

parison, these strategies could not be used effectively during the first few years of the busway program and productivity suffered. In the early 1970s, the program was delayed by political controversy, a year-long court suit, change in scope, and further studies. Openness and bilateral resolution of issues were not permitted by some municipal officials. This resulted in lack of information, lack of mutual respect and trust, subsequent delays in resolution of issues, redoing of work, and missed design opportunities.

Clearly, the management strategies found to be most effective in obtaining quality assurance while maintaining productivity were those that

1. Involved the parties in reaching mutually agreed-on objectives, and more important, agreeing on timely action;
2. Delineated areas of risk;
3. Avoided adversary relationships and encouraged mutual respect, with trust and confidence in the integrity of the involved parties;

4. Were based on open communications that allowed for bilateral resolution of issues;
5. Provided a process for feedback for future actions; and
6. Provided for monetary and nonmonetary rewards.

This list, although it is not exhaustive, has set the stage for effective action. The effectiveness of these strategies in obtaining quality assurance while maintaining construction productivity for the busway program can be further judged from the papers by Drosendahl and Mascaro in this Record, which provide viewpoints from the perspectives of an engineering manager for construction and a contractor.

REFERENCE

1. A.S. Judson. New Productivity Improvement Strategies for the Engineering-Construction Industry. In *The Civil Engineer's Role in Productivity in the Construction Industry*, ASCE, Vol. 1, 1977, pp. 49-67.

Construction of Pittsburgh's South Busway: An Engineer's Viewpoint

JON W. DROSENDAHL

Contractual relationships play an important role in the success of a construction project and must be defined by contract. However, the participants in a project bring their own objectives, ideas, strengths, and resources to the effort. Because of the interrelationships of the participants, these individual characteristics must be understood and a cooperative attitude must be developed. The engineer, because of his or her unique understanding of the project, can play a leadership role in the development of the necessary cooperative attitudes. When the engineer is successful in this role, the project is a success and the objectives of the participants are achieved.

This paper is based on the role of Michael Baker, Jr., Inc., in the development of the busway system for the Port Authority of Allegheny County. As explained in a companion paper by Heintzleman in this Record, a busway is essentially a two-lane highway built for the exclusive use of buses. These busways bypass extremely congested areas of Pittsburgh, which permits rapid movement of the buses into or out of the downtown area during rush hours.

The firm of Michael Baker, Jr., Inc., was engaged as the consulting engineer by the port authority to perform the planning, design, and construction management tasks in conjunction with the development of the South Busway and East Busway. This overall engineering effort was managed by Baker's director of engineering, who supervised the various discipline managers.

As manager of construction inspection services, I reported directly to the director of engineering and was responsible for the management of the construction effort required for busway construction. The actual construction was performed by independent construction companies under contract to the port authority. The viewpoint of one of these contractors is also being presented as a companion paper by Mascaro in this Record.

The busway program is considered quite successful. The South Busway was opened three years ago, within the anticipated time and within the budget. Construction overruns were limited to less than 7 percent of the contractual cost of the project and, in half the cases, it was the result of changes in scope required by the funding agencies after the design phase had been completed. The East Busway, now under construction and scheduled to be in operation by early 1983, is on schedule and within budget.

CONTRACTUAL RELATIONSHIPS

As indicated in Figure 1, both Cameron Construction Company and Michael Baker, Jr., Inc., were under direct contract to the port authority. Cameron was contractually responsible for providing a product that met specifications. To ensure that these specifications were met, Cameron also provided a specified testing program through an independent laboratory.

Michael Baker, Jr., Inc. was contractually responsible for development of the specifications for the product and the specifications for the testing program. Michael Baker, Jr., Inc. was also required to monitor the testing program and conduct inspections to ensure that the product met specifications.

This, of course, is generally regarded as the traditional approach to construction and has been practiced both successfully and unsuccessfully for hundreds of years. However, there is more to quality assurance than is indicated in this sketch. Figure 2 indicates the relationship of the project team as developed for the busway construction. The owner, engineer, and contractor are all shown overlapping at the center of the project because

Figure 1. Contractual relations.

