ANALYSIS OF STATE TRANSPORTATION AGENCY METHODS FOR DETERMINING CONTRACT DURATIONS

BY

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To Anne, for her never-ending patience and support.

ABSTRACT

The ~~primary~~ purpose of this report was to analyze the various methods used by state transportation agencies for determining contract time. The analysis consisted of a discussion of the various considerations and ramifications of highway construction contract time determination, and an examination of the various procedures followed by state agencies across the country in determining contract durations with the use of survey information received. For the purpose of this report, contract time was considered to be synonymous with contract duration.

Evaluation of survey responses revealed that for the majority of cases, there are four basis for which contract time is determined: construction season limits, quantity or production rates, work-flow techniques, and estimated costs. Most commonly it was found that a combination of two or more of these are used to determine contract durations. These findings were in close agreement with those discussed in Transportation Research Board Special Report 79, Contract Time Determination.

With the belief that the use of productivity rates plays an important role in determining highway construction contract durations, special attention was given to methods

involving these rates, with a comparison made of work item productivity rates from several states. A comparison of these rates is found in Appendix A.

Based on analysis of the various methods used by state transportation agencies in determining contract time, this report proposes that, with the exception of large, complex projects, simple bar charts be used for this endeavor. A step-by-step approach to this method is outlined in the final chapter of this report.

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

Figure

CHAPTER I

INTRODUCTION

A. Background.

An essential ingredient in any highway construction contract is the amount of time allowed to complete the work. Because of the increasing complexity of modern highway construction projects, the nature of the contractual relationship between contractors and public agencies, and the desirability of timely completion, sound engineering judgement and careful planning is critical in establishing the contract time for a project.[1] Considerable time and effort is devoted by many state transportation agencies towards setting reasonable highway construction contract durations, because each day of work beyond the project completion date generates proportional costs for the agency, the road user, and the general public.[2]

Because most present-day highway construction projects are directed more towards the improvement of existing roadways rather than the construction of new ones, the affects of close working conditions, traffic interruptions,

conflicts with existing structures and utilities, and political and regulatory encumbrances must all be taken into consideration when determining contract durations. It is these considerations that agencies are responsible for acknowledging when determining contract time allowed for project completion.

Because of the repetitious nature of work items involved in highway construction, one would think that the methods used in determining contract durations would be quite similar from one state to the next, but upon investigation, it is found that many methods, and combinations of methods, are used across the country. The degree of complexity and effort range from conceptual time estimating to a detailed critical path method (CPM) analysis of the project. Techniques that rely on individual judgement contrast with those that draw heavily on historical data accumulated by an agency.

B. Objective.

The objective of this report was to first discuss the various considerations and ramifications of highway construction contract time determination, and then analyze the various procedures followed by state agencies across the country in determining contract durations with the use of survey information received. Comparisons were made, and conclusions and recommendations offered on their use.

With the belief that the use of productivity rates plays an important role in determining highway construction contract durations, special attention was given to methods involving these rates, with a comparison made of work item productivity rates from several states. A comparison of these rates is found in Appendix A.

CHAPTER II

RESPONSIBILITIES AND CONSIDERATIONS IN DETERMINING CONTRACT TIME

A. Highway Construction.

Highway construction is unique from most other categories of construction in that it is very equipment and field material oriented. Projects of this type are characterized by large numbers of power shovels, tractor-scrapers, pile drivers, draglines, large cranes, heavy-duty haulers, paving plants, rock crushers, and associated equipment types.[3] This class of construction covers such things as clearing, excavation, fill, aggregate production, subbase and base, paving, drainage structures, bridges, traffic signs, lighting systems, and curb and gutter.

Because most highway construction differs very little from one contract to the next in comparison to most other types of construction, it lends itself most readily to planning and scheduling efforts that can be depended upon. It is this repetitiveness that aids state agencies in determining construction contract durations.

B. Defining Contract Time.

Before an evaluation of the methods of determining contract durations can be approached, the actual definition of contract time should be defined. Not surprisingly, this definition varies from state to state and from contract to contract. Contract time can be based on an estimated number of working days or calendar days or on a specific completion date, which may be established by computing working days or determined by external influences.[4] The American Association of State Highway Officials defines calendar days and working days as follows:

Calendar day. Any day shown on the calendar beginning and ending at midnight.

Working day. A calendar day during which normal construction operations could proceed for a major part of a shift (Saturdays, Sundays, and holidays are usually excluded).

Controlling items, or items of work that are large in volume, require lengthy periods of time for completion, or are on the critical path of a precedence diagram are usually the basis for charging a work day.[5] Typically, working days are charged to a project when conditions for more than one-half of a normal shift is suitable for work. This varies, however, as several agencies often charge only fractions of a day.

A calendar-day contract is not necessarily the same as a specific completion date contract. Contracts of these types may or may not include provisions for guaranteed work days or a specified number of days per month. The most common types of contracts used by state agencies across the country are completion-date contracts, with or without a guaranteed number of working days. The following completion-date contract specifications were derived from several states[6]:

Completion date (specific). The contractor must have all (essential) work completed by a specific date without regard for working days.

Completion date (guaranteed working days). The contract completion date can be extended if the contractor has not had available the number of working days as stated in the contract. Either the number of working days for each month or the total number of days for the contract period may be stipulated.

The North Carolina DOT Standard Specifications defines contract time as: "The number of calendar days inclusive between the date of availability and the completion date, said dates being set forth in the special provisions, including authorized extensions to the completion date."

C. Determination, Review, and Approval Procedures.

Direct responsibility for determining contract duration varies from state to state depending generally on the method used in establishing contract time limits. If the procedure used is the critical path method, or something on a similar level, design team personnel within a transportation department typically prepare the first estimate which is then reviewed by the department's construction division. If experience or construction seasons are the basis for determining contract durations, construction unit personnel will usually have the responsibility for setting the time limits.[7]

Regardless of who the individuals might be that determine contract duration, it is of utmost importance that a construction data file be maintained for such items as production rates, time, weather effects, job conditions, etc. over the previous 3 to 5 year period for all jobs. The determination of reasonable contract durations can only be expected with the use of reliable historical data.

In Florida, the determination of contract duration is performed at the district level by the District Estimates Engineer during the design phase of a project; this is then reviewed by the District Construction Engineer.[8] Contract durations in some agencies are set by the district office with the approval of the headquarters' design or construction section (see Figure 2.1). The headquarters

level of other agencies set contract durations with districts having input on major or critical projects. Minor projects in these cases might go directly to the contract office (see Figure 2.2). A chart showing the procedure for determining contract time in Georgia is shown in Figure 2.3.[9]

D. Factors Effecting Contract Time.

The contract time set by an agency may require some adjustment because of external factors that affect the construction progress or necessitate the completion of a facility by a specific date. These include[10]:

-Coordination requirements

-Commitments

-Effects on road users and others, and

-Financial requirements.

Coordination Requirements

One important coordination requirement involves staged construction. Because delay in completion by one contractor may result in claims for delay by a subsequent contractor, some contracts or portions of contracts must be completed by a specific date. In these cases, it is often best to make use of a specific-date type contract with a high rate of liquidated damages rather than a working-day or calendar-day contract. Using the latter methods can

quite easily result in follow-on contractors being put at a disadvantage due to relatively minor delays incurred by the first-stage contractor such as delays caused by weather or material shipments. Additionally, because it is the state agencies that determine working days available, it is they that are most vulnerable to claims as a result of late contract completion by an earlier-stage contractor.

Another common requirement in coordination involves the delivery of materials. Bituminous materials, cement, and other essentials necessary in road construction that are most vulnerable to shortages during peak construction periods can cause serious contract delays. One way to handle the problem is to schedule completion so that the critical stages will be completed before shortages develop. In some cases, contracts for major structures are awarded separately at earlier dates in order to ensure that materials are delivered on time.[11]

Some of the most difficult coordination requirements an agency might face are those that involve other events such as the coordination of the completion of a transportation facility with urban renewal, the opening of a major shopping center, construction of a utility or railroad project, or other special events.[12] As with staged construction, specific completion-date contracts with sufficiently large amounts of liquidated damages are best suited for this type of construction.

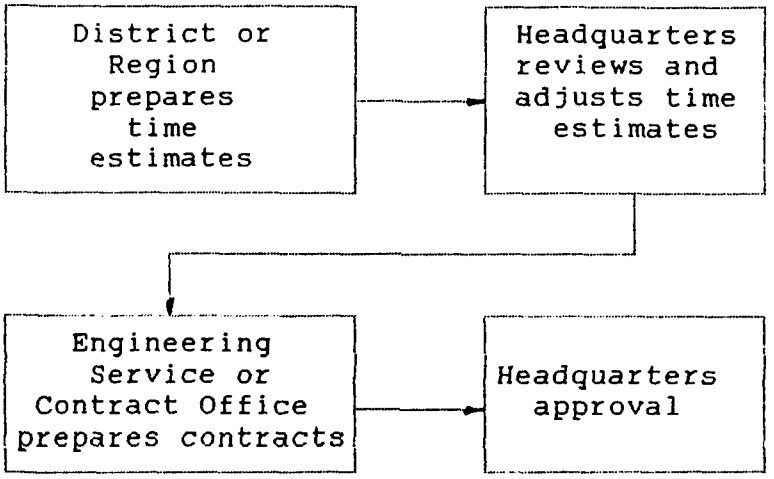

Figure 2.1 Contract Time Determination and Review Originating at the District Level.

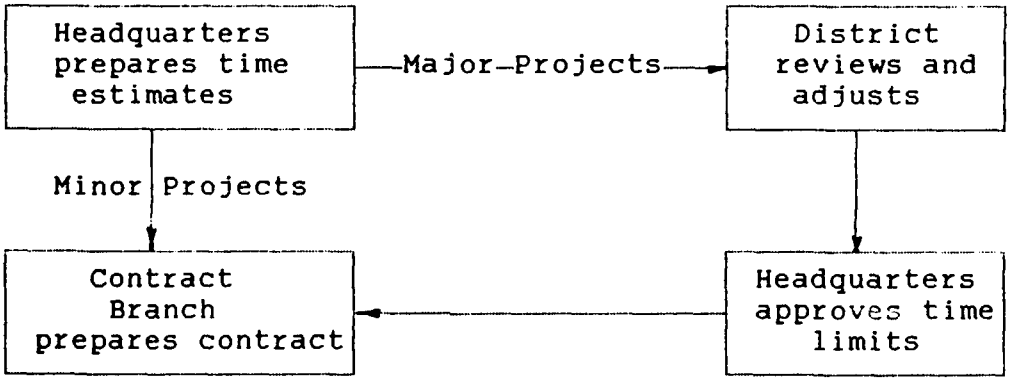

Figure 2.2 Contract Time Determination and Review Originating at the Headquarters Level

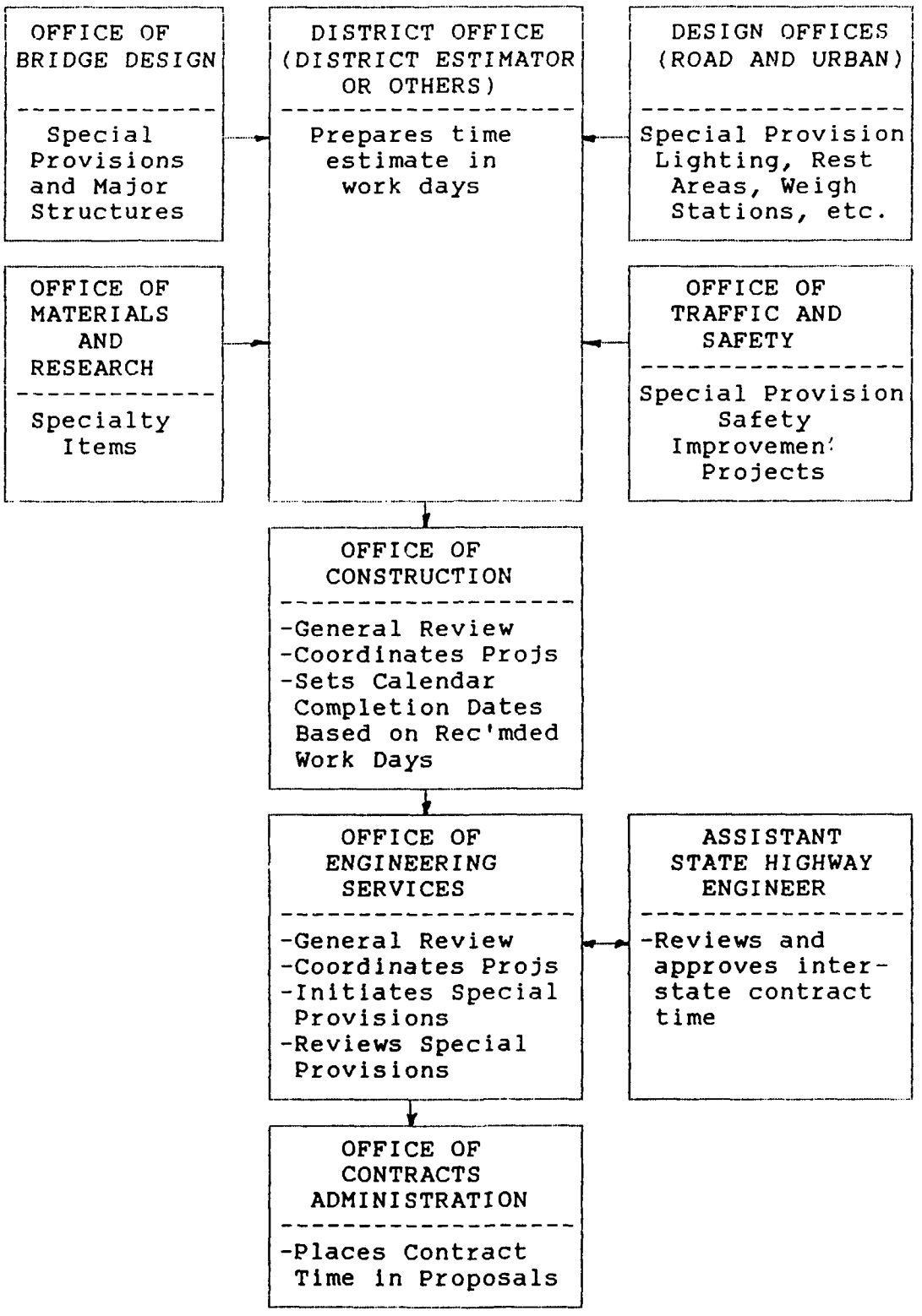

FIGURE 2.3 Procedure for Determining Contract Time (Georgia).

Without proper coordination, contract delays may be encountered due to utility work delays. Avoidance of unnecessary street cuts or other utility work that often follows highway or street paving can be realized with proper attention given to the coordination between transportation and utility departments.

Commitments

State agencies occasionally make commitments to local governments that certain projects will be completed by a specified date. Because of the pressure to fulfill these commitments, these type contracts generally specify a mandatory completion date.

Effects on Road Users and Others[13]

The demands of traffic in urban areas have caused agencies to be extremely careful when setting completion dates. High traffic volumes can greatly delay a contractor's work, and at the same time, construction work can seriously impede traffic. A lengthy detour around a project will generate considerable costs in terms of time, fuel, and maintenance. Travel on a project site that is hindered by construction delays also increases road-user costs in terms of time, safety, and convenience. The increase in such costs is largely affected by field conditions, the degree of completion of the project, and the adequacy of provisions for traffic maintenance and protection. On the other hand, if a contractor were to

initiate double shifts to complete a project by an unreasonable date, greater exposure to hazards and traffic disruptions might result than would occur with the expeditious continuation of work with moderate use of overtime. Therefore, establishing a tight, optimum completion time cannot be justified in all cases solely by road user costs.

Roads under construction generally have a detrimental impact on business and abutting property owners, even when contract provisions have been included to cover this situation. However, once the roadway and driveways are paved, the impact of minor completion work is generally negligible. For this reason, it may be desirable to assess working days and liquidated damages on one level when traffic or access is disrupted and assess them on a smaller level for failure to complete minor work on time.

Financial Requirements

State financing and budgeting personnel across the country are mixed on their feelings towards the importance of precise computation of contract duration for purposes of budgeting. Some agencies feel that there are too many other factors affecting the expenditure rate for this to have any significance, while others feel that contractor payments and contract time are major factors in predicting cash flow.

Engineering manpower and supervision costs are also important considerations when establishing contract durations. The conservation of these costs may be realized with proper planning on the part of state agencies.

E. Working-Day Time Charges.

An agency's policy for making time charges and granting extensions naturally has a direct effect on the completion of construction projects within the allowed contract time. If an agency expects its calculations in determining contract durations to be predictable, it is essential that the charging of time on all contracts be consistent and reasonable. When lenient policies are followed on some projects and more harsh policies on others, time and effort devoted towards establishing reasonable contract durations may be wasted. As discussed above, controlling or major work items identified by the agency are generally the basis for charging time on a project. Another key consideration is the amount of time in which the work may be completed.

Several factors which effect the amount of working days charged to a construction project are left to the discretion of the project engineer. Typically these include adverse weather conditions, material shortages, delays in material deliveries, and labor problems. Factors that generally receive automatic extension of time on a

contract, or result in possible working days not being charged include agency delays, additional items of work, quantity overruns, utility adjustments, coordination with other contractors, scheduled public events, or delays caused by things such as fires, floods, war, or sovereign acts of government.

The effect of adverse weather on a project can be difficult to determine. Large projects may encompass various sites that may experience slightly different weather conditions. Additionally, an evaluation must be made as to whether or not controlling items of work have been effected by the weather. Where cold temperatures might halt pavement striping, they would probably have minimal or no effect on work items such as guard-rail placement, except in the case of frozen ground. Accurate documentation of weather conditions on a daily basis is essential in avoiding later arguments and claims by the contractor that weather conditions were not favorable enough to allow work on particular days.

When there is an unforeseeable shortage of material beyond the control of the contractor, general practice is to not charge resulting delays as working days. Unless there is an industry wide shortage in which an agency would already be aware of the situation, the contractor is responsible in providing documentation to the agency proving that the delay was beyond his control. This

documentation may include a letter from the manufacturer or vendor stating the reason for the delay along with the date that the contractor ordered the material.

Sometimes, when determining contract durations, agencies fail to take into consideration long lead times necessary for the fabrication and delivery of some materials required on a project. If a contractor can show that he placed an order in a timely manner with a reputable supplier, the fabrication and delivery times for that material are reasonable, that the material couldn't have been supplied sooner by any other available supplier, and the delivery of these materials causes a delay, then the delay is generally not charged against working days.

Labor problems incurred by a contractor which create shortages or cause delays are generally given due consideration by most agencies, even on completion-date projects. Labor strikes involving a contractor's employees would result in delays that would be easily calculable, however, the influence of strikes remote from the work area which might hinder a necessary supply of material to the project, although harder to determine, should also be considered when charging time.

Right-of-way and access problems that delay the start or continuation of a controlling work item are agency-caused delays which are considered sufficient justification for not charging work days to a project. In fact, the

Supreme Court of Montana has ruled that an agency's delay in furnishing a highway right-of-way was a breach of contract for which the Montana State Highway Commission was liable.[14] Other agency caused delays might be the result of design changes or errors in field work on the part of the agency. In any case, agencies are generally quite liberal when charging work days or granting time extensions when the reason for the delay was due to their own actions or inactions. In today's litigious society, this policy is normally deemed prudent as agency delays may result in liability for such things as[15]:

-Overhead expenses of the contractor and subcontractors (for both home offices and field offices) attributable to the delay.

-Equipment costs for each additional day equipment must remain on the site.

-Escalation in labor costs due to increases in wage rates during the delay period.

-Direct costs of delay including such items as extra labor.

-Labor inefficiency where scheduling is disrupted owing to the delay, and the work forces are not used at normal efficiency.

F. Liquidated Damages.

It has become almost standard practice to include contract provisions for liquidated damages in construction contracts. Such provisions have been found valid by the courts as a method of compensating a party, in this case an agency, for costs and delays incurred when a project is not completed within the contract time specified. This is considered by the courts as a breach of contract.

The main benefit to the contractor of liquidated damage provisions is the avoidance of subsequent claims for damages. If a contract does not contain a liquidated damages provision, the contractor is liable for actual damages it causes by its delay. Liquidated damages are used in lieu of a determination of the actual damages suffered.

In order for an agreement fixing the amount of damages made in advance of a breach to be enforceable as a contract it must be shown that (a) the amount so fixed is a reasonable forecast of just compensation for the harm caused by the breach, and (b) the harm that is caused by the breach is one that is incapable or very difficult of accurate estimate [Barr & Sons, Inc. v. Cherry Hill Center Inc., 217 A.2d 631 (N.J. Super. Ct. 1966)].

In the event that the requirements stated above have not been met, for example when damage amounts are deemed excessive or unreasonable, liquidated damages provisions

may be considered penalty clauses which are unenforceable. In this case, an agency would either receive nothing or the recovery would be limited to actual damages incurred.

The items most often considered when estimating amounts of liquidated damages are[16]:

-Additional costs of engineering, administration, etc.,
-Loss of time,
-Increased operating costs and safety for facility users, and
-Damage and inconvenience to adjacent property owners.

Typical schedules for liquidated damages in relation to original contract amount are shown in Figure 2.4.[17] Use of these type schedules simply reduces the effort required when preparing contract specifications. As can be seen, rates vary from contract to contract.

