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I-15 CORRIDOR RECONSTRUCTION PROJECT DESIGN/BUILD EVALUATION 2000 ANNUAL REPORT

By: Stanley S. Postma, P.E.
Dennis Anderson
Jim Roberts

Carter & Burgess, Inc
Salt Lake City, Utah

Utah Department of Transportation
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UDOT RESEARCH & DEVELOPMENT REPORT ABSTRACT

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16. Abstract

This report is the third annual report to be produced under a four-year project of evaluation and research into the I-15 design/build project. The Research Division of UDOT commenced this research project as partial fulfillment of the commitments made to the Federal Highway Administration (FHWA) when design/build was permitted for this project. The purpose of the evaluation is to collect and evaluate information derived from the process used in this project and provide this information to other agencies or entities interested in pursuing similar design/build projects in transportation.

This report contains an evaluation of the use of performance specifications, an annual evaluation of the QA/QC process, and an evaluation of the innovative design and construction methods use on the project.

The first area covered by this report is an evaluation of performance specifications on the I-15 reconstruction project. The second chapter covers the second installment on innovative design and construction methods used on the project. The QC/QA is the third of four annual evaluations to be completed.

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2000 ANNUAL REPORT

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I-15 CORRIDOR RECONSTRUCITON PROJECT

SPECIAL EXPERIMENTAL PROJECT 14

2000 REPORT

INTRODUCTION

On April 15, 1996, the Utah Department of Transportation (UDOT) requested approval from the Federal Highway Administration (FHWA) to use design/build for the I-15 Corridor Reconstruction Project under the provisions of Special Experimental Project 14 (SEP 14). April 15, 1997, UDOT issued a Notice to Proceed (NTP) to Wasatch Constructors to design and construct the project. Wasatch Constructor's design/build proposal for the base price plus construction and maintenance options were $1.352 billion, making this the largest single highway contract (traditional or design/build) in the country.

An initial report prepared by UDOT titled "Design/Build Contracting Initial Report" covered the 14 month period from the middle of February 1996 to the April 15, 1997 NTP and described the acquisition strategy process (deciding on the type of design/build), the steps in the process, the development of the Request for Proposal (RFP), and the evaluation and selection of the successful proposer. A copy of the report is available from the UDOT Research Division

The 1998 report covered three areas of investigation. The first was a more detailed presentation of the selection process used by UDOT to select the contractor. This section was prepared as a separate white paper and submitted to the Transportation Research Board and published in 1999. The other two areas covered by this report were evaluations of the design process used by Wasatch Constructors and the QC/QA program established by them for both the design and construction portions of the project.

The 1999 report covered three topics: design process, quality control/quality assurance, and innovative construction methods. This report was published in March 2000 by the UDOT Research Division and is available from them. All prior reports on this project have been placed on a UDOT web page and are available via the internet.

This annual report contains the third year's review of the design and the structure of the QC/QA process. One chapter deals with the innovation construction methods used on the project. The use of performance specifications is also evaluated.

SCOPE OF EVALUATIONS

This report is the third annual report to be produced under a four-year project of evaluation and research into the I-15 design/build project. The Research Division of UDOT commenced this research project as partial fulfillment of the commitments made to the Federal Highway Administration (FHWA) when design/build was permitted for this project. The purpose of the evaluation is to collect and evaluate information derived from the process used in this project and provide this information to other agencies or entities interested in pursuing similar design/build projects in transportation.

The scope of the study will cover several areas. The prior reports prepared by UDOT, and their consultants described the process used to develop the selection procedure and the RFP, the selection process used, documents the procedures that were followed and used by UDOT, an investigation and evaluation of the quality assurance/quality control program instituted for the project and the design process set-up by the design/builder to develop the detailed plans. This report contains an evaluation of the use of performance specifications an annual evaluation of the QA/QC process and an evaluation of the innovative design and construction methods used on the project. Depending on funding availability UDOT has directed additional investigations to be made into the following areas:

1. The Owner Controlled Insurance Program (OCIP) developed by UDOT for this project
2. The Public Relations program used by UDOT
3. The QC/QA program will be investigated to identify and evaluate changes that occur during the progress of the construction
4. The management structure established by UDOT to manage and oversee the project and compare that with the traditional process previously used by UDOT
5. Innovative construction methods, materials, and design techniques used on the project
6. The effectiveness of the partnering process used on the project

AUTHORS AND CONTRIBUTORS

The 2000 report was written based upon a series of interviews conducted with a number of individuals both within the I-15 UDOT Team and the Wasatch Constructors design and construction teams. The innovative construction methods were developed by a team of evaluator's led by Stan Postma, Project Manager. The team consisted of Jim Roberts, Deputy Director of Caltrans; and Robert Brantley, Senior Structural Engineer, Carter & Burgess. The report was reviewed by Ben Watts former Director of Florida Department of Transportation and currently Director of Transportation for Carter and Burgess

Stan Postma and Dennis Anderson, each senior project managers with Carter & Burgess, and Jim Roberts, Chief Deputy Director of CalTrans, prepared the report on quality control/quality assurance. Stan Postma, Roger Cisneros, and Bill Boyd of Carter & Burgess prepared the use of performance specifications report. David Downs and Ben Watts of Carter & Burgess, and various UDOT staff conducted review of the reports.

The Use of
PERFORMANCE SPECIFICATIONS
I-15 Design/Build Project

INTRODUCTION

As part of the evaluation of the I-15 Design/Build Project, UDOT wanted to examine the use of performance specifications on the project. UDOT had not used performance specifications on previous projects so their use is new to the Department. This report presents an evaluation of the performance specifications used on the I-15 Design/Build Project through the end of the year 2000. The report is based upon interviews conducted with key UDOT staff members, their consultants, one representative of the contractor's team, and a review of the specifications included in the request for proposal (RFP) and used for the project.

TYPES OF SPECIFICATIONS

The Transportation Research Board (TRB) published a document in April 1996, "Glossary of Highway Quality Assurance Terms", that established definitions of various specification types. The review team used these definitions to evaluate the specifications prepared for the I-15 project. The definitions are as follows:

> *Material and methods specifications* – also called method specifications, recipe specifications or prescriptive specifications. Specifications that direct the contractor to use specified material in definite proportions and specific types of equipment and methods to place the material. (Each step is directed by a representative of the highway agency. Experience has shown this tends to obligate the agency to accept the completed work.)
>
> *End result specifications* – Specifications that require the contractor to take the entire responsibility for supplying a product or an item of construction. The highway agency's responsibility is to either accept or reject the final product or apply a price adjustment that compensates for the degree of compliance with the specifications.
>
> *Quality assurance specifications* – Also called QA/QC specifications. A combination of end result specifications and material and methods specifications. The Contractor is responsible for quality control and the highway agency is responsible for acceptance of the product.

Performance specifications – Specifications that describe how the finished product should perform over time. For highway projects, performance is typically described in terms of changes in physical condition of the surface and its response to load, or in terms of the cumulative traffic required to bring the pavement to a condition defined as "failure". Specifications containing warranty/guarantee clauses are a form of performance specifications. Other than the warranty/guarantee type, performance specifications have not been used for major highway pavement components because there have not been appropriate nondestructive tests to measure long-term performance immediately after construction.

Performance-based specifications – Specifications that describe the desired levels of fundamental engineering properties that are predictors of performance and appear in primary prediction relationships

Performance-related specifications - Specifications that describe the desired levels of key materials and construction quality characteristics that have been found to correlate with fundamental engineering properties that predict performance. These characteristics are amenable to acceptance testing at the time of construction.

The consensus of those interviewed was that few of the specifications were pure performance specifications. They used a term "Hybrid" to describe the specifications. "Hybrid" was used by UDOT because even though the specification contained performance elements, the UDOT Standard Specifications were also included in the contract. After review of the specifications and how UDOT has been using them it is the evaluator's opinion that many are *material and method specifications* while others are *quality assurance specifications*. The "hybrid" generally falls into *the quality assurance* category although some fall into the *performance – related specification* category.

DEVELOPMENT OF SPECIFICATIONS

When UDOT made the decision to use Design/Build as the contracting vehicle for the I-15 Reconstruction Project they also decided to prepare specifications that were more performance oriented. Their justification was that performance specifications would:

- Provide flexibility to the contractor to propose new methods and ideas for the design and construction of the project
- Provide flexibility to the contractor to meet the time, cost, and quality constraints of the project.
- Assign appropriate responsibility and risk to the Contractor for design and construction means and methods.

- Allow the Contractor to optimize his resources for the project and better match with his capabilities and let the designers' design to the strengths of the contractor.

Additionally, UDOT attempted to incorporate quality into the contract through various "*quality hooks*". These "hooks" included, but were not limited to, ISO 9000 compliance, Award Fee, and Maintenance option. Inherent in the design/build process is the ability of the design/builder to be innovative and creative and to maximize his strengths. UDOT felt that by emphasizing this in the specification it would lead to the feeling of ownership by the contractor, which in turn would lead to better quality. It was felt by UDOT that the use of performance specifications would enhance the opportunity for innovation, creativity, maximizing the contractor's strengths, thus, enhancing the potential for quality. To accomplish this UDOT established a review team to manage and direct the development of the specifications. Several teams were assigned specific specification sections to write for the RFP. The teams were lead by UDOT staff personnel and consisted of UDOT staff, FHWA staff, consultants hired by UDOT, industry and association experts and academia specialists. Many of the team leaders remained on the UDOT I-15 Oversight management team after the project was awarded and continued involvement with the project during both design and construction. More than 100 individuals were used on the teams to prepare the specifications. The smaller teams developed drafts of the specifications and then reviewed them with the review team. The review team was used to develop parameters for the specifications while the smaller teams focused on writing the specific specifications.

Prior to developing the specifications, UDOT developed a risk matrix. They used this matrix to identify the risks associated with the project, evaluate whether UDOT or the contractor was better suited to be assigned the risk and what limitations should be placed in the specifications to achieve the desired results. The risk was assigned to the party best prepared to handle it. This risk matrix was also used as a guide to develop the parameters for the performance specifications.