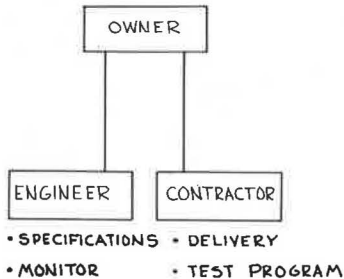
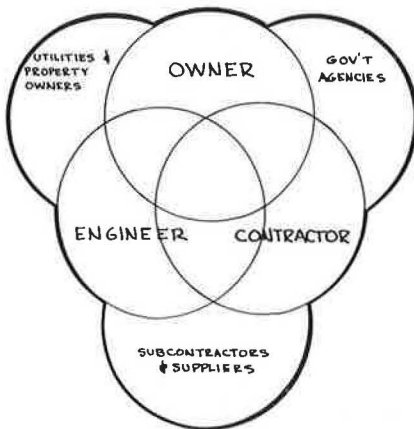


Figure 2. Project team.



each, at various times, is responsible for the success of the project and must interact with the others to fulfill this responsibility. It is within this area that the interrelationships become the most critical.

Each team member brings to the project his or her own goals, ideas, strengths, and resources. Because the engineer has participated in each stage of the project, he or she inherently knows and understands both the concepts and details of the project. This knowledge places the engineer in this center area as the project coordinator and provides the engineer with the opportunity to set the pace for the interactions of the team members.

The engineer coordinates the other team members in the spirit of cooperation, mutual trust, and overall common interest in the project. Through example and leadership, this cooperative spirit must be developed. Perhaps difficult questions must be asked, difficult positions taken, or team members must be reminded of their responsibility, but this cooperative spirit must be maintained.

Importance of Each Team Member

In order to emphasize the team-approach concept, the circles that represent the members in our sketch are of equal size. No matter how vast or narrow a portion of the project each member is responsible for, at some time that portion becomes the most important part. Each member, therefore, must be considered, coordinated, understood, and managed to ensure the fulfillment of his or her particular requirement or obligation to the project.

Interaction of Each Team Member

Again, as shown on our sketch, each member's circle

overlaps that of the others. This overlap indicates the interrelationship and interdependence of all the team members. Interaction occurs among all the members at various times and with different intensities. This is the interaction that accomplishes the work, solves the problems, and determines either the success or failure of the project. Perhaps the interrelationship is required by contract or law, however, its existence must be accepted by each member as a prerequisite to the fair and successful pursuit of the project. The engineer may serve as the catalyst, moderator, or even go-between in some cases, but the major factor in the success or failure of an interaction is the attitudes of the interrelated members.

Attitude

The project is the sum total of the efforts of the team and all the members are bound firmly to it by their obligations and responsibilities. When properly presented, each member understands the implications of this agreement. At the risk of being redundant, the importance of the proper attitude of the members cannot be overemphasized. The rights as well as the responsibilities of others are understood and each member cooperates with the others, perhaps making sacrifices on occasion, in order to advance the project and obtain long-term objectives.

ILLUSTRATIONS OF THE TEAM APPROACH

These successful interrelationships can best be seen through the solution of a job problem that occurred during construction of the South Busway. The specifications as developed by the engineer required the contractor to coat an existing brick tunnel liner with a 5-cm (2-in) thick application of shot crete. Briefly, shot crete is a pneumatically applied mortar that contains pea gravel along with sand, cement, and water. This application was to provide a low-cost method for repointing the masonry as well as provide some additional structural strength.

To accomplish this task and also comply with a minority business enterprise, the contractor subcontracted the work to a small company more experienced in the application of gunite, a pneumatically applied mortar material that does not include the pea gravel contained in shot crete. The subcontractor made several attempts to apply the shot crete as specified but was unsuccessful. Meetings and discussions were held in an attempt to assist the subcontractor and to develop alternate coatings that could be applied more efficiently. Throughout the discussions, the engineer coordinated the objectives of all the participants. Also, he conducted all negotiations and secured all approvals to the general satisfaction of all the involved participants.

Agreement was reached to permit the subcontractor to substitute 2.5-cm (1-in) thick application of gunite instead of the shot crete in return for a credit to the owner. The gunite provided the required repointing of the masonry and, through careful examination of the existing brick surfaces, the additional structural strength required was reduced. The net result was threefold: The subcontractor could proceed efficiently with an application that he was experienced with, the construction could proceed in timely fashion, and the owner was provided with a satisfactory tunnel lining at a reduced price.

