# OPPORTUNITIES AND CONSTRAINTS FOR THE INNOVATIVE GEOTECHNICAL CONTRACTOR

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## ABSTRACT

The American specialty geotechnical construction community has historically been followers rather than leaders. This is due to the nature of past construction demands, and to current litigious and confrontational operating conditions. Today the demand for innovation and sophistication is great, and likely to grow, but the industry is facing major problems associated with low profitability. This paper reviews generic options for survival and growth for innovative contractors. From an internal viewpoint, companies can benefit from the principles of Total Quality Management, improved response to customers, and appropriately structured innovation. From an overall industry viewpoint, all will benefit from alternative bidding practices and dispute resolution, and the new process of Partnering. The principles of each of these options are summarized and illustrated with reference to recent projects.

## 1. INTRODUCTION

When considering innovative processes in specialty geotechnical contracting, one observation is common, namely the virtual absence of U.S. origins (Nicholson, 1986; Bruce, 1988, 1992a, 1992b). One notable exception is in the field of ground treatment, where compaction grouting, referred to by Baker et al. (1982) as a

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"uniquely American process", is now being exported following its development in the early 1950's (Warner, 1982, 1992).

In contrast, most of our techniques, from ground anchors to pinpiles, and from diaphragm walls to soil mixing and jet grouting have been introduced from Europe and Japan. Once these techniques were introduced, however, - largely through the perseverance of sponsoring contractors - they acquired their own distinctly American flavor; maturing in response to demands on scale, speed and economics (e.g., Bruce and Nicholson, 1988). The fact remains, nevertheless, that the U.S. is not renowned internationally as an innovative geotechnical community, despite the adaptability, effort, and resources which are available here.

The reasons for this are complex and deep-rooted, but broadly may be delineated as follows:

- Lack of Necessity. Traditionally we have not had to conceive novel and highly sophisticated technologies to accomplish our major national building tasks, such as the construction of the interstate highways or the railways, or our network of river controls. The country is large, and the population density is about 100 times lower than in industrialized Europe or the Far East. We have often had the luxury of selecting from a number of suitable sites, and this has encouraged the solution of simply avoiding difficult conditions. Now, however, the emphasis has changed within our business to urban and industrial redevelopment, infrastructure upgrading and improvement, and enhanced transportation facilities. One consequence is that we have a growing market for techniques developed abroad during reconstruction after major wars, or in response to rapidly growing population centers. Geotechnical problems must be solved where they occur: relocation is usually not an option.

- Contractural and Legal Processes. Most projects are still awarded to contractors who submit the lowest cost estimate for the work they believe they have to carry out, but which may not be the same work foreseen by the owner. Calculation of a low bid carries no guarantee on the ability to perform satisfactory quality work and yet this "low bidder" paradigm of the consumer society persists. The disillusionment and confrontation arising from this approach have been reflected in a substantial growth of construction disputes. The Arbitration Times (Winter 1990/91)

reports that claims in construction cases increased by 16% from 1988 to 1989 while mediation cases rose 38% in the same period. Total cases submitted to mediation increased fourfold from 1987 to 1989.

According to Business Week (April 13, 1992), the U.S. has 307 lawyers per 100,000 population - three times more than in Britain, and 25 times the Japanese figure. The 1971 census of over 355,000 lawyers compares to over 750,000 in 1990 and a projected 1 million in the year 2000. Our typical contracting methods foster adversarial attitudes, and the reliance on lawyers to resolve these issues deters all but the most hardy and committed contractors. Quite simply, this litigious atmosphere is not compatible with the spirit of innovation, for the real risks far outweigh the potential rewards.

There is a growing need in this country for specialists with the skills necessary to solve a wide range of geotechnical problems. Judging from the scale and complexities of environmental remediation, these skills are equally valuable in that sector also. And yet, set against this demand, is the plain fact that the contracting industry is in disarray: some companies have gone out of business, many are having runs of "bad years", and most are not as profitable as they feel they should be.

