HIGHWAY CONSTRUCT * ABILITY GUIDE

Prepared for

The Texas State Department of Highways and Public Transportation

Research Project 3-6-88-1149

Investigation of Highway Project Constructability Improvement

by

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FOREWORD

DATE: September 1, 1989

TO: Recipients of the *HIGHWAY CONSTRUCTABILITY GUIDE*

FROM: R. G. Welsch, P.E., Deputy Director for Design and Construction

SUBJECT: **Constructability Enhancement Program**

The purpose of the *Highway Constructability Guide* is to help you improve the construction of our highways. The objectives are to identify important issues and to suggest methods and procedures by which the experience acquired building highways can be effectively integrated into the planning, design, and field operations of SDHPT. It is the product of a research project currently underway at the Center for Transportation Research

This Guide marks the introduction of a Constructability Enhancement Program by the Department. It will be followed by other tools to assist with the implementation of the program. I wish to stress that there is no intention here to establish another organizational layer with all its attendant personnel and paperwork. Although the document is intended for senior SDHPT Division and District personnel, to define the functions and benefits of enhancing constructability — i.e., improving how we build highways — it should prove beneficial to all personnel.

If we are able to save only a small fraction of the expenditure on our highway system by implementing the Constructability Enhancement Program, the effort and money will have been well spent!

Thank you for your cooperation.

YOUR COMMENTS ON HIGHWAY CONSTRUCTABILITY PRIMER

The authors would appreciate particular comments concerning any aspect of constructability enhancement.. The comments may be in any form, i.e., statements, questions, suggestions, case studies, etc.

Your name, title/position, division/district and telephone number are requested in order that the authors may contact you for any necessary clarification of your comments.

Thank you again for your feedback.

Name ______________________

Title/Position ______________________

Division/District ______________________

Telephone No. ______________________

Please return this form to Dr. J. T. O'Connor, Center for Transportation Research, 3208 Red River, Suite 200, Austin, Texas 78705-2650.

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PREFACE

Knowing *how* to build highways is essential to optimal planning, designing, and administration of highway construction. Know-how is the consequence of learned and shared experience and, like any other knowledge, once learned it must be cultivated.

Construction experience, in the context of this *Highway Constructability Guide*, is considered a premeditated learning process whereby a participant in, or even an observer of, construction operations, understands what is taking place and can further describe and communicate, to others, the events, their purpose, and outcomes. This action differs from that of a mere spectator who, although excited in the presence of construction operations, has only a superficial and transitory knowledge of the events taking place and is unable to learn from or share these experiences with others. It has been often said that twenty years experience can be one year's experience repeated twenty times or twenty years of accumulative knowledge. It is hoped that, through the institution of a constructability program, the collective construction experience of the Department will represent ten thousand years of experience rather than one year's experience repeated ten thousand times.

It is intended that the *Highway Constructability Guide* contribute to the objective of achieving first-rate construction by suggesting means of focusing on construction issues of essential importance. The document is directed toward senior SDHPT Division and District personnel for the purpose of increasing their awareness of project constructability — its benefits and applicability.

WHAT IS CONSTRUCTABILITY?

Constructability may be defined as a measure of the ease or expediency with which a facility can be constructed.

Constructability is enhanced by the optimum use of construction knowledge and experience in planning, design, procurement, and field operations in achieving overall project objectives. (*Constructability: A Primer*, 1986)

Perhaps because constructability enhancement (CE) is by nature multidisciplinary and multifaceted, it means different things to the various participants in a project. To the project owner, constructability affords the opportunity, on construction projects, for achieving greater efficiency, with resulting lower cost, reduced schedule, or improved quality. To the designer, it is the understanding of the methods and constraints of the actual construction required to execute the design being made. To the constructor, it is a combination of effort required to implement the design most efficiently and the opportunity to minimize resource effort and expenditure.

The Construction Industry Institute (CII) has identified a number of constructability concepts applicable to the different phases of a project. Briefly, these concepts address project execution planning; conceptual project planning; specifications; contracting strategies; schedules; and construction methods, including those concerning preassembly, site layouts, design configurations, accessibility; and adverse weather (*Constructability: A Primer*, 1986). However, while constructability improvement has been studied and applied to many segments of the industrial construction industry, it has not been researched in the context of highway construction.

Constructability is indeed already practiced to some extent by planners and engineers of the Department , although it perhaps has not been formally defined and thought of as a primary factor in highway design and construction. While the bulk of constructability research to date has focused on industrial or commercial construction projects, most concepts are also applicable in the highway sector, and highway project costs and durations may be reduced when attention is directed toward more effective constructability.

RELATIONSHIP BETWEEN CONSTRUCTABILITY, VALUE ENGINEERING, AND PRODUCTIVITY

Value engineering, VE, has similarities to **constructability**, and their differences may not at first seem apparent. Innovative construction practices, leading to cost reductions, can be attributed to both CONSTRUCTABILITY and VE, from which it might be concluded that the two are synonymous. There are similarities in objectives and result, but the scope and reach of CONSTRUCT-ABILITY and VE are quite different.