F. Incentive Payments.

One way in which agencies can keep the amount of construction time to a minimum is to include incentive clauses in the contract. Such provisions provide for a bonus for each day of early completion and liquidated damages for late completion. When used, bonus payments are usually equal to the benefit of early completion. A

SCHEDULE OF LIQUIDATED DAMAGES

Original amount of contract		Per diem Amount of Liquidated Damages	
For more Than	To and Including	Calendar Day	Workday
$ 0	$ 25,000	$ 30	$ 42
25,000	50,000	50	70
50,000	100,000	75	105
100,000	500,000	100	140
500,000	1,000,000	150	210
1,000,000	2,000,000	200	280
2,000,000	---------	300	420

*Calendar day amounts are applicable when the contract time is expressed on the calendar day or calendar workday or fixed date basis.

Schedule of Deductions for Each
Day of Overrun in Contract Time

Original Contract Amount		*Daily Charge	
From More Than	To and Including	Calendar Day	Work Day
$ 0	$ 25,000	$ 30	$ 42
25,000	50,000	50	70
50,000	100,000	75	105
100,000	500,000	100	140
500,000	1,000,000	150	210
1,000,000	2,000,000	200	280
2,000,000	3,000,000	300	420
3,000,000	5,000,000	500	700
5,000,000	7,500,000	750	1,050
10,000,000	15,000,000	1,500	2,100
15,000,000	20,000,000	2,000	2,800
20,000,000	25,000,000	2,500	3,500
25,000,000	30,000,000	3,000	4,200
30,000,000	35,000,000	3,500	4,900
35,000,000	and over	4,000	5,600

*The daily charge shall be made for every day shown on the calendar beyond the specified completion date; and, when the time limit is specified as working days, the daily charge shall be made for each additional working day, computed as specified in Article 108.04.

Figure 2.4 - Typical schedules for liquidated damages.

Charge for liquidated damages for each day of delay

Original contract price		Calendar Day or Specified Completion Date	Working Day
From more than-	To and including-		
$ 0	$ 50,000	$150	$210
50,000	100,000	250	350
100,000	500,000	400	560
500,000	1,000,000	500	700
1,000,000	2,000,000	600	840
2,000,000		700	980

LIQUIDATED DAMAGES. Unless otherwise provided in the contract, liquidated damages will be in accordance with the following schedule:

Original Contract Amount		Daily Charge
From More Than	To And Including	
$ 0	$ 25,000	$ 30.00
25,000	50,000	50.00
50,000	100,000	75.00
100,000	500,000	100.00
500,000	1,000,000	150.00
1,000,000	2,000,000	200.00
2,000,000	---------	300.00

Schedule of Liquidated Damages for Each Day of Overrun in Contract Time.

Original Contract Amount		Daily Charge	
From More Than	To and Including	Calendar Day or Fixed Date	Work Day
$ 0	$ 25,000	$ 30.00	$ 42.00
25,000	50,000	50.00	70.00
50,000	100,000	75.00	105.00
100,000	500,000	100.00	140.00
500,000	1,000,000	150.00	210.00
1,000,000	2,000,000	200.00	280.00
2,000,000	4,000,000	300.00	420.00
4,000,000	7,000,000	400.00	560.00
7,000,000	10,000,000	550.00	770.00
10,000,000	----------	700.00	980.00

Figure 2.4 (continued)

provision of this sort is normally used only for projects that are time-critical.

This concept is also sometimes referred to as "reverse liquidated damages,"[16] whereby damage amounts for both owner-caused delays and contractor-caused delays are stipulated in the construction contract. An advantage to the agency when using this type of provision is that a ceiling is placed on the amount of damages that can be demanded by the contractor for agency-caused delays.

In a survey of state transportation agencies conducted by the National Transportation Research Board, only 10 of 43 respondents indicated that they provide for incentive payments on construction contracts. The reluctance on the part of agencies to use such provisions is due to arguments that include[19]:

-Difficulty in budgeting an amount for bonus payments.
-Need for additional data to decide on an amount or rate.
-Value received may not be proportional to the additional cost.
-Increase in claims by contractors.
-Provision in contract for liquidated damages is sufficient incentive.

CONTRACT #33482
FAI Route 94
Section
1975-118-R&BR
Cook County

SPECIAL PROVISION--INCENTIVE/LIQUIDATED DAMAGES

Because time is of the essence in completing the contract work Sections 108.10, 102.07(c), and 102.07(f) of the Department's Standard Specifications for Road and Bridge Construction are hereby deleted in their entirety and the following is substituted therefor:

FAILURE TO COMPLETE THE WORK ON TIME

NORTHBOUND LANES
Should the Contractor fail to complete all the work including cleanup on the northbound lanes as required by this contract, on or before October 31, 1979, the Contractor shall be liable to the Department for each calendar day after October 31, 1979, as liquidated damages and not as a penalty, in the amount of $10,000. Such daily amount shall continue to accrue until such time as all work on the northbound lanes under this contract is completed. Provided, however, if this contract is part of a combination bid award, such daily amount shall continue to accrue regardless of completion of work on the northbound lanes under this contract until all work on contracts which are a part of the combination award has been completed.

INCENTIVE PAYMENT

NORTHBOUND LANES
Should the Contractor complete all the work on the northbound lanes including cleanup, as required by this contract; before September 30, 1979, the Contractor shall be entitled to $5,000 as an individual incentive payment for each calendar day of completion prior to September 30, 1979. No individual incentive payment will be made should any work not be completed before September 30, 1979, regardless of any extension of time. Individual incentive payments shall in no event be paid for more than 50 calendar days. If this contract is part of a combination award, no individual incentive payment shall commence on this or any other contract which is a part of the combination until all work on contracts which are a part of the combination award has been completed.

Should all work on the northbound lanes be completed for all six sections of the Edens Expressway reconstruction as covered by this contract and by Department contracts numbered 33434, 33470, 33461, 33432, 33433, the Contractor shall be entitled to an additional $5,000 as a cooperative incentive payment for each calendar day of completion prior to September 30, 1979. No cooperative incentive payment will be made solely because the Contractor has finished early and no cooperative incentive payments will begin to accrue until the date of completion of all work on the northbound lanes under this contract and the five contracts enumerated above. The Contractor and the Department recognize that the prosecution of work by other contractors may not be effectively under the control of the Contractor; however, it is also recognized and agree that the nature of the project is such that use of the highway cannot safely and efficiently begin until all sections are completed. No cooperative incentive payment will be made should any work not be completed before September 30, 1979, regardless of any extension of time. Cooperative incentive payments shall in no event be paid for more than 50 calendar days.

Figure 2.5 - Special provisions for incentive payments and liquidated damages (Illinois).

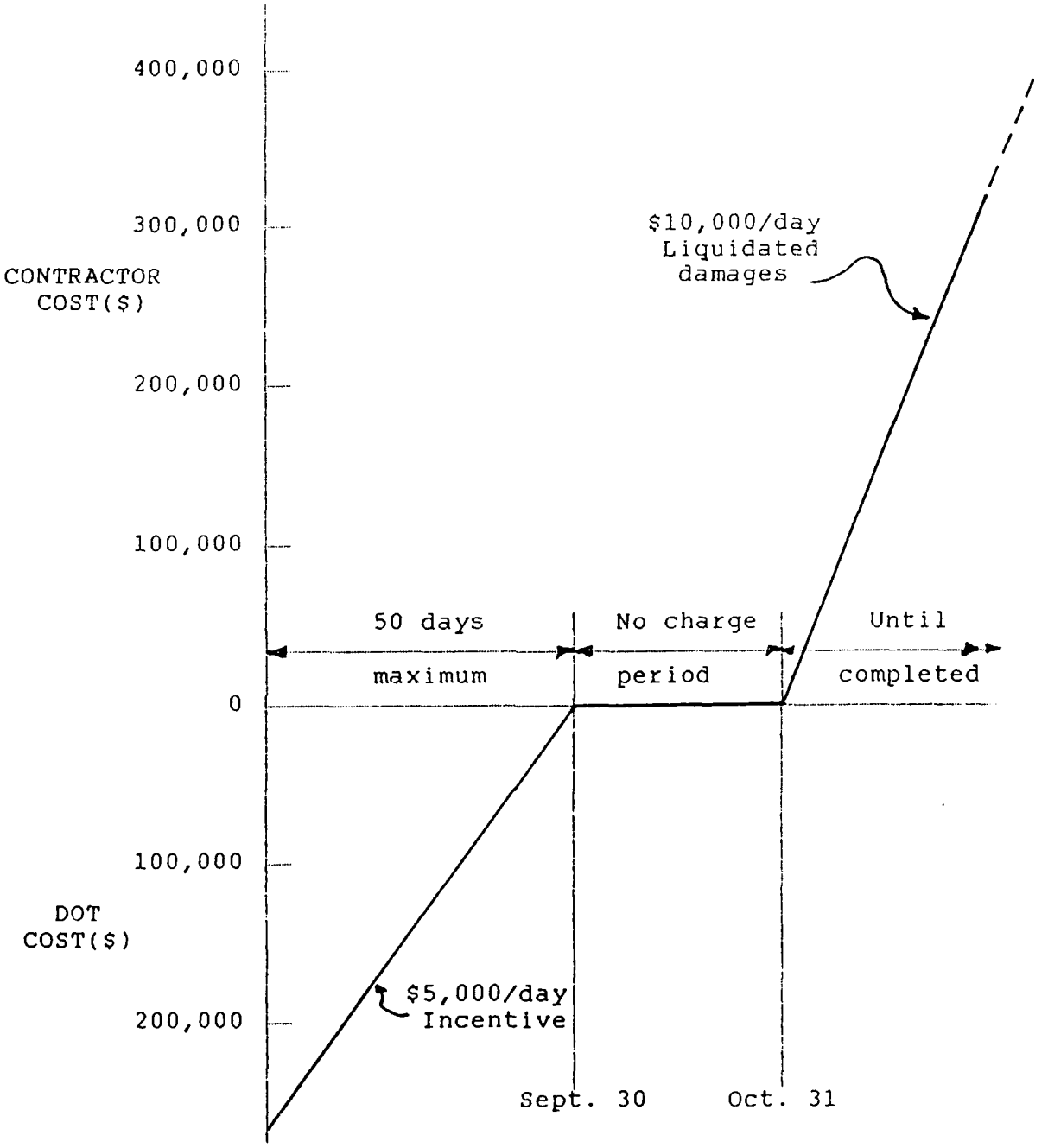

Figure 2.6 Computation of Incentive Payments and Liquidated Damages for a Specific Contract in Illinois [An additional $5,000 per day incentive payment was available if all six contracts were completed early (see Figure 2.5).]

In the interest of being profitable, contractors generally strive to complete a project at the earliest possible date. Early completion of a project results in lower overhead costs, lower interest costs for borrowed dollars, less exposure to damage by the elements (repairs must be made at the contractor's expense), avoidance of increased costs of labor and materials, and freedom to bid on other work.[21]

Contractor delays are quite often the result of incompetence or financial problems, however, a construction contract that does not allow for adequate time to complete the work, or allows for too much time to complete the work also has an effect on contractor performance. Specifically, contracts that specify an excessive number of working days or a long time period may[22]:

-Discourage innovative management or construction techniques.

-Encourage contractors to bid more work than can be handled in a timely manner.

-Require increased agency administration and engineering costs.

-Encourage lower bid prices.

-Permit both high- and low-production contractors to bid on a project.

-Reduce the bonding capacity of contractors.

Additionally, agency officials are wary of the criticism that would likely result if a contractor were to collect a substantial bonus as a result of exceptional diligence, even though possible increased construction costs are avoided, early completion results in earlier use of the facility, and the opportunity to place bids and receive bonus payments are open to other contractors.

An example of special provisions for incentive payments and liquidated damages used by the Illinois Department of Transportation in contracts for rehabilitation projects is shown in Figure 2.5.[20] As illustrated in Figure 2.6, the provisions provide for a maximum incentive payment of $5000 per day for a period of 50 days, then a month of no incentive payments or liquidated damages, and finally a liquidated damages rate of $10,000 per day thereafter.

H. Consequences of Contract Time Determination.

In order to decrease the possibility of differences or disputes with the contractor, setting realistic contract time limits is a primary goal of state transportation agencies. Contractors, in the vast majority of cases, prepare their own estimates of time needed to complete a project based on the abilities of their own companies. If an agency is to set realistic contract durations, it must be aware of contractor capabilities.

Contracts that specify too few working days or a short time period may:

-Encourage higher bids.

-Increase bond costs for contractors.

-Eliminate some qualified contractors.

-Encourage good management and thus high production.

-Cause the contractor to question each work-day charge (on working-day contracts).

-Lower administration and engineering costs.

Good planning and scheduling practices on the part of state agencies not only provide a predictable means for determining reasonable contract durations, but also a means by which to manage and control the progression of contract work. Job progress can be tracked, delays can be better anticipated, scheduling disputes can be more easily resolved, and agency resources such as manpower allocation for project inspection can be managed more effectively.

The 1986 edition of the Florida DOT Specifications, shown in Appendix B, provides an example of how many of the issues discussed above are covered in highway construction contracts.

CHAPTER III

CONTRACT TIME DETERMINATION METHODS SURVEY

A. General.

In order to gather information on methods used to determine construction contract durations by state transportation agencies across the country, a survey was conducted which requested information on procedures followed. An example survey letter which was sent to the Arizona Department of Transportation is shown in Figure 3.1. This survey letter also requested information pertaining to the use of productivity rates used by state agencies. To facilitate replies, a questionnaire (see Figure 3.2) was enclosed for agencies to complete.

B. Survey Response.

Response to the survey was excellent. Of all the requests for information mailed out, nearly three-quarters of those receiving them responded.

Replies received varied from single-sentence answers to packages of considerable volume. As expected, methods of determining contract durations vary from state to state,

COLLEGE
OF
ENGINEERING

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DEPARTMENT OF CIVIL ENGINEERING

September 4, 1987

Mr. Frank R. McCullagh
Director
Arizona Department of Transportation
P. O. Box 13588
Phoenix, AZ 85007

Dear Mr. McCullagh:

We are conducting a research study for the Florida Department of Transportation (FDOT) to evaluate and suggest improvements to their method of determining specified contract durations. The current method employed by FDOT for determining contract duration is based on productivity rates and total material quantities for specific activities.

As a part of our study we are contacting other state transportation authorities in order to learn what methods they are using.

We request your assistance in providing any information available concerning your procedure for establishing contract durations for new contracts. If you also use productivity rates in calculating contract durations, we would very much like to know what the rates are and what adjusting factors, if any, are used.

To assist in your reply, we have enclosed a questionnaire which we would appreciate you returning at your earliest convenience.

Sincerely,

Zohar Herbsman, PhD
Professor

ZH/ckl

Enclosure

Figure 3.1 Arizona DOT Survey Letter

Please Respond As Soon as Possible

REPLY TO:

Dr. Z. Herbsman
University of Florida
Department of Civil Engineering
346 Weil Hall
Gainesville, FL 32611

METHOD USED TO DETERMINE CONTRACT DURATION:

(Please describe your procedure)

Our current practice in determining contract duration is very much like that of most other agencies. Simple bar charts, or something approximating that, are generally prepared by our estimators based on their individual assessments of the amount of time necessary to perform major elements of work. This has been a reasonably reliable technique for all but the very largest and most complex jobs. The time required to do anything more involved than this is just not available. We are moving toward a computerized estimating system which may eventually allow a more sophisticated procedure with possibly greater accuracy. We do have available to us, at present, information developed by another office, which is intended to provide our district offices with manpower projections, however, it has not proven any better than the bar charts for accuracy.

PLEASE SEND US COPIES OF ANY DOCUMENTATION AVAILABLE.

Such as: Written procedures
Work forms, calculation sheets
Schedule of production rates used.

PLEASE GIVE THE NAME OF PERSON WHO MAY BE CONTACTED FOR ADDITIONAL INFORMATION:

Name: DAVID G. ELACK

Position: TRANSPORTATION ENGINEER - SUPERVISOR

State Highway Authority: ARIZONA DEPT. OF TRANSPORTATION

Mailing Address: 1651 W. JACKSON RM 121F

PHOENIX, ARIZONA 85007

Telephone No.: (602) 255-7221

Figure 3.2 Arizona DOT Questionnaire

however, this report has attempted to group together those methods that have enough correlation to be considered similar in procedure.

C. Summary of Findings.

Study of responses received by state transportation agencies on methods used to determine contract durations reveal that there are generally four basis upon which contract durations are commonly calculated. These are:

-Construction season limits,
-Quantity or production rates,
-Work-flow techniques, and
-Estimated costs.

Other less common methods include time unit calculation and completion dates specified by the contractor at the time of the bid.

In their Synthesis of Highway Practice, Special Report Number 79, the Transportation Research Board tabulated results of an extensive survey they conducted in 1981 which gives a breakdown, by state, of procedures used in determining contract time, along with other information discussed earlier in this report such as liquidated damages and incentive payments. This information is shown in Figure 3.3. Chapter IV offers representative methods of

CURRENT PRACTICES FOR DETERMINING CONTRACT TIME

STATE	Contract Time Determined by: Working Days (%)	Calendar Days (%)	Fixed Date (%)	Have Bids Ever Been based on Different Numbers of Days?	Techniques or Procedures Used to Determine Contract Time: Work Season (%)	Production Rates (%)	CPM (%)	Cost Est. (%)	Liquidated Damages Range/Day ($)	Bonus Range/Day ($)
ALABAMA	97	1	2	No	X			X	45 - 980	
ALASKA		X	X	No	X	X			50 - 500	
ARIZONA	X			No		X			42 - 420	
ARKANSAS	X			No		X			42 - 420	
CALIFORNIA	X			No	20	60	20		50 - 1500	
DELAWARE	X	X	X	No	10	30		60	30 - 420	
DIST OF COL				Yes				X	30 - 150	
FLORIDA		X		No		X			(1) - 300	
GEORGIA	60	5	35	No	30	70			30 - 420	
HAWAII	X			No	10	30	30	30	42 - 420	
IDAHO	95	1	4	Yes	X				75 - 1300	
ILLINOIS	99.5		0.5	No		X			30 - 5600	1500 - 10 000
INDIANA	5.2	1	48	No	X	X			30 - 1000	(2) 50 - 1000 day
IOWA	X			Yes (3)		X			42 - 200	
KANSAS	X			No		X			75 - 1500	(11) 750 -
KENTUCKY	35		65	No	65	35			60 - 600	
LOUISIANA	80	20		No		X		X	42 - 420	
MAINE	80		20	No		X			30 - 420	
MARYLAND	75	25		No	X	X		X	(4)	
MASSACHUSETTS			X	No	X			X	30 - 500	
MICHIGAN	70		30	No	20		80		20 - 1000	(5)
MINNESOTA	90		10	No					150 - 900	(6)1000 - 3500
MISSISSIPPI			X			X			0 - 560	
MISSOURI	95		X	No	50	50			50 - 1500	
MONTANA	X			No	X	X			28 - 420	
NEBRASKA	98	2		No		X			42 - 420	(7)
NEVADA	X			No			X		300 - 1000	
NEW HAMPSHIRE	2		98	No	X				30 - 300	(8) 100 - 500
NEW YORK			X	No	X				50 - 1000	
NORTH DAKOTA	20		80	No	75	15		10	50 - 700	(9) - 500
OHIO	X			No	X	X			30 - 600	
OKLAHOMA	75	15	10	No	25	75			30 - 1000	
OREGON (10)	1	50	20	No	X	X		X	40 - 840	
PENNSYLVANIA		X	(12)		X		(13)		300	
RHODE ISLAND		X		Yes	X	X			30 - 300	
SOUTH CAROLINA			X	No	X			X	20 - 420	
SOUTH DAKOTA	X		X	No	X				50 - 600	
TENNESSEE	90		10	No	X	X		X	30 - 420	
UTAH	X	X	X	No	X			X	42 - 420	
VERMONT			X	No	X				42 - 420	
VIRGINIA		X	X	No	X	X			50 - 500	
WASHINGTON	X		0.5	No	X		X		42 - 2000	0 - 2000
WISCONSIN	30	40	30	No		90	10		50 - 595	
WYOMING			X	No	X	X	X		50 - 600	

NOTES: (1) 1/4% of contract amount per day. (2) Used on less than 1% of contracts with "not to exceed limit." (3) Only on selected projects with normal versus round-the-clock day. (4) Based on engineering, administration, and other costs of time overrun. (5) Used in special cases. (6) Bonus set by special provision. (7) Same as penalty, but rarely used. (8) Only for special projects. (9) Recent use on selected projects with $400-500 range. (10) Calendar work days - 29%. (11) One project only. (12) Only under special circumstances. (13) Rar

Figure 3.3 Current Practices for Determining Contract Time

determining contract durations based on survey material received from various states.

Construction Season Limits

Highway construction, particularly surfacing and paving projects, is severely dependent upon the weather. When letting contracts of this nature, state agencies must consider the limits of the construction season where the work is to be performed. Often, contract durations are based on the time that weather is expected to permit work to continue during the construction season.