The authors believe, nevertheless, that there are several options open to the innovative contractor who wishes to survive and grow. Some of these options have an internal focus, while others require bilateral cooperation. The former group include Total Quality Management (TQM) and continuing innovation. The latter group includes alternative bidding practices, Partnering, and dispute resolution.

The authors also believe that while most of our profession have heard many of these terms, few really appreciate the basic principles and the impact they can have on our industry. It is the purpose of this paper to provide an introduction to each of these concepts in turn, and to illustrate their applicability with respect to the authors' recent experiences. No credit is claimed for the development of the concepts themselves, as evidenced by the references and acknowledgements. However, the authors trust the reader will appreciate the originality of addressing this vital issue within a progressive, quality conscious and cooperative framework, as opposed to the confrontational tone common in essays such as "The Contractor's Viewpoint" or "The Consultant's Viewpoint".

## 2. TOTAL QUALITY MANAGEMENT (TQM)

According to proponents of TQM, a "revolution is brewing in American business - one as important to our times as the automobile and the steam engine were to theirs. This revolution is called Quality, and it is reshaping the way we think about everything we do." (Dobyns and Crawford-Mason, 1991). Cynics would say it is simply the current fad, and would in fact suggest that it is already obsolescent. They would argue that it is simply another transient phase in a tenuous path including assurance and control (quality cannot be inspected into a product) and quality circles (collapsed due to the lack of commitment from top management).

However, there are two key issues which cannot be denied. Firstly, there is no doubt that there is a growing awareness of, and real need for, quality in our industry. The quality of the end product reflects the quality of the processes which interact to produce it: the key to each process is people - their attitudes, their commitment, their training, and their management. Secondly, as demonstrated repeatedly by the gurus of the movement - W. Edwards Deming, Philip B. Crosby, Armand V. Feigenbaum, and Joseph M. Juran - and by the success of our "enlightened" companies such as Motorola and Xerox, as well as most of Japanese industry, there is equally no doubt that attention to quality reduces costs by increasing productivity through minimizing rework.

In our industry, this means doing things correctly the first time, at every stage in each process. Designs must be technically correct but practically constructable; bid documents and specifications must be complete, and clear in defining what is expected of the bidder; the bidder must be equally clear in his response and have no "hidden agendas" or conditions on rock bottom prices left trailing as hooks for future claims; the contractor and the site supervision must build what is required where it is required and when it is required; the owner must pay, on time, the amounts actually due, not those manipulatively recalculated to enhance his cash flow. Within each of these groups of parties, quality processes have to be encouraged, and full cooperation and understanding between design, estimating, engineering, construction and administration departments are essential.

Several educational facilities and institutes actively offer training in the concepts and details of TQM. One such short course is offered by Fails Management Institute (FMI), which defines TQM as " a systematic process for continuous improvement throughout the organization."

These words have been precisely chosen, and those underlined (by the authors) each have special significance. FMI summarizes that there are six basics on which the TQM process is built:

1. Every job activity is a process that includes inputs and outputs, suppliers and customers. A corollary is that everyone in the organization should regard himself/herself as everyone else's client and customer. Also inherent is the fact that we have internal and external clients and customers, and that the quality of response we each should give external contacts should be mirrored in our dealings within our own organization.

2. Quality is compliance with the customer's requirements. The requirements are error-free work. In certain ways, compliance is a minimum standard, but it must always be realized that quality is not synonymous with perfection.

3. The method for achieving error-free work is prevention. This reverts to the earlier discussion, and can be studied in four steps:

   - examine the job activity as presently conducted
   - determine the variance from an error-free performance
   - establish a new prevention process
   - measure (and display) the results of the job activity.

4. The cost of quality is measurable, and equals the cost of errors plus the cost of prevention. The cost of errors includes delays, lost customers, accidents, rework, idle time, and litigation. The cost of prevention is in training, planning, supervision and testing. Figure 1 is an excellent representation of the financial impact of reducing the cost of errors: the data are in fact in line with those truly recorded in the construction industry. Basically, the reduction in the cost of errors translates almost wholly to the bottom line since the saving is proportionally much larger than the additional expenditure needed to improve quality.