Value Engineering is defined as a disciplined procedure for analyzing the *functional requirements* of a product or service for the purpose of achieving the essential *functions* of the product or service at the lowest *total cost.* Total cost, in this case, takes into account the owner's cost of planning, design, procurement & contracting, construction, and **maintenance over the life cycle** of the product or service and *may also consider the users' costs.* In the case of a governmental agency responsible for delivering a

Rotomilling ▶

service, users' costs should, of necessity, be considered in addition to production costs when the cost-effectiveness of a service is estimated.

Constructability, more particularly highway constructability, is primarily concerned with optimal construction costs consistent with the *function and quality* requirements and boundaries set out by the standards or policies of the Department. Thus, constructability enhancement (CE) should be considered, in part, one of several tools of VE. The effectiveness of both VE programs and CE programs is dependent upon participants who are willing to work together, and who can contribute and work as members of a team.

From a practical viewpoint and within the Department, contracted construction costs are by far the largest item in the budget, and it is most likely that the most significant improvements in productiv-

Reinforced earth method of construction ▶

ity will come about through constructability enhancement. In the case of the Department, which operates more or less on a fixed annual budget, **productivity** is equated with lower construction costs and/or improved quality. Lower costs means a greater supply of highway services can be purchased for the same amount of money, and quality improvements translates into increased durability and improved operations. One of, if not the most important function of CE, is therefore to provide feedback of construction experience to programming, planning, design, and construction.

The application of VE is similar in many respects to CE in that both concepts are applicable throughout the planning, design, and construction phases, and each is likely to have the most impact **during the early stages of project development**.

With respect to the *Highway Constructability Guide*, it is appropriate and important that the relationship between value engineering, constructability, and productivity also be clarified. By definition, the enhancement of constructability must result in productivity improvement. In contrast, Value Engineering will not necessarily always lead to an increase in productivity since it focuses on other aspects of a project. It should however be clearly understood that all three entities are construction industry cost effectiveness tools. The inter-relationship between the three entities can perhaps best be described schematically as shown in Figure 1.

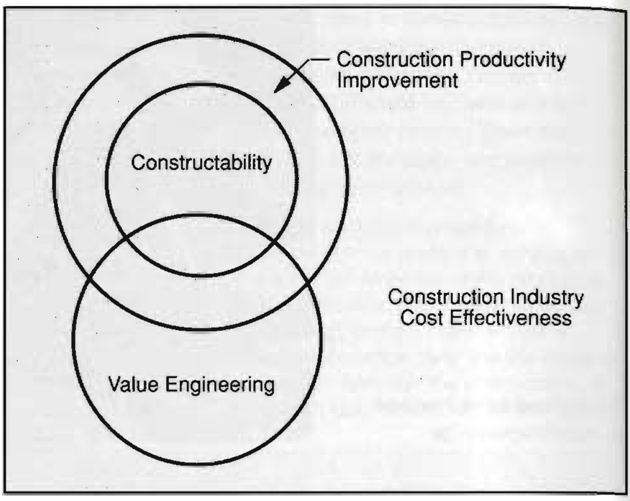


Figure 1. ▶ Construction industry cost effectiveness relationships

Thus, in summary the relationships between

productivity,
value engineering, and
constructability

are that:

(1) Productivity is a measure of the output / input-ratio in constructing a facility.
(2) Value engineering is concerned with providing the required functions of the facility at least cost.
(3) Constructability is a measure of ease or expediency of construction.

However, all have $ savings as a goal!

Geotextiles used in subsurface drains ▶

WHY PURSUE CONSTRUCTABILITY?

A multitude of **complex challenges and inhibitions** confronts highway constructors:

- Public accountability limitations, typical of some public works projects:
  - competitive bidding
  - difficulty of fast-tracking
  - little opportunity for early constructor input
  - higher performance expectations by the user
  - lack of understanding by general public about the long life-cycle cost consequences of poor planning and construction
- Influence of third parties:
  - property owners in ROW acquisition
  - public utilities in adjustments to their systems
  - the traveling public, particularly where construction takes place under traffic
  - institutional complaints by people concerned with environment and neighborhoods
  - political influences
- Design constraints:
  - FHWA and AASHTO directions/guidelines
  - ASTM, ANSI standards
  - maintenance constraints
- Nature of the construction operation itself:
  - unique design
  - separation of planning and execution phases
  - extensive site with varying geotechnical and climatic conditions
  - material-intensive operations
  - plant-intensive operations
  - transient workforce
  - unsheltered from the environment
  - changing technology
  - space intensive
  - abutting properties

Reinforced earth retaining wall under construction ▶

Proper and timely attention to the constructability of projects offers one way to meet the multitude of challenges! In general, the perception is that projects take more time than is necessary and that construction costs can probably be lowered. The **proven benefits** from constructability enhancement can be significant, as demonstrated by research findings in non-highway segments of the industry:

- Project capital cost reductions of 3 to 5%
- Program benefit-cost ratios of 10-20
- Reduced project durations
  - increased contractor productivity
  - reduced delays
  - reduced user costs
- Contractor manhour savings
- Improved public relations
- Enhanced quality & safety
- Reduced conflict/disputes and hence fewer claims
- Improved public relations
- More equitable distribution of risk between owner and contractor
- Capture of potentially lost experience
- Decreased maintenance costs.

