can be found, how quality is to be evaluated, and how to measure payment for work elements, then the CR has met its goal from this perspective. And, if the CM is able to keep administrative efforts on budget, if changes and disputes are kept to a minimum, and if all parties can deliver a quality project to the client, then the CR has met its goal from a management perspective.

The construction documents to be reviewed include draft plans, draft technical specifications and the proposed bid schedule. Depending on time allotted for the review and the direction from the client, the reviewer may also include Special Provisions, the invitation to bid, appendices and reference documents, although the latter three would be unusual. To sum up the why, when and who for CRs: first, a CR is an effort to correct conflicts and clarify requirements; second, CRs are done before issuing the documents for bidding; and third, a CR must be done independently of the designer.

¹ Spelled Constructability with an **a**, not constructability with an **i**, although both word forms are used. The latter form seems to be used more in the mathematical and philosophy fields. Merriam-Webster Inc. finds the former the more common of the two spelling variants overall. Both spellings were entered for the first printing of the Collegiate Dictionary Eleventh Edition of 2003 based on several decades of word use.

² Another definition is from the ASCE's Construction Industry Institute – "*optimum use of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives.*" This and other definitions cast too wide a net for this author.

There are many things a CR is not. A CR is neither a peer review³, Value Engineering⁴ nor a bidability⁵ review. However, a CR can and should overlap with a bidability review in one important way. That is, the bid schedule must be checked against the plans and specs for proper bid item breakdown, appropriate choices of lump sum versus unit price items, and accurate bid descriptions. Bid item quantities will not be checked in the CR, or will the organization of the bid schedule. A CR is not a review to address construction safety, project life cycle, sustainability or an analysis for eventual demolition. The designer and owner have already made those decisions and, theoretically, incorporated them into the work scope long before the documents are available for review. A CR is not an effort to “QC” the documents, as that should have already been done by the time documents are issued for review. However, if there is a quality control issue, all parties are encouraged to address it in the review. See Appendix I for some examples of QC comments.

The evolution of CRs in the building industry is for others to write about. However, it can be said that the need for CRs has gained acceptance by owners over the past decades. It is, or should be, a routine part of the design process. The CR cycles should be included as activities in the master schedule. While most construction management firms offer this service, a few consulting firms offer CR as their sole service.

Not much is published about the CR process. The literature that is published focuses more on the requirements for CR programs, case studies, performance, tools and surveys of individuals doing CRs. Most papers, proceedings and articles focus on the CR concept and implementing reviews in organizations. Moreover, those papers generally relate to building construction and state transportation work. One can assume that little has been written on how to carry out a CR because most firms offer this service in competition with others and do not want to share their approach. What follows will provide an exception.

This paper will not teach you how to find and make comments to plans and specs. That would be impossible for many reasons, although a few reasons are worth noting. The main reason is that the types of construction projects vary greatly (e.g., schools as opposed to dams), and each is unique, requiring a one-time design. Consider a ten-foot steel bridge design compared to a 200-foot steel bridge design where the connections, deflections and traffic loading would be immensely different. Other reasons include: differing needs of owners, regional building standards, materials used in different parts of the country, and environmental issues (e.g. cold weather concrete). Despite these exceptions, this paper provides an introduction to a traditional, yet formal, CR process for those who are unfamiliar with CRs. This paper explains the general approach to performing a review.

This paper is written from the perspective of a third party CM for a standalone project, although the process will work for large construction programs where multiple primes are needed or the smallest work element addressed by a single change order. While it is written from the traditional design-bid-

³ A peer review is an independent review of plans and specs by an outside design firm who looks for local building code compliance, adherence to standards of design practice and design criteria, eliminating design and service conflicts. Examples include use of proper design loads, non-compatibility of materials, soil problems and corrosion attack.

⁴ Value Engineering (VE) has a different set of goals. VE focuses more on function and performance, e.g., project scoping, locating, optimizing processes, energy use, expandability, features, etc. VE is normally done at the 20 percent design stage. CMAA University CM4144, April 7, 2005.

⁵ Bidability has many definitions. The Long Beach City College 2009 Bond Management Team defines it well as, “*The degree to which a set of bid documents could be reasonably expected to permit a bidder to establish a competitive price to perform the Work as defined in the bid documents.*” More to the point, a bidability focuses on whether the bid schedule reflects the work scope, if quantities can be determined from the drawings and if contractors can prepare competent bids at reasonable cost.

build approach, the principles can also be applied to other contracting mechanisms. Whether the planned construction is publicly bid, privately negotiated, or is work done with in-house forces, the points covered apply to all. This paper does not discuss technology-based review tools⁶ or web-based CR sharing applications in any detail, as these technologies are relatively new and continue to evolve.

Why a CR is Needed

What is the purpose of a CR? Why go through this process? Overall, the goal is to save the owner time and money by uncovering problems or potential problems that may be encountered during construction such as errors, omissions, ambiguities and conflicts. Any construction project (and any proposed contract change) will benefit from a CR.

One goal of a CR is to prevent conflicts among documents – that is, conflicts between drawings and specifications, between drawings or between spec sections. When conflicts are minimized, the result is fewer RFIs, fewer field orders, a smaller number of change orders and, hopefully, no disputes, claims or legal action. But beyond this, a CR should also result in fewer addendums, higher quality bids from higher quality construction documents, minimal delays, greater understanding of the project goals, a smoother construction process, construction done more quickly, and less administrative costs over the course of the project for all parties.

The contractor could potentially save money by providing more confident bids, thus saving on estimating time. Smaller bids would preserve the bidder's bonding capacity. This is important because if the owner needs that contractor to bid more of their projects, the construction company may be able to bond more work, thus enabling them to submit more bids. A proper CR could potentially bring more bidders to the table and may result in more competitive and responsive bids. Conversely, a 'bad' set of drawings may prompt a bidder to add a 'nuisance factor' to the estimate.

Why not forego the CR and rely on the bidders to discover problems? Because bidders may not be willing to ask questions regarding problems they discover. For public works, bidders know that all questions and answers will be shared with all other bidders. A bidder may want to use an error he discovered to create a future change in his favor. Or, the bidder may choose to be silent on an ambiguity that can be leveraged to their benefit during the course of work.

Done correctly and thoroughly, the CR will result in cost savings for the owner. Certainly it costs money to have a CM firm perform a CR, and it creates more work for the designer to review comments, decide what to incorporate, and then do so. However, the cost and time saved during construction are greater than the expenditures made to perform the review. At least that is the hypothesis. Cost savings have been estimated to be on the order of \$10 worth of savings for every CR dollar spent. Another estimate is 3 to 5 percent savings on the entire construction cost,^{7,8} while

⁶ Tools would include 3D computer modeling and animations. Electronic CAD modeling would be beyond any CR requirement an owner may need.

⁷ CMAA, 2004 CM eJournal Constructability Reviews: Case Study of Bid Documents Errors and Omissions, Ken Pruett.

⁸ CMAA Southern California Chapter seminar, Long Beach, CA, April 17, 2008.

some estimates are even higher.⁹ Unfortunately, it will never be known how much money a CR saves. Why? Because two identical projects – one benefiting from a CR and the other that didn't – will never be built side-by-side to compare which one saved more money and by how much. Cost savings can only be estimated. On the other hand, errors uncovered during a CR can be estimated immediately by the cost avoided (detailed, order of magnitude or budget level) or by time impacts prevented. Careful, precise estimates will add to the cost of performing CRs.

The proof of savings – time, money and the weight of other impacts – is dependent on the volume, caliber and correctness of the CR comments and how they are ultimately incorporated.

A CR not only benefits the owner and contractor, it also benefits others. These include program managers, construction inspectors, fabricators, suppliers, tenants and building authorities. Program managers will spend less time working out issues between the CM and designer during the construction phase. Inspectors will be able to match work done with the quality expected. Fabricators may spend less time interpreting design details and benefit from fewer submittals returned for corrections. A supplier will more fully understand what is requested before he accepts the purchase order. Tenants may benefit from a reviewer who understands the tenant's desires better than the designer. Local building authorities may expect certain details the reviewer is aware of, but of which an out-of-state designer maybe unaware.

CRs are desirable for all construction projects – traditional, design-build or CM at risk, with the possible exception of work done by the owner's forces or an owner's embedded contractors. Projects done by the owner's forces or embedded contractors tend to be smaller jobs using standard, well-established and proven plans with labor already familiar with the type of work needed.

The importance of providing CRs cannot be over emphasized. The more errors, omissions and conflicts found before advertising, the more impacts – time, costs and frustration – can be avoided.