5. Quality, productivity, and safety are inseparable. A safe act may not be a quality act because it may not be a productive act. A productive act may not be a quality act because it may not be a safe act. However, a quality act will include safety and productivity.

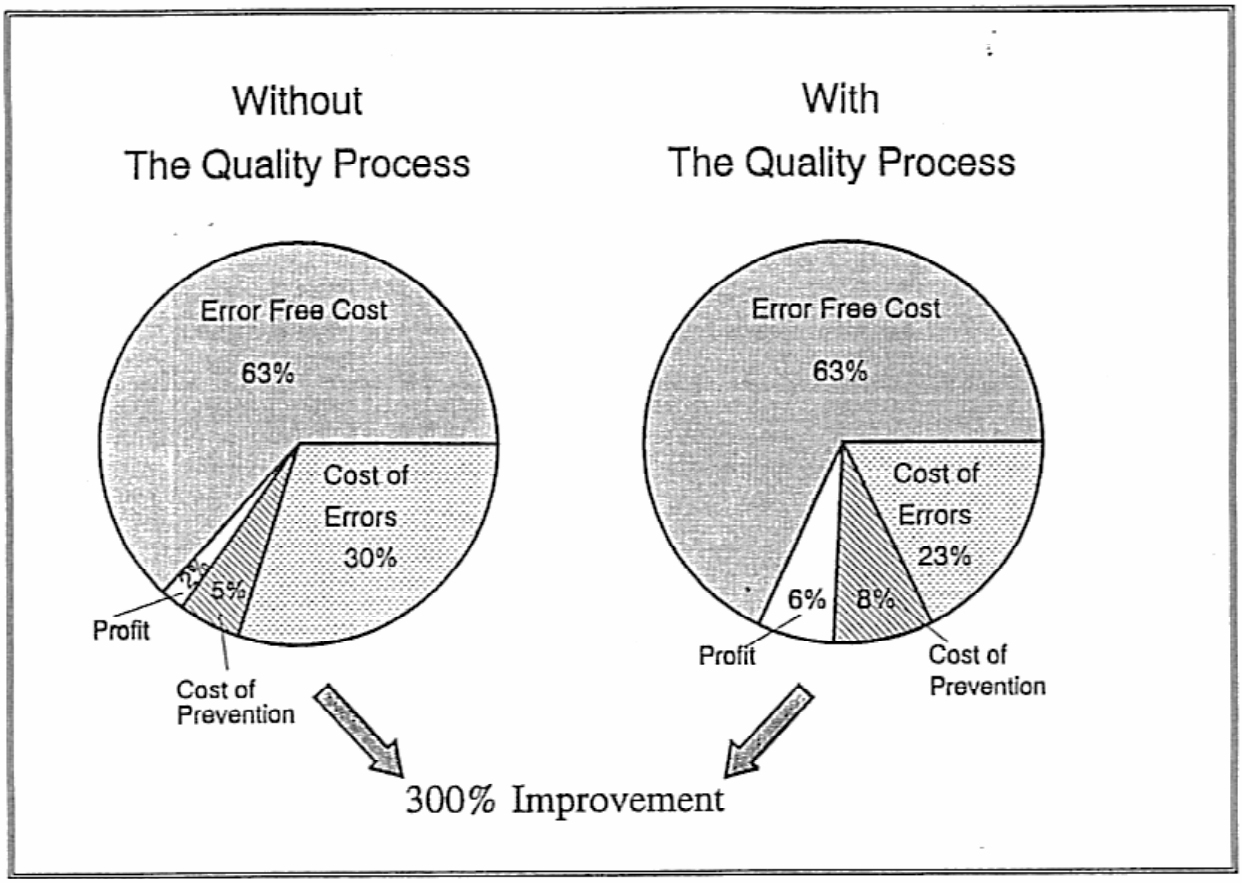


Figure 1. Illustrating how a quality plan acts to reduce the "Cost of Errors" and so increases profitability (courtesy of Fails Management Institute)

6. The keys to quality are commitment and teamwork - again the human factor. Dobyns and Crawford-Mason (1991) are especially interesting in this regard, and conclude "how well you educate, train and treat people in your society becomes more important than the coal you dig, trees you fell or rivers you dam." Equally, the MIT Commission on Industrial Productivity says, "There seems to be a systematic undervaluation in the United States of how much difference it can make when people are well educated and their skills are continuously developed and challenged."

