ARCHITECTURAL CONTRACT DOCUMENT DETAILING FOR SINGLE-PLY MEMBRANE ROOF SYSTEMS

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The designing architect's lack of detailed knowledge of single-ply membrane (SPM) systems, as he specifies a roofing system, is becoming evident as roof failures involving SPM systems rise. Fundamental to all roofing systems, particularly SPM roof systems, is the appropriateness of proper detailing and specification writing.

This paper will present a model in which roof design is viewed structurally as an aspect with a number of phases and variant units. In this model, roofing system design is presented as one aspect of building design (an aspect parallel in position with other aspects such as, structural, electrical and plumbing design), whose phases include such considerations as materials, detailing, specifications, technology and appropriateness to the design. This model is in contrast to the one often applied in architectural education, as well as in the profession which places roof design and detailing in the lowest of priorities.

The paper will include examples and illustrations of single-ply membrane roof systems which have succeeded in responding to the requirements set forth in the design model. Specific detailing and examples of successful roof designs utilizing single-ply membrane roofing systems will be discussed.

KEYWORDS

Aspect, building design, commitment, phase, single-ply membrane, variant unit.

INTRODUCTION

During the late seventies and throughout the eighties, single-ply membranes (SPM); modified bitumen, ethylene propylene diene monomer (EPDM), polyvinyl chloride (PVC), chlorinated polyethylene (CPE), chlorosulfonated Polyethylene (CSPE) and Polyisobutylene (PIB), proliferated the market, not only in the number of suppliers, but also with sophisticated marketing plans.

Architects, as a whole, always desire to be the first to implement "new and improved" materials. Viewing a panacea for all their roofing problems as well as a means of further reducing costs, many architects readily accepted the single-ply membranes without reservation or investigation. Years of both empirical and cognitive knowledge were seemingly abandoned. Specifications were written incorporating the new single-ply membranes. The drawings were often accompanied by standard built-up roof (BUR) details, an occurrence that can still be found today. With errors such as this, failures were imminent.

Of all lawsuits brought against architects, the percentage of those pertaining to roofing problems are greater than all other lawsuit concerns combined. It is inconceivable that architects take so little interest in a portion of the building that, in most cases, covers a third of the exterior, contains so much liability and is involved in so many lawsuits. Yet, this attitude prevails. Errors do occur, but the firm that is knowledgeable of roofing requirements and has taken the time to adequately detail the project with reasonable care is less likely to end up in court than a firm with little knowledge.

Quality single-ply membrane roofing systems can be attained, but the road to achieving success begins in the architect's office. A commitment to achieving a quality roofing system must be made by the architect at the inception of the project. This commitment involves dedication to appropriate detailing to achieve quality. Achieving success is not a matter of luck, but rather a systematic process. Eliminating just one step in the process decreases the likelihood for success. Following is a model for achieving this success.

ROOFING SYSTEM DESIGN AS AN ASPECT OF BUILDING DESIGN

Fundamental to the discussion of any design methodology involving building design is the establishment of an appropriate relationship between building design and roof system design. (Figures 1 and 2 illustrate a model of such a relationship.)

In this model, building design is viewed structurally as a number of aspects or elements, each consisting of a series of phases, a number of arbitrarily selected variant units along each phase, and a grammar which allows for communication. Building designs vary, dependent upon which phases are expressed and which contrasting variant units are emphasized. It follows that appropriate and meaningful roofing system design for a structure, whether performed by one individual within or outside the building design team, must be based upon those phases and units which are recognized to be significant to the building design team.

The model of building design illustrated in Figure 1 examines roof system design as one aspect of building design framework. The phases indicated (investigation, development, design, coordination, etc.) should be noted categories of consideration which exist in all roof system design. It is important to note that each phase is recognized as an equal. A break in the emphasis paid to any one phase will perpetuate itself as the flow from one phase to another is achieved and will manifest itself in the end product.

A number of variant units modify each phase. The significant characteristics of roof system design of a specified building are determined by which units exist, which are

dominant, and how they are ordered and expressed. These units may or may not exist within all roof design. To many architects, the aesthetic concern of a roof is the dominating unit which leads the roof design in a different direction than if the roof is unseen, and whose only dominating unit is to conserve energy and prevent moisture penetration. Regardless, they are nonnegotiable and programmatic to the architect/consultant for they reflect the shared value of what appropriate roof design requires.

Design provides the rules of grammar with which the architect orders phases and contrasting units. By searching for physical solutions based upon the dimensions and units perceived as fundamental by the project design team, the architect may express in build form, a roof system design which embraces the most demanding of variant units and attains quality workmanship and performance.

DESIGN PROCESS

Investigation Phase

Variant Units: Building use, structural systems, climate, codes energy.