Written Scope of Work

The CR work scope should be addressed in the CM-client professional services agreement or by a task order under an existing agreement. The work scope should specify at a minimum the construction documents, form of deliverable, funding and due dates. A budget and a billing account should be set up. The client may require resumes and interviews. Work scopes do not need to discuss fiduciary obligations to provide professional work, as that is addressed in other provisions of the services agreement. Obviously, as a CM, you must do your the best to address constructability based on your knowledge and expertise. You are obligated to put your best effort forward in a short time and in order to save private or public funds. The professional services agreement should make it clear that the owner/client is not to hold the reviewing firm responsible for items that should have been caught during the review. There will be no professional engineering seals required for CR work; rather the Engineer of Record will seal the plans and specs and be responsible for their contents.

The owner should pay for the CR, not the firm that prepared the documents. Otherwise, the reviewer could be perceived as potentially compromising his obligation of impartiality. Since the chain of

⁹ Ten to 20 times the cost of the CM effort per the Business Roundtable "*Integrating Construction Resources and Technology Into Engineering.*" Construction Industry Cost Effectiveness Report, Report B-1A, New York, NY.

custody is important, it is recommended that the CR comments be submitted to the client/owner, not directly to the designer. The owner/client should be given the opportunity to eliminate comments he does not want the designer to consider, especially those comments expressly flagged by the reviewer for the client to review first. Refer to Appendix IV for some example CR written work scopes.

Reviewer's Qualifications

Who is qualified to perform a CR? The short answer is – experienced Construction Managers, inspectors and field engineers. Basically, that includes experienced individuals who have worked closely with contractors and construction documents during any and all phases – bid, award, construction, closeout and the warranty periods. Contractors cannot be reviewers because they could be potential bidders.¹⁰ Contractors may want to offer suggestions or changes that would be advantageous to them in hopes of eliminating competition. Program managers and surveyors are qualified to provide reviews, but generally only to those portions of the documents that are applicable to them. For example, a program manager will want to review for materials that add too much cost or work that affects neighboring tenants or property owners. A surveyor will want to review the survey technical specs and survey control drawings. A case can be made to bring in specialists (e.g., coating, instrumentation, paving or pressure vessel specialists), as the review demands. That usually means subconsultants unless there are people already on staff with the requisite experience. The owner may elect to have another organization perform the CR, i.e., one who will have nothing to do with the construction phase. While this is not the norm, it may be considered. There are plenty of firms that offer CRs in their suite of services and a few that do so as their sole service.

New and fresh eyes are needed. That will exclude the design team. The owner needs an independent review from individuals who know the construction process and who routinely work with contractors. Independent means that the designer who produced the draft plans and specs is exempt, because he would be unable to provide the required *independent* review. This is true even though the designer may offer to do so. Instead, designers are obliged, and sometimes specifically contracted, to provide *quality control* reviews before documents are offered for constructability. Notwithstanding the foregoing, all stakeholders, excepting the designer, should be given the opportunity to review draft bid documents and provide input from their own perspective. These stakeholders are entitled to assure that their needs are met, and they should be encouraged to make their separate comments. Those stakeholders will concentrate on the aspects that concern them and not necessarily on the entire contract.

The ideal CR candidate is experienced. The reviewer should have many years of solid field experience in managing contracts, inspections or both. Field experience provides an understanding of building trades, construction materials, heavy equipment, building techniques, regulations and sequences of construction. Three or four years of 'boots-on-the-ground' experience should be a minimum. Construction management experience must include processing RFIs, reviewing submittals, participation in progress meetings, authorizing payments and some level of involvement with disputes and claims. A CM who has a work history with the client is a great benefit. A CM with construction contracting experience, that is, those who have worked both sides of a construction equation, will be of even greater value. An inspector with experience in interpreting plans against

¹⁰ Some state Associations of General Contractors offer CR services. See ODOT who allow contractors to perform reviews on a volunteer basis.

specifications and building codes, tracking time for changed work and negotiating problems in the field will generally be a good reviewer.

The ideal CR candidate is detailed-oriented. The reviewer must be capable of working quickly, efficiently and confidently. Since generally only two weeks are allotted for the review, the reviewer must be able to rearrange time among competing interests and devote quality time to the effort. One who is confronted by 200 drawings and specifications that are two inches thick without some knowledge of how the CR process works may be intimidated or overwhelmed. If this is your first experience, you must delve into it – you get better the more you do. It is entirely acceptable to look at someone else's comments from a prior review to gain some insight into what you are expected to do. See Appendix III for some example comments. It is beneficial if you are familiar with CSI formatting (or become so) so that you understand that technical specifications are divided into articles of scope, reference documents, products, execution and measurement/payment. Additional positive qualifications are to know the difference between performance and prescriptive specs. Knowing a bit about the codes and standards that apply to the work is helpful as well.

The CR reviewer is one who can use spatial abilities to visualize in three dimensions from two-dimensional drawings. The reviewer is one who can read a spec and visualize the result. A good reviewer can also add the time element of construction and see the order of construction.

The CM who will eventually help manage the construction phase is best suited to fulfill this role. That CM will have a vested interest in the outcome of the review. The more problems solved, the smoother the construction and the lighter the future workload.

A CR done right is not easy. Reviews require an individual who can concentrate and remember how the whole puzzle fits together. For example, the reviewer needs to remember the utility drawings and their corresponding spec requirements when looking at structural drawings. That pipe cannot enter the foundation at an elevation shown on the utility drawings because it goes through a support pile or that fence cannot be erected where shown because it is too close to a building depicted on another drawing.

When is the CR Started

The review is best done at both the 90 and 100 percent design stages.¹¹ At those stages, the work scope has been finalized and all drawing details and notes (at least, in the designer's opinion) have been incorporated and specifications have been assembled. At the 100 percent stage, the designer considers the design complete except for some loose ends. Those loose ends should theoretically be minor and pointed out to the reviewers so time isn't wasted on them.

A CR should never be attempted before the 50 percent design is reached. Little value will be returned from any effort expended before this point. At the 50 percent design stage, the design concept could still change and various design elements will change. Comments on drawings and details that are discarded because the design was changed are a waste of the client's budget. Design documents at the 50 percent stage or less are too close to the Value Engineering stage. Be aware that you may

¹¹ The statement departs from the recommendations of the CMAA 2005 Spring Conference & Leadership Forum of May 24, 2005. *The Quality of Design Documents: What Can the CM Do?*, where it was proposed the CM review and address constructability issues from the beginning of the project.

conclude soon after starting the review that the documents are not at the 90 or 100 percent stage as promulgated by the Engineer. It is the program manager or designer who makes the determination as to what level of completion the documents are in and when documents will be released for the CR. Recognize that the percent complete determination is subjective and sometimes a bit exaggerated.

Sometimes a CR is performed after the bid cycle starts. This typically occurs under two scenarios. First a CR was never ordered or budgeted in the design phase but the volume or complexity of the bidder's inquires places the design in question. Second, which occurs more often, the CR is performed because the project schedule had to be met or was compressed and the contract was let out for bid to keep on a tight schedule. CRs performed during the bid cycle usually means that only significant changes or corrections will be made. Those changes will have to be made by addendum or by an early change order. A review finding could result in an addendum requiring a bid postponement.

As previously stated, the best time for a CR is at the 90 percent stage followed by a 100 percent review one or two months before the plans are to be made available for bidding. This should give enough time for comments to be considered and changes made. As a CM, be certain that the design schedule allows for 90 and 100 percent reviews. At the very least, 100 percent documents should be reviewed for constructability.

Documents Reviewed

As stated in the overview, plans and technical specifications are reviewed for constructability. They must be reviewed cover to cover. For Special Provisions, only those articles that are unique to the project are reviewed for constructability. The contractor-supplied field office, scheduling requirements and the partnering process would be good examples. The Table of Contents must be carefully reviewed to determine what technical specs or appendices are missing. If the drawings show rail signalization and there is no corresponding spec, that would be an important comment. The bid item schedule must be reviewed to ensure that the work scope is adequately broken down so bids can be compared, that bid item titles and descriptions match the drawings and specs, and to confirm that the pay mechanisms are appropriate – lump-sum or unit price.

In addition, draft addendums (changes made after the bid cycle has started) and proposed drawing revisions for changes needed after bid can and should also be reviewed for constructability. Should contractor-provided designs be reviewed for constructability? No, because that would be a submittal review; constructability at that point is the contractor's problem. It is beneficial to explain what bid documents are generally exempt from review, as explained in the next section.

Documents Not Reviewed

Review time is limited, and during that time, the reviewer(s) must be fully engaged in the assignment. For this reason, the review must focus on what is most important – plans and technical specifications. This means some bid documents will not be reviewed. The following documents are not made part of the CR unless required by the consultant agreement or there is some other compelling reason to read them.

Notice to Inviting Bids, Instructions to Bidders – Leave these to the owner and program managers.