Each one of these six basics has a clear and vital message to us in industry, and especially to those of us caught in the rythymns of entrepreneurial geotechnology. So fundamental are these basics that the term TQM is arguably not truly reflective of the subjects it covers. Perhaps ACS (Applied Common Sense) would be more apposite.

Some of these basics are for individual parties to address, and education and productivity are prime examples. However, most involve the active cooperation and interplay of all the contracted parties. These particular areas of common effort are discussed in the following sections, from which it becomes clear that one of the most important opportunities for survival we have is, simply, our mutual common sense and responsibility.

A final point relating to the principles of TQM is the issue of serving customers most efficiently. Companies must establish who their customers really are and what exactly they wish to buy. The key to this process is clearly information on the industry - often more important than the components of the industry themselves. For example, Dun and Bradstreet sold the Official Airlines guide for three times what TWA paid for Ozark Airlines and what Trump paid for the Eastern Shuttle.

Such information in our industry is often most easily gleaned or shared at the conferences, committees or publications of learned and professional societies. The innovative contractor will therefore find active participation in these societies rewarding from many viewpoints.

## 3. INNOVATION: CONSTRAINTS, BENEFITS AND REWARDS

For innovation to flourish, there must be a need and a reward for those who take the risk of funding and implementing the technology. One of the biggest constraints on this is our most commonly used delivery system for a construction project, the Design-Bid-Build System. The steps are well defined:

- Design: The owner, or a consultant selected by the owner, designs the project.

- Bid: A suitable bidding period is established, usually 4-6 weeks, and any contractor who can secure suitable bonding bids the work.

- Build: The low bidder is then selected and the project is built in accordance with the plans and specifications of the owner and consultant.

Along the way there may be some opportunities to innovate - the engineer or constructor can propose value engineering - but these opportunities are limited.

This present low-bidder system, used for the overwhelming majority of public works construction in the United States

has led to other problems in the industry, in addition to the lack of innovation. Disputes, formal arbitration and lawsuits are becoming an everyday occurrence for many contractors. Low profit margins, given the inherent risks of construction, have led to the failure of many companies.

Another factor is that the constructon industry is fragmented to the extent that 1.3 million firms split an annual volume of $450 billion (U.S. Census Bureau). The largest companies still have a miniscule share of the overall market. Based on the reporting of the "Top 400 Contractors", the largest five contractors control less than 10% of the overall domestic market (ENR, 1991). This fragmentation of the industry and low profitability have meant that there is rarely money for research and development. Without research, innovation relies on happenstance or the inventiveness of individuals or small teams of people ("skunk works" in the words of Peters, 1984). As the industry consolidates, it is arguable that we will see larger contractors control more of the market, as is now true in Europe and Japan.

Bonding and financial requirements for the larger public works contractors are becoming more rigorous and this has led to more companies being operated like businesses: many constructors and consultants are now run by financial managers and MBA's. There are still many managed by engineers or tradespeople turned owners, but in the larger, more successful businesses, these entrepreneurs have learned to adapt and be more business oriented. The banks and bonding companies are asking to see detailed business plans and projections of activity and profitability. Financial reporting is expected on a monthly, or at least quarterly, basis, and is assumed to be accurate and without too many surprises - always a dangerous assumption in subsurface activities! If these business functions are not performed and if the company is not consistently profitable, the chances of it remaining in business are greatly reduced.