Specific examples of benefits to highway construction are considered later in this Guide.

WHEN TO PURSUE CONSTRUCTABILITY?

Constructability should be addressed as soon as possible! It has been found repeatedly that project changes become increasingly more difficult to implement as the project progresses through its various phases. In the same vein, the control over cost reduces rapidly with time (see Figure 2). These findings underscore the **significance of early and effective consideration of constructability.** This is particularly true during the project planning and design phases, where the value of construction knowledge and experience, applied at the right time, can render the highest dividends.

When projects have characteristics different from those of previous projects, they require the acquisition and application of additional knowledge, which must be learned by experience.

Experience is gained during field operations, when

(1) Planning and design assumptions and predictions are either realized or not realized.

(2) Errors and omissions are discovered in the translation of the design to a physical reality.

(3) Construction challenges are met by using innovative approaches in the use of resources and methods.

However, construction experience gained from a particular project is frequently not effectively communicated to all concerned within the Department. It is then unavailable for subsequent projects. This happens when:

- The experience is distorted or lost due to faulty memories, poor records, and personnel turnover.
- The individuals with the relevant experiences are too few in number and/or too isolated geographically to conveniently disseminate their experiences to those who could benefit.
- The experience is discovered too late in order to realize any benefits from revisions of the project.

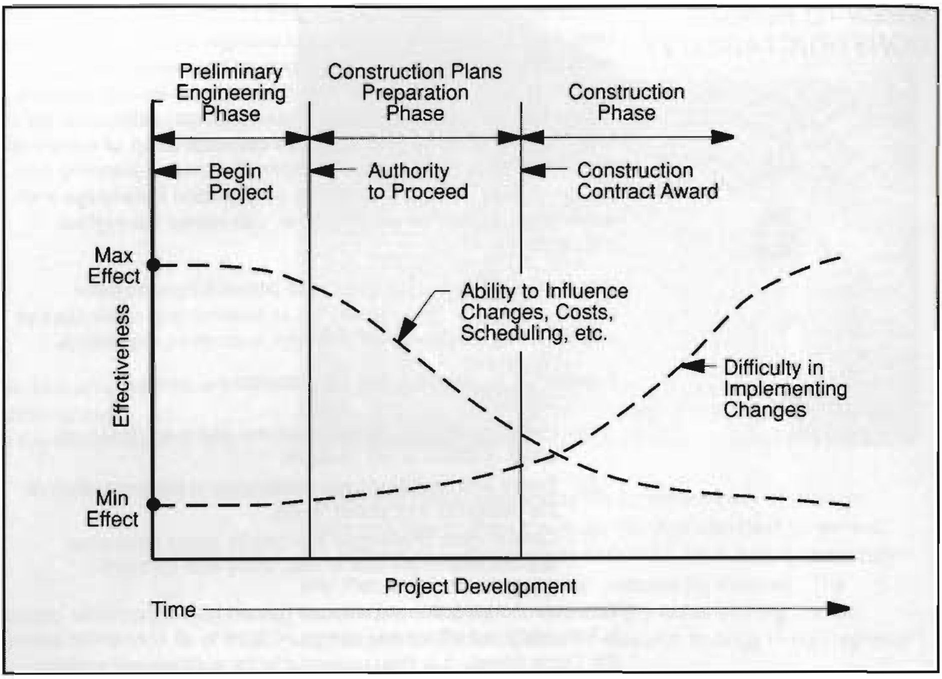


Figure 2. ▲
Significance of early decisions
(Adapted from Azud, 1969)

The above discussion underscores the significance of early and effective consideration of constructability. This is particularly true during the project planning and design phases, where the value of construction knowledge and experience, applied at the right time, can render the highest dividends. It is clear that once the project advances beyond these phases, investment and other commitments generally accumulate at rates depicted by the well-known S-curve. The ability to make changes to a project relates strongly to the S-curve. In the same vein, the ability to influence and control costs reduces rapidly since it is inversely proportional to the same curve. These trends are shown graphically in Figure 2.

FACTORS AFFECTING HIGHWAY CONSTRUCTABILITY

During the development of the various elements of a project, constructability is influenced by numerous and diverse factors. A listing of them is given in Table 1 where the factors have been grouped into seven categories for subsequent incorporation into a knowledge base.