Non-Collusion Affidavits, Bid and Performance Bonds, Surety Certificates and the like are excluded from the review. These are boilerplate documents, based on state law or governmental regulations and have been reviewed by legal entities.

General Provisions/General Conditions – Because, like the contract, they consist of language written by legal counsel and risk managers and reflect the way the owner wishes to administer contracts. They have usually been time-tested and are not to be tampered with. Nonetheless, you should be familiar with their content, as they reflect upon the construction documents as a whole. Do not attempt to amend General Provisions in the Special Provisions unless the owner or program manager specifically allows you to do so.

Special Provisions or General Requirements are not reviewed, as they usually address, but not always, administrative issues. Those Special Provision subsections requiring attorney and risk manager involvement such as bonding, insurance, indemnification, SBE requirements, wage law, order of document precedence, taxation and such are not to be changed. There are exceptions, such as those subsections addressing time allotted for construction, milestones, field engineering, recycling requirements and LDs. Review and comment only on those Special Provision subsections for provisions that inure to fieldwork.

Appendices – Appendices are not generally reviewed. However, the reviewer is expected to be aware of what appendices have been included and what appendices seem to be missing. If you believe an appropriate appendix is missing, list the appendix that should be added to the table of contents. Similarly, mark superfluous appendices for deletion. Appendices consisting of such topics as lease agreements, right-of-way info, AQMD rules and the storm water general permit are not reviewed. However, note their absence if they are missing. The Hazmat appendix may require review as it would state which demo elements of the phase II assessment work were done. The geotech report may be a candidate for a brief review as well. All permits in the appendix must be read to confirm that the plan and specs corroborate permit requirements. For example, the regional water board's waste discharge permit should be read in its entirety to make sure the plan and specs do not conflict with the requirements therein.

Referenced Documents – Documents incorporated by reference such as record drawings, as-builts, reference drawings and standard drawings are not reviewed unless there is a specific reason to do so.

Design Phase Supporting Documents – Supporting project documents such as construction budgets, master schedules, contracting strategies, analyses of local bidding markets and design criteria are not part of the bid package and, therefore, they are not part of the CR. A CR would not include the designer's construction activity schedule except, of course, any schedule that is embedded in the bid documents as a requirement for the contractor to follow.

Formal Contract – As this document is written exclusively by attorneys and those at an executive level, it does not need to be reviewed. The contract most likely will not be available for review anyway because it is normally a separate document incorporating and usually repeating some portions of the general provisions such as contract time, LDs, payment and insurance.

The CR Format

Construction Managers don't always agree on the best means of tackling a CR. One disagreement is the format of the deliverable. There are two basic formats. One format is a listing of review comments using spreadsheet software. The other format is writing review comments directly on drawings and specs. Each has its pros and cons, as explained in the next paragraphs. A third and unusual format, writing comments in text boxes on a PDF of the drawings will not be discussed.

The spreadsheet format generally results in clearer comments and more structure and clearly reveals the volume of comments. With the structure a spreadsheet provides, comments can quickly be sorted by work discipline or document type; plans versus specs versus special conditions, and so forth. However, it then takes time to type entries, organize, proof and spell check. Another advantage of the spreadsheet is it can be shared online or within a local area network, allowing others to add to or comment simultaneously. This eliminates duplicate comments between reviewers and assures that reviewers are reading comments already made. Spreadsheets allow columns to be added for the designer to respond directly to each comment if they are so directed. In fact, it would compel written responses by the Engineer.

Having the reviewer's comments written directly onto documents has the advantage of showing the comments directly where they apply. The designer does not need to track down the location of where each comment applies by looking up the information on a spreadsheet. The downside of handwriting comments on drawings and specs is that they can become unreadable. Clarity can be lost because of poor penmanship or by comments that are too brief or that obscure the details or text they attempt to address. Either format, spreadsheet or handwritten, can suffer by being too cryptic, leading the designer to not fully understand what the problem is. The format will be chosen either by the client or by the review leader based on project complexity, review time allotted and number of reviewers.

Web-based CRs, i.e., multi-user web portals using proprietary software, no doubt will eventually become more common.¹² Among the benefits of this approach will be the ability to add photographs or sketches and obtain concurrent responses by the designer. Another benefit will be the owner or team leader's ability to monitor CR progress daily. All reviewers will be able to sort by the many input fields to suit various needs. The best benefit is that the designer can provide quicker responses to review comments. That allows the constructability reviewer to see responses to his comments while performing the review, rather than a month or so later. The reviewer can then write follow-up comments to responses until a particular comment is resolved between reviewer and designer.

¹² Vanir Construction Management Inc. has a web-based CR software but it is not available for purchase. www.vanir.com/services/ConstructabilityReview.html Likewise, other CM firms have web-based software they use internally. GKKWorks is web-based software available for purchase.

The CR Approach

Another disagreement among CMs is the CR approach. One approach is to divide plans between work disciplines or CSI divisions and have each reviewer concentrate on a single or a few disciplines. For example, a reviewer responsible for the paving portion would review the paving plans and the specifications that cover flexible and rigid pavements along with base course and striping. With another approach, some individuals would review the specifications, others would review the drawings and others review the special provisions. This is not a good idea because the plans and specs are best reviewed together, discipline by discipline. Yet another approach is to have each reviewer attack all plans and specs cover to cover. The decision on which approach to take may be based upon how much time is allotted, how many disciplines are involved, how many reviewers can commit, and the expertise of the reviewers. The approach should be determined by the client or the review leader.

Leadership

Every CR assignment needs a lead person driving the review. That person is assigned by some authority within the organization. The leader should be an active reviewer. Decisions must be made quickly due to time constraints. The leader will select the review team (which the owner may want to approve), obtain plan sets, disperse the documents among the team, give assignments, direct the format of the deliverable and determine the approach. For the assignments, the leader should recognize the following limitations of the individual:

- 1) A reviewer should be able to complete the equivalent of one, 100-sheet contract with its specifications per month without any problem. Two or more contracts of that size in one month and the reviewer's effectiveness diminishes.
- 2) Two CR assignments cannot be done concurrently, as a reviewer may not be able to keep design elements apart in his mind. One assignment must be finished before tackling another.

The leader must be fully aware of the due date be sure each reviewer can commit to that date. He will decide if there will be *back-checks* and may provide review checklists. On a small project, there may be no team. Rather, the review may be done by one person – you.

The leader must make decisions. He has to decide: how structured the process will be, how much time will be allotted to keep on schedule, how large the team should be, and/or whether specialized help is needed. Each reviewer must be given a full set of plans and specs even if that individual is responsible for specific divisions. That individual must know how his review elements fit in with the rest of the project.

The leader will keep the review on track, arrange for questions, marshal the results and watch the time and budget. The leader will also determine if a kickoff meeting is needed and will arrange for team meetings if warranted. However, a kickoff meeting is generally not needed unless the team leader or client determines it would have value. At the kickoff meeting, project phasing may need to be discussed, the reason given for schedule constraints, and an explanation of owner-supplied elements

or why the contractor is required to provide certain designs in lieu of the designer. Generally, a kickoff meeting is usually not warranted except for the most complex projects.

The 5-Step Process

Regardless of the format of the deliverable and how the review is divided, there are five steps to successfully completing a CR. The following explains the procedure.

Step 1 – Prepare

Know your CR team leader's expectations, what disciplines you are to review, the due date and how the leader expects comments to be presented. Budget time and get on with it. If you believe there is not enough time to do the review, tell the leader so accommodations can be made. If the assignment is to be done discipline-by-discipline, divide them according to who has more experience in an area. For example, the reviewer with a rail background probably would not be the best to review dredging. If Hazmat abatement were involved, it would be best to find someone with that forte. Reviewers need to do the following:

1A Arm yourself. Always use half-sized drawings for your review. This is because you will be flipping back and forth frequently between plan sheets and full-size drawings will not accommodate that. If your firm has CR checklists, use them. If not, this may be the time to start them. If a light table is available, overlaying drawings may reveal conflicts not caught otherwise. That level of effort will be your decision. For comments entered into spreadsheets, Excel® software is fine. The spreadsheet columns are set up so a unique number can be assigned to each comment in the first column. The next columns are for spec or drawing reference, reviewers' initials, the comment, perhaps a cost or time impact estimate, with the last column for the reviewer response. Save often, especially if it is a shared spreadsheet, as comments could be lost.

For those comments made directly on the plans and specs, the tools are simple – blue pen or pencil, Wite-Out™ or equivalent for comments you wish to retract, and access to a high-speed photocopier. Pen works best for reproduction. Your handwritten review errors can be lineated if Wite-Out takes too much time. Use of different color pens to differentiate questions and corrections are a wasted effort because it will slow the process. Your name and contact information go on the cover sheet of both plans and specs. This is because you are stating authorship of comments therein and want to encourage callbacks from the designer for any questions they may have about your comments.