The investigation phase begins during the schematic design phase of the building design. The building use, codes and climatic factors that will affect the roofing system can be immediately determined. The owner's request for energy concerns can be addressed as well as proposed structural systems. Investigating these concerns will eliminate from consideration one membrane system over another, as well as the method of securing; ballasted, mechanically fastened, fully adhered, or protected membrane. A site analysis should be performed as building location is an important consideration. Is the building located in the far reaches of Alaska or in the southern part of Arizona? What are the wind considerations? Is it located on a rural avenue or an urban corridor? What is the atmosphere like in the general area? Will the single-ply membrane be affected by air pollution such as oily soot which will cause EPDMs to swell, extract plasticizers and result in localized problems? Manufacturing effluence that may be emitted on to the membrane due to the malfunctioning of HVAC equipment, such as the release of grease from kitchen exhausts or volatile chemicals at pharmaceutical processing plants should be taken into consideration. Failure to do so may result in the deterioration of the membrane with no recourse but go back to the designer of the roof system.

A review of the code requirements and the owner's insurance requirements will also plate demands on the system to be specified. Does the owner require a high R-value, in which large amounts of insulation will be required? What type of structural system are they proposing? Is it an open web steel joist with metal deck, or is it a folded plate concrete? Does the owner's insurance require a Factory Mutual (FM) rating? All of these units should be investigated thoroughly prior to progressing to the development phase.

Development Phase

Variant Units: Roof systems, aesthetics, maintenance, future reroofing and roof use.

Following the investigation of the variant units under the investigation dimension, the natural progression is to move into the development dimension. At this time, it should be determined what the project design manager's aesthetic concerns are for the building. Will the roof system be seen from above? Will it perform as a plaza? Are colored rock pavers required? Are colored membranes required? Are designs to be created out of membranes?

At this point the architect should determine whether or not they are knowledgeable enough about roofing to proceed along the aspect and make sound decisions. If not, it is at this phase juncture that a roof consultant or roofing contractor should be consulted. Their assistance and input may be vital to the success of the project.

Roof use concerns should be determined. Will the roof have to perform as a working surface during or following construction? Are roof davits going to be required for window washing systems? Is access to mechanical penthouses required?

Will the roof be serviced by a qualified building maintenance staff, such as a large corporation may have, or will the owner have a maintenance agreement with a roofing contractor, or will it receive low maintenance; such as educational facilities where the roof drains may rarely be cleaned? Consideration of the owner's long-term building use and occupancy plans should be considered and life cycle cost analysis performed. Intended long-term or short-term use will undoubtedly have bearing on your design considerations.

Future reroofing concerns should be addressed. Copings, metal edge flashings and snap on gravel stops should be removable, not only for future reroofing but also for maintenance. Counterflashing should either be surface mounted or need to incorporate receivers that are installed in reglets during construction. All roof systems have a service life limitation and will at sometime need to be reroofed. Thoughtful planning now may save the owner additional costs in the future.

The final variant unit of the development phase is the review of potential roof systems including life cycle costing for each of the systems. For each roof design proposed, selection of the appropriate roofing system is imperative. If the location, configuration, use, codes and energy requirements as well as structural systems dictate that a SPM not be used, do not force the system or it will fail.

Design Phase

Variant Units: Select membrane and roof system components. Slope, drainage, building elements and details.

The first decision to be made in the design process is the selection of the membrane and the appropriate roofing system. This will be based on the investigation and development dimension research. Regardless of the system and membrane selected, it is imperative that the roof should incorporate a sloped roof system to create positive drainage which will remove water from the roof area within 48 hours of rainfall. This simple requirement must not be ignored. It can be achieved through sloped structural systems or tapered insulation. All of the following components of the building system must be taken into consideration: Parapet walls, chimneys, HVAC units, masonry walls, penthouses, cooling towers, ductwork, drain pipes, etc.

Today's roofing system should be all encompassing, taking into consideration the possible failure of a number of units that impinge upon the roofing system, such as HVAC curbs, masonry walls, roof penthouses, to name just a few. Once all the building elements are identified, the task of identifying the required details begins. Do not rely on

manufacturer's "typical conditions" or expect details to be "worked out in the field" as they will not, and therefore will not be satisfactory. Trouble will be exaggerated when a roofing contractor is selected for the project who doesn't know much about roofing and is allowed to design as he builds. A well thought out design solution incorporating details (designed by a knowledgeable person) will not only reflect favorably upon the firm who provides such details, but also indicates exactly what can be expected of the roofing contractor who installs them. It is beneficial for the designer to conceptually walk along the roof and visualize intersections and problem areas as they might occur, and then to detail them accordingly. Isometric drawings are especially useful for visualizing extremely complicated areas. Stepped isometrics indicating the progression of the installation of the roofing system are also extremely helpful (see Figure 3). A good architect will recognize that roofing details are just as important as the physical massing of a building. Architects and consultants, experienced in the design of roofing systems, incorporate the time that will be necessary to produce completed construction documents into their fees. If these fees are not appropriated up front, the architect or consultant may be indirectly responsible for them by virtue of potential defense expenses.