We will therefore require sophisticated management tools, and information systems that will allow us to manage our businesses better and enable us to assess risk in a more efficient manner. The improved quality of products will be vital in reducing exposure to risks by reducing costs and increasing profitability. These factors will provide incentive for all involved to conduct the necessary research that is not possible at the present time. Once this happens, the opportunity for innovative technologies will increase proportionally, and both consultants and contractors will share in the rewards and benefits.

Consultants are in most cases selected for design by technical merit with price being only one of the determining factors. This is a legal requirement under the Brooks Act. There are times when a consultant will be selected because of original ideas on how to proceed with a project, and occasionally this will involve innovative technology. The potential risk in trying a new technology and having it go wrong would have to be weighed against the possible reward in succeeding and being able to use this success to secure new business and widen reputations. The fact that in most public projects the work will be performed by the low bidder - one who may or may not have the necessary expertise - will increase the risk of problems being encountered in the construction of the project.

There are other issues of risk versus reward for the contractor that can provide more constraints than those of the owner or the consultant. In the Design-Bid-Build system the opportunities may be limited to value engineering. As noted above, profits in the industry are low and there is, in most cases, no substantial money available for research and development. Proven technology or equipment has to be brought in from a foreign country. However, the owner often has a reluctance to specify the product or technology because of concern that there will be lack of competition in the new technique. The rewards for the contractor to spend the time and money to develop or import this equipment or technology are therefore diminished.

Despite these constraints, there are times and projects on which new technology can and is being implemented. If the need is extreme for either owner or constructor, necessity will force the issue. This introduction can be achieved either in the pre-bid stage, by making the owner or the consultant aware of the technology, or sometimes through Value Engineering. When either of these methods is successful, the reward can be very satisfactory.

Different methods of project delivery systems, mainly in the bidding or procurement stage, are beginning to appear. Many of these increase dramatically the balance of reward over risk for the owner, engineer, and constructor.

## 4. ALTERNATIVE BIDDING PRACTICES

The ASCE specialty conference at Cornell University in June, 1990, dealt with the subject of "Design and Performance of Earth Retaining Structures". One section was, significantly, devoted to Contracting Practices. Nicholson's paper compared practices in Europe with those

in the U.S., and discussed associated topics such as research and development, contract documents, liability, and the problems of vested interests. Of special interest, however, was the section dealing with the modifications and alternatives to standard bidding practices.

Nicholson (1990) noted it is common to find contract documents, including qualification clauses, which call for some limited review of a contractor's experience record by the owner or consultant. The owner's approval is (nominally) required before the specialty subcontractor may be employed by the prime. However, it is difficult to ensure that these clauses perform as intended: in a very competitive bidding atmosphere, the low bid prime contractor usually feels he has a "right" to use the subcontractor of his choice. This usually means he will choose on the basis of cost over experience, and rely on his own interpretations of the clauses to justify his selection. For example, certain "experienced" individuals can be hired temporarily, or materials or equipment suppliers can be engaged to furnish "technicians" to supervise certain more critical phases of the work. This state of affairs is another result of the low bid process, and clearly affords no incentive or encouragement to the innovative contractor.

A more attractive method has been the concept of prequalification, whereby only pre-approved contractors are permitted to bid to the prime. About one half of state highway departments currently are using or considering this method for certain types of work. Typically, though, prime contractors find themselves besieged by subcontract bids at the last minute from "new" companies claiming the suitable level of expertise. If the offer is sufficiently low, the contractor is tempted, and rarely does the owner intervene because he submerges his fine intentions in the self justification of "fair and open competition".

The good intentions of prequalification are further diminished by the fact that no national forum exists where standard guidelines are set, although, the Corps of Engineers and others are experimenting with a contractor rating program to prohibit contractors with "unsatisfactory" records from previous works from bidding other work. Each owner, however, typically has his own prequalification system, and tight bidding and award schedules rarely leave time for submitted references to be verified. A drawback of even rigidly applied prequalification is that it rules out the potential for contribution by the innovative specialist during the

project's conceptual and design phases. This is everyone's loss, as the team is that much weaker.