1B First Pass. If there is a project overview specification, read it. Make a forward pass through the plans to gain familiarity with the project scope – that is, briefly look at each drawing. It's fine to make comments as you go, as they can be changed later if needed. A good rule of thumb is to budget 10 seconds to one minute per page, depending on the information provided on the drawing. The forward pass is done from front to back so you have an orderly and complete understanding of the project scope. That way, when later reviewing a single drawing or detail, you will have an overall understanding of the entire work scope and will be better able to understand how each part relates to the overall project.

1C Site Visit Recommended. After the forward pass and, assuming it's feasible, visit the future construction site. There you can mentally absorb the boundary conditions, existing structures, and exposed and overhead utilities. Remember the topography, site grading, flora, refuse piles, site access

points, neighbors, traffic and existing damage. Photographs are beneficial, as they may prove valuable and save on extra trips to the site. Take notes if needed. If there are operations or maintenance people on site, use them as a resource. Briefly explain to them what is to be built and then have them tell you what they know of the site's history or problems they have encountered. Get their contact information. Civil and structural reviewers must visit the site as their work disciplines meet the ground. For others, such as architectural and fire protection reviewers, a site visit would not prove useful.

Step 2 – Review & Comment

Sequester yourself. At this time, 'roll up your sleeves' and place yourself in the role of the contractor building the project. Pretend you are a claims-oriented contractor. This is the contractor who left too much money on the table at bid time and wants it back. This is the contractor who has been ordered by his home office to 'milk' the job for whatever time and money he can get. This would be that nightmare contractor who made your last job miserable.

Select one of your assigned disciplines and review it thoroughly, along with its applicable technical specification section. Start at the first drawing of the discipline and start turning drawing sheets. Another rule of thumb – budget 20 minutes to one hour per drawing. Obviously, some drawings will take more time and others less. For example, electrical one-line schematics will take longer to review than a survey control drawing. Write comments as you encounter problems. When done with that discipline, review its corresponding technical section. If there is no technical specification for what is on the drawing, that may be one of your comments, as all work, with few exceptions, should have a technical spec to go along with it. It is better to review one discipline thoroughly rather than hit and miss throughout the whole contract. If you're not flipping back and forth between drawings to ferret out information, then you're not doing the review right, as one work element usually joins with the others. Understand that other stakeholders usually start at the beginning of the plans and specs, but you might be better to start with underground electrical, usually found at the back of the plan set, as it may not be reviewed by others. Be sure to compare the work discipline to the bid schedule.

Avoid disruptions and keep the review moving. Avoid burnout. Four hours of focused reviewing would be a long time without a few hours off. This is demanding work – it may be better to go back to it the next day.

Unless your leader (or client) wants comments written onto a spreadsheet or entered into specialty software devoted to CRs, write directly on the drawings. No matter the form of the deliverable, try not to make comments in the form of a question, since that would imply you require an answer. Be polite with your comments – the designer may be put off by condemning remarks. However, don't be shy about making comments. It is better to make the comment even if you discover later that it is answered elsewhere. Plus, it's the Engineer of Record's job to sort out all of the comments and either reject them, address them, or ask for clarification.

As you complete one discipline, move onto others. You can always go back as more information is understood. Determine whether an additional site visit is needed.

Utilize review checklists if they are available. If not, now could be a good time to start developing your own review checklists. A client may require that you use them and check off each item as they are verified as covered. Add to existing checklists if time allows. Checklists will be based on the type of contracts or work scopes you and your organization tend to review. Checklists are written by

work discipline and will save time on the next review. Less experienced reviewers will find them valuable.

Some rules need to be established for the review.

Rule 1 – Contract documents lose meaning unless they are fully understandable.

Plans must be clear – construction plans must show the desired end result. If you don't understand the plans or specs, neither will the contractor. Every object line, dimension, leader, cross-section, reference and note must have clear meaning, be appropriate and add to the greater understanding of what is to be built. If it doesn't, it should be changed or deleted. Superfluous text, line work and graphics should be eliminated. Missing information must be added. Likewise, technical specifications must describe the work to be done. They must explain what documents are to be submitted before the work starts and what documents are to be submitted after the work is completed. Technical specifications must discuss the materials to be incorporated, execution of the work, what will be tested, who will provide testing and how the contractor will get paid for the work.

Rule 2 – The drawings must match the specification and vice versa.

The specs must corroborate what is on the drawings. Likewise, the drawings should correspond to the specs. The spec should not discuss work that isn't shown on the plans. For example, an article within the spec that discusses ground rod installation must be supported with an electrical drawing showing where ground rods are to be installed along with the cable connection detail.

Rule 3 – Never allow the documents to specify or suggest *means or methods* of how the work is to be done.

The *means and methods* on how to build the job are to be left up to the expert – the contractor. Text explaining the sequencing of work or how to obtain a desired result should be removed. However, there are exceptions. For example, consider the spec where soils are to be compacted to 90 percent relative density. Since only representative tests for compaction are done, the specs may require the minimum mechanical effort to achieve consolidation by requiring a certain lift thickness, a certain weight vibrating rollers and a specified number of passes.

Rule 4 – You will not catch everything, nor should you.

You are not expected to find every flaw and mistake. The goal is to eliminate as many problems as you can and to make the documents clearer and more easily constructable, all within in a limited amount of review time. There is the very real possibility that you may miss commenting on an obvious or fatal flaw. This can happen and there are many reasons for it. You could be concentrating on the fine details or, opposite of that, moving too fast and not looking at the bigger picture. You may have assumed there is no problem, as the referenced drawings or appendices address what the contractor needed to know.

Rule 5 – You are not directing changes.

You are not directing a change by making a comment. The EOR is the only one who can make a change. The designer's role is to determine if a review comment is incorporated, partially incorporated or disregarded. Designers are not required to explain themselves.

General Review Guidelines:

Reviews are done with two-dimensional drawings, but you must always think in three-dimensional space. Build each feature in your mind's eye as you review each discipline. For example, keep the civil details in mind because they may affect the electrical details.

Study all object lines, dimensions, notes, section cut marks, sections and details. Every mark within the drawing's borders must be reviewed. Ask yourself the following: Are more details needed? Would another section be useful? Do the notes make sense? Are more dimensions needed? Look for needed hidden lines, missing details and ambiguities. What is superfluous? Would an isometric be better? What doesn't belong here?

Make certain that drawings lead the reader logically from general information to precise details. A detail provided without knowing where it originated from is difficult to understand.

Make certain that all relevant existing conditions are clearly depicted and defined by location, size and with a description.

Don't allow narratives, either in the plans or specs, to describe the work to be done. That is what details are for. For example, text stating that a 4-inch layer of shotcrete needs to be placed on top of a rock dike from Station 1+00 to 5+00 should be deleted. Instead the requirement should be clearly depicted on the drawings with object lines, dimensions, callouts and perhaps a graphic indicating the shotcrete layer.

Drawings made to scale help reveal conflicts. Drawing plans, sections and details indicated with "NTS" are to be minimal. If a detail can be drawn to scale, it should be.

Comment on overly crowded drawings. Too many details crowded together on one sheet confuses the work. Some empty space can be used for adding details or notes if the drawing ever needs to be revised during the bid phase or during construction. Also, drawings will need room for future as-building.

Cross-referencing by bubble reference or cut marks must be checked for a match. It is not uncommon to find a detail callout that identifies another sheet, then to go to the sheet and not find it. The opposite can also occur; for example a detail is provided with its cross-referenced origin below it, but the detail is not found on the drawing it was supposed to be from.

Correct awkward text by rewriting it. Run-on sentences must be shortened. Why? Because clear writing avoids questions and confusion during the work. For spelling mistakes, either correct the word or circle it to draw attention to the misspelled word. Some designers may be foreign-raised which could add to language, spelling and syntax challenges. Use proofreader's marks.¹³ All information should be given equal weight, so watch for consistent fonts and point sizes.

Watch for any terms, phrases or symbols that could be interpreted differently between the CM and the contractor. Identify abbreviations used, but not defined in the list of abbreviations.

¹³ A good description and symbols of proofreader's marks can be found at <http://www.swdocs.com/proof.htm>

If the same or similar instructions are found both in the plans and specs, leave them alone. Redundancy between plans and specs is usually all right. However, avoid redundant directives on the same sheet unless it serves a beneficial purpose.

Make certain you can easily differentiate new work from existing work. This is usually done by line weight, (E) for existing, or both.

Although not considered a CR responsibility, suggest alternative materials if you know different materials that would work better or are more easily obtained. Encourage recycling by using material that can be found on or near the project site.