Coordination Phase

Variant Units: HVAC, plumbing, electrical, aesthetic, structural.

As the design dimension progresses, it is imperative that the roof designer coordinate efforts with the HVAC, plumbing, electrical and structural engineers, How often have you seen an HVAC curb for a SPM delivered to the site with a cant? Or roof drains without extension rings? Or electrical conduit zigzagging across the roof? Structural systems must be able to adequately support a ballasted system.

The roof designer should coordinate efforts with the specific people responsible for these units. At this point, exchange of information will reduce the number of problems in the field later. In addition, the installation and quality of the roofing system will be improved. Communicating your requirements for HVAC curbs, plumbing and roof penetrations to the varying consultants or in-house personnel will allow them to be specific in their selection, and the installation of the roofing system will be better for it. A roofing contractor does not check the HVAC or plumbing drawing to verify the type of curb or roof drain being installed, nor does the HVAC or plumbing contractor check the roofing drawings to see that a curb does not have a cant or a roof drain requires an extension ring (see Figures 4 and 5).

Construction Document Phase

Variant Units: Communication, completeness, redundancy, specifications, details, details.

The goal of the construction document phase is to communicate to the roofing contractor the items necessary to properly bid and construct the project. No detail should be left for the contractor to guess at or to design during the bidding and construction phases. This is not to prohibit the architect from contacting roofing contractors to review specific conditions, procedures, etc. Many contractors have a wealth of empirical experience that can be very beneficial to appropriate detailing. Details should be drawn to the largest scale possible in order to indicate as much detail as possible. Each detail should be thoroughly noted so there is no question as to the requirements (see Figure 6). Following the completion of the general roofing details, specific details should then follow. Elevations of terminations, (see Figure 7) counterflashings, gravel stops as they abut adjacent structures, as well as isometrics of complex areas, should be drawn. This should be a refinement of the details previously sketched in the design dimension. The underlying thesis here should be "whatever it takes to properly convey the design intent." Each detail should clearly identify a specific concern. What may appear to be over detailing may, in the long run save hundreds or even thousands of dollars in maintenance, repair and/or legal costs (see Figures 8 and 9).

The growing use of computer assisted drafting (CAD) has potential in roof detailing as it reduces repetitive drawing, allows clean reproductions of repetitive details and allows for modifications. At the same time as the construction documents are being completed, the roof designer should be cognizant of what is being designed and incorporated into the details, and must maintain a project log for specification writing. Types of specific screw fasteners, nails, expansion joint materials, foam rods and flashing materials should all be recorded so that their specifications may be coordinated with the drawings. Nothing proves to be more frustrating to a contractor than conflicts within the construction documents.

Review and Coordination Phase

Variant Units: Review solutions, modification, specifications.

During this dimension the completed construction documents should be reviewed for thoroughness. Are the details properly tagged? Are all notes complete? Is the plan readable? Are the details cross referenced to other details throughout the construction drawings (where they are appropriate)? The appropriate modifications at this time should be noted and corrected. The specifications should also be reviewed and coordinated with the construction drawings. Following the review and coordination dimension, drawings may be released for bidding purposes.

Bidding Phase

Variant Units: Answering questions, prebid conference, addenda, review bids, quality contractors.

More often than not, when a roofing contractor calls an architect to inquire as to his intent on a set of drawings, the architect is unavailable. Contractors must then make their own decisions—right or wrong. The architect needs to be available to respond to these questions, inform contractors and issue clarifying addendum. A prebid meeting is extremely helpful in communicating the design and quality intentions to the contractors (who propose to submit a bid). During this conference, review of the contract documents and any restrictions that may effect the way contractors bid the project are examined. Remember that these contractors deal with 10, 15, or maybe 20 different architects during one year, all with differing requirements. At this time, review the details and bring to the contractors attention any special requirements. Review the plan. Inform the contractors of your intentions. Following these discussions, minutes should be prepared and distributed. Should there be any changes or modifications to the contract documents, issue addenda as expeditiously as possible to allow change in intention known to all contractors preparing a bid.

The bids should be reviewed following their receipt. Are they appropriate? If one contractor's bid is considerably lower than the others is it possible that something was missed? Review the proposals carefully. Call references. Find out as much as possible about the successful bidder. The selection of a quality roofing contractor can, many times, mean the success or failure of a project. Remember, a great deal of time has been invested in providing an excellent set of contract documents. Now find a quality contractor who will furnish the workmanship that you demand. The bidding process is a means of providing an open forum for qualified contractors to prepare bids for the proposed work. This process is a competition and usually results in competitively prepared costs, a practice that assures the owner the cost of the work to be performed is appropriate. At times an owner, who has successfully worked with or been referred to a reputable roofing contractor, may opt to negotiate a contract directly with a roofing contractor. When doing so without the assistance of an architect or roofing consultant, the owner must be fully cognizant of exactly what is desired and spell it out in detail in the contract. It is highly recommended that a knowledgeable architect or roofing consultant be retained to design the new roof system and not leave the design of the roof up to the roofing contractor.