<table>
<tr><th colspan="2">ENVIRONMENTAL SYSTEMS</th></tr>
<tr><td>● Site
- Topographical (Incl. Accessibility)
- Geotechnical
- Hydrological</td><td>● Infrastructural (Incl. Vehicular Traffic)
● Political/Legal/Regulatory
● Economical/Sociological/Financial
● Technological</td></tr>
<tr><th>PROJECT SCOPE</th><th>INFORMATION AND COMMUNICATION</th></tr>
<tr><td>● Operational Requirements
● Facility Characteristics:
- Structural Composition
- Complexity
- Scale
● Financial and Time Constraints:
- Budget and Schedule</td><td>● Documentation/Transmission/Interpretation:
- Availability/Source/Accuracy
- Clarity and Conciseness/Completeness
- Consistancy/Compatibility/Ambiguity
- Timeliness and Frequency
- Relevancy</td></tr>
<tr><th>RESOURCES</th><th>PROCESSES/METHODS PERTAINING TO:</th></tr>
<tr><td>● Material/Manpower/Plant and Equipment:
- Availability
- Variability/Flexibility
- Suitability
- Intrinsic Attributes</td><td>● Planning
● Design, Specification and Estimate
● Procurement/Bidding
● Construction
● Maintenance</td></tr>
<tr><th>CONTROLS</th><th>INNOVATION</th></tr>
<tr><td>● Quality Assurance/Quality Control, Testing and Inspection
● Cost and Financial Control
● Schedule Control
● Productivity Measurement</td><td>● Awareness of Prompters; Recognition of Need
● Stimulation/Encouragement
● Motivation and Freedom to Innovate
● Capability to Innovate: Resources and R&D
● Support of Champion/Innovative Leaders</td></tr>
</table>

Table 1. ▲
Factors affecting highway constructability

A CONSTRUCTABILITY ENHANCEMENT PROGRAM

The Department is a recognized leader in the construction of highway facilities. In a quest to retain its leadership status, the Department initiated a research program in October 1987 to study Highway Constructability Enhancement. The focus of the study has been to accelerate the application of construction experience into all aspects of capital project development. Benefits can be realized only when construction considerations are more effectively incorporated into conceptual planning, feasibility studies, designing, procuring, and field operations. Research is being done to identify procedures and tools for formulating and implementing a constructability program. A brief overview of some of the developments is given below.

Objectives and Issues

Constructability objectives have been established. They are to:

- Increase productivity
- Reduce project costs
- Reduce project durations
- Reduce delays/meet schedules
- Eliminate unnecessary activity
- Reduce physical job stress
- Promote safety on construction sites
- Reduce conflict
- Increase quality

With the assistance of a Departmental steering committee (see Appendix A for the list of members), a listing of constructability issues or concerns has been identified and prioritized for research and development. These are outlined in Table 2. Understandably, the list is long and the topics are rather broad in scope.

Table 2. ▶
Highway constructability issues and concerns

- Planning and design guidelines for enhanced highway construction
- Specification improvements for enhanced highway constructability
- Effective communication of constructability
- Selection, processing and management of materials
- Constructability enhancement through innovation
- Facilitating construction under traffic
- Facilitating future expansion and upgrade
- Optimal utilization of plant and equipment
- Optimal risk/responsibility allocation
- Constructability program implementation

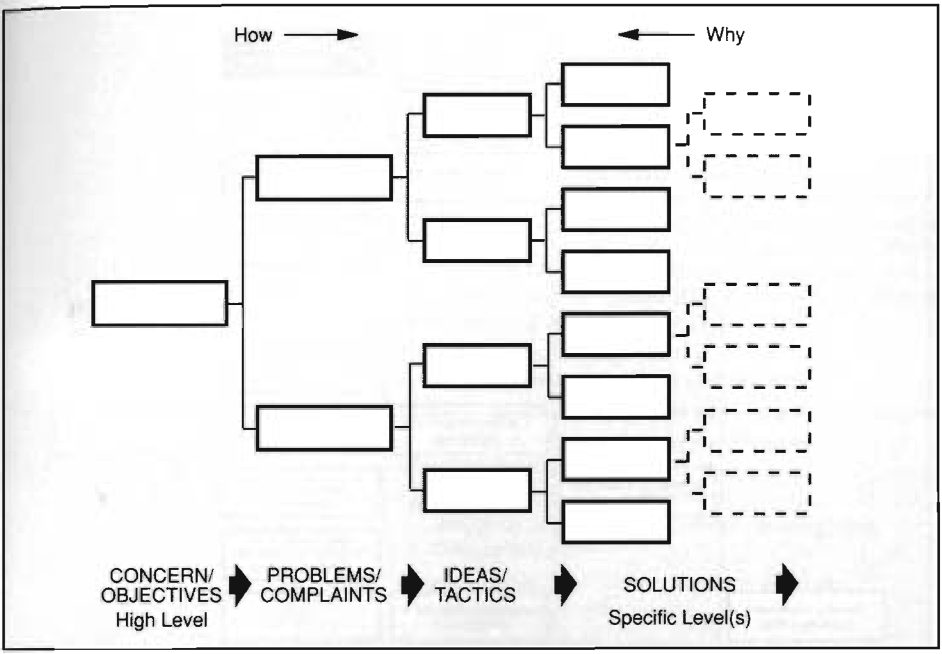


Figure 3. ▲
Constructability HOT diagram logic

Tools for Implementation

This research study was designed to produce results useful in implementing a constructability program. Apart from the *Highway Constructability Guide,* additional developments are underway. These are briefly discussed below.