The "Value Engineering Proposal" is a form of alternate proposal, long established in U.S. practice. Although more progressive in concept, it has found limited use in specialty geotechnical contracting. This is not solely because cost savings must be shared, rather it is because at bid time the prime contractor is typically unable or unwilling to assess the inherent risks. These risks include the fear that change may disrupt the work; the owner may not accept the scheme; and there may be insufficient time for approval. When presented with such concerns, often for little reward in return, most primes simply reject value engineered proposals.

In contrast, some of the most attractive avenues open to innovative contractors are part of the Design-Build concept, common in the bidding climates of Europe and Japan and promoted for many years by the FHWA. Design-Build allows the specialist geotechnical contractor to introduce cost-effective solutions that meet or exceed the owner's performance criteria. Design-Build contracting practices promote innovative design and accelerated construction, often with the use of equipment specially built for the purpose. The traditional role of the owner's representative - the design consultant - is often modified and may be expanded. The design consultant sets the performance criteria within practical limits and provides assurance that the owner's needs are satisfied. Review and critique of competitive proposals from specialty contractors and consultants employed by them ensures that the most economical solution is found. It can be applied in any project where the owner seeks an innovative cost saving solution to a particular geotechnical construction problem. There are four distinct options:

- Post Bid Design. The owner prepares a set of special design criteria (special provisions) that are included in the bid invitation and define the parameters for the alternate design. An owner-designed or "as-designed" system may also be included. After successfully pricing the project and obtaining a contract, the specialist then provides a design to the owner for review and approval.

Difficulty with this approach concerns the ability of the owner and contractor to agree on the design, after the award has been made. Disputes and delays may result, and often the contractor must modify his design, and usually compromise potential profitability. Also, to protect himself, the owner typically over-specifies the design

parameters, and this will stifle innovation. However, this can be a very attractive option, especially for smaller, highly technical projects.

A recent example was the epoxy resin sealing and rebonding of an old concrete dam in North Carolina (Bruce and DePorcellinis, 1991). Although the scale of the work was relatively small, the situation was long standing, deteriorating and not amenable to resolution by conventional grouting methods. Given the wide range of contemporary drilling and grouting concepts - often proprietary - which were feasible, the owner was able to select his preferred technical solution while ensuring it was economically competitive.

• Pre-Bid Design. Prequalified, selected specialists prepare designs for the owner's review prior to the bid. Approved designs become part of the bid package and the specialty subcontractor prepares a price to construct only his proprietary design. This method works best when the contractor is permitted to prepare plans of a conceptual nature only. Such plans exclude details which the contractor feels are unique to his design. So long as the supporting calculations address these details, the bid documents may include only enough information to make other contractors aware of the nature of the work. This is a positive opportunity for innovative contractors, who of course, must still remain cost effective.

An example of this approach has been described by Nicholson and Wolosick (1988) for the construction of a vertically post-tensioned caisson retaining wall in Atlanta, Georgia. In this project, conventional, inclined tie-backs could not be placed due to property right of way restraints. The contractor therefore had to be innovative in designing a solution to satisfy the performance criteria, while the owner again benefitted by being able to select the lowest responsive price.

• Negotiated Work. The owner is committed to a team approach wherein the contractor becomes an important part of the team for all foundation and ground support aspects of the project. Risk sharing is integral: the contractor is responsible for the adequacy of the design and its construction, the owner is responsible for the accuracy of the information upon which the design is based. Costs are reduced, as the contractor includes less contingencies, and innovation is encouraged because the contractor is rewarded for economies of design and installation. And, of course, quality is enhanced due to the team partnering approach.

This principle was adopted for the recent sealing of seepage through the Left Abutment of Lake Jocassee Dam, North Carolina (Bruce, et al., 1992). An awkward seepage problem was described by the owner in contract documents and technical and financial proposals invited. Detailed discussions with responsive bidders were conducted, and the successful contractor was chosen on the basis of his perceived ability to respond in the field to provide a solution within the limits of the quantities of work originally foreseen.