Contract Administration Phase

Variant Units: Preconstruction conference, submittals, inspection, knowledge, field decision, field reports.

Prior to the commencement of any roofing construction, a preroofing conference on new roofing and/or reroofing applications should be held. It is imperative to have the roofing contractor's foreman (who will be running the job) attend this meeting. This individual is the one who will be installing the roof system—not the owner of the company or the superintendent. Therefore, he needs to be aware of your intentions. Also, representatives from HVAC, plumbing, electrical, masonry (any trade that will impinge on the roofing system) should attend this meeting. This meeting will initiate the coordination process for the installation of the roofing system. Masonry walls should be acid washed prior to the application of the SPM roofing system below. HVAC units must be appropriately located and fastened to the deck. Plumbing vents must be stubbed through and roof drains properly located. Determine who is responsible to keep the deck clean. These decisions should be made prior to the arrival of roofing crew members on the job site. The presence of an inspector on the job site is necessary to ensure that the agreements made during the preroofing conference meeting are carried out, and that the contractor is performing the work as specified. This inspector needs to be knowledgeable in the application of the roofing system being installed. Prior to the installation of roofing components, submittals should be appropriately submitted, reviewed and approved. This is the last opportunity to make sure that specified materials are strictly adhered to and that there is attention to detail. Require shop drawings that have been prepared by the roofing contractor to be submitted for review. Manufacturer's standard details, in many cases, are not appropriate to the specific conditions detailed. The installation of a roofing system is a "hands-on" job. In many cases the building does not get constructed exactly as drawn. Field decisions will be required. When possible these decisions should be made expeditiously and then documented, (even if in a brief, handwritten speed memo) confirming the decision made in the field. Remember: If a problem arises in the future, a written documentation is much more valuable than a memory of a verbal direction.

An architect should vigorously inspect the roofing system being installed, not only to insure the project is progressing as specified and that the roof is being installed accordingly, but also to answer field questions. I have been informed on many occasions that there is nothing more agonizing than an architect who doesn't show up on the job until the roof is complete and then begins listing numerous items that are not acceptable. Following each days inspections, the field inspector should prepare a field report indicating the activities taking place, concerns and other observations.

Project Closeout Phase

Variant Units: Final inspection, inspection list, warranties, warranty file.

Upon notification from the contractor that final completion has been attained, a final inspection should be made of the roofing system to verify compliance with the contract documents. At this time a list should be prepared indicting all of the items which are incomplete, and/or unacceptable. Be specific as to the nature of the problem and what solution you expect. Assist the contractor in defining what is required to meet your requirements. If a lap seam needs additional lap sealant, be sure to indicate where it is on the roof. Refer to this as an inspection list rather than a punch list. A punch list has a negative connotation to it. However, an inspection list is a method of assisting the contractor in attaining final completion. Prior to closing out the project, verification should be made that all warranties have been submitted and that they are appropriate to the project. Also, an in-house, post roofing file should be created for the project, incorporating reduced photocopies of the roof system design, and copies of warranties and letters pertaining specifically to the roofing system. A copy of the file in the form of a warranty manual should be prepared for the owner. Should problems arise in the future, this method of documentation will prove invaluable.

Post Roofing Construction Phase

Variant Units: Warranty repair, confirmation letters, communication.

Following the final completion of the project a meeting should be held with the owner and the personnel responsible for maintenance. At this meeting the warranty manual referenced in the project closeout phase should be reviewed, and the owner advised of maintenance requirements and the need for periodic inspection of the new roof system.

Should the roof require warranty repairs following the installation of a roofing system, the roofing contractor is generally required to make these repairs for a period of two years. After that time, the manufacturer is required to be notified of the problem in writing by the owner. The requirements of the warranty are that notification in writing must be made by the owner. The letter may be prepared for the owner, but it is the owner who must notify the manufacturer. Lines of communication with the owner must remain open. Just as the contractor is expected to respond to the architect's needs during construction, the architect needs to be responsive to the owner after project completion. The owner will

remember that the roof leak was repaired expeditiously more than the roof leak itself.

CONCLUSION

Good roofs do not occur on their own. Attaining a quality roofing system is hard work, as well it should be since it is a major component of the building. The majority of other major components of the building are fabricated under factory conditions. A roof system is manufactured on the roof, often under adverse climatic conditions, and severe time constraints. The attainment of a quality roofing system should be viewed as a series of details. Each detail is interrelated and extremely important. The model proposed utilizing the phase and variant units can be related to this thought: Phase is the plan, and the units are the details. If any one plan or detail fails the entire framework will crumble. In the past, as well as the present, many architects circumvent the process of this dimensional framework. Those who continue to do so will find themselves involved in possible legal issues. It has been said that nothing supplants quality workmanship. This is true, however, it must begin in the architect's office during the conception of the project. Only determination and perseverance throughout will eliminate the possibilities for failure and increase the chances for success.