- **Hierarchy of Objectives Technique (HOT)**:
This graphical technique for hierarchically modelling constructability objectives was adapted from value engineering techniques (Brown 1988 and Fisher 1989). Once major concerns or issues have been identified, high-order objectives (concepts or strategies) are followed by lower-order objectives (tactics or ideas). Diagrams may be developed in as much detail as desired, with the end nodes often serving as a catalyst for innovative problem-solving. In this way, objectives may always be viewed in their proper perspective. The logic used is that the question "how?" is asked as one moves from left to right through the diagram, and the question "why?" is asked as one moves from right to left through the diagram. A minimum of four tiers was established for the process logic of the diagram. These four basic tiers are concern, problems, ideas, and solutions. Figure 3 illustrates the logic used for the HOT diagram. A typical HOT diagram is shown in Figure 4. It depicts the optimizing of productivity for pavement operations.

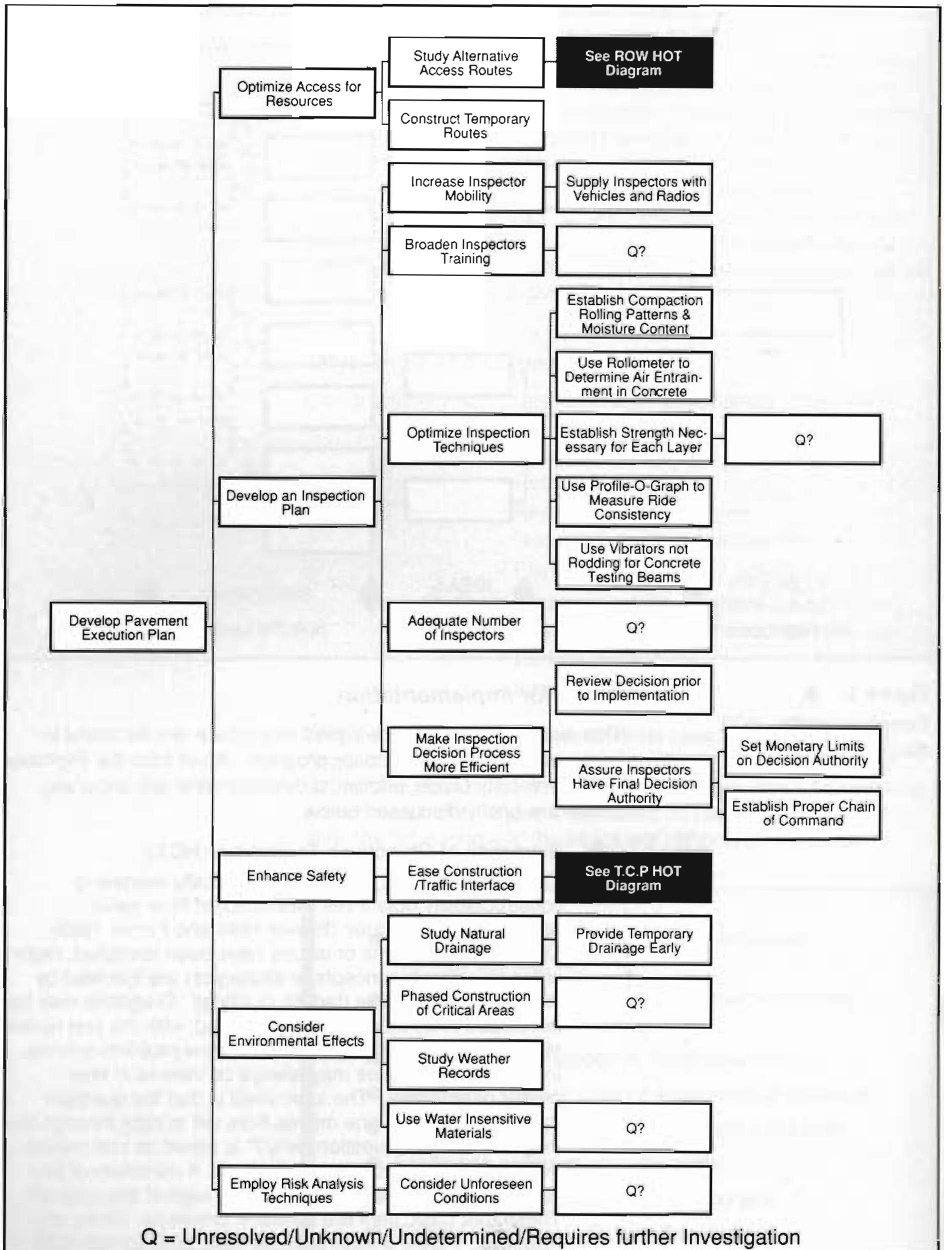


Figure 4. ▲

Typical HOT diagram (extract from pavement HOT diagram)