Because the I-15 facility is such a vital element of the transportation system in the Salt Lake City area UDOT decided to set goals for design life or service life of the major components of the project much longer than normally used in the transportation industry. For example, the structures and walls were designed for a 75-year design life while the pavement was designed for a 40-year service life. These design or service lives were criteria used to develop the performance specifications.

Drafts of the specifications were released to the three short-listed contractors during the RFP process. The Contractors were given opportunities to comment on the content. As comments were received the specifications in some cases were revised, finalized and released to the contractors in the final RFP.

As a result of the comments received from the contractors, changes were made to the specifications. One significant change was the maintenance period required in the contract. Originally UDOT had intended to require an extended warranty for performance of up to 20 years. Based on comments received from contractors, UDOT came to the conclusion that this long of warranty was not feasible. They ended up modifying the requirements to include up to ten years of maintenance by the Contractor of specific elements. The final RFP required the contractor to provide a cost to provide maintenance for the first five years and five one-year periods up to a total of ten years of maintenance. This is an option that UDOT evaluated and elected to not exercise in April 2001.

UDOT indicated that during the development of the performance specifications they had not yet finalized the role of quality control and quality assurance (QC/QA) on the project. When UDOT finally decided to include these activities as contractor provided it was very late in the development of the specifications. As a consequence, not much time was permitted to revise the specifications to address the planned QC/QA roles. UDOT staff indicated they could have used more time to consider the effects of this decision on preparing the specifications. It is important to define the QA/QC role early in the development of the specifications so that they can be developed consistent with the goals of the project.

USE IN DESIGN

It was the consensus of the people interviewed that even though they were not true *Performance Specifications;* the developed specifications did work well during the design stage. It provided the Designer latitude in the development of the design, yet there was enough prescriptive language in the document to give the Department a comfort level that the end product would be a facility that they felt would meet their expectations.

The specifications worked well in allowing the Design/Build team to pursue innovative ideas to address challenging field conditions, as well as being able to maintain the very aggressive work schedule.

An example of this design latitude was the use of “Geofoam” in areas where subsurface conditions would have resulted in severe settlement or it would have taken more time to settle if normal embankment construction methods had been used. Extensive use of “Wick Drains” was used to accelerate the consolidation of sub-surface materials and expedite the construction of new embankments. Two-stage mechanically stabilized earth (MSE) retaining walls, lime cement columns, transverse post-tensioned deck slabs and spliced girders are also examples of innovative ideas the designer considered and included in the construction plans. It is a direct result of the flexibility provided by UDOT in the specification that these ideas were used on the project. Ideas proposed by

the contractor that UDOT agreed met the performance specification were incorporated into the construction documents.

There were exceptions when the flexibility provided by the specifications did not provide positive results. For example, there was concern the "Traffic Signals" section of the specifications was too "Performance" related. There were designs developed that, while in conformance with the "performance specification", were not what UDOT had used in the past and now accepted as a standard. It was believed, by the people interviewed, some specifications should have included more prescriptive language to assure the products to be furnished and installed were materials that UDOT personnel were familiar with. Where the Design/Build firm has the contractual ability to incorporate new materials/equipment into the design, it should be remembered that maintenance forces must be familiar with them or early maintenance may suffer until adequate maintenance procedures could be developed.

The majority of the UDOT structure engineers interviewed believed the structure specifications were satisfactory. Although the "Performance Specification" contained a number of prescriptive requirements, they were still performance orientated to the extent that it permitted the contractor latitude to pursue innovative or alternative ideas. The contractor had a different perspective on this matter. The Contractor's position was that even though they had the opportunity to explore a number of different types of bridges, the prescriptive part of the specifications addressing such things as rebar types and sizes, concrete cover, etc., did limit his ability to developadditional concepts.

It was pretty much agreed to by all the people interviewed that, with one or two exceptions, the developed specifications were probably more of a prescriptive specification than a performance one; at least when the definition for these two types of specification is applied. The exceptions were the Lighting and Traffic Control Equipment, the Epoxy Paint, and the Landscape Aesthetics. These specifications generally addressed only the end results and did not specify the means the contractor was to use to obtain the result.

USE IN CONSTRUCTION.

It was the consensus of those interviewed that the RFP and the documents the Design/Builders were governed by in preparing their Technical Proposals did allow some latitude in the design. However when the plans and specifications were completed and released for construction the contractor was very limited in what could change.

There were also difficulties experienced in the early stages of the construction of the project with changes in conditions and changes the contractor wanted to make to "sealed" plans that were completed by UDOT and included in the RFP. The original contract

documents did not permit changes to the contract without processing change orders and considering price changes. The Contractor wanted to make changes to both the "sealed" plans and contract provisions. He felt that the "performance" specifications gave him flexibility to modify either document to suit his capabilities. UDOT interpreted the provision differently. They felt that a change order, and possible associated credit should apply if the Contractor wanted to make changes to the contract documents.

In January 1998, the Contractor and UDOT conducted a partnering session to address these problems. As a consequence of that session, a memorandum of understanding (MOU) was developed and agreed to by both parties that provided more flexibility in considering design or construction changes. This agreement simply stated that if a contractor proposed change provided "equal to or better quality" than that proposed in the contract that UDOT would accept that change using a Technical Agreement process and no change to contract price or time would occur. UDOT retained the authority to determine if the change was "equal or better quality" and the Contractor was free to present any information he wanted to have UDOT consider in a proposed change.

The process agreed to in the MOU is viewed by both parties to have been a significant and critical change to the contract language and the success of the project. There have been more than three hundred Technical Agreements processed during the design and construction of the project to date. This process greatly reduced the processing time of proposed changes and provided UDOT with the comfort that the change would not affect the contract value or schedule.

It was agreed by those interviewed that the construction plans released to the field for construction were prescriptive in nature. The contractor generated prescriptive specifications (during the design) to be used by the Construction personnel. This was required for the contractor to direct his crews during construction and also to commit his subcontractors to specific elements of work.

USE IN MAINTENANCE.

The RFP addressed three types of maintenance requirements. Two of these were intended to be used during the construction of the project, Maintenance During Construction and Maintenance of Traffic. A third governs the activities during the maintenance period after construction is deemed to have reached substantial completion, Maintenance After Construction.

The Maintenance During Construction was intended to cover both maintenance of existing facilities used during early stages of the construction and the new facilities constructed by the Contractor. The portion that covered the existing facilities was intended to provide performance requirements the Contractor was expected to maintain on existing bridges, pavement and other facilities until they were replaced by new

construction. The specification also involved minimum required maintenance levels of the new construction features prior to final Owner acceptance. The specification identified a list of activities that were to be considered as included in the lump sum bid and what items would be treated as force account items to be reimbursed separately.

Early on in the construction phase UDOT discovered that the maintenance level of the existing roadway included on the RFP did not meet an acceptable standard. As a result, UDOT was faced with the choice of either paying the contractor a change order, estimated to be $1.0 million, to improve the level of maintenance so that it would conform to the intent, or have UDOT Region 2 forces perform this maintenance during the construction. UDOT elected to delete the maintenance during construction from the contract and have their own forces perform this work. Therefore, UDOT initiated a Contract Change Order that removed the responsibility from the Contractor for the maintenance of the existing facilities. UDOT assumed the responsibility and a reduction in the contract price was negotiated to compensate for this change. The Change Order left the responsibility with the Contractor for any maintenance on the new construction so that once an element was removed from service and replaced by the Contractor he assumed the maintenance responsibility.

UDOT felt this change was fair and equitable to both parties. The price reduction in the contract was adequate to cover the costs incurred by UDOT. It was UDOT's position that their maintenance forces were better able to perform the necessary maintenance work at a lesser cost and, more importantly, responded to the public's concern on a more timely basis. The contract anticipated that UDOT was responsible for snow removal, weed control, graffiti removal and third party damages so this did not change. The Contractor has remained responsible for the maintenance of the new facilities and will remain responsible until UDOT deems the work to have reached substantial completion.

The Maintenance of Traffic specification required the contractor conform to three standards, UDOT Standard Traffic Control Plans, Part VI of the Manual of Uniform Traffic Control Devices (MUTCD) as revised in September 1993, and the MUTCD 1988 edition. It also specified certain operational conditions through the construction zone. For example, the contractor was required to maintain two lanes of mainline traffic in each direction during weekday and weekend peak periods defined in the contract. Minimum lane widths, shoulder widths and pullout lane frequency and sizes were specified. Similar provisions were listed for the closure of interchanges and the duration. Most interchange closures were restricted to a maximum of one year and no two adjacent interchanges could be closed at the same time. Arterial streets at interchanges were only allowed to be closed for up to six months.

The Contractor was required to provide a traffic control plan with his proposal that became a requirement of the contract. He was permitted to revise his plan and a procedure was outlined in the specification to accomplish this. This has been revised

often to match the Contractor's construction sequencing and both parties felt the processes to handle modifications have been reasonable to process and accept.

This specification has been followed during the construction. UDOT's traffic engineer assigned to the project did indicate that the provisions were too flexible to achieve all that UDOT had intended. UDOT had intended to permit the contractor to close the mainline during demolition periods and when overhead construction occurred above traffic lanes such as setting girders. The Contractor used the flexibility of the provisions of this specification and has closed the mainline much more frequently than UDOT had expected. During peak pavement and construction periods, primarily in summer time, the Contractor chose to close the entire mainline after 10:00 p.m. and reopened it prior to 6:00 a.m. to facilitate his construction. UDOT agreed to permit these closures because they were not specifically prohibited by the specifications and UDOT did not view this as unacceptable to the general public. It resulted in accelerated construction because the contractor could work more safely and efficiently during nighttime with reduced impacts to motorists.