Consider seasonal influences that may affect progress during construction. Deep excavation work during the wet season invites problems. Placing mass concrete during hot weather may require ice in the concrete mix that will add to the cost and create inspection challenges.

The bid schedule must be reviewed concurrently with the particular drawings and spec section that apply to the appropriate bid item. Verify that the bid schedule item description generally mirrors the work scope and confirm that the pay mechanism (LS, unit price, allowance) is appropriate.

Watch for any requirement that inappropriately shifts risk to the owner. The opposite holds true for a requirement that shifts risk to the contractor where the owner should assume the risk.

Be vigilant in recognizing whether there are requirements specified or missing information that the contractor can exploit to his own benefit.

Some final words to Step 2 – Review & Comment.

Suppose you just can't figure out what is required for a specific element or how to build an element, even though you tried to find the missing information within the plans. The question then becomes, how far should you go and how much time should be expended to track down information? There are two answers to this dilemma. If not shown in the detail, check the spec for an explanation. Likewise, if not understandable in the spec, go to the drawings. Go to the next associated and logical document and only if you can afford the time to do so. You are not required to have all referenced standards, record drawings or other resources. If they are available, you should not have to delve into them. For example, if anchor-bolting requirements were unclear on the concrete drawings, you would go to the specs and then to the miscellaneous metals drawings. If the question is still unresolved, your CR comment should be "Specify where the AB information can be found."

You may think twice before making some comment, as it may seem to be too trivial. How trivial should you get? If it is wrong, point it out – that is, unless too many trivial items are cutting into more important aspects or speed of the review. In that case, it may be best to point out several trivial items and make a general comment that the designer should 'QC' the documents more closely. Should you stop a CR and return for QC? No. However, let the team leader and owner know that in your opinion they have not been QC'd and continue the review.

Should you make a second pass through the plans and specs? That is up to you based on the need and the time allotted. Ask for more time if you believe it is needed.

Perhaps you find a detail or specification that you believe violates a building code. Unless you are absolutely sure of a violation, it is best not to question the design based on your understanding of a code. It is not your responsibility to know, interpret or apply building codes.

What if the designer accepts a CR change that later becomes a focal point of a construction dispute or claim? This can happen. However, the designer is the arbiter of what changes are made based on the review comments he receives.

One final note on reviews: Keep in mind your fiduciary responsibility. For the client, a CR is not an exercise to *charge* the owner billable hours. Make your hours count. Neither is a review an exercise to show how bad the design is or a means to embarrass the design team. In fact, comments must be written in a proper tone in order not to be perceived as a challenge to the design team. Please be diplomatic with your comments.

Step 3 – Final Check and Repro

The client deliverable will be either: 1) your set of marked-up plans and specs with, if prudent, a typed narrative of some of the bigger issues that did not lend to handwritten comments, or, 2) a comment spreadsheet, either printed or e-mailed to the client. An executive summary is not needed for either.

If time allows, re-read all comments to make sure they are clear. If you do not understand a comment, your reader won't either. Especially for spreadsheets, consider having a colleague review your comments and edit as he sees fit. For those CRs written directly on contract documents, make a photocopy of the entire review – both plans and specs. Color photocopies are best because comments will stand out over black-line drawings and blackface specs. For comments made on spreadsheets, print them out and save a copy of the spreadsheet for yourself. The copy will be needed to make a comparison as to which comments were incorporated and which were not (refer to *Back-Check* below). You may also need the copy for possible reference during construction. Why? Because it is possible that the CM, client or contractor may later determine either that the design element should have been different or that, if a particular flaw had been caught, it should have been addressed in the CR. Worse, the contractor may encounter some difficulty and the CM or owner found that it was brought to the attention of the designer in the review but was never incorporated. Your photocopy record may show that you questioned a particular detail or commented on the way a note was written, or that you pointed out a flaw, but that the comments were disregarded by the designer. That copy may be tabled in the project post-mortem. For those review comments handwritten onto drawings and specs, do not commingle your comments with those of other team members. Each team member is to provide a complete plan set and spec book with his own comments.

As previously stated, your name is to be written on the cover of the plans and specs along with your contact information so the designer can follow up with you if questions arise about your comments. The original marked plans and specs will be turned over to the designer (or owner) after the *Spec Read* as discussed below. The designer will assemble your comments along with those of the other stakeholders.

Step 4 – Spec-Read

CR comments can be shared in an open forum with the designer, client and other reviewers. Sharing is done in roundtable discussions known as a *Spec-Read*, i.e., a review meeting to discuss the bid documents. *Spec-Reads* are not a hard and fast requirement, but they can be very useful to discuss the results of the review, share ideas and especially to discuss major concerns. Either the owner, Engineer, Program Manager or review team leader hosts it. All stakeholders who may or may not have provided a review can participate – client, designer, CM, inspector, program manager, tenant and others. Depending on the project scope and complexity, this can be an all-day affair or even take several days. The *spec-read* can be done for each review cycle, e.g., 90 or 100 percent.

Bring your plans, specs and spreadsheet to this meeting. Drawings are usually covered first, starting with the title sheet. Each drawing is presented in turn and offered for criticism. Likewise each technical specification is given its turn, section by section with the possible exception of CSI Division 1. Only significant comments should be “tabled,” i.e., those comments that may need some explanation or may be contentious. Due to time constraints, the discussion must not get bogged down in minutiae. It is the host’s responsibility to keep the *spec-read* moving. You may have opinions as to what others table, and others will have opinions on your thoughts. Modify your written comments on the spot as needed during the *spec-read* as you reflect on what others say or if you become convinced your comment should be deleted or embellished. Do not table all your comments. Assume the designer will consider all your written comments.

Hand over your work product, marked-up plans and specs or comment spreadsheet, to the host at the end of the *spec-read*. After the *spec-read*, the designer should end up with many sets of plans and specs from the different reviewers. The designer is expected to consider all of the comments for possible changes in the design. The plans and specs are subsequently revised and returned to the owner. The program manager will determine if the documents are to be reissued for another CR or if they can be finalized and issued for construction. If the review is complete, a final copy should be issued to the reviewer for his record.

Step 5 – Back-Check

A *Back-Check* is the process of reviewing the revised plans and specs to determine which of your CR comments the designer has incorporated and how he chose to incorporate them. It is also a study of which comments the designer chose not to incorporate. The *back-check* should be done for each revision of the contract documents that are made available to you, as well as the final set that was approved for bidding. You should be given a copy of the final revision – the bid set. If not, seek one. *Back-checks* are not mandatory.

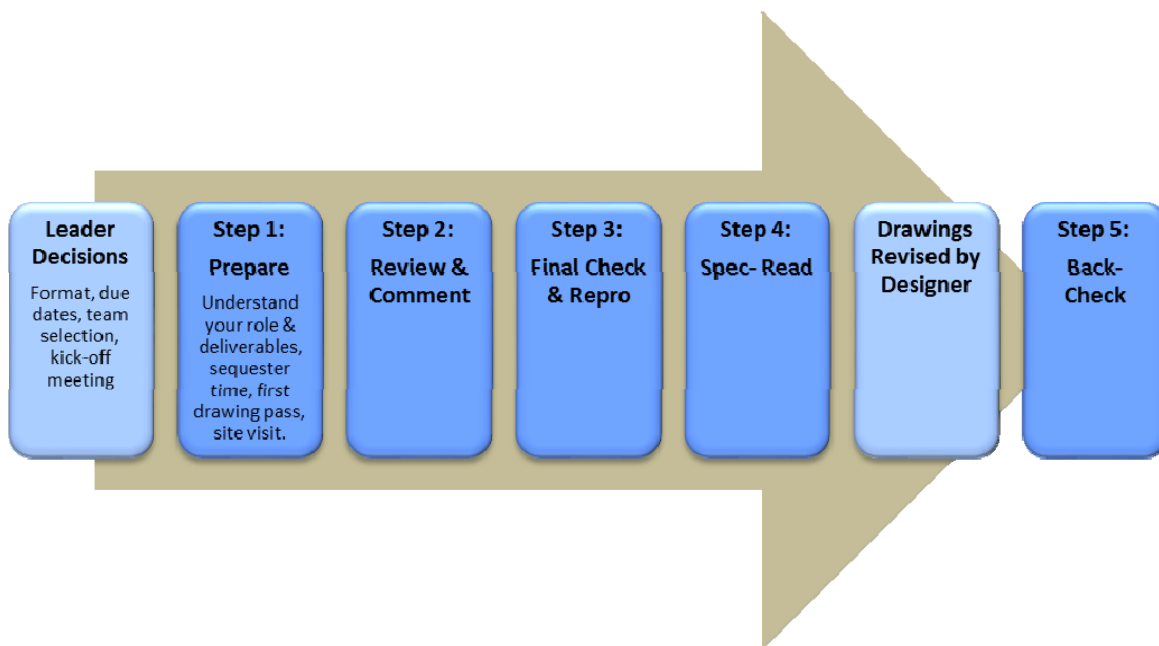
Sometimes it may be difficult to determine whether or not your comments were incorporated. This is because a CR comment made on a drawing may have instead been addressed in the specification or vice versa. You might have to forego tracking down whether a comment was incorporated or not if the search is taking too much time. Assume the comment was not incorporated and move on. Remember, the mere fact that a CR comment is made does not require it to be incorporated.