ACKNOWLEDGMENT

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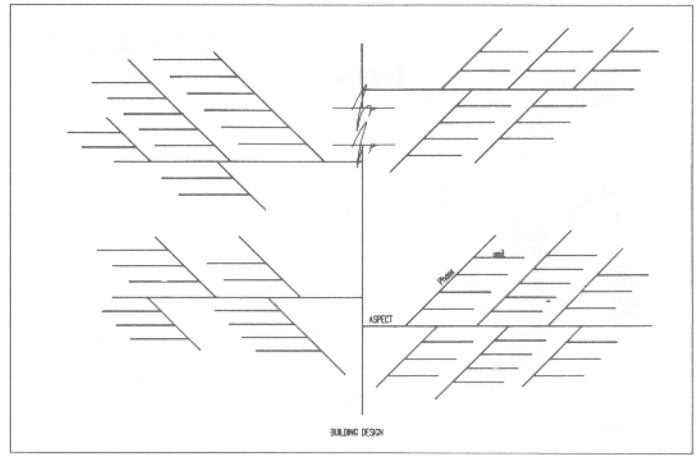

Figure 1 *Aspects, phases and units on the model.*

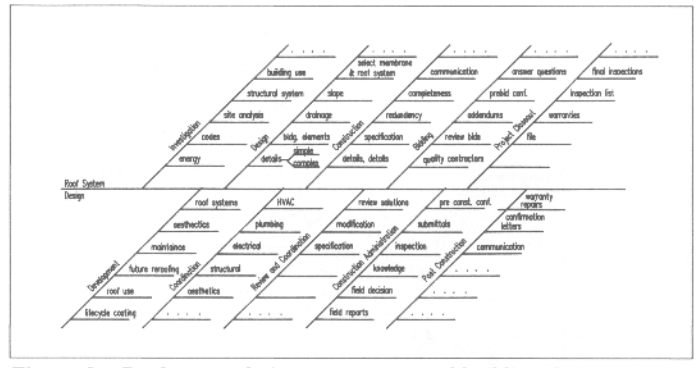

Figure 2 *Roof system design as an aspect of building design.*

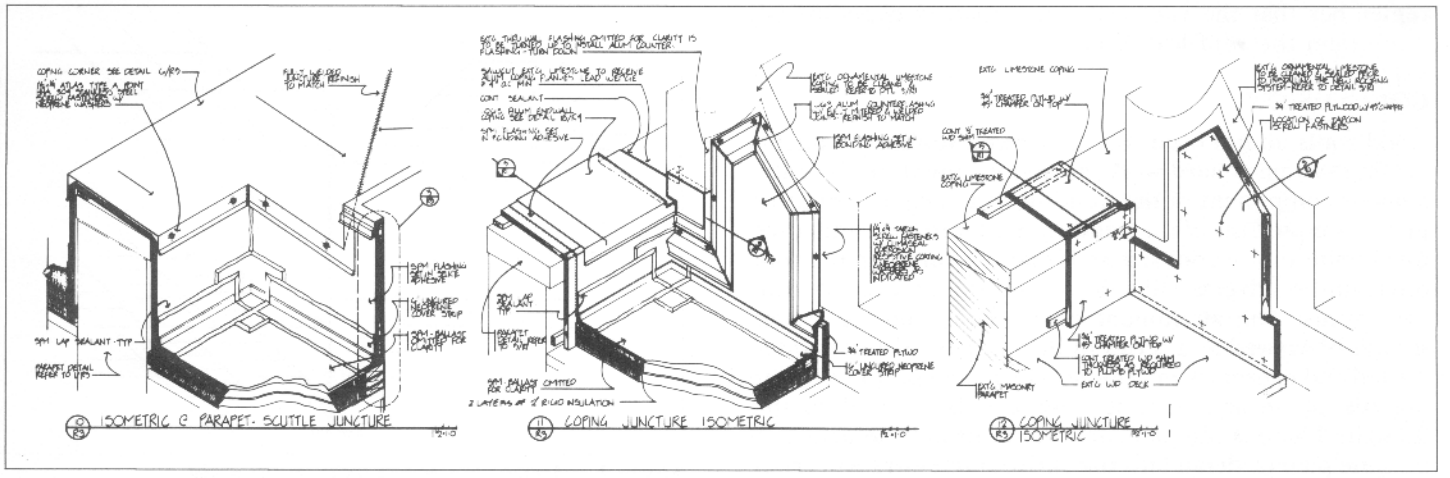

Figure 3 *Stepped isometrics indicating the progression of installation of the roofing system is extremely helpful in communicating the architect's intentions.*