UDOT also felt they should have been more prescriptive in the provisions for closure of interchanges to include the ramps and arterial streets passing across the mainline. There have been times when the contractor closed portions of interchanges sooner than construction activities dictated and UDOT felt they should have been left open as a convenience to the public until the construction activity actually affected the traffic

The Maintenance After Construction was an option UDOT could have invoke if they had desired and the Contractor provided a cost for this work at the time of selection. The contract permits UDOT to accept an initial five-year maintenance option and then, later, five one-year options. UDOT reviewed these specifications in coordination with the Contractor's submittal scheduled for January through April of 2001. This is when the maintenance plan is to be prepared by the Contractor and UDOT could elect to accept it. More is discussed about this element later in this report.

EVALUATION OF THE SPECIFICATIONS

Upon review of the specifications few of them are true performance specifications. Some are a "hybrid" specification with elements of both performance and prescriptive in the specifications.

The review team reviewed the specifications and placed them into three broad categories that they felt best characterized the type.

Performance	Hybrid	Prescriptive
Landscape and Aesthetics	Roadway Geometrics	Pavement Design
Epoxy Paint	Drainage	Concrete Barrier
Geotechnical	Structures	Signing
Lighting	Water Quality	
Traffic Signals	Weigh-in-motion	
Maintenance of Traffic	Fiber Optic Utility Conduit	
Maintenance During Construction	Maintenance After Construction	

MEMORANDUM OF UNDERSTANDING

The "Memorandum of Understanding" (MOU) developed by Wasatch and UDOT was cited by many interviewed as being a *critical* element which helped mitigate problems related to the inflexibility of some of the specifications. The MOU allowed Wasatch to make changes to their proposal, performance specifications or standard specifications if the changes resulted in "equal to or better quality" than the original contract requirement. The MOU also provided flexibility to Wasatch to meet the time constraints of the project. It is recommended that this concept be considered for incorporation in other projects to encourage "partnering" and to allow appropriate changes to be made in a timely manner.

During the design process UDOT and Wasatch used the Design Task Forces to provide direction and review to the design teams. It was indicated by both UDOT and Wasatch that this process helped to develop many of the procedures and methods not otherwise detailed in the contract. The interaction between UDOT and Wasatch, which took place during the Design Task Force meetings, helped fill many of the overlaps/voids that were unintentionally contained in the written specifications. UDOT also had the goal of partnering with the contractor when issues could not be resolved in the Design Task Forces. It was also felt that having the authors of the performance specifications involved in the Design Task Force assisted in the interpretation of the specifications and it is recommended that a similar process be used on other projects.

PERFORMANCE SPECIFICATIONS

Maintenance of Traffic – UDOT's Operations Oversight Manager indicated that this specification was primarily a performance specification. This specification contained minimal requirements and restrictions and basically required the contractor to follow the MUTCD and conform to the UDOT Standard Traffic Control Plans (Sheet 4's) used by UDOT. Although this specification did allow the Contractor maximum flexibility, some areas of the specifications created problems during construction.

UDOT's Project Traffic Engineer indicated that there was not enough specific information in the specification to limit nighttime closures or closures at times of significant community events, such as sporting events. The language in the specification required

maintaining mainline traffic during peak hours and the Contractor interpreted that he could close the freeway at all other times. The Contractor closed the Interstate on many occasions (particularly at nighttime), which was not the original intent of UDOT. The ability of the Contractor to close complete sections of the freeway *could have* been more restrictive than was specified in the specification.

It was also indicated that the closing of on/off ramps to arterials was loosely described in the specification. An example of this was the requirement that an arterial road at an interchange only be closed for a maximum of six months. In actuality, some of these areas were effectively cut off for up to two years. This did not meet UDOT's intent, but they were tied to the specific language of the contract. The intent of the specification c*ould have* been clearer, tying the ramp operations to the arterials so that the combined closure was limited.

Maintenance During Construction – Again, it was felt that this was a true performance specification, which required the Contractor to perform routine maintenance (pothole repair, striping, edge drop off, etc.) on the existing facility. After award of the contract UDOT recognized that the condition of the existing pavement and roadway was not as it had been represented in the RFP. The conditions had deteriorated to a point that the Contractor requested additional payment to continue to maintain the existing facilities during the construction period. The estimated cost of this change order was approximately $1 million. UDOT was faced with the choice of either paying the Contractor the additional amount or take the entire responsibility back to the department to maintain the facilities. It was decided by UDOT to remove this portion of the contract and assume this responsibility using their existing Region 2 maintenance group. As a result of this decision, maintenance during construction was removed from the contract with a change order resulting in a credit to UDOT.

Traffic Signals – This was a true performance specification that *could have* been more prescriptive in certain areas of the specification. One example cited was the method used to wire the sensors for traffic control loop detectors. It was indicated that the specification was silent on whether the contractor could use parallel or series wiring configuration. UDOT has had difficulty with some of the sensors that the Contractor installed because the method used does not work well in Utah's environment.

Geotechnical - The flexibility in this specification allowed the Contractor to come up with innovative solutions for construction on soft foundations needed to meet the time schedule of the project. The consensus of those interviewed was that this flexibility was critical to the *success* of the completion of this project. Examples of these innovative methods included the use of wick drains, two-stage walls, geofoam, lime cement columns and stone columns.

The flexibility in the specification allowed the contractor to come up with a Two-Stage Mechanically Stabilized Earth (MSE) wall solution to address the settlement issues. However, because UDOT did not have an existing prescriptive specification to cover this type of wall, the Contractor prepared the specification with requirements that were in conflict with recommendations made by the FHWA in published reports. These FHWA reports were listed as references in the specifications not requirements. It was indicated that in future projects, these types of references be converted to requirements, which would then be binding on the Contractor.

HYBRID SPECIFICATIONS

Structures – This specification had a mixture of prescription and performance provisions. The specification was very prescriptive in areas UDOT wanted to tie down; such as materials, concrete cover, reinforcing steel, etc., however, allowed flexibility as far as the bridge type. The objective was to permit the use of structural types beyond those utilized in the past and to facilitate the proposed construction schedule. This flexibility allowed for the use of "spliced-girder" and transverse post-tension decks as options that would not have otherwise been used.

It was indicated, by those interviewed that they would consider adding criteria for deck cracking on future projects. It was indicated that there was ambiguity in the performance specifications as to when and how to apply concrete cracking acceptance criteria and how to develop methods for repair. Methods of acceptance and repair were not specified and this has become a point of contention on how to interpret what is a suitable repair. If the agency has a preferred acceptance criteria and repair method it should be specified.

Maintenance After Construction – This element of the work probably contributed as much as any to the concept that performance specifications could be developed for the project. The RFP required the contractor to include as part of his lump sum bid for the work, a cost for maintaining certain elements of the work for a specified period of time after substantial completion. The first segment consisted of an initial 5-year period, with additional five 1-year periods at the option of UDOT. In addition, the contractor was required to submit a Maintenance Plan specifying the maintenance effort that would be performed upon substantial completion of the project.

Acceptance of the maintenance plan will be based on UDOT's comparison of the cost proposal and effort they expect will be required to maintain the project in accordance with the RFP requirements. After review of the plan, UDOT has the option to approve the plan or reject it. It is unclear, at least in the specifications that were reviewed, what the next step will be if UDOT considers the plan unacceptable but still wants the contractor to perform the work. It is assumed that, by reviewing the contractor's escrowed cost documents for his cost proposal, it can be determined if the work shown in

the plan is reflective of the price shown. A partnering escalation process could be used, if necessary, to resolve this issue.

The specifications addressing Maintenance After Construction are some of the more performance-related specifications in the contract. There are many instances in the specification sections where reference is made to occurrences which require corrective action be taken. There are also many specification sections, which do not specify the frequency of inspection, what corrective action will be acceptable; or if a situation is corrected does this now fulfill the maintenance requirements. A task force is reviewing Maintenance After Construction specifications and is reviewing the contractor's plan to provide this. There is wide variance of times in which inspection and repair of the element is to be made. As an example, inspection of the PCC pavement is only made at the end of the 5th and 9th years of the maintenance period. Slope/Erosion; Storm Drain Systems; Curb and Gutter; Paved Ditches: Abutments; Walls; are items that require inspection yearly. Other items, mainly bridge related, are silent on the frequency of inspection or the method of repairs.

Of all the specifications reviewed it is believed the Maintenance after Construction are the ones that are most ambiguous in their intent. This is especially true when considering they will be governing the maintenance operations for ten years after completion of the work. It can be conceived that not any or many of the people involved in the development of the specifications or those on the contractor's side who were involved in establishing the cost will still be active at the end of ten years. This is being addressed in the negotiations between UDOT and Wasatch.

PRESCRIPTIVE SPECIFICATIONS

Pavement Design - It was UDOT's original intent to make this specification as performance based as possible. As the specification was being developed, UDOT added several requirements to tighten up the specification, thus making it more prescriptive than performance. Following are a few condition items that were added:

- The contractor shall design a Portland Cement Concrete Pavement (PCCP) section for mainline, ramps, collectors/distributors, auxiliary lanes and the east/west arterial pavement under the new SPUI interchanges for a minimum distance of 60 meters beyond the ramps or at the beginning of the left turn bays whichever is greater.
- The Contractor shall make adjustments to minimum layer thickness to accommodate climatic conditions such as frost depth. A minimum of 36 inches will be required to address frost.
- The Contractor shall design the PCCP joints with load transfer devises (i.e. dowels) to ensure minimum 80% load transfer at the joints.

The specification required a profile-o-graph before acceptance and a profile-o-meter test at four and nine year intervals after substantial completion if the maintenance after construction is exercised. It is recommended that this be *changed* to require a profile-o-meter at year zero for comparison with the tests at four and nine years. Profile-o-graphs cannot be easily conducted unless you close the facility to conduct the test.

Signing – This section was prescriptive. UDOT used much of their standard specification to prepare this section and most of the specification deals with the fabrication and materials involved in preparing the signs.