When based on construction season limits, contract times are only effectively predictable when projects are awarded sufficiently early in the construction season to allow completion, a large number of jobs are not given to a single contractor, materials are readily available, and the contractor is held responsible for the expense of maintaining the project over the winter or paying liquidated damages.[23]

Meteorological data has been collected by many of the state agencies and combined with experience and historical construction data in the attempt to determine just how many working days there are in a year for areas under agency cognizance for various types of construction. Working-day charts and tables for the state of Georgia are shown in Figures 3.4 and 3.5, and for the state of Indiana in Figures

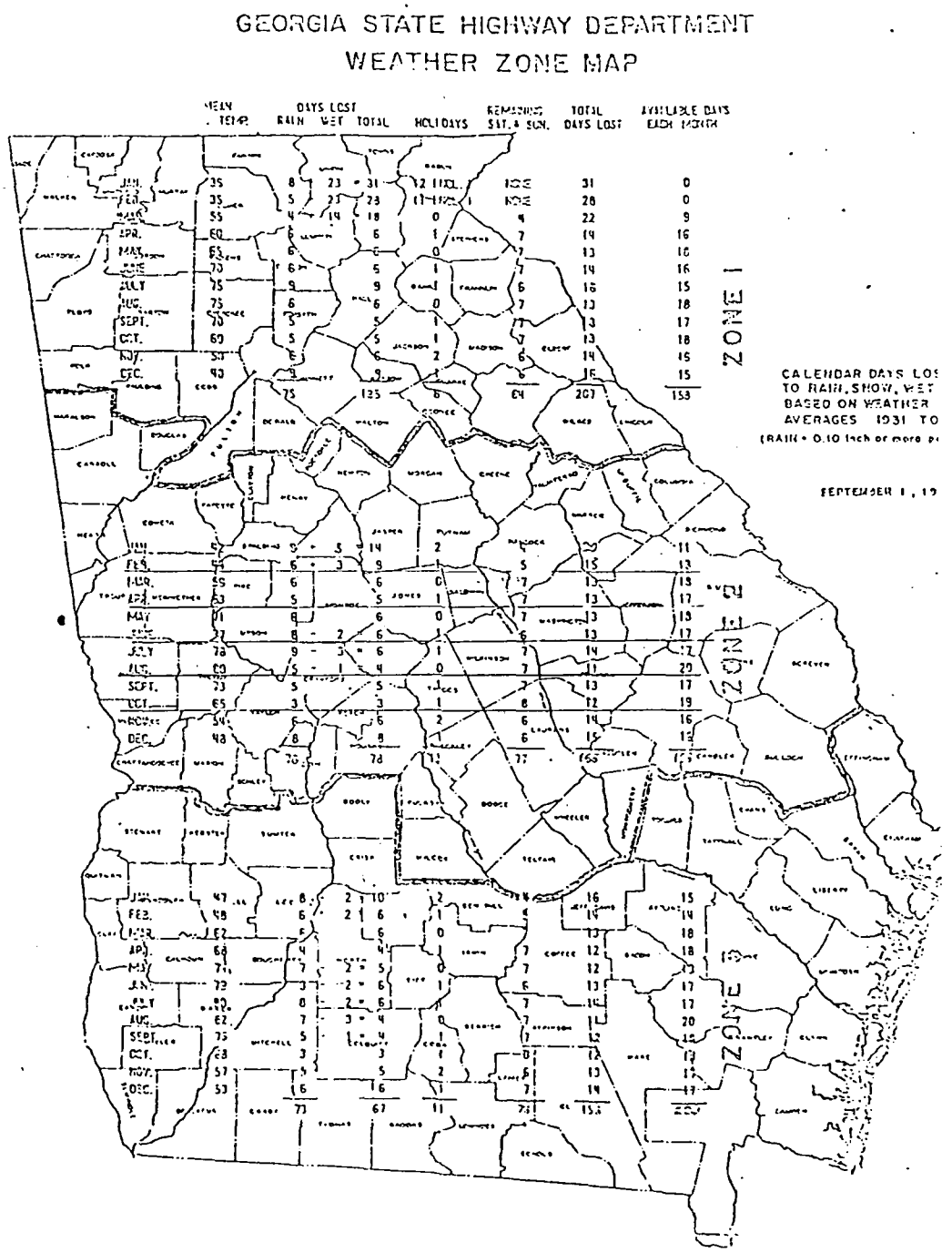


Figure 3.4 Available Work Day Zone Map (Georgia)

AVERAGE AVAILABLE WORKING DAYS FOR BRIDGE CONSTRUCTION
IN THE ATLANTA AREA AS OF OCTOBER 1967

JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
8.	16	31	49	69	89	108	128	147	165	182	201
	8	23	41	61	81	100	120	139	157	174	193
		15	33	53	73	92	112	131	149	166	185
			18	38	58	77	97	116	134	151	170
				20	40	59	79	98	116	133	152
					20	39	59	78	96	113	132
						19	39	58	76	93	112
							20	39	57	74	93
								19	37	54	73
									18	35	54
										17	36
											19

Figure 3.5 Working Day Chart for Bridge Construction
(Atlanta, Georgia)

3.6, 3.7, and 3.8. These figures are fairly representative of the manner in which working-days are calculated and tabulated among the states that take construction seasons into consideration when determining contract durations. As demonstrated in the charts formulated by the Indiana DOT, working-day calculations are sometimes established for different types of work such as bridge construction, light grading and urban construction, or medium and heavy grading work.

Calculated values of available work-days are most often used in combination with the other methods of determining contract durations; rarely are they used alone.

Quantity or Production Rates

Based on experience and past data from completed projects, many states compute daily production rates for work items that effect project time. Figures 3.9, 3.10, and 3.11 illustrate the tabulation of these values. The advantage of this system is that it breaks down projects into critical work activities, just as contractors would normally do when they determine the time needed to complete a job.

Some states have gone a step further and developed productivity curves based on the quantity of work involved for different work items in a project. These allow agency

APRIL 1971

BRIDGE

DISTRIBUTION OF WORKING DAYS
BY MONTHS, THRU 135 W.D. YEAR
CUMULATIVE TOTALS PER MONTH.

		JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEPT.	OCT.	NOV.	DEC.
	JAN.												
	FEB.												
	MAR.												
14	APR.	14	14	14	14	MAY							
16	MAY	30	30	30	30	16	JUN.						
18	JUN	48	48	48	48	34	18	JUL.					
19	JUL	67	67	67	67	53	37	19	AUG.				
18	AUG	85	85	85	85	71	55	37	18	SEPT.			
18	SEP	103	103	103	103	89	73	55	36	18	OCT.		
17	OCT	120	120	120	120	106	90	72	53	35	17	NOV.	
15	NOV	135	135	135	135	121	105	87	68	50	32	15	DEC.
0	DEC												0
0	JAN												
0	FEB												
0	MAR												
14	APR	149	149	149	149	135	119	101	82	64	46	29	14
16	MAY	165	165	165	165	151	135	117	98	80	62	45	30
18	JUN	183	183	183	183	169	153	135	116	98	80	63	48
19	JUL	202	202	202	202	188	172	154	135	117	99	82	67
18	AUG	220	220	220	220	206	190	172	153	135	117	100	85
18	SEP	238	238	238	238	224	208	190	171	153	135	118	103
17	OCT	255	255	255	255	241	225	207	188	170	152	135	120
15	NOV	270	270	270	270	256	240	222	203	185	167	150	135
0	DEC												
0	JAN												
0	FEB												
0	MAR												
14	APR	284	284	284	284	270	254	236	217	199	181	164	149
16	MAY	300	300	300	300	286	270	252	233	215	197	180	165
18	JUN	318	318	318	318	304	288	270	251	233	215	198	183
19	JUL	337	337	337	337	323	307	289	270	252	234	217	202
18	AUG	355	355	355	355	341	325	307	288	270	252	235	220
18	SEP	373	373	373	373	359	343	325	306	288	270	253	238
17	OCT	390	390	390	390	376	360	342	323	305	287	270	255
15	NOV	405	405	405	405	391	375	357	338	320	302	285	270
0	DEC												
0	JAN												
0	FEB												
0	MAR												
14	APR	419	419	419	419	405	389	371	352	334	316	299	284
16	MAY	435	435	435	435	421	405	387	368	350	332	315	300
18	JUN	453	453	453	453	439	423	405	386	368	350	333	318
19	JUL	472	472	472	472	458	442	424	405	387	369	352	337
18	AUG	490	490	490	490	476	460	442	423	405	387	370	355
18	SEP	508	508	508	508	494	478	460	441	423	405	388	373
17	OCT	525	525	525	525	511	495	477	458	440	422	405	390
15	NOV	540	540	540	540	526	510	492	473	455	437	420	405
0	DEC												

Figure 3.6 Working Day Chart for Bridge Construction (Indiana)

APRIL 1971

DISTRIBUTION OF WORKING DAYS
BY MONTHS, THRU 110 W.D. YEAR
CUMULATIVE TOTALS PER MONTH.

LIGHT GRADING & URBAN

		JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEPT.	OCT.	NOV.	DEC.
0	JAN.												
0	FEB.												
0	MAR.												
4	APR.	4	4	4	4	MAY							
13	MAY	17	17	17	17	13	JUN.						
17	JUN.	34	34	34	34	30	17	JUL.					
18	JUL.	52	52	52	52	48	35	18	AUG.				
18	AUG.	70	70	70	70	66	53	36	18	SEPT.			
18	SEP.	88	88	88	88	84	71	54	36	18	OCT.		
17	OCT.	105	105	105	105	101	88	71	53	35	17	NOV.	
5	NOV.	110	110	110	110	106	93	76	58	40	22	5	DEC.
0	DEC.												0
0	JAN.												
0	FEB.												
0	MAR.												
4	APR.	114	114	114	114	110	97	80	62	44	26	9	4
13	MAY	127	127	127	127	123	110	93	75	57	39	22	17
17	JUN.	144	144	144	144	140	127	110	92	74	56	39	34
18	JUL.	162	162	162	162	158	145	128	110	92	74	57	52
18	AUG.	180	180	180	180	176	163	146	128	110	92	75	70
18	SEP.	198	198	198	198	194	181	164	146	128	110	93	88
17	OCT.	215	215	215	215	211	198	181	163	145	127	110	105
5	NOV.	220	220	220	220	216	203	186	168	150	132	115	110
0	DEC.												
0	JAN.												
0	FEB.												
0	MAR.												
4	APR.	224	224	224	224	220	207	190	172	154	136	119	114
13	MAY	237	237	237	237	233	220	203	185	167	149	132	127
17	JUN.	254	254	254	254	250	237	220	202	184	166	149	144
18	JUL.	272	272	272	272	268	255	238	220	202	184	167	162
18	AUG.	290	290	290	290	286	273	256	238	220	202	185	180
18	SEP.	308	308	308	308	304	291	274	256	238	220	203	198
17	OCT.	325	325	325	325	321	308	291	273	255	237	220	215
5	NOV.	330	330	330	330	326	313	296	278	260	242	225	220
0	DEC.												
0	JAN.												
0	FEB.												
0	MAR.												
4	APR.	334	334	334	334	330	317	300	282	264	246	229	224
13	MAY	347	347	347	347	343	330	313	295	277	259	242	237
17	JUN.	364	364	364	364	360	347	330	312	294	276	259	254
18	JUL.	382	382	382	382	378	365	348	330	312	294	277	272
18	AUG.	400	400	400	400	396	383	366	348	330	312	295	290
18	SEP.	418	418	418	418	414	401	384	366	348	330	313	308
17	OCT.	435	435	435	435	431	418	401	383	365	347	330	325
5	NOV.	440	440	440	440	436	423	406	388	370	352	335	330
0	DEC.												

Figure 3.7 Working Day Chart for Light Grading and Urban Construction (Indiana)

APRIL 1971

DISTRIBUTION OF WORKING DAYS
BY MONTHS, THRU 100 W.D. YEAR
CUMULATIVE TOTALS PER MONTH.

MEDIUM & HEAVY GRADING

		JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEPT.	OCT.	NOV.	DEC.
0	JAN												0
0	FEB												
0	MAR												
4	APR	4	4	4	4	4							
13	MAY	17	17	17	17	13	JUN.						
15	JUN	32	32	32	32	28	15	JUL.					
16	JUL	48	48	48	48	44	31	16	AUG.				
17	AUG	65	65	65	65	61	48	33	17	SEPT.			
15	SEP	80	80	80	80	76	63	48	32	15	OCT.		
15	OCT	95	95	95	95	91	78	63	47	30	15	NOV.	
5	NOV	100	100	100	100	96	83	68	52	35	20	5	DEC.
0	DEC												0
0	JAN												
0	FEB												
0	MAR												
4	APR	104	104	104	104	100	87	72	56	39	24	9	4
13	MAY	117	117	117	117	113	100	85	69	52	37	22	17
15	JUN	132	132	132	132	128	115	100	84	67	52	37	32
16	JUL	148	148	148	148	144	131	116	100	83	68	53	48
17	AUG	165	165	165	165	161	148	133	117	100	85	70	65
15	SEP	180	180	180	180	176	163	148	132	115	100	85	80
15	OCT	195	195	195	195	191	178	163	147	130	115	100	95
5	NOV	200	200	200	200	196	183	168	152	135	120	105	100
0	DEC												
0	JAN												
0	FEB												
0	MAR												
4	APR	204	204	204	204	200	187	172	156	139	124	109	104
13	MAY	217	217	217	217	213	200	185	169	152	137	122	117
15	JUN	232	232	232	232	228	215	200	184	167	152	137	132
16	JUL	248	248	248	248	244	231	216	200	183	168	153	148
17	AUG	265	265	265	265	261	248	233	217	200	185	170	165
15	SEP	280	280	280	280	276	263	248	232	215	200	185	180
15	OCT	295	295	295	295	291	278	263	247	230	215	200	195
5	NOV	300	300	300	300	296	283	268	252	235	220	205	200
0	DEC												
0	JAN												
0	FEB												
0	MAR												
4	APR	304	304	304	304	300	287	272	256	239	224	209	204
13	MAY	317	317	317	317	313	300	285	269	252	237	222	217
15	JUN	332	332	332	332	328	315	300	284	267	252	237	232
16	JUL	348	348	348	348	344	331	316	300	283	268	253	248
17	AUG	365	365	365	365	361	348	333	317	300	285	270	265
15	SEP	380	380	380	380	376	363	348	332	315	300	285	280
15	OCT	395	395	395	395	391	378	363	347	330	315	300	295
5	NOV	400	400	400	400	396	383	368	352	335	320	305	300
0	DEC												

Figure 3.8 Working Day Chart for Medium and Heavy Grading (Indiana)

FLORIDA DEPARTMENT OF TRANSPORTATION

SPECIFICATIONS

Criteria Used For Estimating Working Days

Work to be Considered	Number of Working Days
1. Clearing and Grubbing. 000023 Ac./SF	1 to 10 Acres per day, depending upon nature; NOT to exceed 20 (Grading time will govern after 20 days)
2. Excavation (Regular, Lat. Ditch, Subsoil; Convert grading roadway to Cu. Yds. for this purpose). Shldr. grading (Resurfacing) at 1 mi/day	(See chart for No. Days)
3. Stabilized Roadbed	5,000 Sq. Yds. per day (Not to exceed 10 days)
4. Bases (Sand-Clay; Limerock; Limerock Stabilized, Shell Stabilized; and Soil Cement Base)	(See chart for No. Days)
5. Surface Treatment	200 Cu. Yds. per day
6. Cement Concrete	5,000 Sq. Yds. per day
7. Milling Existing Pavement	4,000 Sq. Yds. per day (Max 20 days)
8. Plant mixed surfaces (in tons- for conversion see * below)	(See chart for No. Days)
9. Storm Sewers (on Munic. Const.; includes pipe, inlets, manholes, etc.)	100 to 400 linear ft. per day
10. Curb and Gutter, Valley Gutter, etc.	300 to 700 linear ft. per day
11. Sidewalk	300 Sq. Yds. per day
12. Sprigging/Grassing 2420 S	15,000 Sq. Yds. per day (Not to exceed 15 days) (225,000)

Figure 3.9 Standard Productivity Rates (Florida)

TIME LIMIT INFORMATION

CONTRACTS AND SPECIFICATIONS SECTION

(Select Controlling Items)

SECTION	ITEM	CTR. TIME
201	Clearing and Grubbing	1.5 Acres/Day
202	Removal of Timber Bridge	2 Spans/Day
202	Removal of P. C. C. Pavement	500 Sq.Yd./Day
202	Removal of Conc. Box Culverts	1/Day
202	Removal of Asph. Concrete Surf.	1 Mile/Day
203	Excavation or Embankment (Figure highest quantity only)	3,000 Cu.Yds./Day (Country) 1,000 Cu.Yds./Day (City)
203	Mucking Ditches (consider section)	1,000 Ft./-0.5 Mile/Day
203	Mucking (Very large quantity)	3,500 Cu.Yds./Day
203	Shaping Roadbed	1 Mile/Day
203	Shaping Roadway, Ditches & Slopes	0.5 Mile/Day
203	Shell (Spot Dumped)	500 Cu.Yds./Day
301	Base Course (Non-Stabilized)	1,500 Cu.Yds./Day
301	Base Course (Class I)	1,000 Cu.Yds./Day
302	Scarifying and Compacting Roadbead	1 Mile/Day
303	In-Place Cement Stabilized Base Course	6,000 Sq.Yds./Day
304	Lime Treatment (24 Ft. Width) (20 Ft. Width)	6,000 Sq.Yds./Day 5,000 Sq.Yds./Day
305	Subbase Treatment	8,000 Sq.Yds. or 1 Mi./Day

Figure 3.10 Standard Productivity Rates (Louisiana)

CRITICAL PATH

APRIL 1984

CONSTRUCTION TIME ESTIMATES

I.	AWARD CONTRACT	USE "WW" CODE	28 DAYS @ 7 DAY WEEK
II.	MOVE IN TIME	USE "WW" CODE	10 DAYS @ 7 DAY WEEK

III.	DRAINAGE	
	A. CROSS CULVERTS (GENERALLY INCLUDED IN G&DS)	
	1. RURAL HIGHWAYS	120 LFT./DAY
	2. EXPRESSWAYS	150 LFT./DAY
	3. LARGE HEADWALLS	5 DAYS/UNIT
	4. SLAB OR BOX CULVERTS	5 DAYS/POUR
	5. PLOWED IN EDGE DRAIN (PRODUCTION TYPE PROJECT)	150 STAS/DAY
	6. OPEN-GRADED UNDERDRAIN (PRODUCTION TYPE PROJECT)	40 STAS/DAY
	B. SEWERS	
	1. 0'-14' (UP TO 60")	120 LFT./DAY
	2. 0'-14' (OVER 60")	80 LFT./DAY
	3. 14'-OVER (UP TO 60")	80 LTF./DAY
	4. 14'-OVER (OVER 60")	60 LFT./DAY
	5. JACKED-IN-PLACE	40 LFT./DAY
	INCLUD. EXC. PIT AND SETUP	MIN. 5 DAYS
	6. TUNNELS	
	a. Hand Mining	24 LFT./DAY
	b. Machine Mining	60 LFT./DAY
	INCLUD. EXC. PIT AND SETUP	MIN. 5 DAYS
	C. MANHOLES	3 UNITS/DAY
	D. CATCHBASIN	4 UNITS/DAY

IV.	UTILITIES	
	A. WATER MAIN (TO 16")	300 LFT./DAY
	FLUSHING, TESTING & CHLORINATION	4 DAYS
	B. WATER MAIN (20" TO 42")	80 LFT./DAY
	FLUSHING, TESTING & CHLORINATION	5 DAYS
	C. ORDER AND DELIVER 24" HP WATERMAIN	50 DAYS @ 5 DAY WEEK
	D. GAS LINES	300 LFT./DAY

V.	EARTHWORK AND GRADING	DET.EXP.	RURAL
	A. EMB. CIP	2000	7000 CYDS/DAY
	B. EXC. AND/OR EMB. (FREEWAY)	2000	12000 CYDS/DAY
	C. EXC. AND/OR EMB. (RECONST.)	1000	5000 CYDS/DAY
	D. EMB. (LIGHT WEIGHT FILL)	400	800 CYDS/DAY
	E. MUCK (EXC. WASTE & BACKFILL)		2000 CYDS/DAY
	F. EXC. (WIDENING)		20 STAS/DAY
	G. GRADING (G&DS)		25 STAS/DAY
	H. SUBBASE AND SEL SUB (24' OR LESS)		20 STAS/DAY
	I. SUBBASE AND SEL SUB (MORE THAN 24')		15 STAS/DAY
	K. SUBGRADE UNDERCUT AND BACKFILL		2000 CYDS/DAY
	L. SUBBASE AND OPEN GRADED DRAINAGE COURSE		15 STAS/DAY

Figure 3.11 Standard Productivity Rates (Michigan)

officials to determine a more predictable contract duration for jobs of various sizes. Figures 3.12 and 3.13 are representative of this method.

An additional concern when basing contract durations on production rates is that the rates used will determine the qualifications needed by the contractor to complete the work within the allotted time. To insure reliable bids, care and sound judgement must be exercised when selecting these rates.

There are also differing opinions among the states as to the period of time that production rate data is accumulated. Where some agencies believe that production rates used in determining contract durations should be based on recent data to reflect advances in technology, others believe that "state-of-the-art" production rates could hinder those contractors that might use older equipment.