- **The Highway Constructability Knowledge Base**:

  The Highway Constructability knowledge base (KBS) is a collection of ideas obtained by personal interviews, expert sessions and literature reviews. A computerized information retrieval system for detailed treatment of constructability ideas is being developed (Redelinghuys, 1989). This will relate the HOT diagrams to the various elements of highway projects to be constructed, for example pavements. The HOT diagrams will also be related to other aspects, such as constructability factors in Table 1 and the applicable engineering phase. This approach also offers an efficient structure for continuing analyses and further research. Typical examples of applications or solutions to constructability constraints are given below:

(1) Acquire ROW in a timely manner
- resolve problematic ROW parcels early

(2) Minimize demands for ROW likely to be difficult to acquire
- employ techniques for achieving steeper cuts/ fills when necessary

(3) Reduce delays in utility adjustments
- design to avoid utility adjustment by using utility bridges or tunnels

(4) Ease or secure the traffic/construction interface
- use concrete safety barriers

(5) Speed up on-site bridge construction
- optimize off-site prefabrication for bridge construction

(6) Provide space for contractor accessibility and staging
- early consideration of additional ROW needs of constructor for storage and staging, access, and parking

(7) Employ tactics to reduce overall project duration
- ensure efficient scheduling of construction activities
- effective use of liquidated damages and incentives

(8) Optimize pavement unit productivity
- minimize the number of pavement layers, particularly in intersection design

(9) Develop a pavement construction execution plan
- develop a comprehensive inspection plan commensurate with the anticipated progress of the project

(10) Design earthworks to enhance constructability
- allow innovative deep-lift compaction

(11) Facilitate future expansion and upgrade
- locate utilities to minimize future adjustments
- design to take into account future maintenance and expansion

(12) Minimize specification-related problems
- change unrealistic tolerances
- remove references to obsolete methods or materials
- ensure consistent interpretation by removing ambiguity and educating and training users

Case Histories

Selected examples of constructability enhancement case histories that have been uncovered during the research studies are given below.

- **Working around utilities.**

  Case History: *A consultant was hired by the utility agency to redesign a highway to pass around a utility to avoid the need for relocation. This work cost the utility agency $1M, which was still significantly less than the probable cost of moving nine miles of underground piping.*

- **Dealing with congestion.**

  Case History: *In Houston, a junction box was designed to encompass a sewer pipe (See Figure 5). This design saved 8 to 9 months, which would have been needed to move the two 36-inch sewer pipes. Cost of the new junction box was $1,800 as compared to the $200,000 - $300,000 for moving*

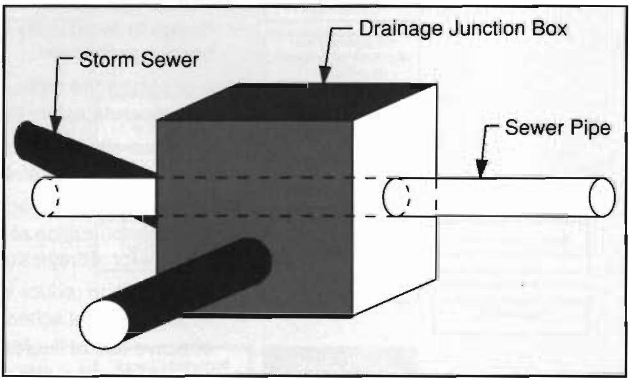


Figure 5. ▶
A junction box designed around a sewer pipe

the pipes and burying them at a 20-foot depth to avoid the drains. Some companies, however, are concerned about this arrangement because a break in the sewer pipeline at that point could pollute a large area via the drainage network.

- **Sloping the road so that side drains are on the driver's left in an area congested by utility lines.**

  Case History: *In an Austin project, where geometric constraints meant that the road had to pass close to one side of the ROW, where utility lines were buried, the designers sloped the road to the driver's left*

- **Protecting an underground pipeline with a reinforced concrete slab which was designed to support the heavy equipment construction loads.**

  Case History: *An underground pipeline discovered in the* *field was protected by an 8-foot-wide, 52-foot-long, and 6-inch-thick concrete slab to allow it to withstand equipment loading and reenforce later traffic loading.*

- **Allowing some utility lines to be carried across SDHPT-structures.**

  Case History: *Fiberglass ducts have been used to carry utility lines supported and suspended underneath bridges in order to reduce the dead load.*

- **Altering the design to allow for unexpected conditions.**

  Case History: *A major utility line, discovered in the field, was projected to run right through the position of a proposed bridge footing. The design of the footing was modified to avoid moving the utility.*

  Case History: *During construction, a water line was found to conflict with the top of a proposed junction box. Moving the water line at that stage would have delayed the job. A field change was issued, allowing the redesign of the box to prevent routing the pipe under the box. The redesign cost was $1,300, compared to the $30,000 - $40,000 estimated for relocating the water line.*