What should you do if you know a comment was not incorporated? If you deem your comment to be important enough, it should be reconciled with the designer. Discuss the issue with the team leader, designer or owner as appropriate. If a review comment was not addressed in an earlier review and you believe it remains viable, repeat the comment on the current review. Keep carrying comments forward to subsequent reviews if you believe they still apply – but with an expanded explanation.

The designer may resist incorporating a comment for any number of reasons: 1) it was considered too minor, 2) it was not understood, 3) the designer was unable to incorporate it due to time constraints, 4) the design changed, and/or 5) the designer did not agree with the comment. A possible sixth reason could be that the designer was directed to use a standard detail, or in other words, would not change an owner's standard. In that case, ask him to change it anyway because the owner's boilerplate detail may not work in the particular instance. At the very worst, a seventh reason for not incorporating a comment is that the designer was compelled to defend the original design. In this case, the team leader will decide if it should be escalated.

We want satisfied clients. Ask for feedback as an individual reviewer or team. A reconciliation meeting may be needed for complex projects. The team leader will decide if a stakeholder's meeting is necessary. Make note of what elements the designer refused to incorporate so that if problems arise and that should have been caught in the review, your record will show it was addressed but not incorporated. It is a good idea to keep a rough track of the percent of your comments ultimately incorporated. The experienced reviewer who finds that less than 50 percent of his comments are addressed may be a red flag. The designer may not be taking the comments seriously or there may be a breakdown in the CR process.

The ideal 5-step process is illustrated in the following flowchart.



Improve Your CR Expertise

You can learn from the CR process. Determine why the designer does not incorporate certain comments, as there may be a good reason. Read other reviewers' comments and learn from them. Be willing to tackle new assignments and don't be afraid to try other disciplines. The more CRs you do, the more proficient you will become; your comments will be clearer and more concise, done more quickly and confidently. Start your personal CR checklists. Lessons learned on past jobs can become

comments on the next review. Remember those problems you encounter on your current construction project so they can be avoided on the next review and hopefully the same problems won't be repeated. Become the go-to reviewer of choice within your firm or the reviewer the client requests.

Summary

Constructability Reviews are an important part of the design phase. Reviews done properly will reveal conflicts that can impact construction time and cost. Reviews must be done independently of the designer and completed well before the bid cycle begins so that there is ample time for corrections to be made. Seasoned Construction Managers and experienced inspectors are candidates to provide CRs because of their knowledge of construction, contractors and the bidding process. Although it is nearly impossible to train a person to make relevant review comments, the CR process itself can be taught. Not all documents need be reviewed for constructability, but the plans, specifications, bid form and relevant special provisions must be reviewed. CRs are ideally done in a five-step process – Prepare, Review, Final Check/Reproduction, *Spec-Read* and *Back-Check*.

Keywords

Back-Check, constructability, Spec-Read

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Appendix I

General Problems with Plans & Specs

The designer has an obligation to provide a quality control check (not a CR) on his work before the plans and specs are offered for the final review. However, some items are often missed and discovered during the review. CRs reveal recurring quality problems with the plans and specs. Below are some general, yet important considerations that apply to most types of construction. It is not a complete list. See Appendix II for Recurring Design Omissions.

The following can apply to either Drawings or Specifications:

- Be cautious of specifications requiring the contractor to provide designs. The only design work contractors are expected to perform is to design concrete forms, shoring, scaffolding, concrete mixes, AC mixes and specialty fabrications. Specialty fabrications may be such items as precast concrete elements, highmast light poles, mechanical/electrical gear and their foundations. All contractor designs that are to become a permanent part of the work must be submitted for review to the Engineer.
- Requiring the contractor to coordinate directly with the tenant or other general contractors can be a recipe for problems. The construction manager should manage the coordination. Similarly, watch for any text requiring coordination work between contractors where one contractor is required to have another contractor to perform some work. This rarely works and the CM will be forced to referee and sort out the impacts to each contractor's work.
- Change the verbs “*should*” and “*must*” to “*shall*” anywhere in the plans or specs. This changes permissive language to mandatory requirements.
- Phrases such as “*work done at no additional cost to the Owner,*” “*...as deemed necessary by the Engineer,*” “*...as determined by the Engineer,*” “*to be certified,*” “*Contractor to field verify*” and the like should generally be eliminated or re-written to provide clearer direction.
- Upper case the first letter of Contractor, Engineer, Owner, City, Tenant and similar entities to properly identify them. Similarly, the first letter of Contract, Special Provisions, Specification(s) and Drawing(s) should be in upper case.
- Unless sole-sourcing is desired, write, “*or-equal*” after specifying a product wherever a particular product is used in the drawings or specs. The term “*or equal*” should be used after a specific product is named even if it stated elsewhere in front-end documents that “*or equal*” is to be assumed. Otherwise, contractors may successfully argue it was the owner's desire to sole-source and may use that ideology to their benefit. An example would be a specified product that could not be fabricated by the manufacturer in time to support the project, thus earning the contractor a time extension.

Drawings – Specific to drawings, be on the alert for the following...

- Work disciplines interfering with each other. Two objects cannot occupy the same space at the same time. For example, the electrical designer may inadvertently require an electrical

vault that is found to encroach into the pipe zone of a proposed or existing storm drain. In this example, the electrical designer did not account for the civil work.

- Design not meeting the client's or owner's standards. The designer may be unfamiliar with owner's needs. You may have more experience working with the particular owner than the designer. Therefore you may be in a better position to alert the designer to the owner's preferences or standards.
- Think access. Determine if the contractor can gain reasonable access to the site and, once there, has enough room to operate.
- Do not allow for standard drawings or reference drawings to be referred to, but not included. Standard plans can be easily inserted in a spec appendix or added to the plans. Reference drawings should be included unless they are too voluminous, in which case their location should be made available.
- Watch for "*furnished by others*" language that does not specify who – owner or another contractor – furnishes them or when the item will be available. "*Work by others*" – needs to clearly specify who does the "*other*" work on the drawings and also when it will be done.
- Use verbiage "*protect in place*" where appropriate for those existing elements on the site that are to be preserved or kept from being damaged.
- Make certain systems are coordinated. A simple example would be when an anchor bolt length required in the specs exceeds the concrete foundation thickness detailed in the drawings.
- Watch for non-standard sizes. For example, a 34-inch manhole cover is specified whereas foundries cast them 30- or 36-inch diameter.
- Look for too light of line work used for existing utilities. Existing features should be clear and easily discernable, especially since they will be reduced to half-sized drawings.
- Review survey control data – can't build unless the datum and grid control are given.
- Show existing water sources available to the contractor for use, whether gratis or at some charge.
- Show existing features applicable to the SWPPP – curbs, catch basins, open channels, etc. They should be presented for possible use during SWPPP development.
- Ensure site access limitations such as turning radius, traffic volume, offsite staging, laydown, etc. are considered. With that in mind, consider availability of separate access gates in case of labor union action against a non-union contractor.
- Show emergency fire access – usually a requirement of the permitting authority.
- Provide minimum information needed to support existing utilities in crossing trenches and excavations. Consider it part of the design. Don't leave it all up to the contractor.

- **QC** Not only must match lines accurately carry onto the next page, all object lines must also carry across the match line.
- **QC** Watch for any specification referred to on the drawing that does not exist.
- **QC** Correct drawing titles that do not match drawing content. Also, make certain the drawing title is repeated exactly on the drawing index sheet.
- **QC** Graphics – Material graphics should differ. Cross-sections of concrete should look like concrete, gravel should look like gravel and asphalt should look like asphalt. Make sure consistent graphics are used throughout various work disciplines.
- **QC** Include bar scales on all drawings that have scaled plan views, sections or details. This is needed because full-size drawings are usually reduced to half size and the reduction may not be exact.
- **QC** Key plans are usually helpful.
- **QC** Require a list of abbreviations for each discipline. Watch for abbreviations used, but not listed in each legend table.

Specs – Specific to specifications, be on the alert to the following...