In the interest of comparing various production rates used by state agencies across the country, Appendix A is a tabulation of standard production rates used in determining working-days from 12 respondents who provided these values in the survey. Work item categories varied significantly from one state to the next so in many cases similar work items were grouped together to facilitate comparison. Many categories were unique to just one or two states, but were still included to show their existence. In fact, unique work categories appeared to be more common than similar

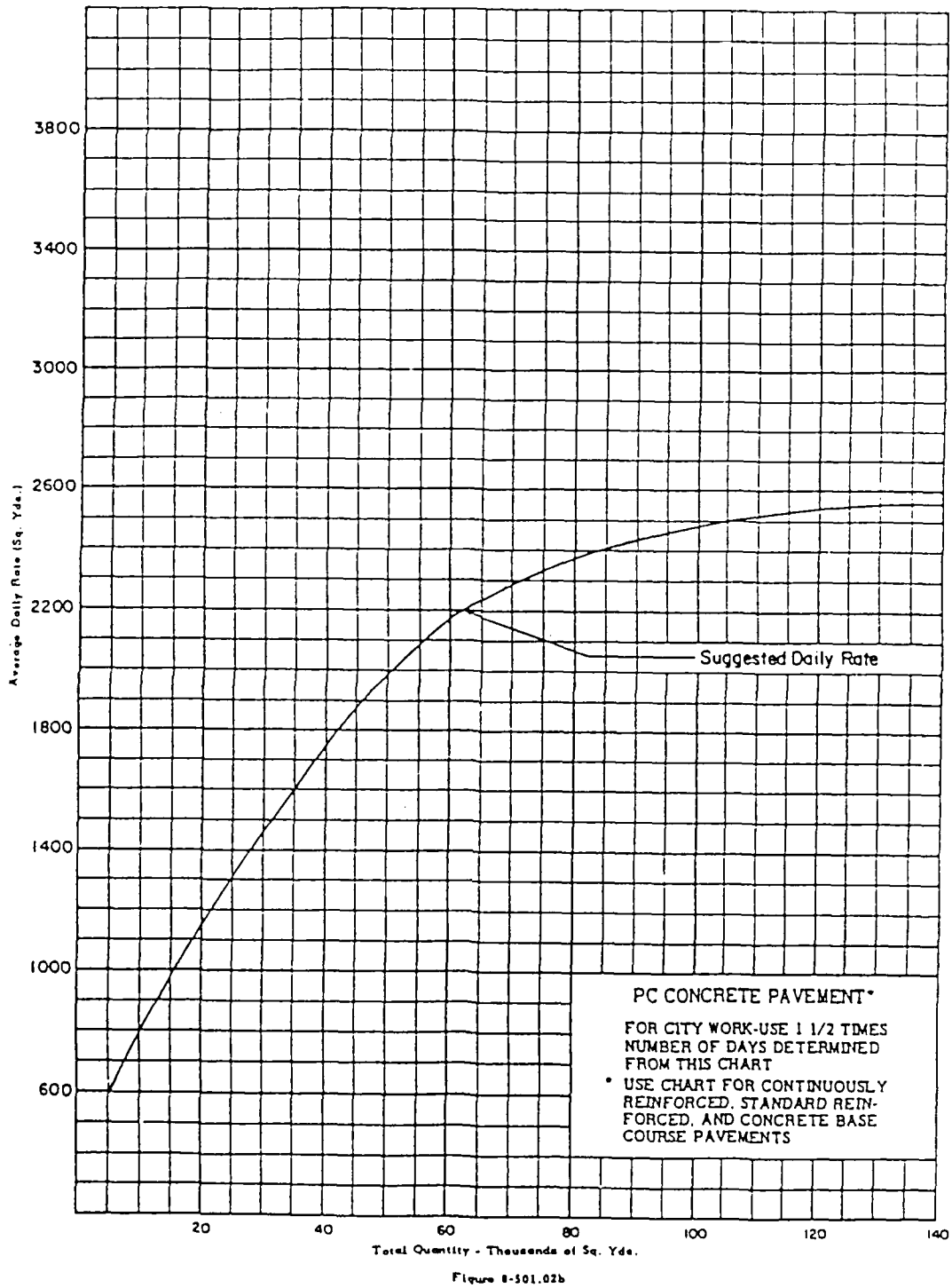


Figure 3.12 Productivity Curve (Illinois)

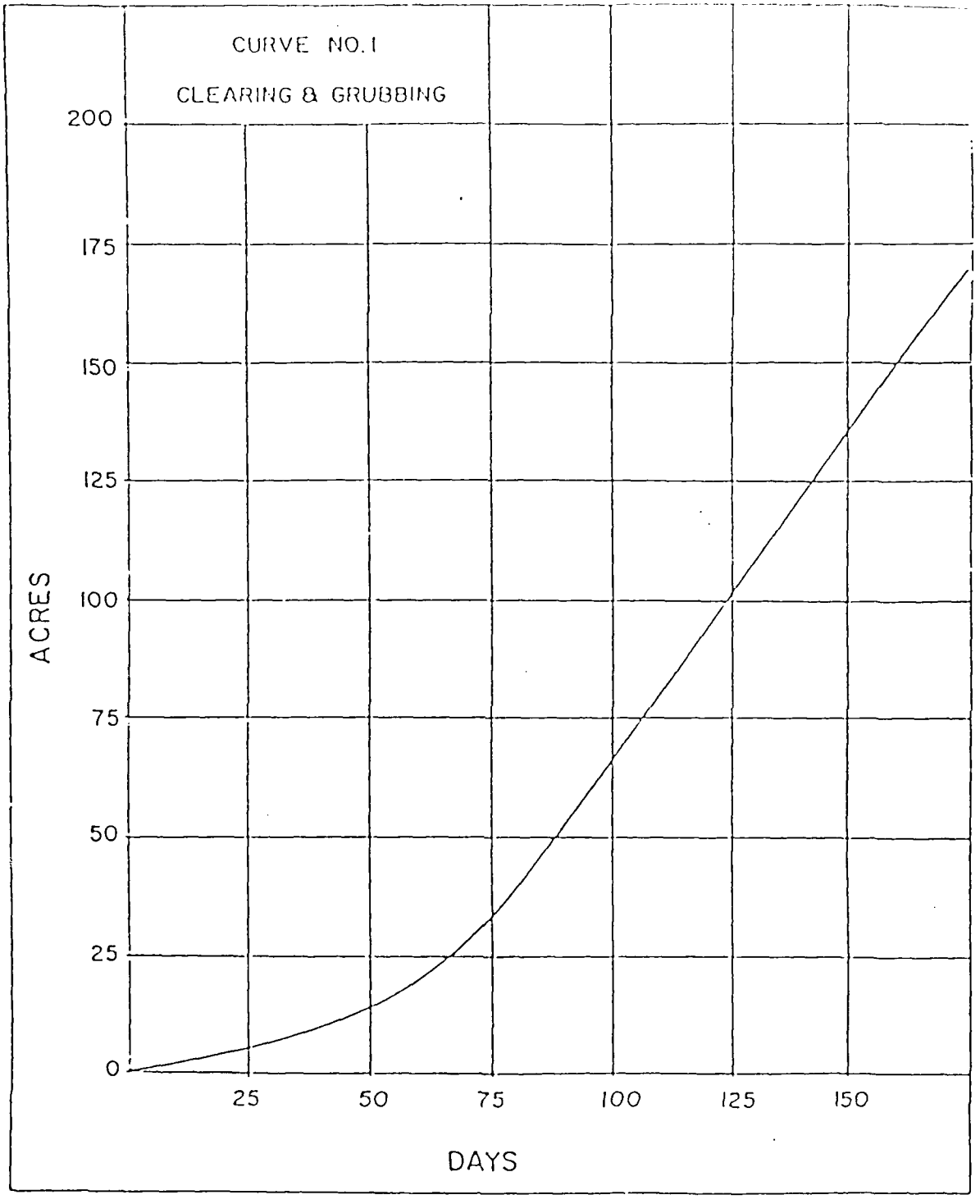


Figure 3.13 Productivity Curve (Louisiana)

work categories. The tables in Appendix A contain 81 separate work categories which were culled from several hundred standard work activities used by the states responding. Some categories were identical to others in scope, only differing by title.

It is obvious when comparing productivity rates from the various states that each state, in many cases, seems to have a different interpretation of what a particular work category includes. In some instances the analogy of mixing apples and oranges is appropriate. This is especially true with the items that include earthwork and paving. For instance, "base" is considered a bituminous layer by most agencies, but a crushed aggregate layer by others.

Further, not only do production rates vary significantly in several categories, but the units of measurement also vary. For example, most states measure paving in tons per day while Michigan measures this work category in stations per day.

Another variance is the type or size of project to which a particular work category is applied. Some of the states apply varying production rates based on whether the job is "small" or "large", or "rural" or "urban". No further explanation is usually provided for these distinctions. These contrast with states that divide projects up into several types. North Carolina, for example, has six standard project categories:

-Major Urban and Rural Projects

-Grading & Paving Projects

-Paving Projects

-Small Rural Widening Projects

-Small Urban Projects-Grading and Paving

-Resurfacing and Surfacing

The only distinctions offered for these differing project categories, however, is that the "Major Urban and Rural Projects" category applies to jobs with grading in excess of 1,000,000 cubic yards, the "Grading & Paving Projects" category applies to jobs with less than 1,000,000 cubic yards, and the "Small Urban Projects-Grading and Paving" category applies to both widening and new location jobs. As with the majority of information provided by the survey respondents, further interpretation is left to the reader.

The use of productivity rates is almost always combined with a work-flow method to determine expected contract duration. In most cases, overlapping work-items are taken into consideration when calculating contract time, however, in some cases, states simply add calculated durations of each controlling work-item as if they were unaffected by other work. This procedure can often lead to excessive contract time allowed in a contract.

Work-Flow Techniques

Although many forms of scheduling techniques exist, the methods most widely used by state agencies are bar charts and/or the critical path method. Often the type of scheduling method used is dependent upon the complexity of the project in question.

Bar charts are favored by many state agencies because of the ease in which all parties involved in the construction process can readily understand them and determine progress on the job. They are also easily understood by those not involved in construction which is an advantage when using a schedule as evidence in court.

A typical bar chart used by the state of Indiana is shown in Figure 3.14. As can be seen from this figure, a significant amount of scheduling information can be presented in a simple and clear manner. These type of charts generally include the number and description of each activity along with each activity's quantity of work and daily productivity rate and early start and early finish dates. The critical path can easily be shown by high-lighting, or other means, and float times can also be shown in a similar manner.

A drawback in the use of bar charts, however, is the inability of those using them to easily determine activity dependencies. To aid in better understanding bar charts, dependencies, along with duration, early start, early

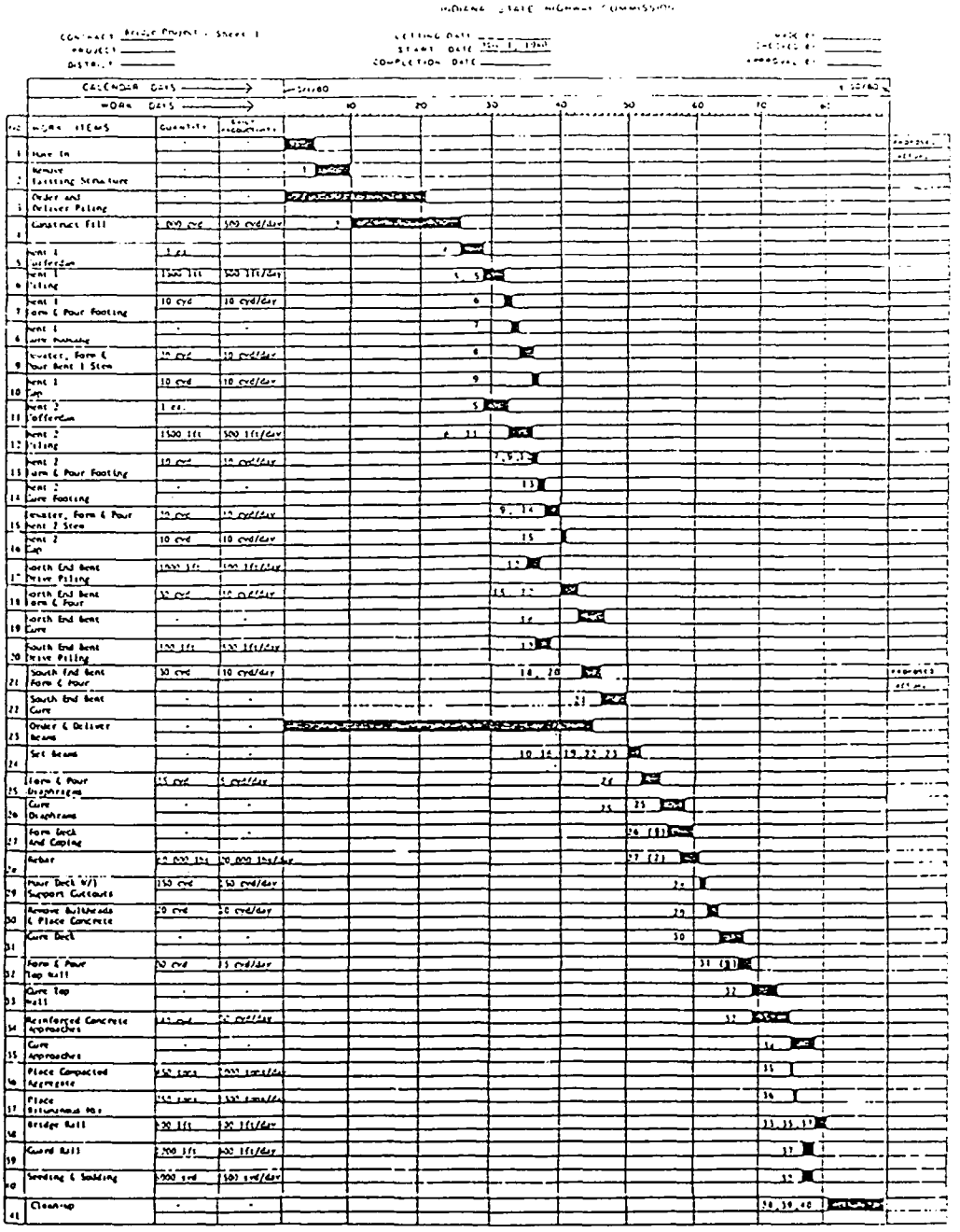


Figure 3.14 Highway Project Bar Chart (Indiana)

finish, late start, late finish, and total float times, as well as critical path notations, are quite often tabulated and used as a supplement to the bar chart.

An answer to the problem of not being able to quickly and easily determine activity dependencies for a project is solved with the use of network scheduling. The critical path method (CPM) is a network scheduling technique that clearly displays, in a schematic form, dependencies an activity has on any other activities in a project. This method of determining contract duration is most useful for large, complicated projects that require extensive coordination of materials, equipment, personnel, and administrative support. Because it does not show job progress as readily as a bar chart might, bar charts are often used in conjunction with CPM diagrams. Although several states use the critical path method for major projects, only seven state agencies use CPMs regularly.

As with most scheduling techniques, several distinct CPM methods exist. The most prevalent method used by state agencies is arrow diagramming. Information on the basic elements of CPM by arrow diagramming is given in Appendix C.[24] Figure 3.15, as supported by information in Figure 3.16, further illustrates the use of this method. As can be seen in Figure 3.16, determining activity dependencies, when using this method, is a relatively simple matter.

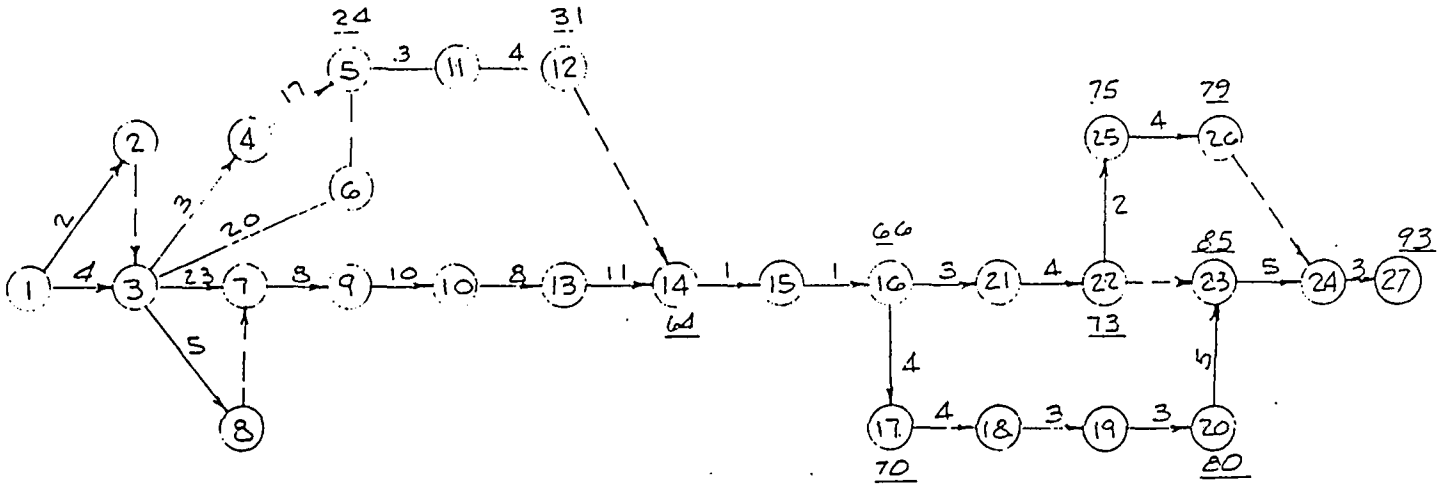


Figure 3.15 CPM Network (Missouri)

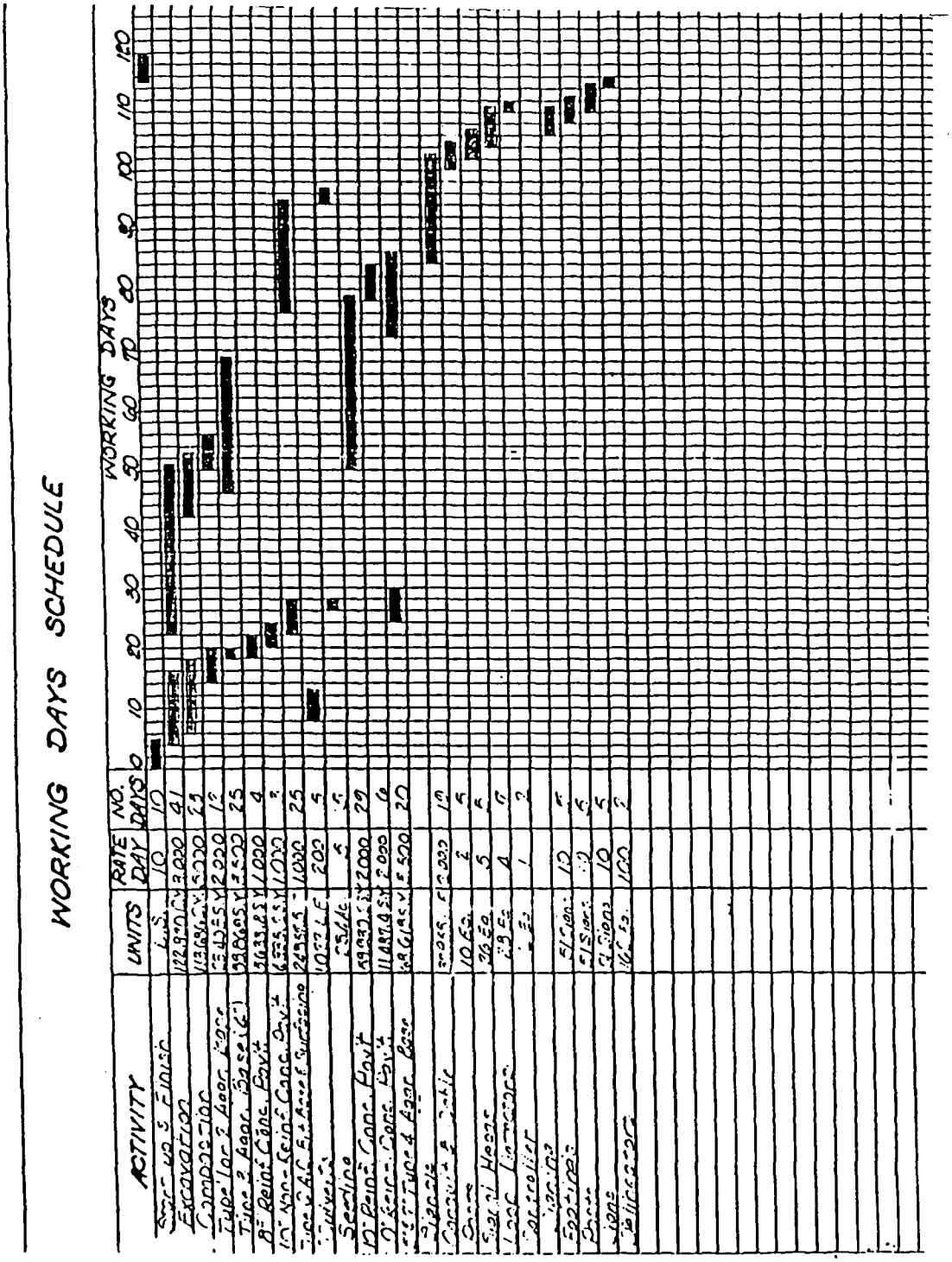


Figure 3.16 CPM Network Information (Missouri)

Estimated Costs

Another method used by some state agencies in determining contract durations is based on the estimated costs of projects. With the idea that more costly projects will require more time, and vice-versa, contract durations are established accordingly. Although some agencies only use this method of contract time determination for smaller or less complicated projects, some use it exclusively for certain type jobs, regardless of size.