LESSONS LEARNED

Performance Measurement Criteria. A pure performance specification requires that specific performance criteria and measurement standards be included. This is difficult in highway construction because in many cases the appropriate time to measure performance is several years after construction is completed. Examples of this are settlement of structures and fill and smoothness of pavement after several years of use. It demands that the writer anticipate many years into the future to establish appropriate performance and measurement criteria.

Flexibility. Only permit flexibility where the Owner wants to permit the contractor/designer to have flexibility. If the Owner wants proven methods to be used then prescriptive specifications are more appropriate.

Outcome Expectations. Where the Owner can define a method to achieve a specific outcome, a prescriptive specification is more appropriate than a performance specification. As an example UDOT intended to have pavement be a performance specification but upon review and development of the specification so many prescriptions were added that the specification became a prescriptive specification.

Measurement of Performance. The Owner should perform a thorough assessment of the project and the desired outcome before deciding what type of specification to use. If the measurement of performance cannot be adequately measured within the contract period then a prescriptive specification is more appropriate.

Review of Specifications. Where an Owner has not had a track record using performance specifications it is vital that a thorough review of the performance specifications be conducted to remove ambiguities and unenforceable requirements.

Maintenance Specifications. If maintenance is part of the contract then the Owner should have people with maintenance backgrounds on the development team to prepare the specifications. The maintenance specifications included in this project are not as well defined as they could have been.

Flexibility in Use of New Methods/Materials The performance specification did provide the opportunity for the Designer to be innovative in some aspects of the design. Geofoam, Wick Drains, 2-stage retaining walls, lime cement columns and spliced girders are examples of methods of construction that were adopted.

Equal or Better: The addition of an agreement to accept equal or better substitutions on methods, means and materials has proven to be critical to the success of this project. Similar provisions should be considered for inclusion in contract documents for design/build project to provide the flexibility both the Owner and Contractor will require to work out performance specifications that contain ambiguities.

Design Task Force. The use of design task forces composed of Owner and Contractor staff has proven critical to interpret the intent of the specifications. On this project many of the authors of the specifications were included on the Task Forces further enhancing the ability to interpret the specifications at the design stage where it is most effective.

Maintenance During Construction. Because the condition of the existing pavement and structures did not meet the expectations contained in the contract and the RFP intent, a change order was initiated to remove this from the contract and have UDOT assume responsibility. If the Owner wishes to place this kind of requirement on a contractor they must be prepared to evaluate the condition at the time of award to verify that the condition is consistent with the intent of the specifications.

Experience with Performance Specifications. As more experience is gained in the transportation industry with performance specifications it is expected that more specifications will be developed and proven in practice. This additional experience will be invaluable in improving the quality of the specifications and their application to the transportation industry. UDOT was one of the first to attempt to use performance specifications on this type of project and the lessons learned will be valuable to the industry.

Patterning Specifications after Existing Ones. Care should be exercised in using other specifications as a pattern to make sure they still include all of the important elements. During the process of modifying the UDOT standard specifications and making them more performance oriented, sections of the specification that were viewed as being too prescriptive were removed. This led to unintentionally removing sections that were not covered anywhere else in the specification.

An example was the use of grounding rods at the control cabinets in the traffic signal. The only place that the grounding rods were referenced was in the measurement portion of the standard specification. This portion was removed and therefore it became difficult to enforce the requirement of grounding rods because the specification did not include them.

INNOVATIVE CONSTRUCTION METHODS
2000 Annual Update Report

Purpose

The purpose of this report is to document the "innovative" construction methods and techniques employed on the I-15 Design/Build project being completed by Wasatch Constructors (Wasatch) for the Utah Department of Transportation (UDOT). In 1999 a report was prepared which outlined the items considered to be "innovative". These included:

- foundations
- design life
- MSE walls
- moment slabs
- jumbo slabs
- Nebraska spliced girders
- geo-foam fills
- lime-cement columns
- stone columns
- pre-cast deck forms
- seismic design criteria

The initial report provided a description of the methods and design examples of each use. In some cases, pictures were included showing the application of the techniques.

This report is intended to be a progress report on the use of these new techniques. At the time of the initial report many of the methods and techniques were just being constructed or used. Therefore, the opportunity to observe the performance of the method was limited. This report is prepared one year after the initial reviews and includes a performance evaluation of some of `the methods in place. It is expected that a final review will be conducted next year and a similar progress report prepared.

Foundation Treatments

Wasatch used several methods to treat the foundation conditions present in the Salt Lake Valley. These consisted of vertical corrugated plastic "wicks" inserted in the foundation soils to expedite the removal of water from the soils and accelerating the consolidation of the soils. He used wick drains extensively to accelerate and control the settlement within fill areas. These types of drains were used in areas where there was sufficient time to permit fills to settle before construction had to proceed. Many areas meet these criteria so wick drains have been used extensively on the project Photos 1 and 2 show typical installations of wick drains.

The use of wick drains is considered to be a great success on the project. Wasatch indicated that the drains produced the results expected and were relatively easy to install. Most of the drains were installed by pushing them into the foundation areas. Typical depths were up to 40 meters. Once the wick drains were installed, a blanket of free draining material was placed over the tops of the wick drains and extended to the outside edge of the fill areas, providing a drain path for any water exiting the drains. Then embankment materials were placed on top of the drain blanket. Surcharge was placed on top the embankment to accelerate the settlement. The reader is referred to the 1999 Annual Report for a further discussion and examples of the design used.

UDOT has been pleased with the performance of the wick drains. They have not observed significant problems with the use of the wick drains.

The foundation problems encountered were observed on some of the initial embankments where adjacent properties experienced some settlement outside of the embankment area. This occurred in the northern most segment of the project, where the foundation soils are softest. The areas impacted included foundations of adjacent buildings, which settled. Wasatch responded to these problems in a very expeditious manner and has performed repairs to structures affected, including jacking foundations and other remedial measures where it occurred.

Once these problems were encountered, Wasatch modified the methods used to install the embankment fills to reduce the potential for a similar problem. He modified the gradation of the fill material and his process of placement and compaction of the fill material in the areas where high embankments are located. These changes to methods and procedures have resulted in reducing the settlement that has occurred outside of the embankment areas.

Wasatch used stone columns in isolated areas to mitigate liquifaction-induced settlement in case of a seismic event. These areas were limited due to the cost of this treatment and it has been used only where alternative methods were not feasible. The predominant areas have been near the Jordan River. This process has been found to be very acceptable. The reader is referred to last years report for a more detailed description.

Lime-cement columns were proposed in many areas for foundation stabilization. However, as was discussed in the prior year's report, this method proved to be too slow to produce the results the contractor required to meet his schedule requirements. Therefore, this method was only used in one location where Wasatch decided there was potential for damage to adjacent commercial building if wick drains were used. UDOT has installed monitors at this location to observe the long-term performance and they intend to publish reports of their findings at a future time.

MSE Walls

Mechanically stabilized earth walls (MSE) were used extensively on the project. This included two types of walls, single and two-stage walls. The difference between the two is how the facing panels are placed. In the single stage wall the facing panels contain the fill and are placed as the embankment is constructed. In two-stage walls the embankment is placed and contained with a wire-faced panel and allowed to settle before the facing panels are erected and connected to the embankment walls. The two-stage walls are used in areas where extensive settlement was expected.

During the first year of construction several tall walls were erected using the two-staged method. After erection and before placing the facing panels, some of these walls experienced unexpected deformation along the welded wire wall face resulting in

localized "bulging" areas. This tended to occur near the base of the walls but also occurred higher up in the wall along the face on others. This became an issue that was investigated thoroughly by Wasatch's engineers, UDOT personnel, FHWA and special consultants engaged to investigate how serious the bulging would be to the performance of the walls. After completion of the investigation, it was determined that the walls were stable and that the two-staged wall system could be used even with the bulging. Several changes were made to prevent or reduce the bulging on walls constructed after this problem was encountered. This included changing the type of embankment material used on the tall walls, the addition of closer spaced reinforcing straps near the base of the walls, and modify the compaction procedures along the face of the walls. Wasatch made these modifications and walls erected subsequently have experienced fewer bulging incidents.

The use of two-staged MSE walls is viewed as a critical element in the success of this project. The use of these types of structures has enabled the contractor to complete the work in the time frame required. Without their use it was probably not possible to expect the schedule to be met. Photos 3 and 4 show examples of two-staged MSE wall construction.

Geofoam Fills

Geofoam fills have been used in areas where either the schedule did not allow sufficient time for settlement within the MSE embankments to occur or where significant utility relocations could be avoided. The geofoam material was used in place of earth materials to reduce the weight of the fills resulting in little or no settlement of foundation soils. Photos 5 and 6 show a full section constructed of geofoam. Photo 5 shows concrete panels being placed on the outside face of a geofoam wall. Photo 6 shows construction of the concrete load - distribution slab on top of a geo-foam fill.

An unexpected issue involving the use of geofoam has been the settlement measured within and between the geofoam blocks themselves. Both the designers and UDOT staff expected minimal settlement to occur within and between the geofoam blocks. Measurements have indicated as much as 4 centimeters of settlement has occurred. While unexpected, this degree of settlement has not resulted in any significant problems in the construction or performance of these walls.

Another issue that has been encountered with geofoam fill walls and the settlement has been with the connection of the top of the facing panels to the load distribution slabs. The plans called for a steel pin cast into the load distribution slab to connect to the panels. Some of these have sheared, disconnecting the top of the panels and in some cases causing the panel to tilt. Wasatch has repaired this by installing new anchors drilling from the outside, through the panel and into the load distribution slab. They have also lengthened the anchors to increase the embedenment length in the load distribution slab. This seems to have successfully addressed the problems.

To date the use of these types of walls has been very successful. UDOT is conducting a long-term evaluation of the use of geofoam on the project. It is expected that results of these longer-term studies will not be available for a few more years. They have installed instrumentation to monitor movement of the fills for both settlement and creep. The reader is referred to the UDOT Research Division for further information about these studies and the results observed.