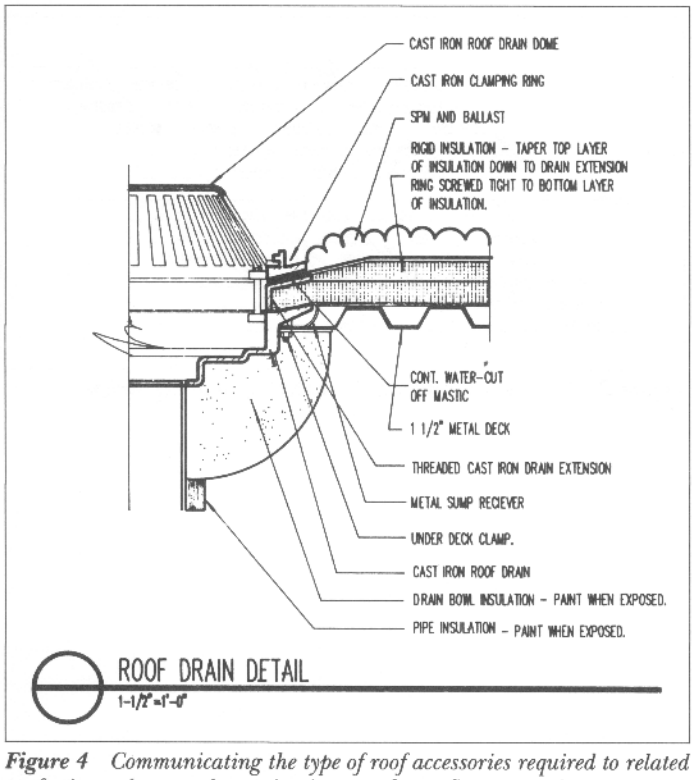

Figure 4 *Communicating the type of roof accessories required to related professions whose work may impinge on the roofing system is necessary to achieve cohesiveness and success.*

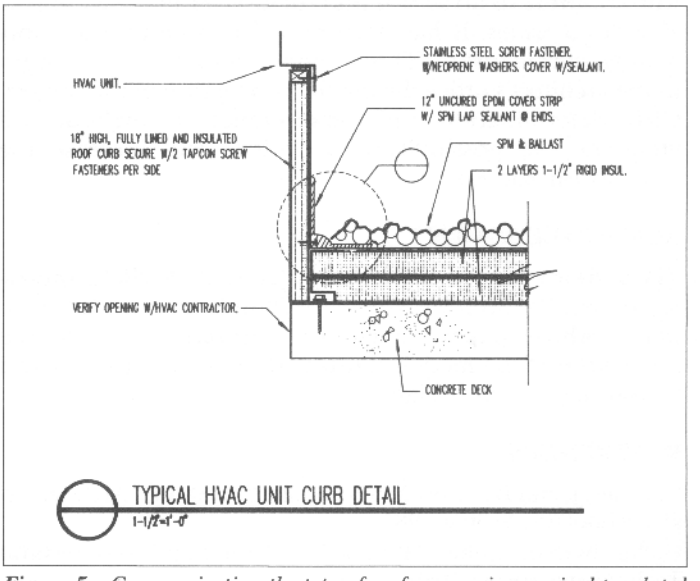

Figure 5 *Communicating the type of roof accessories required to related professions whose work may impinge on the roofing system is necessary to achieve cohesiveness and success.*