A method such as this requires a considerable amount of data gathering based on location and type of work in order for it to be effective. Data compiled by New Mexico on grading and paving projects, and by Washington D.C. on structural projects is shown in Figure 3.17.[25]

The graph in Figure 3.18 was developed by the State of Idaho Transportation Department. In developing this graph, Idaho broadly classified several bands of work and project terrains, and used working days for the ordinate and dollars for the abscissa. Establishment of the bands was from calculations based on statistical data, and this particular chart has seen no major changes since it was first published in 1981. In addition to the time period derived from this figure, Idaho officials adjust the contract time depending on the time of year the contract is awarded and any seasonal limitations.

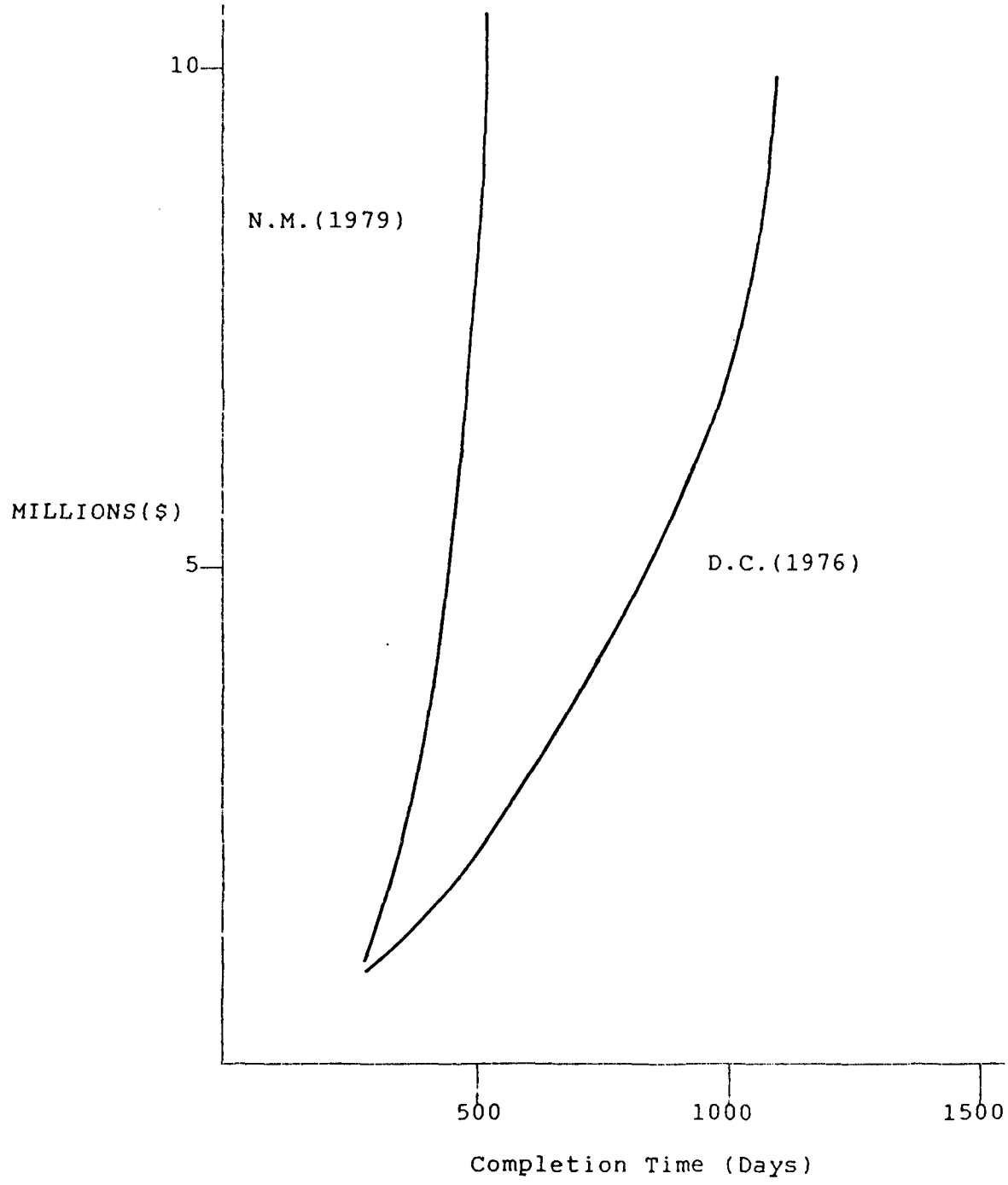


Figure 3.17 Cost-vs-Completion Time Curves (New Mexico, Washington D.C.)

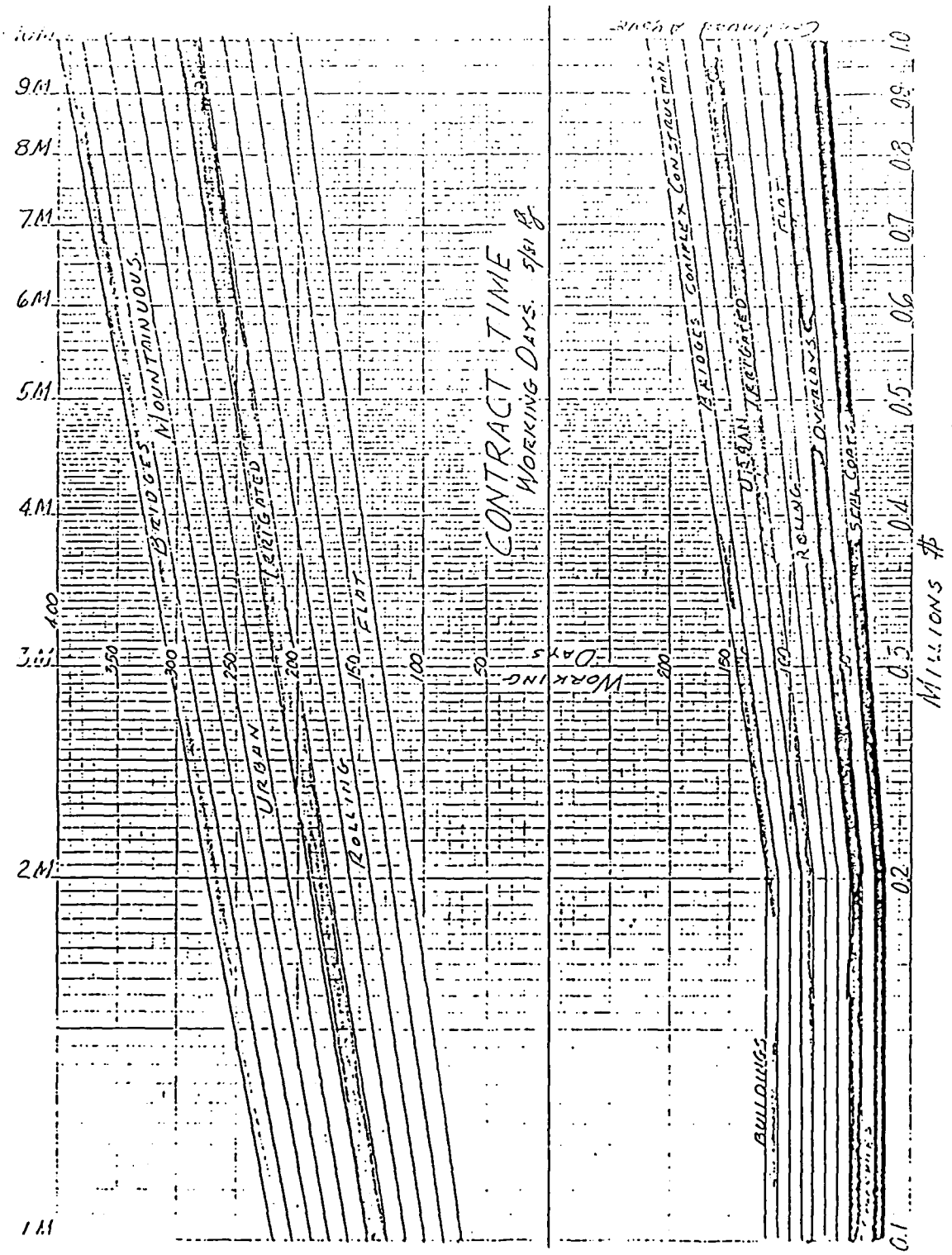


Figure 3.18 Cost-vs-Contract Time Chart (Idaho)

In Oklahoma, when only the program amount for a project is available, a "guesstimate" of working days is made from values found in Figure 3.19.

Other Methods

While the vast majority of state agencies use one of the previously discussed methods for determining contract durations, or more likely a combination of these methods, there are some methods that stand apart.

After research at Mississippi State University, J.H. Oswalt, L.R. Johnson, and D.G. Hotard submitted their report *A Method to Determine Contract Work Days-Implementation* in 1975 to the Mississippi State Highway Department, in cooperation with the Federal Highway Administration, which contained the development of a computer-generated procedure for estimating work time and for reporting and monitoring contractor progress. In this system, time units are used as the measure of work with each month having an assigned number of time units available depending on the type of work. A brief description of the Mississippi procedure taken from Transportation Research Board Special Report 79, is given in Appendix D.

Another method that is not often used is the allowing of contractors to play a role in the selection of contract completion dates. In some Washington D.C. projects, the choice of two different contract durations is presented to

GUESSTIMATE

RULE OF THUMB FOR WORKING DAYS

WHEN ONLY PROGRAM AMOUNT IS AVAILABLE

Grading and Drainage Projects	
Under $100,000 (Minimum 30 days)	$1,000/day
$100,000 to $200,000	$1,250/day + 10 days
$200,000 to $300,000	$1,500/day + 10 days
Over $300,000	$2,000/day + 10 days

Grading, Drainage, & Dustless Type Surface Projects	
Under $100,000 (Minimum 40 days)	$1,500/day
$100,000 to $200,000	$2,000/day + 10 days
$200,000 to $300,000	$2,500/day + 10 days
Over $300,000	$3,000/day + 10 days

Dustless Surface Projects	
Under $200,000 (Minimum 40 days)	$3,000/day + 10 days
Over $200,000	$3,500/day + 10 days

Figure 3.19 Contract Duration Estimate By Project Cost (Oklahoma)

contractors; the lowest valid bid by either date is accepted by the agency. In Mississippi, one project was awarded based on different completion dates included by contractors in their bids. Increased road user costs on the job were calculated at $7,000 per day, so to determine the low bidder, the number of contract days submitted by contractors was multiplied by $7,000 and added to the contractors' dollar amounts for the job. The four low bidders for the project are presented in the table below. As can be seen in the table, the apparent low bidder (with 151 days) did not have the lowest dollar amount, however, after including road user costs, he was low overall. When administering the contract, the $7,000 per day road user cost was added to the amount normally charged for liquidated damages.

Table 3.1 - Low Bidder Calculation (Mississippi)[26]

Bidder	Direct Work Total Items($)	No. Days @ $7,000	Total Work and Days Comparison($)
1	4,721,599.82	151	5,778,599.82
2	4,544,930.31	250	6,294,930.41
3	5,271,196.81	212	6,755,196.81
4	5,215,617.29	266	7,077,617.24

CHAPTER IV

REPRESENTATIVE METHODS FOR DETERMINING CONTRACT DURATION

A. General.

Although the methods used by state transportation agencies in determining contract durations can be grouped into similar types, the following sections of this chapter illustrate that each and every organization has its own procedure that is unique in some way.

ALABAMA

Alabama is typical of those states that rely heavily on the experience of their personnel in determining contract durations. Considerations in determining contract time include the anticipated contract dollar amount, traffic conditions, location, and individual items of work in the project. Work item production rates are not considered in this process.

With the factors that are considered, the determination is made as to how many construction seasons or partial seasons may be needed to complete the work. This process is

followed independently by the Construction Bureau and the Construction Division within the Alabama Highway Department, and after discussion between the two, a contract time is agreed upon.

ARKANSAS

The determination of contract durations by the Arkansas State Highway and Transportation Department is based on standard work item productivity rates. With the use of these rates, and a work item quantity breakdown such as that shown in Figure 4.1, a bar chart is generated showing the logical progression of work in work days (see Figure 4.2). With the number of work days calculated from the bar chart, the corresponding number of calendar days is established by comparing the number of work days necessary to complete the work to the allotted number of work days per month by zone as determined by geographical location and type of work (see Figure 4.3) and the number of calendar days per month.

In the process of the work, working days are defined as days on which the weather, condition of the ground, or the condition of the materials being used are such that the contractor can employ 60% of his forces and equipment to prosecute the work required at that time in the regular sequence of operations as determined by the Resident Engineer.

ARKANSAS STATE HIGHWAY AND TRANSPORTATION DEPARTMENT

JOB R10013

WITTSBURG-HWY. 64 (BASE & SURFACE)

STATE JOB

The proposed project consists of approximately 2.011 miles of Reconstructed Base Course, Bank Gravel Base Course, Bituminous Surface Treatment (Shoulders), Asphaltic Concrete Hot Mix Surface Course and Misc. Items on the Wittsburg-Hwy. 64 Base and Surfacing Project, State Highway 163, Section 1, Cross County.

It begins at the intersection of Hwy. 64 and Hwy. 163 and extends south 2.20 miles including 0.189 mile exception.

The following items and approximate quantities are involved:

92	Stas	Reconst.Base Crse.
1662	CuYds	Bank Gravel Base Crse.
14058	Gals	Prime Coat
257	Gals	Tack Coat
331	CuYds	Min.Aggr.in Bit Surf.Trmt.(Cl.10)
7929	Gals	Asph.in Bit.Surf.Trmt.
2816	Tons	Min.Aggr.in ACHM Surf.Crse.(Ty.2)
164	Tons	Asph.Cem.in ACHM Surf.Crse.
1	L.S.	Maint.of Traffic
114	SqFt	Signs
1063	LinFt	Temp.Pvmt.Mkgs.
1	L.S.	Mobilization

The successful bidder will be required to complete this contract on or before November 19, 1986.

Figure 4.1 Proposed Project Work Items (Arkansas)

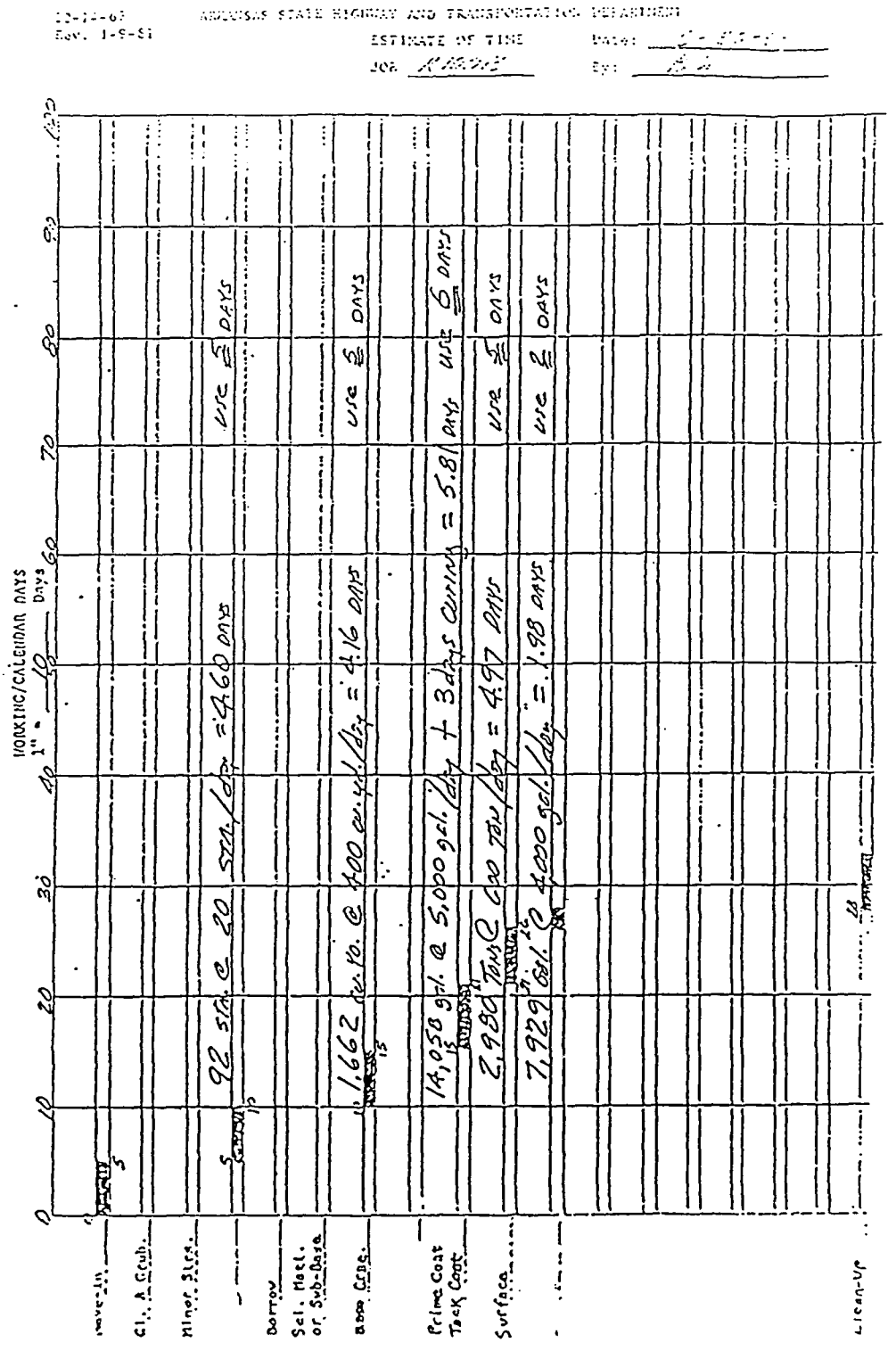


Figure 4.2 Project Bar Chart (Arkansas)

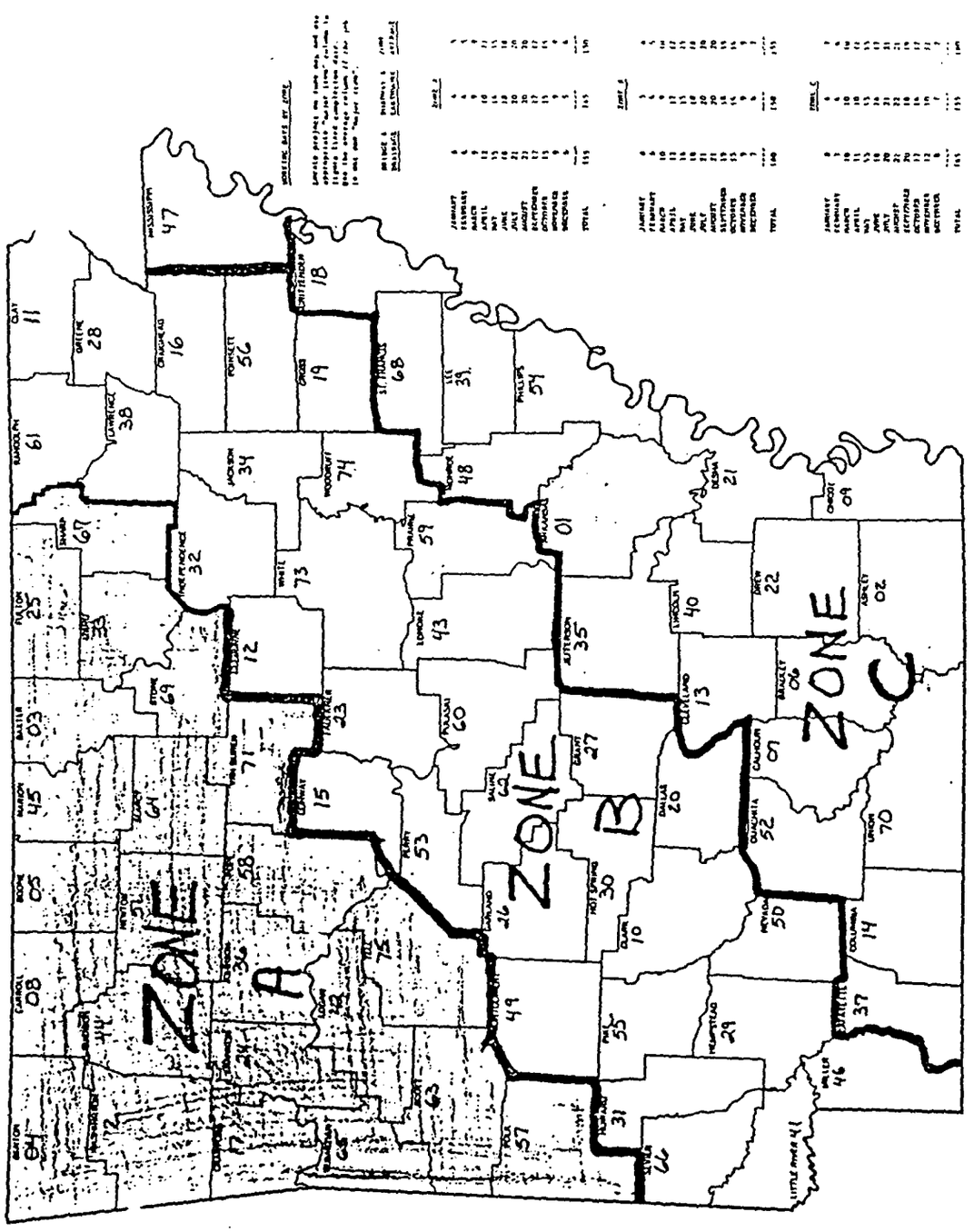


Figure 4.3 Work Day Zone Chart (Arkansas)

Once the number of calendar days needed for the work is established, a fixed completion date is determined based on an estimated starting date of the project. When other factors, such as seasonal limitations, utility adjustments, projects with specialty items, or jobs on which quick completion is desired, are of importance, the fixed completion date is adjusted accordingly. It is only this fixed completion date that the contractor sees in proposal documents; he is responsible for establishing his own progress scnedule for completing the work within the allotted time.