- **Using innovation.**

  Case History: *A box culvert had to be installed through an embankment beneath a railway line. The culvert was precast in an excavation beside the railway line and then jacked beneath the rails, which were closed for a few hours.*

  Case History: *On a project in District 17, it was necessary to remove and stockpile approximately 90,400 square yards of concrete pavement on a recently completed widening project. The contractor proposed that the old concrete pavement with its overlying hot mix, be recycled and used in the Type B mix. This was approved and the material was crushed, screened and stockpiled. The recycled material was added to the mix as 40% of the course aggregate to produce a good quality mix. The recycled material was sufficient to produce approximately 36,400 tons of Type B mix thus saving $50,000.*

  Case History: *In critical construction areas, storm water installations should be backfilled with cement-stabilized material in lieu of compacted soil, in order to expedite the construction and reduce the risk of delaying layer work.*

- **Using special structures to carry the utility lines over freeways.**

  Case History: *On a project where the cost of a utility bridge was borne by several utility owners, the total structure cost was reduced by the value of an overhead sign, otherwise required if the utility bridge were not needed. The increase* *in cost incurred in the design of the utility bridge in order to carry the weight of the signs and the additional wind load was negligible.*

Program Implementation: Barriers and Recommendations

While the benefits of a Constructability Enhancement Program have been demonstrated, it is also true that barriers to practicing good constructability are common. Managers should be aware of these barriers and they must be challenged.

Barriers

- Barriers to communication and design-construct integration

(1) contract terms
(2) lack of time
(3) lack of field feedback
(4) failure to document and communicate "lessons learned"
(5) lack of construction experience

- Barriers to utilization of advanced construction technologies

(1) lack of awareness of technologies/inadequate communication
(2) lack of necessary training
(3) regulatory inhibitors
(4) institutional and individual resistance to change
(5) reluctance to deviate from current and proven standard operations

- Barriers to innovation

(1) discouragement of personal initiative and perceived lack of freedom
(2) failure to recognize opportunities
(3) lack of personal creative ability
(4) lack of tools
(5) lack of senior support of champions

Recommendations

The following recommendations should be considered in implementing a highway constructability program:

(1) The **commitment of senior management** at the Division and District levels, which is crucial in support of constructability, must be obtained.
(2) A **strong approach to project management** with a single point of responsibility should be pursued.
(3) **Project execution plans** should be developed for large complex projects during the project concept conference (see Appendix B). Additional planning meetings and design reviews should be added to the traditional precon-

struction process. Some **issues should be treated earlier** and involve **greater participation** of involved parties.

(4) **A proactive approach** to constructability needs to be taken. Over reliance on late, reactive design reviews should be avoided.

(5) **Feedback from the field,** if not forthcoming, should be solicited on a periodic basis, both prior to, during, and after construction. This feedback should involve both **Department personnel, contractors and suppliers.**

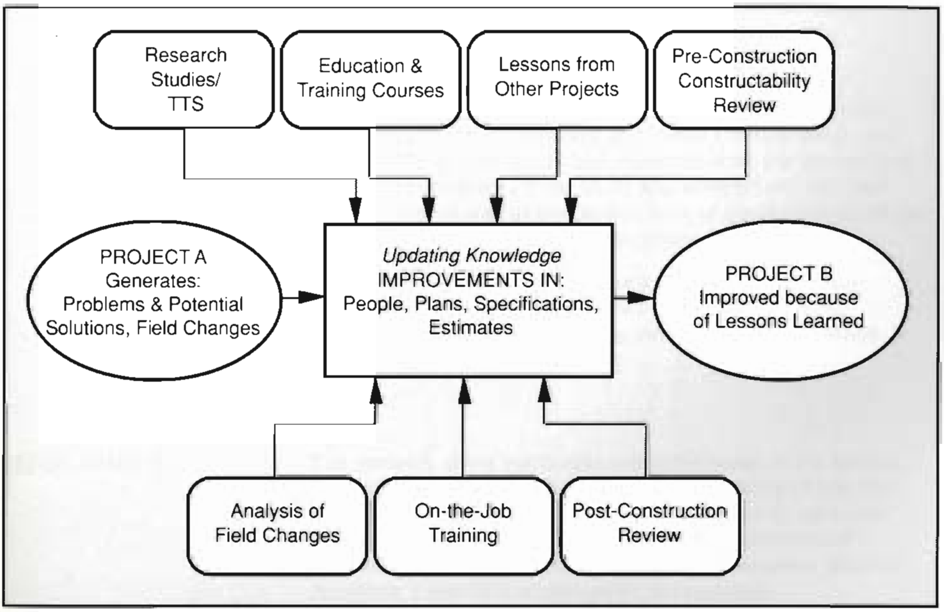
(6) "**Post-mortems**" should be conducted upon completion of all projects. They should be attended by representatives from both the Department and the contractor. Other interested parties should also be invited. These meetings should be utilized to report on **"failures"** as well as **"successes."** Increased opportunities for site visits should be made available.

(7) Management training programs that promote **communication and integration** between design and construction should be conducted. Project "team building" should be initiated on a trial basis and should include exercises for developing team leadership skills.