- Two Phase Bidding. It many ways another type of negotiated bid, this has gained favor in recent years with many Federal and State agencies. Prequalified contractors are invited to submit separate very detailed technical and financial offers. The technical aims of the project, and special restrictions are clearly specified, but great scope is afforded to the inventive bidder. Each proposal is assessed independently by separate committees, and graded on a points system disclosed in advance. The value of the technical proposal typically exceeds that of the price proposal, and emphasizes technical competence, personnel and corporate experience, and safety. There may be successive "rounds" of bidding, with the responsive contractors being interviewed between times so that they can optimize their proposals to a "Best and Final" submittal.

During the negotiations, the successful contractor should have developed a full understanding of the requirements of the job, and so there should be no subsequent controversy over the specifications, scope of work, or the quality level intended. He may also not have the "low bid". Unsuccessful contractors will have incurred a great deal of bidding cost, but this prospect alone will deter all but the most serious contenders. This process also involves considerable effort on behalf of the owner, and so is really viable only on particularly large and/or complex projects such as the major repairs conducted at Fontenelle Dam, Wyoming, and Stewart Mountain Dam, Arizona (Bruce, et al., 1991).

Overall, therefore, there are significant opportunities for the owner and the consultant, as well as the contractor, in pursuing design-build options as opposed to the traditional low bid approach. These should be aggressively promoted throughout our industry. In summary, Design-Build provides benefits by

- providing optimum solutions at the lowest possible cost;
- encouraging innovation through contractor-sponsored research and development;

- fostering improvements in quality, performance and cost; and
- incorporating the most advanced and practical designs by prequalified contractors who are regularly and exclusively engaged in the business.

## 5. PARTNERING AND THE ROLES OF THE CONTRACTED PARTIES

The concept of partnering is not new - it has always been the fair basis of doing business between honest and responsible parties. In recent years, however, the formal process of partnering has attracted much favorable attention as an aid to avoiding conflict between contracted parties. Significantly, this initiative has now been fully endorsed by the Association of General Contractors, who have not always been so supportive of innovations in contracting or procurement procedures in the past. In September, 1991, they issued a booklet entitled "Partnering - A Concept for Success" which describes in detail the respective benefits to each party, potential limitations, and the basic mechanisms of the process.

It must be realized that partnering "is not a contract, but a recognition that every contract includes an implied covenant of good faith. While the contract establishes the legal relationships, the Partnering *process* attempts to establish working relationships among the parties (stakeholders) through a mutually-developed, formal strategy of commitment and communication. It attempts to create an environment where trust and teamwork prevent disputes, foster a cooperative bond to everyone's benefit, and facilitate the completion of a successful project" (AGC, 1991).

Recurrent themes in the respective benefits to each partner include reduced exposure to litigation, lower risk of cost overruns or project delays, enhanced quality and safety, and an "increased opportunity for innovation through open communication and element of trust, especially in the development of value engineering changes and constructability improvements". It is intended to be an opportunity in public sector contracting, where the open competitive-bid process keeps the parties at arm's length prior to award, to achieve some of the benefits of closer personal contact which are possible in negotiated or design-build contracts.

Regarding potential problems, it is fundamental that all parties fully commit to the concept. This may prove very difficult for those conditioned in an adversarial environment, or those who regard it as just another "fad",

or those who thrive on daily confrontation and cannot entertain the idea of "win-win" thinking.

The AGC booklet (1991) provides a model to pursue on any given project, acknowledging that the details and personalities involved will necessitate appropriate "tailoring". Early steps in the process include educating one's organization in advance, making partnering intentions clear (from bid solicitation onwards), and committing and involving top management from award onwards.

Thereafter, a partnering workshop should be held before starting work on site, and in the authors' experience, this is an extremely valuable and interesting exercise. Preferably facilitated by neutral, trained specialists to aid focus, this workshop is an excellent opportunity to share concerns and establish common goals and objectives. It permits the team members to establish personal rapport, and should establish a clear communication framework. Partners can introduce specific proposals for innovation, both in the technical sense, and in others, such as an alternative issue escalation and resolution process. Ideally, the workshop will end with the creation of a partnering charter, signed at that time by each of the attendees.