MARYLAND

The method used by the Maryland Department of Transportation in determining contract durations is very similar to that used in Arkansas; production rates based on historical data are the foundation of contract time determination.

Using the Engineer's project estimate, controlling work item quantities are divided by standard productivity rates which provide "unadjusted" work days for each work item. These unadjusted work days are then multiplied by the "Average Overlap %" to determine adjusted work days for each work item. This value is the average amount of time, based on historical data, that work items are considered controlling

versus overlapping. Figure 4.4 displays these values for various work items and shows how adjusted work days are computed.

After adjusted work days have been calculated, consideration is given to construction seasons. To do this, the adjusted work days are charted on a bar chart (see Figure 4.5) based on the anticipated Notice to Proceed date and the average number of work days per region depending on the type of job, as shown in Figure 4.6. This enables the estimator to foresee if certain items of work might be delayed due to temperature or weather restrictions, or other limiting conditions.

Other considerations include:

-Lead time needed for approval of plans, shop drawings, and pile hammers

-Time for fabrication of structural steel and other specialty items

-Curing time and waiting periods between successive paving courses and between concrete placement operations, as well as specified embankment settlement periods

-Conflicting operations of adjacent projects both public and private

-Necessity for coordination of road construction with utility construction or relocation, when indicated in contract provisions

OVERLAP/SPECIAL CONDITIONS

OPERATION	*AVERAGE OVERLAP	SPECIAL CONDITIONS
Preliminary/Prep Time	100%	Max. 10 Days
Grading	70%	Usually includes drainage
Drainage	0-25%	Drainage items are usually completed during grading.
STRUCTURES		
Excavation	25%	
Piling	25%	
Footing Concrete	25%	
Substructure	75%	
Struct. Steel	75%	Minimum 150 CD required
Superstructure	100%	to fabricate & furnish
Deck Coatings	100%	struct. steel.
PAVING	70%	Resurface = 100%
SHOULDERS	70%	Resurface = 100%
LANDSCAPING	100%	
UTILITIES (included in contract)		
Water, Sewage	0	
Lighting, Signing, Signals	0 - 50%	
CLEANUP, FINALIZE PROJECT	100%	Max. 10 Days

*No. of adjusted work days = No. of unadjusted work days x Average Overlap (controlling %)

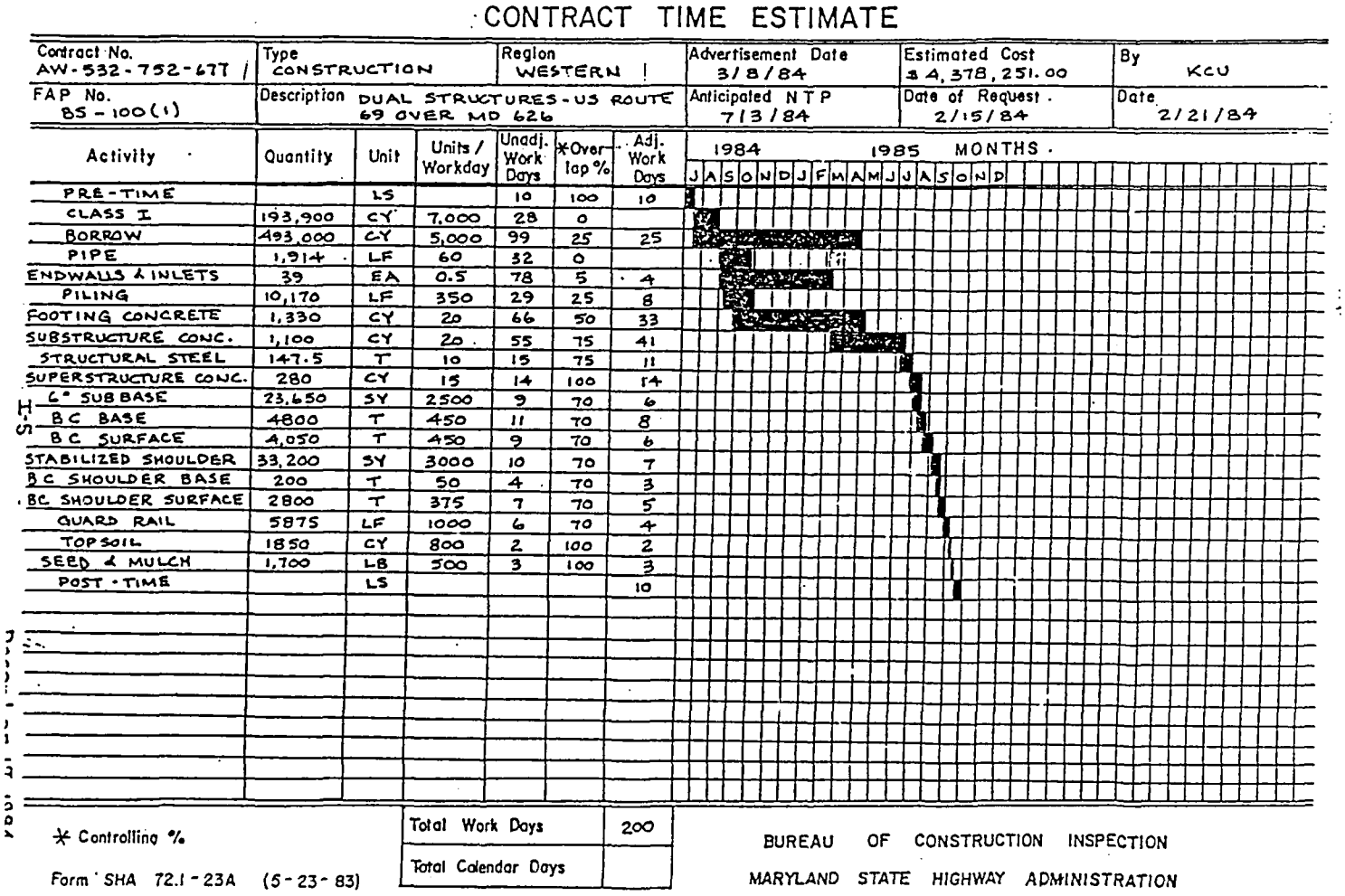
where the no. of unadjusted work days = $\frac{\text{plan quantity}}{\text{productivity rate}}$

(Convert controlling % to decimal by dividing by 100 before multiplying))

Ex. $\frac{120 \text{ C.Y.}}{15 \text{ C.Y./day (Productivity rate)}} = \frac{\text{(plan quantity)}}{}$ = 8 unadjusted work days

8 unadj. work days x . 25 (25% controlling %)= 2 adjusted workdays

Figure 4.4 Average Overlap Values (Maryland)



CONTRACT TIME ESTIMATE

Contract No.	Type	Region	Advertisement Date	Estimated Cost	By
AW-532-752-677	CONSTRUCTION	WESTERN	3/8/84	$4,378,251.00	KCU
FAP No.	**Description**		**Anticipated NTP**	**Date of Request**	**Date**
BS-100(1)	DUAL STRUCTURES-US ROUTE 69 OVER MD 626		7/3/84	2/15/84	2/21/84

Activity	Quantity	Unit	Units / Workday	Unadj. Work Days	*Overlap %	Adj. Work Days
PRE-TIME		LS		10	100	10
CLASS I	193,900	CY	7,000	28	0	
BORROW	493,000	CY	5,000	99	25	25
PIPE	1,914	LF	60	32	0	
ENDWALLS & INLETS	39	EA	0.5	78	5	4
PILING	10,170	LF	350	29	25	8
FOOTING CONCRETE	1,330	CY	20	66	50	33
SUBSTRUCTURE CONC.	1,100	CY	20	55	75	41
STRUCTURAL STEEL	147.5	T	10	15	75	11
SUPERSTRUCTURE CONC.	280	CY	15	14	100	14
6" SUB BASE	23,650	SY	2500	9	70	6
BC BASE	4800	T	450	11	70	8
BC SURFACE	4,050	T	450	9	70	6
STABILIZED SHOULDER	33,200	SY	3000	10	70	7
BC SHOULDER BASE	200	T	50	4	70	3
BC SHOULDER SURFACE	2800	T	375	7	70	5
GUARD RAIL	5875	LF	1000	6	70	4
TOPSOIL	1850	CY	800	2	100	2
SEED & MULCH	1,700	LB	500	3	100	3
POST-TIME		LS				10

1984 1985 MONTHS
J A S O N D J F M A M J J A S O N D

Total Work Days	200
Total Calendar Days	

* Controlling %

Form SHA 72.1-23A (5-23-83)

BUREAU OF CONSTRUCTION INSPECTION
MARYLAND STATE HIGHWAY ADMINISTRATION

Figure 4.5 Contract Time Estimate (Maryland)

AVERAGE NUMBER OF WORKING DAYS ON CONSTRUCTION CONTRACTS

	SOUTH/EASTERN MD.		CENTRAL MARYLAND		WESTERN MARYLAND	
	Bridges	Roads	Bridges	Roads	Bridges	Roads
January	8	5	4	4	4	2
February	8	5	5	5	4	2
March	11	8	9	8	5	4
April	14	15	15	15	14	13
May	18	14	16	18	16	15
June	18	17	18	19	16	18
July	19	17	19	18	19	17
August	18	18	20	18	19	17
September	18	18	19	17	18	18
October	19	18	19	18	16	16
November	16	13	15	16	10	10
December	10	9	10	8	2	4
TOTAL	177	157	169	164	143	136

Calvert	Baltimore	Garrett
Charles	Cecil	Allegany
Caroline	Carroll	
Dorchester	Frederick	
Kent	Harford	
Prince George's	Howard	
Queen Anne's	Montgomery	
St. Mary's	Washington	
Somerset	Anne Arundel	
Talbot		
Wicomico		
Worcester		

The region into which borderline counties are categorized may vary depending upon job location within the county. Use average work days per pertinent regio accordingly.

ffective Dec. 19, 1983

Norman G. Harris, Chief

Bureau of Construction Inspection

December 17, 1984

Figure 4.6 Average Number of Working Days by Location and Job Type (Maryland)

-Duration of disruption to traveling public caused by construction

-Duration of delay in providing relief for heavily congested routes

-Schedule of work on alternate routes

-Loss of revenue to businesses within affected areas

-Timely response of emergency vehicles

-Cost of the project

-Cash flow of the State Highway Administration

From experience, Maryland officials have determined that the most benefit is achieved, in almost all situations, by allowing the least amount of time for contract completion based on <u>average</u> productivity rates. The time allowed in Maryland contracts is almost always in working days, however, for major projects of a sensitive nature, construction time is by specified completion date. In this situation, <u>increased</u> productivity rates are used in anticipation of an accelerated construction schedule which might require the use of multiple shifts and crews, weekend work, etc.

Finally, aside from those considerations given to the unique characteristics of each project, it is felt by Maryland officials that sound engineering judgement is of the utmost importance in the estimation of allowable contract time.

PENNSYLVANIA

Contract durations for ninety-five percent of all projects in Pennsylvania are determined with the aid of a computer generated bar chart. Input by the users of the computer program "Construction Estimator" includes the work days of each operation as calculated from anticipated quantities and productivity rates, the anticipated Notice to Proceed date of the contract, the work activity logic, and a working day calendar based on location and whether or not the project is standard (135 work days/year), accelerated (180 work days/year), or slow (102 work days/year). The input for the working day calendar is shown in Figure 4.7.

The output generated by the computer software consists of a conversion chart of work days to calendar days (see Figure 4.8), and a final calendar day bar chart, as shown in Figure 4.9, which is included in the contract bid proposal for informational purposes in the majority of construction contracts let by the agency.

For projects which are large and complex, and in highly urbanized areas, Critical Path Method (CPM) charts are provided to the Pennsylvania Department of Transportation by design consultants hired by the Department. These type contracts also sometimes include incentive/disincentive clauses for intermediate milestone dates, and increased liquidated damages for contractor failure to meet contract completion dates. Because department personnel have orly limited knowledge of CPM, construction management consultants

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W O R K I N G D A Y C A L E N D A R S

****

filename	working days/month											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
STD135	2	2	7	12	18	18	18	18	18	15	5	2
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
STDBR (standard bridge)	5	5	10	14	18	18	18	18	18	15	10	5
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
STD180 (accelerated)	6	6	11	16	21	20	21	21	20	18	12	8
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
STD109 (signals/lighting)	8	8	11	16	21	20	21	21	20	18	15	8
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
SLOW1-0 (reduced Dist. 1-0)	1	1	1	3	12	17	17	15	15	13	6	1
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NORTH2-0 (Elk, Cameron, North Centre, North Clinton, Clearfield)	0	0	2	6	11	15	15	15	15	13	9	2
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
SOUTH2-0 (Mifflin, South Centre, South Clinton)	2	2	5	7	12	16	16	16	16	14	10	2
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MCKPOT (McKean, Potter)	0	0	2	5	8	14	14	14	14	10	5	2
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
CLAJEF (Clarion, Jefferson)	2	2	4	5	16	18	18	18	11	9	5	2

Figure 4.7 Working Day Calendar (Pennsylvania)

CONVERSION OF WORKING DAYS TO CONSECUTIVE CALENDAR DAYS

BY: JEB DATE: 06-16-1987

****

CONTRACT NUMBER: 111203 LETTING: 7 - 30 - 87

COUNTY: ALLEGHENY NOTICE TO PROCEED: 9 - 14 - 87

ROUTE: 0837 SEC: 52M START WORK: 9 - 14 - 87

CITY-TWP-BORO: DUQUESNE HOURS/DAY: 8

FPN: 010-0019-023
A14-0019-023 DAYS/WEEK: 5

SPN: B 0837052M1110-383 REVISION NO: 00 TRAINEES: Y

****

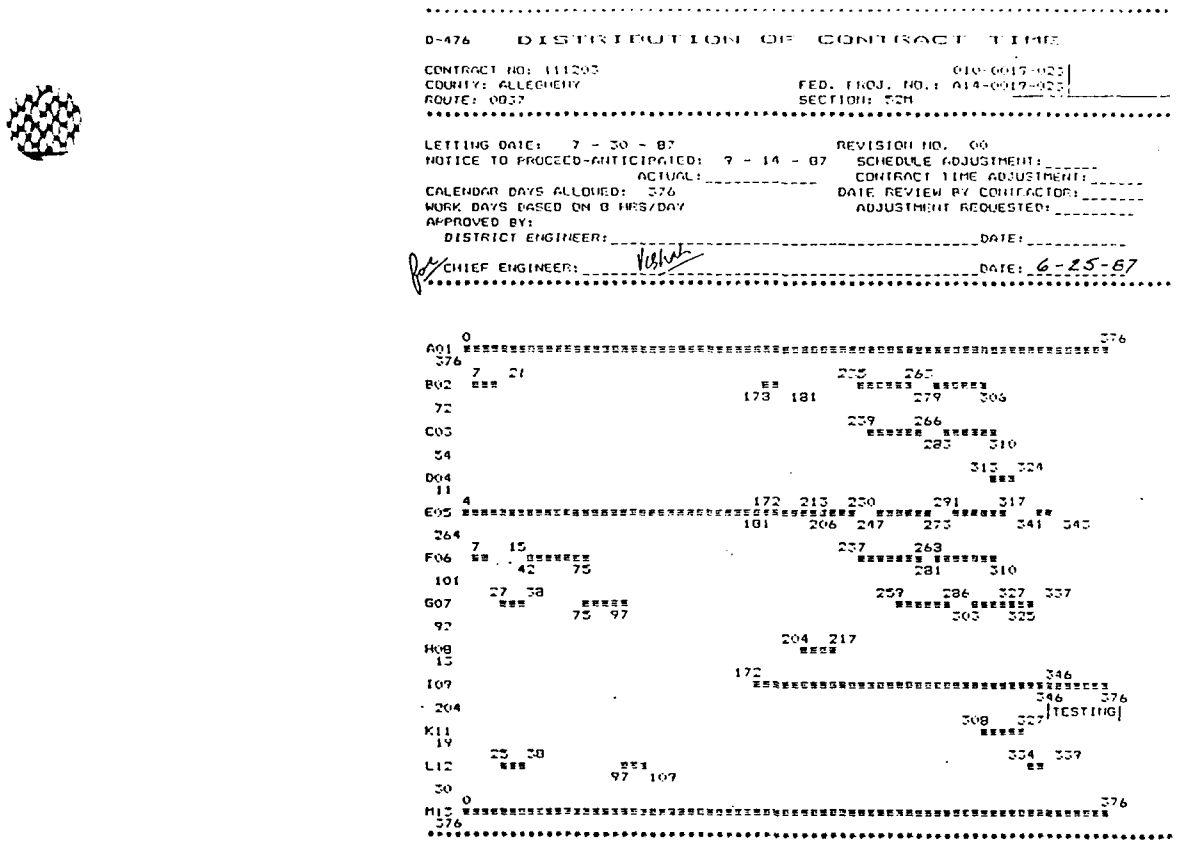
OPERATION	WORKING DAYS BEGIN	WORKING DAYS END	CALENDAR DAYS BEGIN	CALENDAR DAYS END	TOTAL OPERATION CALENDAR DAYS
A01	0	3	0	5	5
B02	4	12	7	21	
B02	53	54	178	181	
B02	77	93	235	263	
B02	103	119	279	306	72
C03	79	95	239	266	
C03	105	121	283	310	54
D04	123	129	313	324	11
E05	2	51	4	172	
E05	54	63	181	206	
E05	66	74	213	230	
E05	84	99	247	273	
E05	110	125	291	317	
E05	139	140	341	343	264
F06	4	9	7	15	
F06	22	34	42	75	
F06	78	96	237	268	
F06	104	121	281	310	101
G07	15	20	27	38	
G07	34	38	75	97	
G07	91	107	259	286	
G07	117	130	303	325	
G07	131	137	327	337	92
H08	62	68	204	217	13
I09	51	142	172	346	
I09	142	144	346	376	204
K11	120	131	308	327	19
L12	14	20	25	38	
L12	38	40	97	109	
L12	135	138	334	339	30
M13	0	143	0	370	370

****

A01T = 1 TO 376

****

Figure 4.8 Work Day to Calendar Day Conversion Chart (Pennsylvania)



SCHEDULE OF OPERATIONS

CONTRACT NO: 111203

OPERATION	BEGIN DATE	END DATE
A01 PROJECT PREP. & MISC.	9 - 14 - 87	9 - 23 - 87
B02 EARTHWORK	9 - 20 - 87	10 - 4 - 87
	3 - 9 - 88	3 - 12 - 88
	5 - 5 - 88	6 - 2 - 88
	6 - 18 - 88	7 - 15 - 88
C03 SUBBASE	5 - 9 - 88	6 - 5 - 88
	6 - 22 - 88	7 - 19 - 88
D04 BITUM. PAVE. & BASE COURSES	7 - 22 - 88	8 - 2 - 88
E05 RIGID PAVEMENT	9 - 17 - 87	3 - 3 - 88
	3 - 12 - 88	4 - 6 - 88
	4 - 13 - 88	4 - 20 - 88
	5 - 17 - 88	6 - 12 - 88
	6 - 30 - 88	7 - 26 - 88
	8 - 19 - 88	8 - 21 - 88
F06 DRAINAGE	9 - 20 - 87	9 - 28 - 87
	10 - 25 - 87	11 - 27 - 87
	5 - 7 - 88	6 - 7 - 88
	6 - 20 - 88	7 - 19 - 88
G07 CURBS & GUTTERS	10 - 10 - 87	10 - 21 - 87
	11 - 27 - 87	12 - 17 - 87
	5 - 29 - 88	6 - 25 - 88
	7 - 12 - 88	8 - 3 - 88
	8 - 5 - 88	8 - 15 - 88
H08 LANDSCAPING	4 - 4 - 88	4 - 17 - 88
I09 TRAFFIC ACC. & CONTROL	5 - 5 - 88	8 - 24 - 88
TESTING	8 - 24 - 88	9 - 23 - 88
K11 SHOULDERS	7 - 17 - 88	8 - 5 - 88
L12 GUIDE RAILS, ETC.	10 - 8 - 87	10 - 21 - 87
	12 - 17 - 87	12 - 31 - 87
	8 - 12 - 88	8 - 17 - 88
M13 TEMP. TRAFFIC ACCOM.	9 - 14 - 87	9 - 23 - 88

Figure 4.9 Final Calendar Day Bar Chart (Pennsylvania)

are retained to monitor and analyze project CPM charts during project construction.