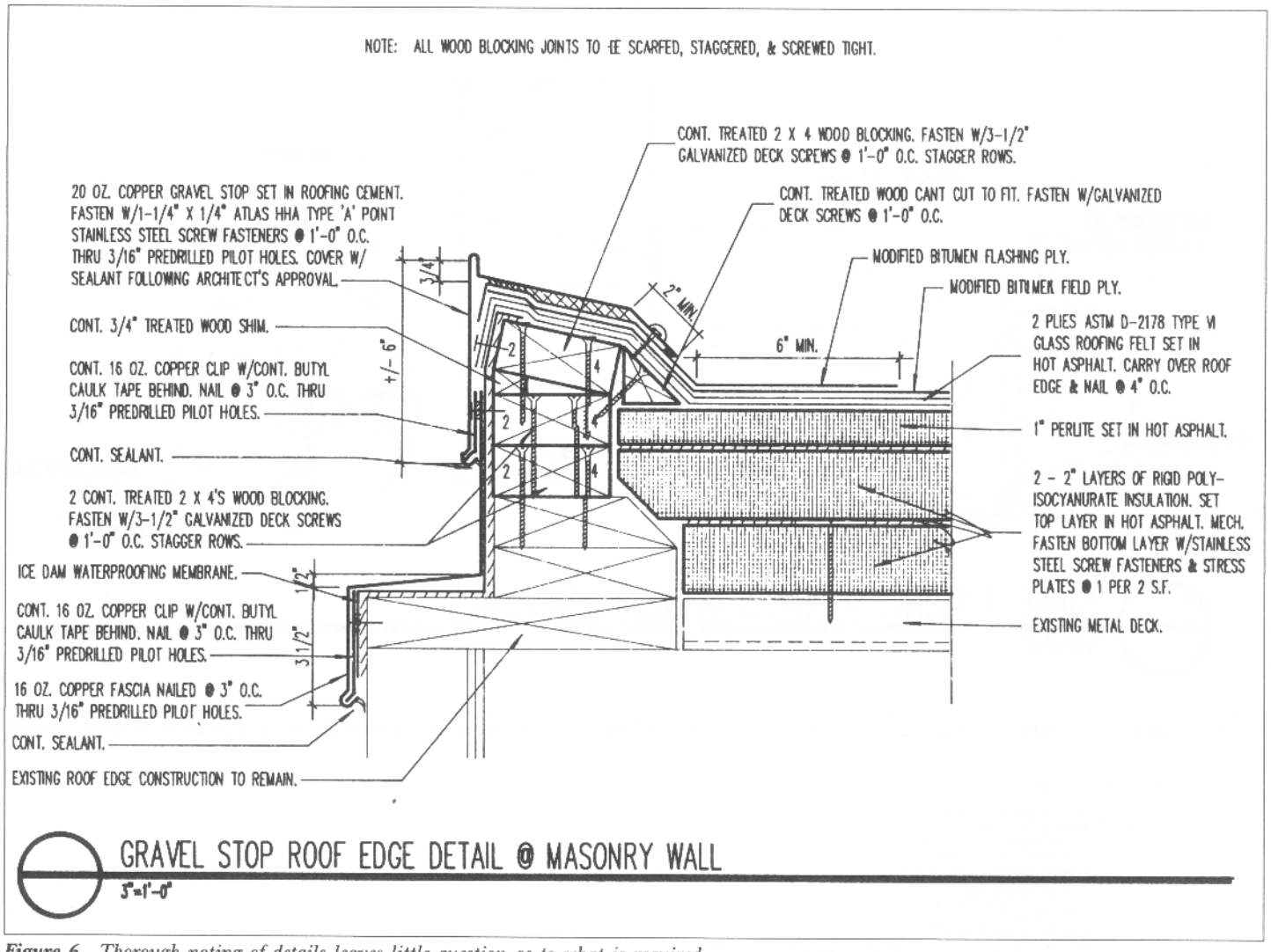

Figure 6 *Thorough noting of details leaves little question as to what is required.*

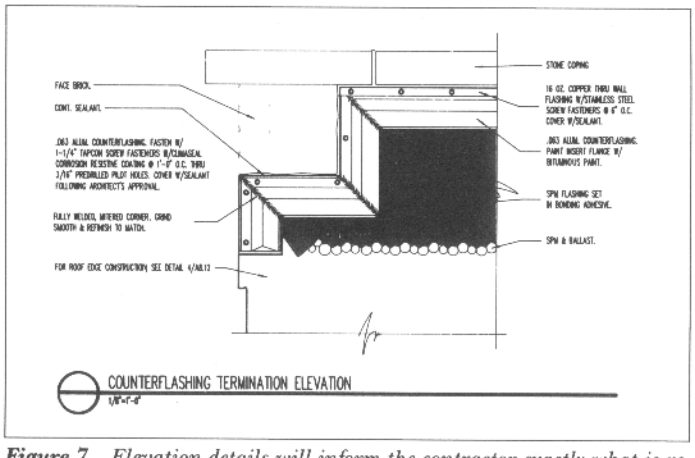

Figure 7 *Elevation details will inform the contractor exactly what is required.*