- The 1.01 Scope of Work articles of each technical division must describe what is to be done. Avoid boilerplate and generic work scopes.
- Eliminate superfluous submittal requirements. If a submittal is not truly needed, delete the requirement. For example, samples of electrical cable need not be submitted if the manufacturer’s product data sheets clearly provide information that the Engineer can review to see if the cable meets the minimum specified standards.
- No payment mechanism for work – e.g., explain how the work item will be paid for. This has more to do with bidability reviews. The objective is to make sure the contractor can’t take the position of “I’ll do it, but where do I get paid for it?” A claim may be avoided.
- Be clear what permits the contractor is to obtain. Further, be clear which permits the contractor is expected to pay for. Make certain the time needed to obtain permits from governmental regulators is accommodated in the project durations. If permitting lead-time is an issue, the Engineer should obtain the required permits before work starts. An example would be a RWCB Waste Discharge Permit that can take over six months for the regulators to approve.
- Materials that are shown on the plans must be clearly specified either on the drawings or under the products article in the appropriate technical spec. It’s always best if all equipment and materials are clearly specified.¹⁴

¹⁴ California State Law §3400 of the Public Contracting Code requires two products be listed followed by the words “or-equal.”

- Boilerplate specifications that were not modified for the project can be problematic. Designers are known to cut and paste text into specs in order to save time. All specs must be read to make certain they conform to the project. If there is a superfluous spec, the contractor could take the position that other specs are superfluous, making it difficult for the CM to enforce contract provisions.
- Specify manufactured goods with either a prescriptive¹⁵ or performance¹⁶-based spec. Do not mix the two within the product sub-specification. If a manufactured product is specified as performance-based, it should stay performance-based and not drift into prescriptive language.
- Specs requiring the contractor to provide third-party inspections invite problems. In these cases, quality control will suffer. Instead, the CM or owner should provide a third-party inspector or should provide for inspection themselves. The CM must never be placed at odds interpreting quality when an inspector who is hired and paid for by the contractor decides the level of quality.
- Do not allow designers or design subconsultants to write their services into the spec. This occurs when the contractor finds that the only party who can meet the specified requirement is the designer who wrote the spec and thus, is compelled to hire him. In other words, when the only organization that can meet the specified requirement is the design organization that wrote the spec, the contractor is forced to hire the designer or a subsidiary of the designer. This creates an unacceptable conflict of interest.
- Be careful using “...as directed by the Engineer.” Except for the rarest of occasions, the Engineer does not direct the work. Be cautious of phrases such as “...where indicated on the drawings,” “...as indicated on drawings” or “...as shown on the drawings.” Check to make certain it is indeed clearly shown on the drawings. Similarly, the phrase done “... in an approved manner,” holds little weight and is always open to interpretation.
- Change or drop any spec or drawing text that uses the term “*intent*” e.g., “*the intent of the design is to ...*” A specifier should never have to explain the design intent to a bidder/contractor. The design should stand by itself.
- Some specs may not clearly indicate which party is to perform a task. Make certain tasks specify who does what: contractor, CM, owner or a third party. For example, the spec may require AC pavement to be tested for stability, but the spec does not explain which party is responsible to perform the test.
- Require that Certificates of Conformance, mill certifications and test reports be converted to English units and to English text for materials manufactured overseas. It makes no sense to accept a test report written in Italian when it cannot be understood.
- Address the level of Engineer’s QC and QA so the contractor can be assured they are not being overly inspected. Alternatively, if inspection is to be continuous, then state so in the

¹⁵ Prescriptive specified – Specifically defines a product, equipment or system to be used by the manufacturer’s name, model and sometime particular options for that model.

¹⁶ Performance specified – Defines the work to be performed by describing the operational capabilities the completed work must possess. Contractor is allowed discretion in determining how to construct the work in order to meet those requirements. Proof of a product meeting the spec is based on performance data submitted for approval.

specs. For example, specify the frequency of shop tests to measure DFT, field tests for dirt compaction, UT for welding, concrete pipe D-load tests, and so forth. Explain what minimum lab work will be done. Explain what shop inspection will be done by the CM or explain that the manufacturer's submitted test results or Certificates of Conformance will suffice.

- Consider possible material delivery delays due to specified products. If the designer specifies a particular manufacturer, he must make certain the manufacturer can deliver when needed.
- Listing the year of adaptation of a national standard in specs should not be done.¹⁷ Since only the most recently adapted standard should apply as of the bid date, the date is not needed. The problem with date suffixes is that old dates find their way into specs because boilerplate specs are used and have not been updated.
- References to national standards that don't apply to the work are superfluous and should be deleted. Designers tend to throw in the kitchen sink by listing all codes and standards. For example, it makes no sense to reference the American Wood Preservers Association unless timber or lumber is to be pressure-treated.
- Equipment salvage – Make certain specifications include where salvaged items are to be delivered, in what condition salvaged items must be before delivery, and if any coordination with the receiving party must be done before delivery.
- Spare parts – Make certain spare materials and spare equipment requirements are clearly specified. Never leave it to the manufacturer to determine what spare parts to provide. Specify each item, the quantity, and how they are to be packaged and labeled.
- O&M manuals – Verify that the specification is clear about what systems require O&M manuals. Verify that the spec requires O&M manuals be submitted in the form the owner prefers.
- Warrantees – Make certain warranty periods are defined and which items require separate written warranties.

¹⁷ The exception is ACI 318 and other building codes, as Building Authorities require date suffixes that list the year of adaptation. Therefore, the year of publication should appear on drawings, not in the specs.

Appendix II

Recurring Design Omissions

The following are some recurring design omissions the author has found for various work disciplines. They are presented as possible comments for your review.

First Sheet – Include the project street address on the lead sheet. If included, the address will be readily available for the permit desk, building authority inspection callouts, contractor deliveries and inquiries by third parties.

Demolition – Provide thickness of existing AC pavements. Pavement cores should be taken in the design phase to confirm thickness and to verify that no Petromat® is present. Demolition work usually requires existing water valves to be closed. Since some old water valves never close tight enough to completely shut off water, have the designer address the possibility by explaining what the contractor is to do. Specify who is responsible for site trash and spoils and what to do with them. For existing sanitary sewers, address whether they should be purged before removal.

Utilities – Show connection details to existing utilities, such as DI pipe connecting to existing ACP. For those utilities to be cut and abandoned, provide plug or cap details. Show how to support existing utilities encountered across trenches or require contractor to provide a support design for approval. Always show size and material of existing utilities if known and, if not known, state so.

AWWA Standard for Ductile Iron Pipe, Centrifugally Cast, For Water, Section III.A.

Discusses what could be addressed in specifications such as joint type, certifications and tests.

Earthwork – It is usually best to scarify before fills are placed on native soils. Benching into embankments is best done before fill is placed. Topsoil should always be salvaged for reuse or future use on other projects. Test pits should be dug for landscape areas in the design phase to assure there are no deep layers of base or other objectionable material. Encourage use of recycled aggregates such as CMB.

Reinforcing Steel – Watch for nonstandard bends and, if a non-standard bend is needed, specifically call out as a *special bend*. For those non-standard bends, provide bending pin and tail dimensions. Be careful of requirements for many bends with large bars, as they may cause placing problems especially at structural joints. Make certain the type of epoxy coating, e.g., green, yellow, used for rebar protection is specified. Discourage rebars over 60-ft long. Insist that splice locations are shown.

CRSI Manual of Standard Practice, Chapter 4, Notes to Architect/Engineer, Subsection 6 Project Drawings. This standard explains important information that the designer is to include but is often missed. For example, the standard requires the designer to specify whether the clear cover is to the ties or the main steel. It also requires the designer to show preferred splice locations.

Concrete – Always specify the class of concrete and its compressive strength. Show assumed construction joint locations. The contractor or rebar detailer can seek approval later if they desire to change them. Verify that corner finish treatments are clear – e.g., chamfers, tooled edge. The type of finish must be specified, e.g., broom, steel trowel or other. Pay attention to slab sizes and, if too

large, suggest adding green cuts to control shrinkage cracks. Make certain spec addresses cold jointing.

ACI 117 Standard Specifications for Tolerances for Concrete Construction Materials. The standard suggests the designer use the “Mandatory Specification Checklist.” For example, the standard explains that the Architect/Engineer must specify class of surface and floor finish tolerances.

ACI 301 Specifications for Structural Concrete. Suggest you recommend the designer utilize the “Mandatory Requirements Checklist” and perhaps the optional checklist. As examples, one requirement explains that rebar splice locations must be shown and another that the subgrade soil density must be provided in the drawings.

Miscellaneous Metal – For stainless steel, make certain the steel grade is clearly defined. Otherwise the supplier will provide ASTM 304 instead of a more durable grade. Opt for hot dipped galvanized in lieu of painting. Painting becomes a maintenance issue. Make certain weld designs will not trap air before HDG. The size and length of welded studs and anchors must be specified. Address requirements to prevent white rust of important galvanized metals for visual appearance.