UDOT is also monitoring the performance of the geofoam embankments to determine if there are any problems associated with differential settlement where the geofoam ends. These studies are still on going and results will not be available until the longer-term evaluations are reported on by UDOT.

Post-Tensioned Concrete Decks

While not new to the industry, post-tensioned concrete decks on structures have not been used extensively by UDOT. This has been primarily because UDOT wanted to be able to replace bridge decks easily, should they become distressed or begin to fail. Corrosion of reinforcing steel and deck joints have been major problems in the past for UDOT on older structures. Wasatch chose to use this type of deck design to permit girders to be spaced at wider spacing, thus reducing the number of girders required.

Most of the steel girder structures use a post-tensioned concrete deck design. This type of structure was used where long or curved spans were required.

UDOT oversight and research staff noticed that some bridges appeared to have a significant number of observable cracks in the decks. This has occurred most often on decks that are supported by steel girders and use transverse post-tensioning. The cracking appears more frequently than was expected in this type of construction. UDOT and Wasatch are investigating this to determine whether it is serious enough to warrant taking remediation measures. The results of this investigation are not yet available.

Pre-Cast Panels On Post-Tensioned Girders

The Contractor has used pre-cast, pre-stressed concrete panels as stay-in-place forms for bridge decks placed on pre-stressed concrete girders. Photo 7 shows a typical placement of these panels. They were used to reduce forming and to accelerate construction. While not new to the industry, the use of these panels is new to UDOT. Therefore they have not had any previous experience with the use of these panels. The UDOT oversight staff had observed cracks in some of these panels and some cracking in the decks of the bridges where the panels are used. UDOT was concerned about the potential for cracking in the deck at the edge of the panels and whether the panels acted as a composite with the cast-in place concrete deck. Wasatch and UDOT jointly investigated this and determined this cracking will not affect the intended performance.

Basic Pre-cast Concrete, a local manufacturer, produced the pre-stressed girders and many of the stay-in-place deck panels. Wasatch indicated that they had difficulties in the first year of construction with consistent quality of the panels and girders. Wasatch improved quality control procedures with Basic Pre-cast that have resulted in more uniform and acceptable panel and girder manufacture.

The UDOT manager for segment 1, the southern segment, indicated that they have removed one deck that used pre-cast panels and concrete girders. They specifically examined the bond between the panels and cast-in-place concrete deck. Their observations confirmed that the panels appeared to bond well with the deck concrete and it was difficult to define the interface between the panel and cast-in-place deck. His evaluation was that the panels performed very well.

Jumbo Slabs (Bridge Approach Slabs)

Jumbo slabs have been used at approaches to bridges where settlement after construction could occur. The purpose of the design was to increase the distance between the pavement and bridge deck and reduce the ramp effect of settlement of the slab. Conduit was placed in the slab that could be used to inject grout or mud to raise the slab to match the adjacent pavement or structure. These were called jumbo slabs. The slabs are reinforced to act as a beam so that it could be jacked into place.

Problems were observed with cracking at reentrant corners on the approach pavement. Photo 8 illustrates these cracks. It is not difficult to explain the cracks at the re-entrant corners. The designers modified the details and placed short reinforcing bars diagonally across the re-entrant corners, once this was observed, correcting the problem.

Moment Slabs (At Shoulders)

The designers developed a concept called moment slabs to be used above the two-staged MSE walls and geofoam fills. The purpose of the slab is to cantilever the pavement over the top of the wall panels and not transfer load into them. Instead the loads imposed by traffic and the roadside barriers are transferred into the moment slab. The moment slabs are thickened and reinforced to provide the moment carrying capacity.

There are cracks in the moment slabs located at the 9000 South Northbound on ramp and several other moment slabs on the project. The moment slabs are several hundred meters long without expansion or contraction joints. This has resulted in transverse cracking in the panels. The cracking is random, ranging from 2 meter to 4 meter spacing on centers. Photo 9 shows an example of these cracks.

There are also cracks in the safety barrier at several locations where the moment slab cracks appear to have propagated into the barrier. Photo 10 shows an example of these cracks. In this instance the barrier has cracked even though there is a contraction joint between the cracks.

Wasatch has modified this practice since the cracks first appeared. They are now placing contraction scores at uniform intervals to accommodate the cracking. More than half the moment slabs have been completed, however and this does not address a remedy for the constructed slabs. Wasatch is sealing all cracks wider than 0.5 mm.

The UDOT Segment 2 oversight manager also reports that at some locations the moment slab and pavement are separating at the joint because there are no ties between the two sections. It was designed this way to prevent loads from being transferred to pavement slabs. The slab and pavement are placed abutting each other but there is no dowel or load transfer bar placed in this joint. Some UDOT personnel are concerned that this could be a problem if either slab moves significantly. There has been some horizontal movement observed at a few locations.

SPLICED GIRDER BRIDGES

Wasatch chose to use a spliced, pre-stressed and post-tensioned concrete girder design on several structures. He elected to use this design on most of the single point urban interchanges located on the project, for structures approximately 100 meters in length. He used a modified Nebraska pre-stressed concrete girder design. Three girder segments are spliced together using a concrete diaphragm at the splice points and post tensioning the spliced segments. Concrete pre-cast deck panels were used to form the deck and a reinforced concrete deck placed on top.

Spliced concrete girder construction was chosen as the solution at several long-span bridge locations since the concrete girders can be designed to accommodate post-tensioning steel. In addition to increasing the allowable span length of a conventional pre-stressed concrete girder, post-tensioning of the girders enhances the continuity, load carrying capacity, and seismic performance of the bridge.

UDOT oversight noted that there was some misalignment of the post-tensioning ducts in adjacent girders. This can be caused by fabrication techniques, mismatch of adjacent girders in the field, or creep due to girder pre-stressing. Ducts either placed incorrectly or loosely during girder fabrication can shift resulting in misalignment. Girder mismatch could occur during erection, and can be avoided by carefully marking adjacent girders during fabrication and/or delivery. Mismatched girders should be adjusted during erection although it can be time consuming. Misalignments due to girder creep, camber, or shrinkage are much more difficult to detect and control. Due to the time dependent nature of these phenomena this misalignment can vary over time. Additionally, girders which were designed, fabricated, and shipped identically can exhibit vastly different geometric distortions due to their effects. It appears that the majority of difficulties encountered due to misalignment of the post-tensioning ducts in the spliced girders were due to creep, camber, and shrinkage. Wasatch mentioned that they had some success in reducing the misalignments by changing the support width on their girders while they were in storage.

Some difficulties with the use of thin walled PVC ducts in the girders have been observed on the project. It is believed the difficulty is caused by the heat of hydration of the girder concrete. During girder fabrication, the heat from concrete hydration softens the plastic walls of the PVC ducts. The weight of liquid concrete and perhaps expansion of the concrete, constrained within the girder forms, causes the softened walls of the PVC ducts to collapse. When the girders are erected it is difficult to feed the post-tensioning strand through the collapsed ducts. This can be avoided by the use of metal ducts or thicker walled PVC ducts.

Deck Replacement

The original RFP contained a requirement that all bridge decks be designed to be replaceable at a future date in the event that freeze-thaw, de-icing salts, or unforeseen circumstances caused degradation of the bridge decks.

Steel girder bridges with composite concrete decks can be resurfaced using conventional methods. While transverse post-tensioning of these decks complicates the resurfacing process it can still be performed without specialized techniques or engineering requirements. A large majority of the new bridges built on the project fall into this category. However, replacement of a portion of the deck would require full width replacement resulting in total closure of the bridge during repairs.

Resurfacing of pre-stressed concrete girder bridges, or pre-stressed post-tensioned spliced girder bridges is a more complicated process. The difficulties encountered are related to the potential for overstressing the girders upon removal of the deck surface. In most cases, a specialized engineering design will be required for performing the deck replacements on these types of bridges.

Miscellaneous Construction Issues

Some construction issues were noted concerning the abutment end-diaphragm placement sequence on concrete pre-cast-pre-stressed girder bridges. On some bridges the girder ends, at the bearing location, were supported on temporary false work while the bottom half of the end-diaphragm was placed. The end diaphragms are designed to be monolithic with the pre-stressed girders. The temporary false work supports were removed prior to completion of the upper end-diaphragm placement and the deck placement. As the deck concrete was placed the entire dead load was supported by the end diaphragm, the flexural capacity of the lower half of the end diaphragm was exceeded and cracking occurred along the diaphragm soffit. These cracking stresses are then locked into the diaphragm when the deck placement sets-up, possibly causing overstress in the end diaphragm under combined dead and live loads. This can be avoided by designing the diaphragm to support the construction loads or allowing the false work supports to remain in place until the upper diaphragm half and deck placement are complete.

The longitudinal bolsters, a seismic design appurtenance, were difficult to install in some locations. These bolsters are essentially an L-shaped fabricated steel shoe that is attached

to the bottom flange of steel girders using high-strength bolts. These bolsters are designed to engage the adjacent pier cap and prevent excessive relative longitudinal displacements, between the substructure and superstructure, during strong ground motions (earthquakes). The installation difficulties were encountered on several horizontally curved girder bridges, where the curvature caused the bolsters, which were predrilled, to be located skewed to the face of the adjacent pier cap. The solution recommended by the designers, in order that the bolsters be perpendicular to the face of pier cap, was to field weld the bolsters to the bottom flange of the girders.

CONCLUSIONS

Each of the innovative methods used on the project has resulted in significant benefits to the project. Most of the methods and procedures have functioned as expected. There have been many changes made in construction methods and procedures over time that have resulted in improvements to the construction quality. It was expected that these improvements would occur as they were used more frequently on the project and construction crews became more familiar with the use and erection processes.

An example of these improvements was the decision to place all deck concrete during nighttime hours to reduce the problems associated with hot ambient temperatures and related concrete placement and curing problems. These and similar changes have resulted in improved quality of the project.