The CPM chart developed by the department's design consultant (see Figure 4.10) is included with the contract bid proposal along with special contract provisions that discuss its use. These provisions state that deviations may be made, upon approval, from the general logic sequence of the Pre-Bid Schedule to suit the sequence preferred by the contractor, however, the contract completion date and the milestone dates in the schedule are considered binding.

As a back-up to the methods discussed above, the Pennsylvania Department of Transportation also prepares additional documents that show the schedule of work for projects. These include a "Straight-Line Diagram and Analysis of Operations" (see Figure 4.11), and a work day bar chart as shown in Figure 4.12. The first document includes a diagram that shows the limits of work by stations, quantities and productivity rates of project work items, the construction sequence of the project, and the duration of each work item in work days. The second document summarizes the work item information from the first in the form of a bar chart.

One important aspect of this process that was not made clear in the Pennsylvania DOT survey response is the manner in which productivity rates are determined. It appears from the information provided that the determination of these values is left to the discretion and experience of individual District offices.

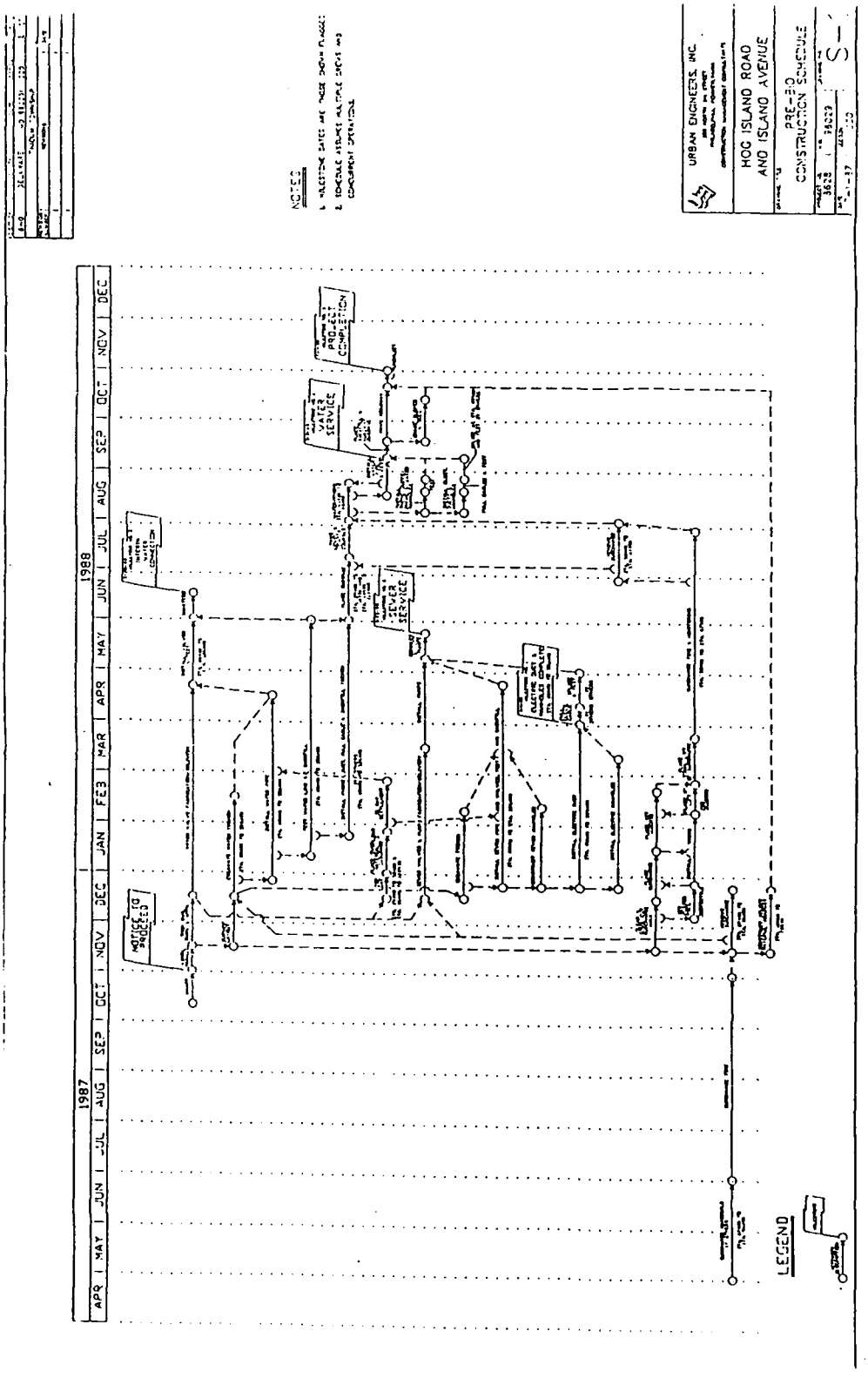
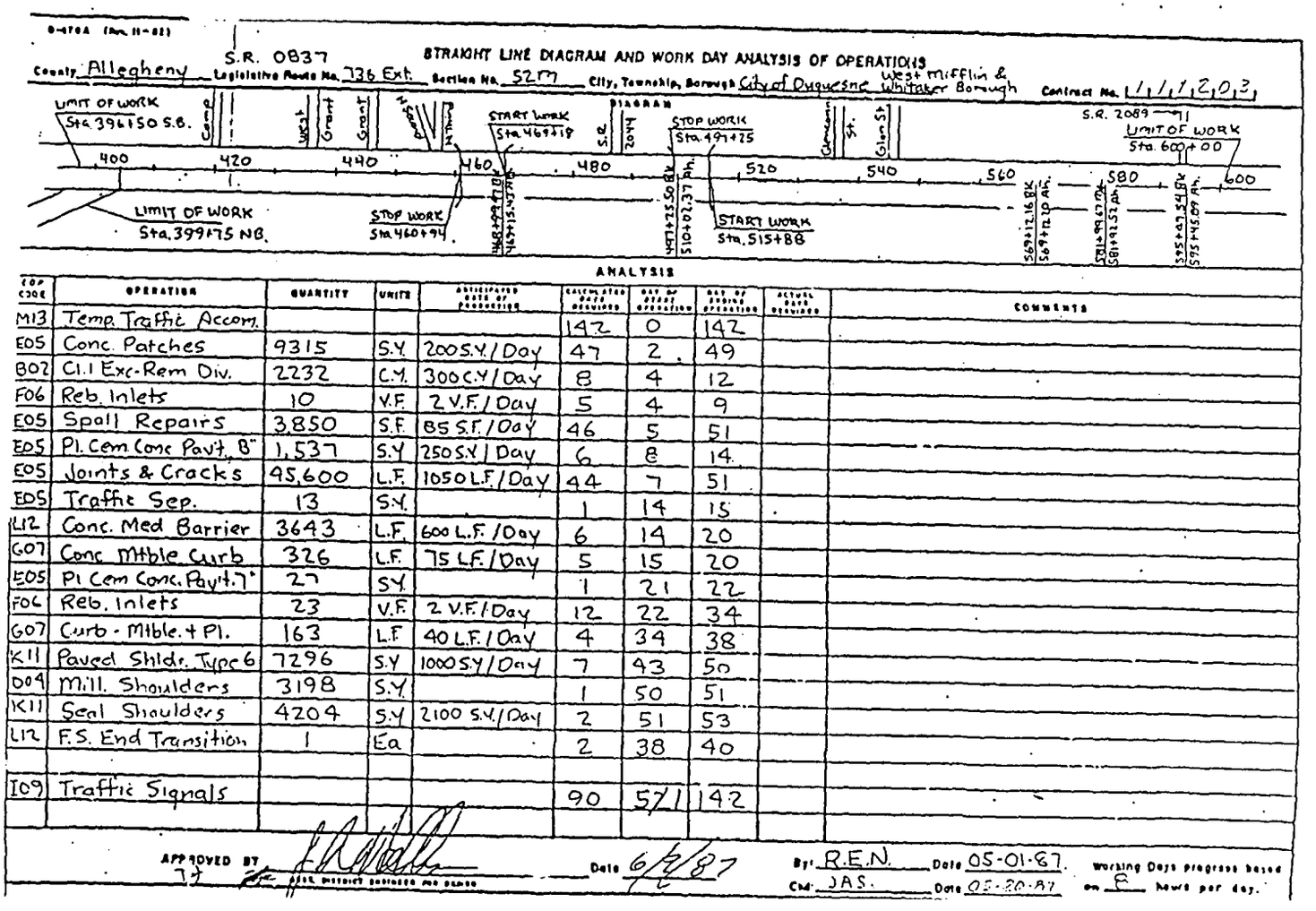


Figure 4.10 Pre-Bid CPM Construction Schedule (Pennsylvania)



STRAIGHT LINE DIAGRAM AND WORK DAY ANALYSIS OF OPERATIONS

S.R. 0837 | County: Allegheny | Legislative Route No. 736 Ext. | Section No. 52M | City, Township, Borough: City of Duquesne, West Mifflin & Whitaker Borough | Contract No. 1,1,1,2,0,3,1

DIAGRAM

LIMIT OF WORK Sta. 396+50 S.B. | Center | West | Grant | Grant | Duquesne | Mifflin | START WORK Sta. 469+18 | S.R. 2049 | STOP WORK Sta. 497+25 | Concession | St. | Glen St | S.R. 2089 | LIMIT OF WORK Sta. 600+00

400 | 420 | 440 | 460 | 480 | 520 | 540 | 560 | 580 | 600

LIMIT OF WORK Sta. 399+75 NB.

STOP WORK Sta. 460+94

START WORK Sta. 515+88

ANALYSIS

COP CODE	OPERATION	QUANTITY	UNITS	ANTICIPATED RATE OF PRODUCTION	CALENDAR DAYS REQUIRED	DAY OF START OPERATION	DAY OF ENDING OPERATION	ACTUAL DAYS REQUIRED	COMMENTS
M13	Temp. Traffic Accom.				142	0	142		
E05	Conc. Patches	9315	S.Y.	200 S.Y./Day	47	2	49		
B02	Cl. 1 Exc-Rem Div.	2232	C.Y.	300 C.Y./Day	8	4	12		
F06	Reb. Inlets	10	V.F.	2 V.F./Day	5	4	9		
E05	Spall Repairs	3850	S.F.	85 S.F./Day	46	5	51		
E05	Pl. Cem Conc Pavt. 8"	1,537	S.Y.	250 S.Y./Day	6	8	14		
E05	Joints & Cracks	95,600	L.F.	1050 L.F./Day	44	7	51		
E05	Traffic Sep.	13	S.Y.		1	14	15		
L12	Conc. Med Barrier	3643	L.F.	600 L.F./Day	6	14	20		
G07	Conc. Mtble Curb	326	L.F.	75 L.F./Day	5	15	20		
E05	Pl Cem Conc. Pavt. 7"	27	S.Y.		1	21	22		
F06	Reb. Inlets	23	V.F.	2 V.F./Day	12	22	34		
G07	Curb - Mtble. + Pl.	163	L.F.	40 L.F./Day	4	34	38		
K11	Paved Shldr. Type 6	7296	S.Y.	1000 S.Y./Day	7	43	50		
D04	Mill. Shoulders	3198	S.Y.		1	50	51		
K11	Seal Shoulders	4204	S.Y.	2100 S.Y./Day	2	51	53		
L12	F.S. End Transition	1	Ea		2	38	40		
I09	Traffic Signals				90	52	142		

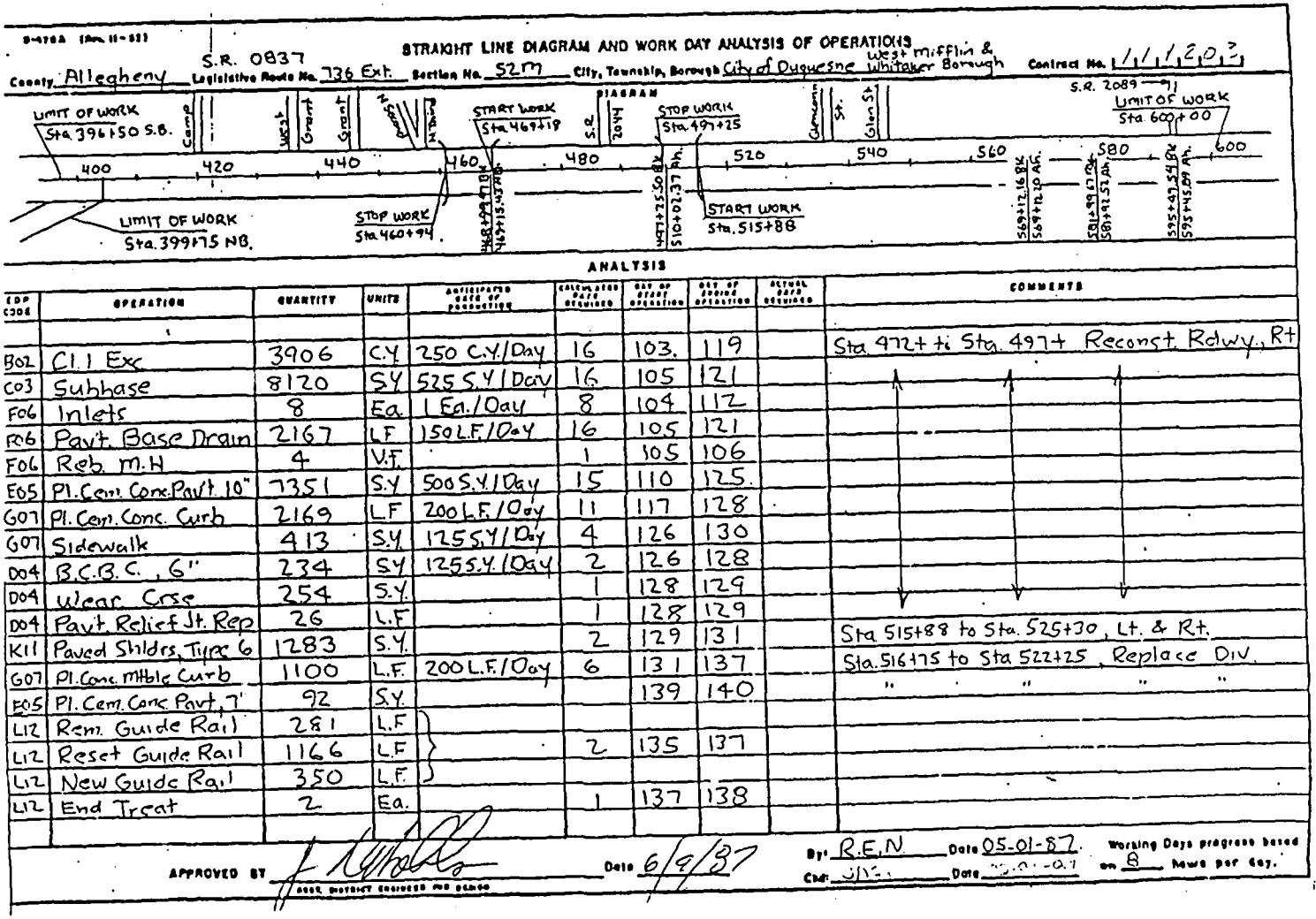
APPROVED BY [signature] Date 6/2/87

By: R.E.N. Date 05-01-87.

Chd: JAS. Date 05-20-87

Working Days progress based on 8 hours per day.

Figure 4.11 Straight-Line Diagram & Analysis of Operations (Pennsylvania)



STRAIGHT LINE DIAGRAM AND WORK DAY ANALYSIS OF OPERATIONS

S.R. 0837 | County: Allegheny | Legislative Route No. 736 Ext. | Section No. 52M | City, Township, Borough: City of Duquesne, West Mifflin & Whitaker Borough | Contract No. 1/1/1/2/0/3

DIAGRAM

ANALYSIS

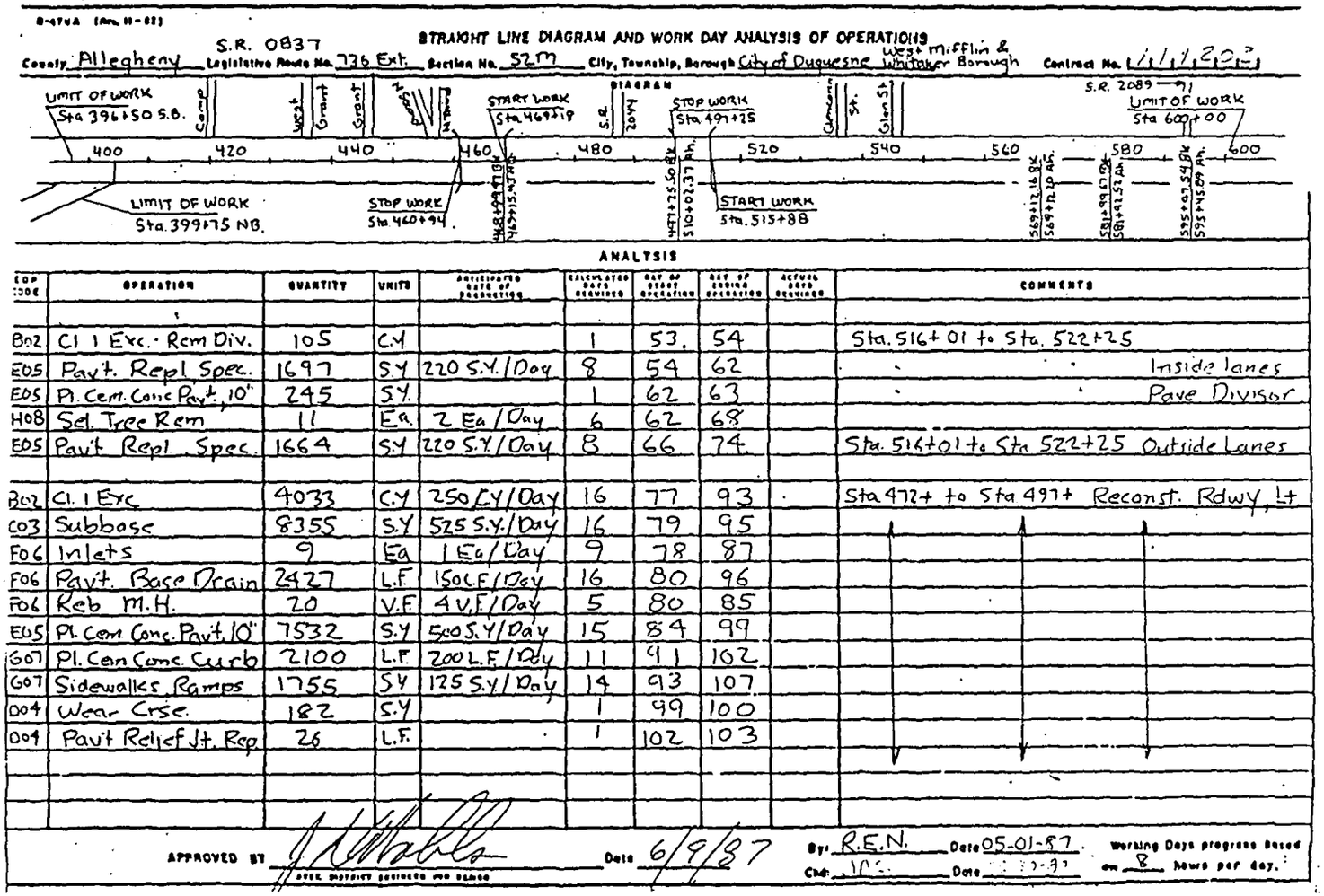
EDP CODE	OPERATION	QUANTITY	UNITS	ANTICIPATED RATE OF PRODUCTION	CALENDAR DAYS REQUIRED	DAY OF START OPERATION	DAY OF ENDING OPERATION	ACTUAL DAYS REQUIRED	COMMENTS
B02	Cl. 1 Exc	3906	C.Y.	250 C.Y./Day	16	103.	119		Sta. 472+ti Sta. 497+ Reconst. Rdwy., Rt
C03	Subbase	8120	S.Y.	525 S.Y./Day	16	105	121		
F06	Inlets	8	Ea.	1 Ea./Day	8	104	112		
R06	Pavt. Base Drain	2167	L.F.	150 L.F./Day	16	105	121		
F06	Reb. M.H.	4	V.F.		1	105	106		
E05	Pl. Cem. Conc. Pavt. 10"	7351	S.Y.	500 S.Y./Day	15	110	125.		
G07	Pl. Cem. Conc. Curb	2169	L.F.	200 L.F./Day	11	117	128		
G07	Sidewalk	413	S.Y.	125 S.Y./Day	4	126	130		
D04	B.C.B.C., 6"	234	S.Y.	125 S.Y./Day	2	126	128		
D04	Wear Crse	254	S.Y.		1	128	129		
D04	Pavt. Relief Jt. Rep	26	L.F.		1	128	129		
K11	Paved Shlders, Type 6	1283	S.Y.		2	129	131		Sta. 515+88 to Sta. 525+30, Lt. & Rt.
G07	Pl. Conc. mtble Curb	1100	L.F.	200 L.F./Day	6	131	137		Sta. 516+75 to Sta. 522+25, Replace Div.
E05	Pl. Cem. Conc. Pavt. 7"	92	S.Y.			139	140		" " " "
L12	Rem. Guide Rail	281	L.F.						
L12	Reset Guide Rail	1166	L.F.		2	135	137		
L12	New Guide Rail	350	L.F.						
L12	End Treat	2	Ea.		1	137	138		

APPROVED BY _____ Date 6/9/87
(DIST. DISTRICT ENGINEER AND DESIGN)

By: R.E.N Date 05-01-87 Working Days progress based on 8 hours per day.