Another example of the successful management of the project team's interrelationship is demonstrated in the quality-assurance program developed for the

concrete incorporated in the busway construction. The engineer recognized that concrete could be subject to problems attributable to the aggregate available in the Pittsburgh area. These aggregate, generally obtained by dredging the rivers or mining bank deposits, contain soft particles, coated pieces, or other troublesome materials.

In the design stage, the engineer selected concrete strengths to be specified that were within the experience record of the local concrete industry. Furthermore, a testing program was developed and incorporated into the specifications that would ensure that the aggregates used would be properly monitored in order to provide the necessary concrete strengths.

During the prebid stage, the engineer reviewed the specifications and required testing program with the local concrete suppliers and potential bidders. Discussions were held and the objectives behind these requirements were explained to the industry.

After the award of the contracts, the engineer met with the successful bidders, their appointed testing laboratories, and their concrete suppliers and assisted in the preparation of the quality-control manual for concrete. As concrete was supplied to the job, the results of the quality-control pro-

gram were monitored and adjustments were made.

Throughout this procedure, the engineer assumed a leadership role, through the coordination of the efforts of the other team members. Through definition of objections, persuasion, and open discussions, the contractors and their suppliers were convinced that the program was to their advantage as well as to the advantage of the owner. The result of this effort is that the East Busway construction has proceeded without any concrete being removed because of insufficient strength.

CONCLUSION

Contractual relationships are an essential ingredient of the quality-assurance programs of all construction projects. Responsibilities and obligations must be clearly defined by contracts and the team members must undertake the fulfillment of these responsibilities. However, the success of the project is dependent on the team members' performance and interrelationships with the other team members. All the team members must function in this area, but the engineer, because of this understanding of the work, has the opportunity to develop the relationship necessary for success.

Contractor's Viewpoint and Case Study of Pittsburgh's \$27 Million South Busway Program

JOHN C. MASCARO

Project participants on Pittsburgh's new South Busway worked hard to create a productive climate for the successful completion of their \$27 million busway program. Throughout this project, quality assurance was of paramount importance. Quality construction and a productive climate were compatible through cooperation, goodwill, mutual trust, and teamwork among the owner, consulting engineer, contractor, and other parties. The project was completed on time and within budget through the owner's willingness to assume a fair share of risk. The principles and philosophies illustrated by this case study are not new and were used with a common-sense approach to the successful completion of this project.

This paper presents a case study of the contractual relationships among owner, engineer, and contractor on Pittsburgh's South Busway Program and their effect on quality assurance. For the purposes of this paper, the following definitions are applicable:

1. Quality assurance is the total system that is used by management, their engineers, and their consultants to answer the general question, Are we doing the right things?
2. Quality control is that control that a person undertakes to check in a systematic manner, that the steps for implementation are correct and will enable the project to be constructed in the specified way.

The owner of the project was the Port Authority of Allegheny County, the engineer was Michael Baker, Jr., and the contractor was Cameron Construction Company, a Pittsburgh-based construction engineering and management firm.

Although traditional contractual relations among owner, engineer, and contractor were employed, a

productive climate was created through cooperation, goodwill, mutual trust, and respect. More importantly, the project was completed on time, within budget, and with quality construction.

TRADITIONAL APPROACH TO THE CONSTRUCTION PROCESS

The owner's need to build usually results in a construction project. Owners are individuals, companies, or governments that must satisfy physical needs. Construction projects are physical needs and might be in the form of a home for a family, a large office building for a corporation's headquarters, or a new highway or dam for the federal government.

Once an owner decides to build, an engineer or architect is hired to evaluate the owner's needs. Throughout this paper, engineer, architect, and designer will be used interchangeably and synonymously. They shall represent a person, company, or group of partners that provides feasibility studies and conceptual designs based on the owner's scope parameters and budget. This is the first phase in the traditional construction approach and is called the decision phase. Once these initial items are completed, the owner then hires an architect or engineer to finalize the overall design and to make the drawings and specifications. This is the second phase, called the design phase, in which the architect or engineer develops a solution to meet the owner's requirements. These solutions are evidenced by plans and specifications and are referred to as the contract documents.

The third phase is the bid phase, which can