Welding – Use of non-standard welding symbols is problematic. Consider adding requirements for WPSs and PQRs. Address whether weld tabs are to remain or if they are to be removed. Address the extent of non-destructive testing and preheat requirements. State that “minimum welds” are required just in case a weld callout is missed. If “rat” holes are allowed or required, show them in the connection details or acknowledge their permissive use in specs. Watch for steel designs that will collect storm water, e.g., an upturned channel. Correct field welding situations that will be impossible to reach with an electrode. Use weld dressing symbols where appropriate.

Structural Steel – For nonstandard sections, have the designer check availability before specifying.

AISC Specification for the Design, Fabrication and Erection of Structural Steel for Buildings, Section 1.1 – although very general, the standard requires specifying Type 1, 2 & 3 construction and friction or bearing connections. The detailer and erector will need to know both.

AISC Code of Standard Practice, 3.1 Structural Design Drawings and Specifications. Also very general; it explains what structural steel fabricators and erectors expect the design document to encompass. For example, the standard requires data on assumed loads, shears, moments and axial forces required for connection details and erection of the structure.

Electrical – Make certain electrical “listing” requirements are made clear for specially fabricated equipment such as switchgears and switchboards. Require burn-in of electrical systems, especially lighting systems. Manholes can get quite deep so address groundwater and foundation bedding for deep manholes.

Appendix III

Sample Comments

Below are selected examples of CR comments. They are presented here to illustrate some typical comment, but more so to give the novice a level of comfort on the caliber of comments that can be made. They originated from review comments that were written directly upon various 90 percent design drawings and specs. However, the comments are written more clearly here, as the original comments tended to be more cryptic.

Specs – Discuss which party will pay for UBC 1701 required *special inspections*. Require that vendor contact information be included in O&M manuals. Define what is meant by “interconnection diagrams.”

General Drawings – Specify if the existing structure is to be protected in place. Specify minimum width of fire lanes. Do not provide northings and eastings to three significant digits.

Earthwork – Change 98% RC to 95%, as the former is too difficult and costly to obtain. Test for moisture content on import fill so truck scale weights can be adjusted for payment. Gunite is shown, but there is no corresponding spec for it.

Utilities – Class 52 DIP is a thickness class, not a pressure class as stated. Require record surveys before underground utilities are backfilled. An existing waterline is shown but no information is given as to size and material. Provide required D-loading for all RCP. Show thrust blocks at waterline angle points. Explain what contractor is to do with test water after pipe is dechlorinated.

Reinforcing – Impact gun will not be able to reach the rebar couplers. There is no reason to galvanize dowel bars because they will be encased shortly after installation. Show clear cover to spiral reinforcement. Wall is too thin to accommodate a #5 std. hook. Specify lap length for splice.

Concrete – Require backup (spare) vibrators. Specified construction joint spacing conflicts with drawings. Specify compressive strength required for this element. Structure is designed that prevents concrete forms from being stripped. Future coring will cut rebar unless reinforcing is moved.

Paving – Require flood test after paving and before stripping so any birdbaths can be located and repaired. Determine if manhole lids need to be cleaned of all asphalt after paving or if they should be removed and plated before paving.

Miscellaneous Metals – For those welds that cannot be done in the shop, show as field welds. Specify embedment depth of anchor bolts. Use drop-in or expansion anchors. Use headed studs instead of welded-on bolts. Embedded wide flanges shown will conflict with slab reinforcement.

Welding – Require existing coatings be protected before welding to avoid weld splatter damage to paint. Use proper weld symbols. Half inch fillets will distort sheet metal due to weld heat.

Coating – Specify a maximum wind speed before field painting will be stopped. Do not allow contractor to provide an independent inspector, require owner to provide inspector.

Electrical General – Include requirements to repair damaged Ocal® coatings on conduit. Specify size of Unistrut. Fiberglass pull box will not withstand stress when pulling 500MCM cable. Require contractor to submit conduit sidewall pulling pressure calculations.

Underground Electrical – Show warning tape in all duct bank cross sections. Provide coordinates for all electrical vaults. Show manhole shafting, grade rings and manhole bedding clearly in details. Show underground duct bank profiles no matter how short the run. Provide top of vault setting tolerance to +/- 1/4-inch. In manhole plan views; show preferred entry point of ductbanks and conduits. Insist on embedded sleeves to bring ground wires into manholes. Make certain any electrical symbol used is defined in the legend. State the possibility of groundwater in existing manholes.

Switchgear/Panelboards – Provide NEMA rating for all panels. On panel schedules, clearly show which slots are spares and which are spaces. Include convenience receptacles in each switchgear. Require sloping roofs on gear used outdoors.

Appendix - IV

Examples of CR Scope of Services

The following are examples of owner/consultant CR contract language. They are presented in order of increasing complexity for CR work scopes. They should serve as a launching point and may be modified as needed depending on your scope of services to the client.

Perform constructability reviews as requested. Make written comments to plans and specifications. Submit comments to the Owner within required time frames. Participate in review meetings to discuss comments.

Review the contract documents to determine their adequacy and completeness for construction of the project. Review shall consist of plans and specifications and consider information found in reference documents, geotechnical reports, and required permits. Site inspection will be required. Identify risks including conflicts, errors and omissions that could impact cost, schedule or quality of the work. Provide written comments and participate in review meetings as directed.¹⁸

Perform constructability reviews when directed and within the required time frame. Review the contract documents to ensure an accurate and well-coordinated set of plans and specifications. Determine the adequacy and completeness for both bidding and construction of the project. The review shall encompass information from the plans, technical specifications, appropriate special provisions and appendices and information gained by site inspections. Identify risks including conflicts, errors, omissions and any unorthodox construction requirements that could impact cost, schedule or quality of the work. Make recommendations to improve the quality of all documents. Consultant shall participate, or if directed, host spec-reads and perform back-checks. Cost impacts shall be estimated for major review comments. Consultant will not be held accountable for items missed; however, Consultant shall use due diligence to meet the standard of care commensurate with that of the construction document review industry.

Consultant shall provide a written approach explaining how he intends to perform constructability reviews with an estimate of the cost and time needed to perform the review. Consultant shall provide the qualifications of the proposed reviewers. Consultant shall advise if specialty consultants are required. Receipt of the documents from the Owner shall indicate the Owner's permission to proceed with the review. Distribute contract documents to other stakeholders in a timely manner for their review and collect and combine all comments. Consultant shall review all contract documents to suggest corrections in order to help ensure an accurate and well-coordinated set of plans and specifications. Consultant shall suggest construction phasing,

¹⁸ Similar to the Port of Los Angeles consultant agreement.

milestones, overall duration of construction, liquidated damages, contingency, budget, contracting mechanism and provide an opinion of particular project risks. Determine the adequacy and completeness of documents for bidding, construction, inspection and management during the construction and the warranty phase. Review shall consider information from the proposed plans, specifications, and appropriate appendices including, but not limited to, required permits. Review shall include comments from mandatory inspections of the proposed jobsite. Identify risks including conflicts, errors or omissions that could impact schedule, cost or quality of the work. Coordinate with operations and maintenance personnel, as needed. Consultant shall maintain a database of all comments and their resolution. Reviewer shall specifically flag any comments that the Owner should consider in lieu of the Designer. Consultant shall organize and host spec-reads with all stakeholders and perform back-checks to assure the Designer has addressed all comments. Consultant shall agree with each comment's final resolution or notify the Owner if particular comments are not resolved. Cost impacts shall be estimated for each review comment. Provide a written, overall opinion whether the 100 percent documents are ready for bidding. Consultant shall perform similar reviews for proposed change order work during the construction phase as requested. Consultant will not be held accountable for items missed; however, Consultant shall meet a standard of care that is commensurate in the constructability review industry. Consultant will not be held accountable for conflicts and errors not discovered. The budget for the 90 percent reviews is \$xxxx and the final review is \$xxxx. All deliverables shall be submitted to the Owner.

Abstract

You, the Construction Manager, are given the task to provide a Constructability Review (CR) of a client's plans and specifications, as that is part of your firm's scope of work for the client. It is due in two weeks. You have no experience performing CRs and are not sure of what you are expected to do or how to attack the assignment. This paper will provide the reader with an understanding of what a CR is and its importance, and will describe how to approach a review in a manner that will maximize the benefits a CR can offer to a client or project. It also explains why CRs are needed, what skills and knowledge are required of the reviewer, what construction documents are normally included in the review, and the traditional five-step review process. General problems encountered in drawings and specifications are also discussed, along with example CR comments. This introduction to CRs can apply to one-reviewer assignments or multi-reviewer assignments for complex projects, and will give readers a clearer picture of why and how the CR is such an important element in project success.