(8) An accessible and current **knowledge base of "lessons learned"** should be maintained. Advanced, computerized systems are being developed for storing and retrieving the information.

The practice of constructability enhancement is also illustrated by Figure 6, which shows various activities and interactions within the Department that lead to improvement in the constructability of a project.

Figure 6. ▼
Improving constructability



CLOSURE

Constructability enhancement primarily involves the communication of accumulated construction knowledge and experience. Thus it is essential that participants be *knowledgeable about highway construction* or, at the very least, be eager to acquire this knowledge. Such knowledge, to be communicated, must be relevant, sufficient, and timely.

The following aspects of constructability need to be aggressively addressed:

- Timely action
- Effective communication of constructability knowledge
- Systematic integration of constructability lessons
- Effective monitoring of technological developments
- Innovation

Project management addresses such items as cost, schedule, quality, safety, and aesthetics. It should be apparent that constructability is equally important. Where necessary, formal steps should be taken to ensure that it is.

Enhanced project constructability is a worthy goal, one requiring the commitment and enthusiasm of all Department personnel. Research developments are continuing and the findings should serve as tools for further enhancement of constructability.

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The photographs depicting methods of enhancing highway constructability were taken on several construction sites. Permission to reproduce them, by the companies concerned, is gratefully acknowledged.

DISCLAIMER

APPENDIX A. MEMBERS OF THE CONSTRUCTABILITY STEERING COMMITTEE

Roger G. Welsch	SDHPT — Deputy Director, Design and Construction
Benjamin W. Bohuslav	SDHPT — District Engineer, District 13
James E. Johnson	SDHPT — Highway Design Division
William R. Cox	SDHPT — Bridge Division
Gilbert M. Barr	SDHPT — Materials and Tests Division
W. W. (Wayne) Chambers	SDHPT — Construction Division
Tom Griebel	SDHPT — Planning and Policy Division
Gary K. Trietsch	SDHPT — Maintenance and Operations Division
James P. Opiela	SDHPT — District 16
Miles H. Hardy	SDHPT — District 15
Jon P. Underwood	SDHPT — Transportation Planning Division
James D. (Doug) Pitcock, Jr.	Williams Bros., Inc.
Roger Bailey	Austin Paving Co., Inc.
William L. Miller	J. D. Abrams, Inc.

APPENDIX B. SUGGESTED OUTLINE – HIGHWAY PROJECT EXECUTION PLAN FOR COMPLEX PROJECTS

I. Purpose

- Sets forth what is to be done, by whom, in what time frame, and with what resources.
- Documents all relevant facts, assumptions, and policies.
- Identifies all internal and external influences which will bear on the project.
- Communicates relevant project information to all project participants.
- Identifies unanswered questions/unresolved issues and assigns responsibility for action with the necessary completion date.

II. Scope of Work

- Provides detailed definition of all work to be performed as a part of the project, including supporting utilities and facilities.
- Defines interfaces and interactions with other facilities, systems, or projects.
- Where scope is indefinite, identifies the conditions required for its specific definition.

III. Project Objectives — Provides a statement of objectives/ policies such as

- balance between cost and schedule
- completion date
- quality
- safety
- specific operational requirements
- design life
- maintenance
- constructability
- productivity

IV. Project Team and Organization

- Identifies all personnel assigned to the Project Team, either full-time or part-time, including consultants.
- As contracts are awarded, identifies appropriate contractor personnel.
- When necessary, includes descriptions of responsibilities will be included.
- Includes organization charts for the Project Team to varying levels of detail.
- As contractors are brought on board, includes their organization charts to an appropriate level of detail.

V. Basis for Design

- Utility Requirements
- Aesthetic Requirements
- People Loading/Structural Loading
- Traffic Loading
- Weather Assumptions

- Functional Requirements
- Owner Standards/Design Criteria/Specifications
- Price/Budget Target for Scope of Work
- ROW requirements

VI. Project Schedule

- At first, presentation of an overall project schedule derived from required completion data allocating the total project duration to all functions specifically, including the conceptual planning by the owner.
- As project proceeds, this section will be expanded to set forth critical milestones for the project. The implications of missing a milestone will be set forth.
- Long-load procurements.

VII. Project Budget

- Statement of the financial budget approved for the budget at the level of detail by which financial review will be conducted.
- Estimates of cash flow from the owner throughout the life of the project.

VIII. Design

- By Owner (SDHPT)
- By Consultants
- Design Interfaces
- Design Schedules
- Design Quality Assurance
- Constructability Considerations

IX. Constructability – How will construction knowledge and experience be integrated into project planning and design?

X. Material Control

- Procurement Policies, Procedures, Responsibilities
- Vendor Shop Inspection
- Temporary Storage Facilities/Areas

XI. Construction

- Sequence of Operations
- Construction Schedule
- Training Requirements
- Safety
- Temporary Facilities
- Community Relations
- Progress Measurement/Reporting
- Quality Assurance/Control