Many of the problems associated with the use of these "innovative" methods have been related to construction processes and procedures. Once these have been refined many of the problem areas have been reduced or eliminated. The issue then becomes, how serious are the problems with the early uses and do they need to be corrected? Certainly the more extensive deck cracking problems need to be addressed to reduce the potential for further deterioration of the decks. Sealing or some other suitable methods may need to be performed to fix these problems.

UDOT is conducting other studies of some of these innovative methods. Some of these studies are long-term studies and results will not be available until more time has passed and observations and measurement made.

In summary the following is observed on each method reviewed:

Foundation Treatments: Wick drains have worked very well and within the expected ranges on the project. The use of lime-cement and stone columns was more limited than originally proposed. Stone columns were used but only in limited areas along the Jordan River where they have performed well.

MSE Walls: These walls have generally performed well on the project. Bulging and misalignment of facing panels has occurred in some locations. Additional reinforcing and care in placement of backfill materials in the walls on tall applications have reduced

the bulging that occurred. Care must be given to the construction of the walls in areas where existing adjacent structures could be influenced by the wall settlement to reduce the impacts to these structures.

GEOFOAM Fills: The use of these fills has been successful. Designers should expect settlement within the blocks to occur. UDOT's testing of this will yield helpful information to future designers. The connections of wall panels, especially at the load distribution slabs, need to be carefully considered to reduce potential problems.

Post-Tensioned Concrete Decks: The problems encountered with the cracking of these decks needs to be carefully considered. Generally these structures are quite flexible and this results in some of the crack formation. The procedures of placing decks during nighttime hours in cooler weather conditions appears to be beneficial.

Pre-cast Deck Panels: Once the manufacture process was improved the use of these panels appears to have been successful. None of the deck cracking observed appears to result from the use of the panels.

Jumbo Slabs: The reentrant corners on adjacent pavement need to be reinforced to prevent diagonal cracking at the corners. Once Wasatch began doing this the corner cracking was resolved. Further study of the cracking probably should be made to identify the causes.

Moment Slabs: The use of moment slabs appears to have been successful. However, some provisions for expansion and contraction of these long slabs should be made. These slabs are cracking due to shrinkage of the concrete during the curing period. The contractor has begun to place scores in the concrete to control the location of the cracking.

Spliced Girder Bridges: The use of these girders has been successful. There have been construction problems associated with some of these girders but they appear to be related to problems in alignment of ducts and shoring under the diaphragms during their construction. It is questionable whether these types of bridge decks are replaceable as required by the specifications because of the potential of over stressing the post-tensioned girders when the deck is removed.

Photo 1 Typical Installation of Wick Drains

Photo 2 Detail of top of Wick Drain

Photo 3 Two-Stage MSE wall connection detail

Photo 4 Two-stage MSE wall construction example

Photo 5 Concrete Panels on outside of geofoam wall

Photo 6 Distribution slab on top of geofoam fill

Photo 7 Stay-in-place deck Form

Photo 8 Diagonal Cracks at Reentrant Corner

Photo 9 Transverse Cracks in Moment Slab

Photo 10 Cracks in Safety Barrier Wall at Edge of Moment Slab

ANNUAL QC/QA PROGRAM REPORT
FOR THE I-15 DESIGN/BUILD PROJECT 2000

INTRODUCTION

This is the third in a series of annual reports on the QC/QA process being used on the I-15 Design/Build project. This report covers the period from July 1999 to July 2000. In addition to this report UDOT has already published reports covering the selection process and design process. In this and future years UDOT intends to prepare evaluation reports covering topics such as partnering, use of innovative design and construction methods and materials, the use of performance specifications, and public relations programs used on the project. Annual reports will be published which contain the results of the evaluations and a final report summarizing the entire project is scheduled for publication in 2002.

The project was begun in April 1997 when the contract for the design/build services was awarded to Wasatch Constructors (Wasatch). The reports prepared in prior years presented discussions of the organization set up used in the first year of the contract and an evaluation of the second year's function. The QC/QA program was developed during the first year and certification under ISO 9001 was obtained during that period of time.

This report covers the second full year of implementation of the QC/QA program by the contractor. At the time of the evaluation, June 2000, the construction has progressed to approximately three-fourths of the contract time and about 80 percent of contract value. Construction activity included the completion of several of the interchanges in the south third of the project, Segment 1, scheduled for opening later in 2000, continued construction of the major interchanges located at I-80 and SR-201, and the I-80 West interchange. Approximately 90 percent of the earthwork for embankment construction is completed, all structures have been started with approximately 40 bridges completed and open to traffic. About one-third of the concrete pavement has been completed with another one-half to be completed this year. Most of the utility relocation work has been completed.

Two QC/QA programs were developed for the design/build project. The first was developed and used to monitor and control the design process. The second focused specifically on the construction activities. Reports were developed in 1998 and 1999, which describe the QC/QA program involved in the design process and the "over the shoulder" review process used by UDOT. The reader is referred to those reports for a discussion on the design QC/QA program.

This report specifically evaluates the programs used for the construction activities. This report serves as one of four evaluations of the QC/QA program, which will be completed during the construction of the project. Changes to the program, which have occurred since the project began, are evaluated in this report.

BACKGROUND

This project is the largest design/build project under contract with a State Department of Transportation. Selection of a design/build team was made under conditions known as "best value" selection. The process of selection was developed by UDOT specifically for this project.

The selection process began in March 1996 with issuance of a notice of interest in the project. A contract was awarded to Wasatch Constructors on April 15, 1997 and a notice to proceed immediately given. The contract called for the design/build team to complete design and construct 17 miles of new freeway system to replace an existing facility. The contractor was required to maintain at least two lanes of traffic in each direction while the new facilities are constructed. A completion deadline of October 15, 2001 was placed on the contract requiring the facilities to be fully open and functional within 4 ½ years to reduce the inconvenience to the driving public and also accommodate the 2002 Winter Olympics to be held in Salt Lake City in February 2002.

Design/build was chosen as the contracting vehicle because it was felt that this was the only way to accomplish the project within the allotted time limit. Other reasons include dealing with a single source for both design and construction and minimizing claims. UDOT had not used this process on such a large-scale project in the past so all of the contracting procedures were developed specifically for this project. They based some of their process on similar successful transportation projects underway in Southern California and Denver, Colorado and were assisted by consultants.

CURRENT CONTRACT STATUS

The construction contract for the project totals $ 1.325 billion. This included a lump sum contract for $1.018 billion and the balance unit cost bid items specified in the contract. The overall project cost, including UDOT costs, is $1.59 billion.

As of the date (June 2000) of this evaluation the contract status as estimated by UDOT is as follows:

- Time is 75 percent complete
- Costs are 80 percent spent
- Construction is just under 75 percent completed as estimated by UDOT

TYPE OF WORK ACTIVITIES

During the first year of the contract, through 1998, most of the construction activities consisted of demolition of portions of the existing freeway and construction of embankments with surcharge used to accelerate settlement. There were some facilities, which had been designed by UDOT that were completed during this time period. An example is the new interchange that was completed at 600 North Street.

During 1999 and early 2000 several interchanges have been reopened to traffic. The 400 South Interchange into Downtown Salt Lake City and the 600 South off-ramp were opened to traffic. Two major interchanges; SR-201 and 9000 South were closed to facilitate construction. The Contractor has been concentrating on completing structures in Segment 2, the middle portion of the project, completing the entire Segment 1 in anticipation of an October 15, 2000 opening, and continued construction in Segment 3, the north portion of the project. Approximately one-half the total main line concrete pavement is expected to be constructed during this calendar year.

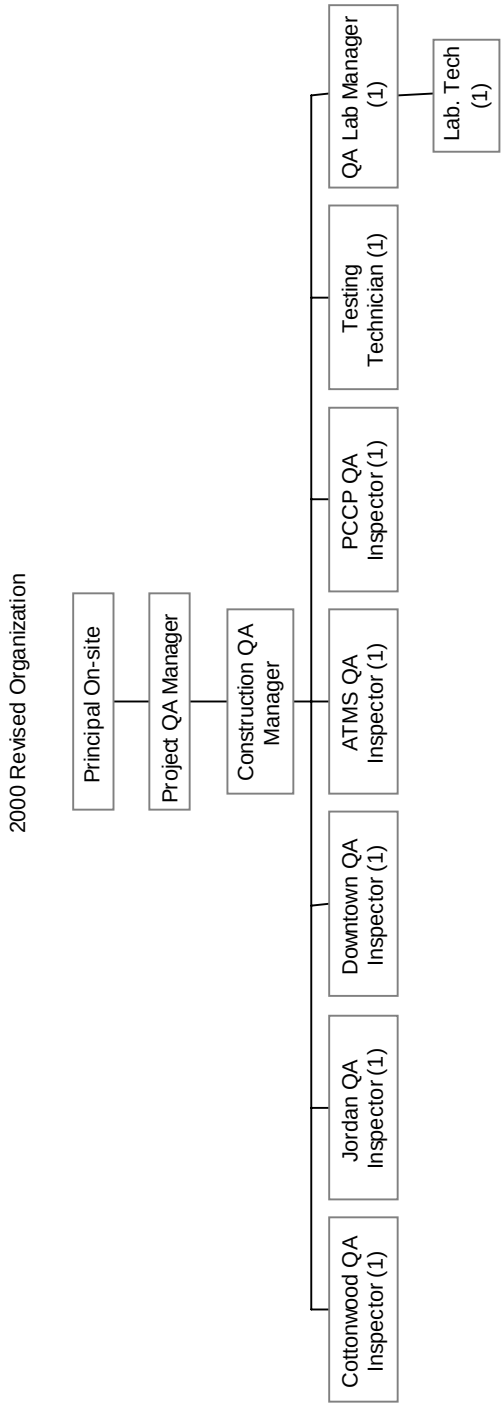
CHANGES TO QA/QC PROCESS THIS PAST YEAR

The Contractor has modified their QA staff assignments this year. In prior years the Contractor had assigned a QA manager to each segment. There was also an overall manager of QA for the entire project. The segment managers had one QA inspector, one technician and a document control person assigned to each segment. During this past winter UDOT and Wasatch agreed to a reduction in this staff level. The Wasatch staff dedicated to QA was subsequently reduced to a single overall QA manager and a QA inspector for each segment with one testing technician, who covers all segments. This resulted in the reduction of about ten people assigned to the QA role. Figure 1 shows the current organization

UDOT accepted this change because they have been performing some of the same tasks in their Independent Verification process as were being performed by Wasatch's QA organization and recognized this duplication of effort. UDOT is satisfied that Wasatch is providing an equivalent level of performance with fewer personnel. Wasatch's sub consultant who prepared the design provides the QA staff personnel.