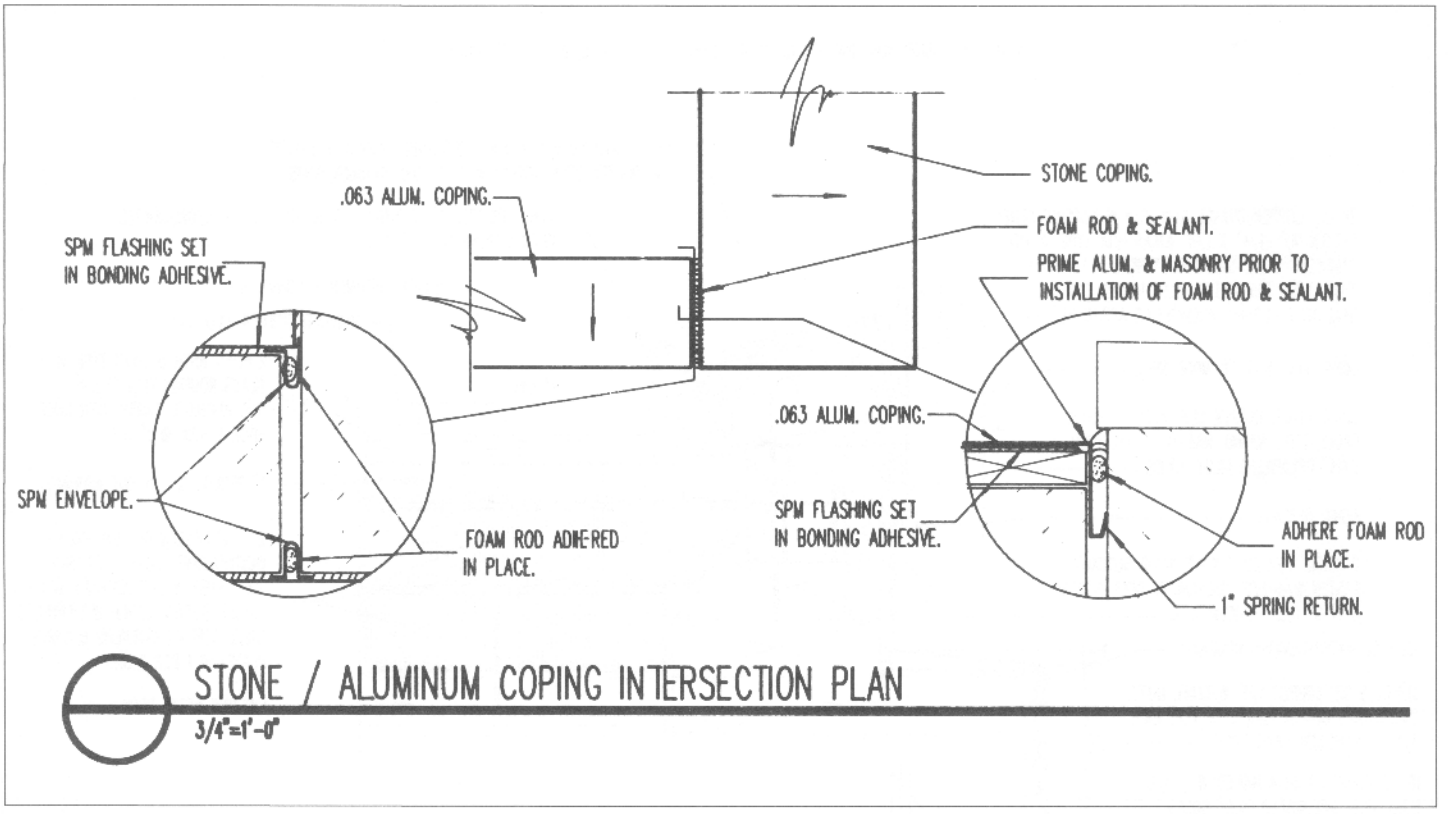

Figure 8 *All detail conditions encompassing the roof should be addressed and whatever detail information required to communicate same should be presented.*

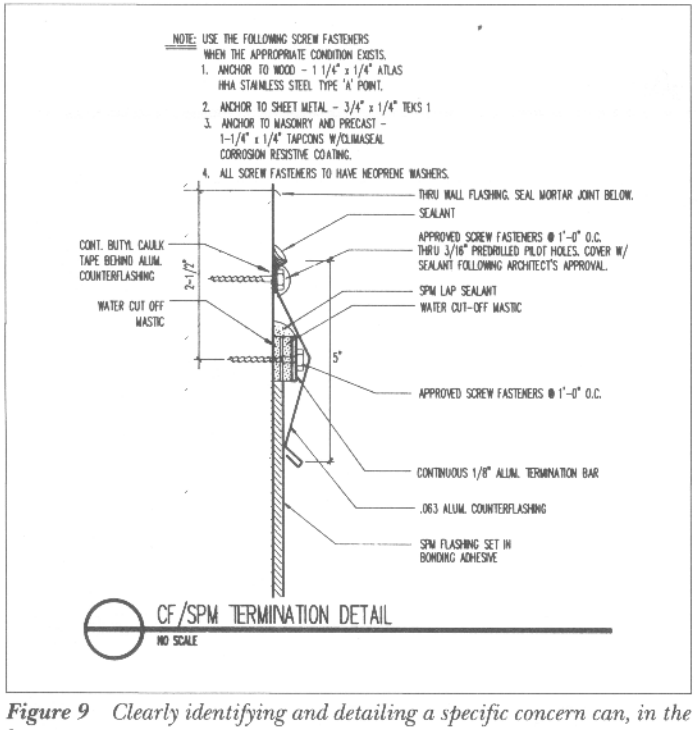

Figure 9 *Clearly identifying and detailing a specific concern can, in the long run, save on maintenance, repair and legal costs.*