This whole formalized process may appear to some to be somewhat superfluous, even leaving aside the question of the extra time and cost initially involved. Indeed, the objectives of partnering have often been achieved by reasonable people without recourse to such a structure. However, the authors view this formality as a necessary discipline to reinforce natural good cooperative instincts and personal relationships. Interim and end of contract evaluations are also an essential part of the charter, and help keep the concept in clear focus.

## 6. DISPUTES RESOLUTION

Typically in this process, an independent panel, paid jointly by the owner and contractor, meets on a regularly scheduled basis and is empowered to settle disputes among the owner, engineer and contractor as they occur. The keys to this are a knowledgeable board, a commitment by the owner, engineer, and contractor, and speedy resolution of problems as they arise. The board must have some power and authority, but usually this is limited to recommendations.

The greatest value of this process is forcing the parties to address the issues on a timely basis and with a neutral

third party acting as a mediator. Once each party is forced to explain its own position and listen to the other party's position, a compromise solution can generally be achieved. In our present adversarial system, accusations and denials are issued in writing, without the benefit of a face to face meeting of the people who are decision-makers. If the party seeking additional money or a changed condition (typically the contractor) feels strongly enough about its position the dispute will escalate but only after many months or years have passed. In the meantime, positions will have hardened on both sides and the lawyers are called in for a legal resolution, either in court or formal arbitration.

Sometimes in addition to the Disputes Review Board, the contract will call for bid documents to be submitted separately but at the same time as the bid. These documents contain the contractor's estimate for the work and will show how the work was assumed to proceed. They are held in escrow pending a dispute that cannot be concluded by mediation before the Disputes Review Board. Either the Board or another arbitration authority will be authorized to open these documents and utilize their contents to determine intent and cost on the part of the contractor. This is a method of determining what was assumed to be the conditions at the time of entering into the contract and is a deterrent to the unscrupulous and a vindication of the honest.

## 7. FINAL REMARKS

For many years, the construction sector considered itself relatively isolated from the various forces impacting the American way of life, such was the strength of our domestic market and our power overseas. In recent years, however, intense competitive pressures have been brought to bear, as reported daily in the media, and experienced constantly by the participants. It has become a critical interlude in our corporate times, and one which will demand substantial change in attitudes and philosophies.

Already among contractors, consultants and owners there are encouraging signs that new approaches to contracting procedures, the concept of Partnering and alternative methods of disputes resolution are being promoted in a concerted effort to reduce confrontation and litigation.

Innovation and new technology must be addressed so that companies can become more productive, and responsive to clients. In this regard, there is an increasing awareness of the revived acknowledgement that quality is not just

extra, quality is fundamental: the essence of TQM is that costs can be reduced and profitability increased.

On the other hand, there are several other factors which will probably remain outside our industry's collective ability to impact. Apart from imponderables such as Federal government fiscal policies, there will continue to be burdensome factors such as inflated insurance premiums and restrictive regulatory controls.

Nevertheless, it does seem that innovative and well managed geotechnical constructors can survive and prosper if they pursue the following basic goals:

- Innovate, by continually challenging technical and administrative paradigms.
- Recruit and train committed employees, empower them and remember that they are the company's most valuable asset.
- Understand and supply what the customer really wants.
- Promote alternative procurement procedures, especially design-build.
- Promote and embrace Partnering, team building, and non-litigious dispute resolution processes.
- Commit to total quality in every process of the operation, both internally and externally.
- Continue to innovate, in all phases of the operation!

In summary, risk and reward provide both the opportunities and constraints to the introduction of new technology. Under the present system, perceived and real risk on the part of the owner, engineer, and constructor have a dramatic effect on the acceptance of innovation. The team approach, rather than the present adversarial system is vital to successful change. It is essential to bring all the parties together during all stages of the project to work as a team to reduce risk and so gain the most economies. Equally, there must be a reward for those entrepreneurs who invest their resources into innovative technologies. Quality, not just minimum acceptable standards, must be maintained and rewarded.

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