No other changes to the organization structure of either QA or QC were reported. UDOT indicated that they have observed fewer inspectors assigned to the project than in prior years. Some inspectors have left the project without being replaced. Construction activity in Segment 2 has increased significantly over prior years all contributing to this perception.

WASATCH CONSTRUCTORS
Quality Assurance Organization



UDOT continues to use ATSER (an independent testing firm) for independent verification testing on the project and uses this information to correlate to the QC and QA reports generated by Wasatch. UDOT is also using their region laboratory to monitor the Wasatch laboratory. UDOT uses their laboratory to conduct independent assurance of testing procedures and calibrate equipment used by Wasatch and to check certification of technicians used in testing, but they do not conduct independent tests. ATSER performs all independent verification tests for UDOT.

We observed that there is a continued level of concern among the UDOT oversight staff and Wasatch staff with the QA role on the project. Some of the UDOT staff expressed concerned about the lack of independence of the QA staff from the Contractor. Our observations are that most of this discomfort stems from the cultural change that results from having a contractor provide QA services. This is not the customary role historically used on UDOT projects. Getting their staff to accept this new role for the Contractor has been a challenge for UDOT on this project. It is believed that any agency unfamiliar with design/build will experience similar cultural discomforts initially.

UDOT staff is comfortable with the QC role being played by the Contractor.

UDOT is proceeding with another large Design/Build project known as Legacy Parkway. UDOT modified their approach to the QA role on that project by requiring that an independent firm, not associated with either the designer or contractor, be hired by the Contractor. This QA firm will report directly to both UDOT and the Contractor and will be kept independent from the Contractor, although paid through the Contractor. This is an attempt to make the QA role more independent. This project is just proceeding to the selection phase so the QA firm has not yet been chosen.

PARTNERING AS PART OF QA/QC

By joint agreement of UDOT and Wasatch, partnering was made a part of the project from its inception. A partnering process was established with escalation processes identified to handle and resolve issues. The emphasis of the partnering process was to enable resolution of issues and problems at the lowest level possible in the project organization and in a timely fashion.

Both UDOT and Wasatch Constructors have firmly supported the concept of partnering and stated that they feel that the partnering process on this project has been very helpful and worked well. Wasatch indicated strong support for partnering from UDOT's top management level and stated they felt that this commitment has been critical to the success of this project. Very few issues have been escalated above the segment level for resolution.

The most significant issue that was escalated dealt with construction issues that arose at the north end of the project. At 600 North UDOT provided completed plans (sealed

drawings) for the construction of an interchange and railroad overpass to the contractor in hopes this could expedite the start of construction. However, there have been numerous problems associated with the construction of this interchange. These issues included potential claims for changed conditions, excessive settlement, changes to the original designs and other construction related issues. Early in the project a partnering session was held between Wasatch and UDOT to address the issues that developed at this interchange. The result of the partnering session was development of a Memorandum of Understanding (MOU) that became a partnering document.

This agreement outlined the methods to be used to resolve construction issues associated with changes to the original design parameters. Specifically this addresses the process required to modify the project without processing a change order or a claim. A process called a Technical Agreement was established so that the Contractor could propose changes to the original contract documents or his own proposed execution plans. If UDOT agrees that the proposed changes are at least equal to or better than that included in the original proposal then they can be approved without processing a change order. A technical agreement is processed to document the change. This process has been used extensively to handle changes to the original proposal. All parties to the contract signed a partnering agreement that spelled out this process and agreed to accept the process to be followed.

As a consequence of the partnering process no claims have been made to date on the project by Wasatch. About two hundred design changes have been agreed to using the Technical Agreement process.

The Wasatch and UDOT oversight teams hold a partnering meeting once per month to discuss what is working well and where improvements are needed. These meetings are held at the project manager level and are used for coordination. Segment level meetings are held as needed when issues are raised requiring a decision.

Wasatch has expressed their concern that the Award Fee process is counter productive to the concept of partnering on this project. The Award Fee was established by UDOT to provide incentives for quality and performance on the project. The amount of the fee is determined and awarded semi-annually. UDOT established the value of each semi-annual Award Fee in the contract documents. Wasatch feels that the Award Fee has resulted in increasing potential friction between the Owner and Contractor, which is contrary to the partnering concept that is intended to increase cooperation between the Owner and Contractor.

QUALIFICATIONS OF QA/QC STAFF

The Quality Control (QC) and Quality Assurance (QA) roles are provided by Wasatch under terms of the contract. The Owner provides what is termed "oversight" on the project with a small staff assigned to each segment. This staff is lead by an oversight manager who is an experienced UDOT resident engineer. He is assisted by two or three experienced UDOT construction inspectors, an FHWA engineer, one or two other employees (resident or design engineer level persons), and then one or two UDOT trainees. Part of the UDOT oversight staff is provided by consultants. The trainees and FHWA staff generally changes during the year while the rest of the over sight staff has generally remained stable throughout the duration of the project.

UDOT oversight staff continues to express concern over the experience level and number of inspectors assigned to the project by Wasatch. They have felt that the inspectors assigned to the project by Wasatch do not have sufficient experience in the types of construction executed on the project. This has been particularly true of the inspectors working on the paving segment. UDOT feels that few of the Contractor's inspectors have worked on large concrete pavement projects before. They have relied on UDOT oversight staff to assist in training them for their role on the project. UDOT has been willing to provide this training but it has concerned them that Wasatch has not provided their own training to supplement this.

On a traditional project the inspectors are given the charge to monitor quality and ensure that it is obtained. On this Design/Build project the Contractor has placed more responsibility on his production staff to provide the quality and has used the inspectors to assist the production staff accomplish this. This is a much different role than UDOT is accustomed to providing

UDOT oversight staff attributes the quality of the project more directly to the commitment of the Wasatch production staff and less to the inspection process. Schedule has been the driving force for the project and production has controlled the schedule. UDOT staff feels that the inspectors have not had as significant an impact on the quality of the project as UDOT expected. Wasatch has relied more heavily on the production staff to do the work correctly and to rework the areas that are unacceptable rather than have an inspector require this.

PERFORMANCE SPECIFICATIONS

The initial UDOT plan was to prepare many performance specifications for the work and use their standard prescriptive specifications for other elements. It is interesting that the Wasatch management feels that the performance specifications worked well but the UDOT oversight managers felt that they were not as enforceable as they would have preferred because some did not include sufficient specific enforceable performance criteria to go along with the specifications. Each UDOT segment manager expressed similar comments about this weakness.

The RFP required the contractor to develop procedures and specifications to meet the performance specifications. The contractor proceeded to prepare specifications, procedures and details to implement the performance specifications. If the contractor did not meet his own procedures he was asked to comply by UDOT management. Wasatch management felt that, since the work met the UDOT standard prescriptive specifications, it was not necessary to meet their own performance criteria, which often times differed. UDOT took the position that the contractor was given the flexibility to develop their own procedures. These procedures became a part of the contract and the contractor was therefore bound by his own criteria. In essence, the contractor's procedures transformed the performance specifications into prescriptive specifications. The contractor's management felt that they painted themselves into a corner sometimes with this process.

The UDOT manager for QC/QA oversight expressed his concern that many of the specifications developed by the contractor related more to the design activities than the construction activities. He thought there should have been more emphasis placed on the construction activities and quality of the end product. He strongly feels that if the performance specifications are used there needs to be a comprehensive set of criteria against which to gauge the performance.

SETTLEMENT OF EMBANKMENTS

A focus of the entire design process was to develop options that would result in reducing or minimizing the long-term settlement potential of the numerous earth fills on the project. The use of wick drains and mechanically stabilized earth (MSE) walls and two-staged walls were made to address these issues. From all indications these features have performed as intended. No significant settlement problems have been encountered in the project to date, even though some fills have settled almost 2 meters during the construction.

The only concerns expressed so far have been with cracks that have developed in approach slabs to structures. Some of these have been attributed to settlement under the slabs. Most of these slabs were designed to be jacked up if unacceptable amounts of settlement occur. These slabs have also been designed thicker than normal to withstand additional loads. UDOT and this review team will investigate this specific problem as the innovative method used in construction is evaluated later in this year. A separate chapter of the annual report will address these issues. The reader is referred to that chapter for a more detailed discussion of the problem and evaluation of the causes.

BRIDGE DECK CONSTRUCTION

Issues have been raised by UDOT staff concerning the bridge deck construction on the project. All of the steel girder bridges use a transverse post-tensioned concrete deck system. The post-tensioning is placed in the transverse direction and is used to widen the spacing between girders. There have been some cracking of decks observed. UDOT is

going to conduct a specific investigation into the cause of this cracking, whether it is serious, and assess whether it is a potential maintenance concern in the future.

Another issue UDOT has raised is the use of pre-cast deck panels on the bridges supported by pre-stressed concrete girders. These panels are used to form the deck and remain as part of the cast deck upon completion. UDOT has not used this process previously and they are uneasy with the use of such panels given the cold climate and extensive use of de-icing salts in Utah. Their concerns center on the long-term viability of the deck along the edges of the panels and the durability of the panels themselves. They have seen some cracks in the panels after they are in place and UDOT is not sure if this is a problem or not. They are also concerned that cracks will develop at the edges of the panels where the cast-in-place deck thickness is a minimum. So far cracks in this region have not been a concern. The panels have performed well and appear to be meeting the designers' expectations.

OTHER CONSTRUCTION RELATED ISSUES

The intensity of the construction activities is a challenge for the QA/QC and oversight teams to keep pace with. Much of the pavement and deck work is accomplished in the nighttime hours. The Contractor has chosen to do this for two main reasons. The first is the nighttime periods generally are cooler and makes it easier to handle and work the concrete. The secondary reason is that he has been able to close the traffic lanes during nighttime periods, typically between 10:00 p.m. and 6:00 a.m. This has allowed him to use closed traffic lanes as haul roads for concrete trucks which increases the volume of material he can place in a given time period. Construction also occurs during day light hours so both the QA/QC and over sight staffs have needed to plan for 20 hour per day operations. This requires double shifts and more personnel to cover all time periods.

The concrete pavement operations have been set up as its own segment, similar to the ATMS (automated traffic management system). This was done to provide more consistency in the construction and better use and coordination of the available equipment. This segment is responsible for all main line pavements throughout the entire length of the project. A major challenge for this group has been completing the pavement within the time frame required. The summer of 2000 is scheduled to have more than 300,000 cubic meters of pavement placed, more than half the project total. As mentioned in earlier sections, the QC staff on the project is relatively inexperienced in such a large Portland Cement Concrete pavement project. UDOT oversight staff has spent considerable time working with the Wasatch QC staff to help train the inspectors and respond to questions that have developed. UDOT has been agreeable to this arrangement because it has given them an opportunity to provide more direct input.

There has been some concern expressed by UDOT oversight staff that the Contractor has not had "hold" times built into the QC program where work is completed to a certain stage and inspected before proceeding. In some cases cited by the UDOT oversight staff

the Contractor's production staff has preceded forward with work when questions were still being considered about the prior work. In most instances the work has been found to be satisfactory but there have been some cases where rework has been required to correct problems. There are no contract provisions requiring a "hold" time so the contractor has proceeded with the work assuming the risk of possible rework or replacement if the construction work turned out to be unsatisfactory.

On the Legacy project, another UDOT sponsored Design/Build project scheduled for construction beginning in 2001, UDOT has modified the performance specifications. For that project provisions requiring a "hold" time at specified stages of the construction that permit UDOT or FHWA oversight staff to review the prior work before the Contractor proceeds have been added. The provisions provide a window of time, usually 24 to 48 hours, in which to complete the review before the Contractor can proceed. If UDOT does not perform a review within the time frame the contractor can proceed without the review

DATA COORDINATION & SECURITY

At the beginning of the project "Primavera Expedition" contract control software was in place and being used by both UDOT and Wasatch to track project information. The software was accessible through a computer network. UDOT staff recommended that a firewall be installed to provide security and protection for the programs' database. This was not done, therefore the reports in the database were not secure and it was possible for unauthorized access to occur and reported data could be changed. UDOT determined this was unacceptable, and a new secure database was created. This required an extensive effort to get the database established and populated with both old and new data. UDOT has successfully accomplished this but it was an inconvenience for a period of time.

These software programs help organize project data so managers can monitor the progress of the project and coordinate activities with the appropriate people. They enable project participants to access the data necessary to perform their responsibilities and make sure all elements of the project are on schedule. These software programs also allow for setting access rights (read/write, read only). It is recommended that the project Request for Proposals address this issue even to the extent of selecting a program and implementing it during the planning phase of the project.

ACCEPTANCE TESTING

Important Definitions:

Contractor Acceptance Testing (CAT) is a test or inspection that determines the acceptability of permanent work as each construction stage progresse**s.**

Owner Assurance Testing (OAT) is testing that is conducted to determine if the CAT and QA tests that are being taken are representative of the work being tested. These tests

are taken at a lower frequency than the CAT tests and are taken at random locations, not necessarily the same locations as the CAT tests.

Independent Assurance Testing (IAT) is the testing conducted to verify the calibration of testing equipment and processes being used.

Independent Assurance (IA) is an unbiased and independent audit of the Quality Assurance OAT, and Acceptance Systems used and is an independent verification of reliability of the test results obtained in the regular sampling and testing activities. The results of IA tests are not used as a basis of acceptance of material or work.

An independent private testing firm, ATSER, is performing OAT testing. ATSER is a subcontractor to the Utah Department of Transportation (UDOT). They make approximately 10% as many tests as the QC testers. ATSER prepares a statistical report that provides a means to measure or a benchmark, to compare the Contractor Acceptance Testing results. The reports from ATSER are available to the UDOT field personnel approximately a month after the tests are taken. This lag in reporting delays any proactive measures that could be implemented to correct improper testing or inspection procedures.

UDOT Region 2 is performing the Independent Assurance. They prepare a statistical report that compares the CAT, OAT and IA testing results. The report rates the quality of the test results in four categories:

1. Excellent
2. Good
3. Fair
4. Poor

Most of the results have been in the “Excellent” category.

Based on the information gathered in our interviews, this process should be looked at carefully in design-build-projects. A natural conflict occurs by having the contractor doing the inspection and testing. The contractor’s goal is to be on time and make a profit. It is natural for the construction personnel to look at an inspection as a potential problem. However, having the design/builder responsible for the QC process has the advantage of making the Contractor responsible for scheduling the QC process and controlling his own schedule.

INCENTIVE PROVISIONS

An Award Fee process was set forth in the contract to serve as an incentive to provide quality and enhance schedule performance for the project. The process has not functioned as well as either UDOT or Wasatch expected. The program has been revised

and modified several times to attempt to improve its implementation. The process is functioning as an incentive for schedule compliance and the Contractor has been awarded virtually all-eligible amounts of the award fee to date. The process is viewed as having less effect on the quality of the project because of the formulas used to determine the award fee earned and the factors used to weigh the elements of the project.

Segment 3's Oversight Staff indicated that there may be a deduction in the award fee for their segment due to quality related issues during 2000. The award fee had not yet been determined for that period when this evaluation was prepared. These issues are related to the amount of rework that has occurred to bring the project into conformance with the contract requirements in this segment.

On Legacy Parkway, UDOT has redesigned the Award Fee program. It was changed to be more of an incentive program that would reward the Contractor if he exceeded the contract terms on quality, performance or completion.

There are warranty provisions in the contract. UDOT has the option to accept bid items that require the Contractor to provide longer-term maintenance of the project. Specifically, UDOT can select options that require a five-year maintenance period, and then five one-year periods for up to ten years total. The contract specifies the type of maintenance that is required of the Contractor. Some maintenance items, such as litter pick up and snow removal, remain UDOT's responsibility. The contract contains conditions that require UDOT to exercise their first five-year option within the six-month window of time just before completion of the construction. They have the option to accept the five one-year extensions within six months of the start of that period. This was established to permit UDOT to evaluate the construction and then decide whether to invoke it. It was also provided as an incentive to the Contractor to build in quality so that if he were required to maintain the facilities his costs would be reduced.

UDOT has not yet reached the time period when these provisions can be invoked. However, there is some concern expressed by the UDOT oversight staff that UDOT may not decide to invoke those provisions. Each UDOT segment staff stated that they have been conducting their oversight with the expectation that the long-term maintenance clauses would be exercised. They each stated that they would have conducted their oversight activities differently had they expected UDOT to not exercise the maintenance provisions. The UDOT staff stated they would have assigned more UDOT personnel to the project and had a more traditional Owner inspection process if the maintenance provisions had not been in the contract.

Lessons Learned

Warranty. A key to this project, and any design-build project, is the need to have a warranty that the contractor knows will be enforced. On this project there are several warranty options but UDOT management has not yet been able to invoke the warranty options. It is expected that they will exercise at least some of them.

Award Fee. It is agreed by all we interviewed, with the sole exception of one UDOT manager, that the award fee was not as successful as was expected. It was originally designed to award a fee of up to $5 million each six months based on progress and quality. As it has been administered only progress had a significant impact and the contractor has been awarded nearly 100% each six-month period. The Legacy Parkway project has modified the program to be more incentive based on performance above and beyond the required level.

Settlement. While there was considerable concern during design regarding settlement of embankments, the design measures included in the contract seem to have been effective. After three years there are no significant settlement problems. The large settlements in high embankments occurred during the construction period prior to paving. Some settlements of the base foundation material were as much as two meters. Some UDOT staff is concerned about the potential for differential settlement at the interfaces between the normal weight fill and the lightweight fill but no significant problems are evident at this time. UDOT is conducting long-term studies to monitor these sites. Future reports are expected to be produced by the UDOT Research Division as results are obtained.

Stay-in-place Deck Panels. UDOT had never used stay-in-place deck panels and some of their staff was concerned that there could be bonding problems between the pre-cast stay-in-place forms and the cast-in-place deck concrete. After two years there are no apparent problems with these deck panels.

Nighttime work. This project has involved extensive nighttime work, especially in concrete placement for bridge decks and roadway pavement. This has placed a strain on both UDOT and Contractor resources to properly staff the QA and QC and over sight staff for both day and night time operations. Agencies and contractors contemplating design/ build where schedule is critical need to plan for additional staff requirements to meet this type of schedule.

Partnering. Both Wasatch and UDOT have expressed support for partnering on the project, including on the QA and QC programs. They each indicated that partnering has been valuable in resolving issues during the construction phase of the project.

Reduction of QA staff. After some experience with the plans both UDOT and Wasatch were using to monitor the QC program each realized that there was duplication that could be avoided. Therefore, Wasatch was permitted to reduce their staffing level on the QA process without appreciable reduction of results.

Contractor Hold Time. Consideration should be given to revise the specifications to require "hold" times at important stages of the project to permit time for Owner review of the work before proceeding. UDOT is proposing such changes on the Legacy Parkway Design/Build project to require an opportunity to review the work before proceeding.