Chk: _____ Date _____

Figure 4.11 (Continued)



STRAIGHT LINE DIAGRAM AND WORK DAY ANALYSIS OF OPERATIONS

S.R. 0837

County Allegheny Legislative Route No. 736 Ext. Section No. 52M City, Township, Borough City of Duquesne West Mifflin & Whitaker Borough Contract No. 1/1/1/2/2-1

DIAGRAM

ANALYSIS

EQP CODE	OPERATION	QUANTITY	UNITS	ANTICIPATED RATE OF PRODUCTION	CALENDAR DAYS REQUIRED	DAY OF START OPERATION	DAY OF ENDING OPERATION	ACTUAL DAYS REQUIRED	COMMENTS
B02	Cl 1 Exc. · Rem Div.	105	C.Y.		1	53	54		Sta. 516+01 to Sta. 522+25
E05	Pavt. Repl Spec.	1697	S.Y.	220 S.Y./Day	8	54	62		Inside lanes
E05	Pl. Con. Conc Pavt. 10"	245	S.Y.		1	62	63		Pave Divisor
H08	Sel. Tree Rem	11	Ea.	2 Ea/Day	6	62	68		
E05	Pavt Repl Spec.	1664	S.Y.	220 S.Y./Day	8	66	74		Sta. 516+01 to Sta 522+25 Outside Lanes
B02	Cl. 1 Exc	4033	C.Y.	250 C.Y./Day	16	77	93		Sta 472+ to Sta 497+ Reconst. Rdwy, Lt
C03	Subbase	8355	S.Y.	525 S.Y./Day	16	79	95		
F06	Inlets	9	Ea	1 Ea/Day	9	78	87		
F06	Pavt. Base Drain	2427	L.F.	150 L.F./Day	16	80	96		
F06	Reb M.H.	20	V.F.	4 V.F./Day	5	80	85		
E05	Pl. Con Conc. Pavt. 10"	7532	S.Y.	500 S.Y./Day	15	84	99		
G07	Pl. Con Conc Curb	2100	L.F.	200 L.F./Day	11	91	102		
G07	Sidewalks, Ramps	1755	S.Y.	125 S.Y./Day	14	93	107		
D04	Wear Crse.	182	S.Y.		1	99	100		
D04	Pavt Relief Jt. Rep	26	L.F.		1	102	103		

APPROVED BY _____ (STATE DISTRICT ENGINEER AND DESIGN) Date 6/9/87

By: R.E.N. Date 05-01-87 Working Days progress based on 8 hours per day.

Chd: [illegible] Date [illegible]-87

Figure 4.11 (Continued)

D-476 (12-82)

DISTRIBUTION OF CONTRACT TIME

CONTRACT NUMBER 1/1/12/013

FEDERAL PROJECT NUMBER

COUNTY	ROUTE	SECTION	CITY - TOWNSHIP - BORO	PREPARED FOR LETTING OF	NOTICE TO PROCEED ANTICIPATED. ACTUAL.	142 WORKING DAYS BASED ON X hrs/day CALENDAR DATES ALLOWED	Date original schedule reviewed with contractor. Did contractor request adjustment of schedule or of contract time?	APPROVED REVISIONS Revision No. For Adjustment of Schedule ☐ For Adjustment of Contract Time ☐	APPROVED BY
Allegheny	0837	52M1	City of Duquesne West Mifflin Boro Whitaker Boro	July 30, 1987					for DISTRICT ENGINEER 6/9/87 DATE CHIEF ENGINEER DATE

SCHEDULE OF OPERATIONS

YEAR

MONTH

CALENDAR DAY / WORK

10 20 30 40 50 60 70 80 90 100 110 120 130 140

OPERATION	
A01 PROJECT PREPARATION AND MISCELLANEOUS	
B02 EARTHWORK	4-12 77-93 41 W.D. 53-54 103-119
C03 SUBBASE	79-95 32 W.D 105-121
D04 BITUMINOUS PAVEMENTS AND BASE COURSES	6 W.D 123-129
E05 RIGID PAVEMENTS	2-31 84-99 97 W.D. 54-63 110-125 66-74 139-140
F06 DRAINAGE	78-96 4-9 52 W.D. 22-34 104-121
G07 CURBS AND GUTTERS	15-20 117-130 14 W.D. 34-38 131-137 91-107
H08 LANDSCAPING	6 W.D. 62-68
I09 TRAFFIC ACCOMMODATION AND CONTROL	51 90 W.D. 52-142
J10 STRUCTURES	142-160 TESTING
K11 SHOULDERS	11 W.D 120-131
L12 GUIDE RAIL, MEDIAN BARRIER, R/W FENCE	14-20 135-138 11 W.D. 38-90
M13 TEMPORARY TRAFFIC ACCOMMODATION	142 W.D. 0-142
CONCURRENT WORK BY OTHERS	

Figure 4.12 Work Day Bar Chart (Pennsylvania)

SOUTH CAROLINA

The method used to determine contract durations by the South Carolina Department of Highways and Public Transportation is similar to that used in Maryland. Standard productivity rates based on project size and type, and estimated work item quantities determine an unadjusted amount of time needed to complete the work. While Maryland adjusts each individual work item according to "Average Overlap" values, South Carolina adjusts the sum of all controlling work item work days by multiplying the total value by a "concurrency factor" which accounts for the number of potential activities which can be performed simultaneously. This factor can range between 0.5 and 1.0, depending on the type and complexity of the project. The lower end of this range is typical for grading, drainage, paving, and bridge projects, while the upper end of the scale is more suited towards resurfacing projects.

Once the adjusted number of work days has been calculated, the effect of work seasons on contract time is determined. This is accomplished by the use of a "time chart" which accounts for the number of anticipated days per month, depending on type of job, that would be suitable for performing construction work.

Figure 4.13 and 4.14 illustrate this process. As seen in Figure 4.13, the total amount of work days, when adjusted by a concurrency factor of 0.5 applicable to the project

CALCULATION OF CONTRACT TIME

PROJECTS(ESTIMATED COST-OVER $1,000,000)

TYP. PRIM. PROJ. (WID.,GRAD.,DRAIN.,C&G.,REHAB.) LETTING: JUNE 1987

FILE NO.: 32.806 etc. PROJECT NO.: IR-IRG-20-2(57) COUNTY: RICH/LEX LENGTH: 12.071 MI.

ITEMS	QUANTITY	UNIT	UNITS/DAY	DAYS
CLEARING AND GRUBBING	12.071	MILE	0.3	40
UNCLASSIFIED EXCAVATION	216675	CY	(a) 3000	72
TRAFFIC ITEMS	0	NA	1	40
MAC. OR STAB. AGGR. BASE CR.	2670	SY	1000	3
EARTH TYPE BASE COURSE	0	CY	800	0
SCARIFYING,MIXING,ETC.	0	MSY	4	0
MILLING	0	SY	8000	0
REM. OF EXIST. PAVT.	16296	SY	800	20
ASPH. CONC. SURF. CR.	56227	TON	(a) 1200	47
ASPH. CONC. BIND. CR.	91255	TON	(a) 1200	76
ASPH. AGGR. BASE CR.	135642	TON	(a) 1200	113
CONC. CURB & GUTTER	18152	LF	300	61
CONC. MED. BARRIER	39823	LF	1000	40
CONC. MEDIAN	2168	SY	150	14
PIPE CULVERTS(15"-24")	25040	LF	200	125
PIPE CULVERTS(30"-54")	1672	LF	150	11
PIPE CULVERTS(60" OR))	0	LF	100	0
CATCH BASINS ,MANHOLES,ETC.	283	EACH	8	35
GUARD RAIL	31667	LF	300	106
PIPE UNDERDRAINS	0	LF	300	0
BRICK MASONRY	0	CY	25	0
CONC. FOR STRUCTURES	353	CY	8	44
FENCE	11600	LF	300	39
SEEDING	142	MSY	18	8

(a) Note: Units adjusted for this type of project due to length of haul, location of asphalt plants, etc.

TOTAL 894

(CONCURRENCY FACTOR = 0.5) ADJUSTED TOTAL(DAYS) 447

COMPLETION DATE : JUNE 30, 1990 — OK —

Figure 4.13 Calculation of Contract Time Sheet (South Carolina)

GRADING, DRAINAGE, BASE & SURFACING PROJECTS

LETTING DATE

Month	Working Days/Month	January	February	March	April	May	June	July	August	September	October	November	December
January	5	311	297	278	260	239	219	201	184	173	168	163	157
February	6	317	303	284	266	245	225	207	190	179	174	169	163
March	9	326	312	293	275	254	234	216	199	188	183	178	172
April	14	14	326	307	289	268	248	230	213	202	197	192	186
May	19	33	19	326	308	287	267	249	232	221	216	211	205
June	18	51	37	18	326	305	285	267	250	239	234	229	223
July	21	72	58	39	21	326	306	288	271	260	255	250	244
August	20	92	78	59	41	20	326	308	291	280	275	270	264
September	18	110	96	77	59	38	18	326	309	298	293	288	282
October	17	127	113	94	76	55	35	17	326	315	310	305	299
November	11	138	124	105	87	66	46	28	11	326	321	316	310
December	5	143	129	110	92	71	51	33	16	5	326	321	315
January	5	148	134	115	97	76	56	38	21	10	5	326	320
February	6	154	140	121	103	82	62	44	27	16	11	6	326
March	9	163	149	130	112	91	71	53	36	25	20	15	9
April	14	177	163	144	126	105	85	67	50	39	34	29	23
May	19	196	182	163	145	124	104	86	69	58	53	48	42
June	18	214	200	181	163	142	122	104	87	76	71	66	60
July	21	235	221	202	184	163	143	125	108	97	92	87	81
August	20	255	241	222	204	183	163	145	128	117	112	107	101
September	18	273	259	240	222	201	181	163	146	135	130	125	119
October	17	290	276	257	239	218	198	180	163	152	147	142	136
November	11	301	287	268	250	229	209	191	174	163	158	153	147
December	5	306	292	273	255	234	214	196	179	168	163	158	152

File No. 32.806 etc. - Roadway items were determining factor.

(1) Allowed two months for scheduling and mobilization: Began counting time in September 1987.

(2) 447 days required. - 326 + 122 = 448 - Set C.D. - June 30, 1990

Figure 4.14 Grading, Drainage, Base, and Surfacing Project Time Chart (South Carolina)

shown, equals 447 work days. Considering a contract letting in June, 1987, and 163 work days/year as determined by the time chart of Figure 4.14, work through the full month of June, 1990 is necessary for this particular project.

To show the effect on the number of anticipated work days per month by the type of job involved, a time chart for resurfacing projects is shown in Figure 4.15. As can be seen, these values differ significantly from those of Figure 4.14, and the total number of anticipated work days per year is calculated as 147 vice 163.

WYOMING

The Critical Path Method is used by the Wyoming Highway Department in determining contract durations. The procedures followed were summarized by the Transportation Research Board in their Synthesis of Highway Practice, Special Report 79 entitled "Contract Time Determination" and are included as Appendix E.

RESURFACING PROJECTS

LETTING DATE

Month	Working Days/Month	January	February	March	April	May	June	July	August	September	October	November	December
January	0	285	271	252	234	213	193	175	158	147	147	147	147
February	0	285	271	252	234	213	193	175	158	147	147	147	147
March	9	294	280	261	243	222	202	184	167	156	156	156	156
April	14	14	294	275	257	236	216	198	181	170	170	170	170
May	19	33	19	294	276	255	235	217	200	189	189	189	189
June	18	51	37	18	294	273	253	235	218	207	207	207	207
July	21	72	58	39	21	294	274	256	239	228	228	228	228
August	20	92	78	59	41	20	294	276	259	248	248	248	248
September	18	110	96	77	59	38	18	294	277	266	266	266	266
October	17	127	113	94	76	55	35	17	294	283	283	283	283
November	11	138	124	105	87	66	46	28	11	294	294	294	294
December	0	138	124	105	87	66	46	28	11	0	294	294	294
January	0	138	124	105	87	66	46	28	11	0	0	294	294
February	0	138	124	105	87	66	46	28	11	0	0	0	294
March	9	147	133	114	96	75	55	37	20	9	9	9	9
April	14	161	147	128	110	89	69	51	34	23	23	23	23
May	19	180	166	147	129	108	88	70	53	42	42	42	42
June	18	198	184	165	147	126	106	88	71	60	60	60	60
July	21	219	205	186	168	147	127	109	92	81	81	81	81
August	20	239	225	206	188	167	147	129	112	101	101	101	101
September	18	257	243	224	206	185	165	147	130	119	119	119	119
October	17	274	260	241	223	202	182	164	147	136	136	136	136
November	11	285	271	252	234	213	193	175	158	147	147	147	147
December	0	285	271	252	234	213	193	175	158	147	147	147	147

Charts allow couple of months for scheduling and mobilization.

Figure 4.15 Resurfacing Project Time Chart (South Carolina)

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions.

As outlined in this report, there are various methods used by state transportation agencies for setting time limits on construction projects. Most commonly, the basis for determining contract time includes reliance on construction seasons, anticipated production rates, work-flow techniques, and estimated project cost. In most cases, a combination of two or more of these methods is used in contract time determination, depending on the size, type, and urgency of the work involved.

Probably one of the most important factors in the determination of reasonable contract durations is the performance evaluation of existing methods being used. While most agencies stated that their procedures were based on historical data, only the Maine Department of Transportation provided documentation (although "sketchy") in their survey response that showed the monitoring of estimated work days versus actual work days, and estimated productivity values versus actual productivity values (see Figures 5.1 and 5.2).

Town / Project No.	Total Cost	Working Days: Allowed	Adjusted	Changed	Liq. Dam.: Under	Over	Production Notes: Days Est	Worked Actual
Harmony-Cambridge 0241(18)	1489100	125		116			120	135
Fairfield-Norridgewock 045-1(7)	936000	110		109			112	96
Wayne 013-1(2)	292800	65		64			65	61
China 028-1(23) & 0210(30)	412000	60		58			60	44
Belgrade-Oakland 0228(2)	295000	15		19			15	19
Winslow M-7505(3)	2750000	40		42			40	40
Crawford 046-1(26)	647800	85		66			85	72
Wells 06-1(15) & 07-1(6)	281500	40		97			40	36
Chelsea 0204(2)		22		20			22	21
Mt Desert 0257(14)	2946000	45		46			45	59
Gardiner BS-0165(5)	1316000	65		31			65	27
Albion to Belfast 0210(19) 021(16) 021(17) 0283(12)	929900	45		45			45	40
Auburn 111-0224(1)	3610000	50		47			70	68
Perry-Robbinston 044-2(24) & 044-2(23)	1,147,000	80		47			115	121
Crawford 046-1(31)	164500	75		57			75	53
Littleton-Monticello 050-3(28)	1485100	115		101			113	145
Scarborough M-0527(1)	4227600	90		994			90	105
Mt Desert 0257(16)	2390000	55		464			55	43
Milo-Monson 50-1(90) Etc	1530??	50		79			50	60
Hancock 044-1(29)	7A2000	75		75			100	115
Caswell 0332(22)	1353392	120		127			116	125
Gorham-Monmouth 015-1(99)	722503	70		72			70	73
Harrison-Otisfield 019-1(11)	7756000	115		162			148	254
Eagle Lake 0340(25)	1,586,000	150		135			150	133
Skowhegan Pond 0112(11)	582800	65		84			75	120
Scarborough 01-116(6)E 59	894000						80	142

Figure 5.1 Estimated-vs-Actual Work Days (Maine)

PRODUCTIONS

FAP Highway 5-10

Item	Hot Top D		Hot Top B		Hot Top C		HT Misc	
Town	Actual	Est.	Actual	Est.	Actual	Est.	Actual	Est.
Chelsea	530	603					17	33
Mt. Desert-			→		290	285		
Gardiner			130	225	268	230		
Fryeburg			→		396	196		
Albion to Belfast	1282	1146					25	52
Auburn			277	404	368	395	49	50
Perry-Robbinston	532	550			589	563	20	-
Perry	416	550			463	590	15	40
Crawford			412	525	406	488		
Littleton-Monticello	461	760	298 Base	975		760	93	57
" "			686 "B"	777				
Scarborough			410	315	450	277	39	45
Mt. Desert			311	207	241	250		
Milo-Enfield	1195	1114						
Lincoln-Macwahoc	1621	1089					53	50
Jackman-Moose River	249	390						
Hancock			382	593	409	700	57	60
Cornwall			695	591	639	275	51	67
Greene-Minot	456	761	760	227	513	778	52	22
Harrison-Otisfield			500	528	485	450		
Eagle Lake			Base 524 B 688	463 458	514	443	55	100
Kennebunkport			729	421	452	550	39	55
Scarboro	344	360	316	536	547	487	63	40

Figure 5.2 Estimated-vs-Actual Productivity Rates (Maine)

To determine the validity of existing procedures, it is essential that careful observance be made on all jobs, whether they are completed early, late, or on time, with diary notes kept on determining conditions of each.

To best make use of historical data, an agency should maintain a construction data file that contains such items as production rates, time, weather effects, effects of various job conditions, etc. that cover the previous 3 to 5 year period. Factors discussed earlier in this report including construction season effects, agency cash flow, availability of potential contractors and/or materials, related utility work, and agency commitments should also be given due consideration before final determination of contract time is made. In many cases, standard productivity rates included with agency survey responses were not the same rates used in representative project time determination worksheets provided by the same state agency. As previously discussed, revising figures to accommodate the unique conditions of each particular project is important, but when doing so, it is just as important to document reasons for revisions for future evaluation.

The objective of the agency is the satisfactory and timely completion of work; not the collection of liquidated damages[27]. To this end, it is the agency's responsibility to ensure that contract times are reasonable. Contracts that contain more time than is necessary to complete the work, as

well as contracts that do not allow adequate time for project completion, may result in a poorer quality job, or an increased cost of construction.

Even with utmost care and consideration given to the determination of contract durations, problems may still occur. Factors may be overlooked during the planning stages of a project, contractors may bid more work than they can handle, union difficulties may arise, or site conditions may vary from those thought to exist at the time of contract time determination. It is this point in time that an agency's scheduling efforts in determining contract time becomes extremely valuable. Schedules developed by an agency can be very useful for monitoring work progress, and aid in determining whether steps must be taken to get the contractor back on schedule. They also help substantiate liquidated damages that may be assessed against a contractor, or refute unjustified contractor claims for time extensions.

B. General Recommendations.

The Transportation Research Board has suggested the following general guidelines for state agencies when computing contract durations[28]:

1. It is recommended that agencies be flexible in establishing project working days or completion dates. It is not desirable to be highly restrictive in specifying contract duration. For some projects, selecting contract time based

on construction seasons appears to have merit. Liberal use of construction-season time limits on paving and resurfacing projects will help contractors in keeping bids reasonable.

2. When a contract must be completed within a narrow range of time, specifying a contract completion date is preferable to the stipulation of the number of working or calendar days.

3. Once specified, contract time becomes a contractual condition and should be rigorously enforced.

4. Liquidated damages should be prescribed according to the time that traffic and/or the general public is inconvenienced, and for direct engineering supervision costs of minor completion off the roadway.

5. The time required to complete a construction project may be based on past experience with similar work. It is recommended that a formal rational approach be developed for use in determining time requirements.

6. Some means of showing the time available for specific items of project work is recommended. A precedence (CPM) chart or bar chart may be prepared manually or with the aid of a computer.

7. Time schedules should be compared with the actual progress on the project. The contractor should be required to prepare a revised schedule if a work slowdown occurs.

8. Enforcement of time charges on working-day contracts should be administered uniformly and fairly. The contractor should be given the opportunity to contest time charges.

9. Production rates and other variables used to estimate contract time should be updated monthly or after each major letting. Data not reflecting current conditions should be removed from the file.

10. In setting contract time limits, a decision must be made on whether to have the construction project completed by a specific date at any cost or to have the project completed in a reasonable period of time at reasonable cost. The agency should be responsible for identifying the projects that must be completed at the earliest practical date. The agency must also decide whether to use only liquidated damages or to specify incentive payments in addition to liquidated damages.

11. Each method of setting contract time should be evaluated by comparing contract completion times to actual completion times. An analysis of the frequency of the use of liquidated damages and bonuses should be made when modifications of the methods are considered.

Another recommendation is that the states make an attempt to establish common terminology for work categories so that comparisons can be made, at least within geographical regions, to assist in the evaluation and updating of currently used productivity rates and other job factors.

C. Proposed Methodology for Determining Contract Time.

In the vast majority of cases it is not necessary for agencies to determine exact day-to-day schedules for projects when establishing contract time, it is only necessary to consider those work items that are significant or controlling in nature. For this reason, with the exception of large, complex projects, simple bar charts are more than adequate when determining reasonable contract durations. They are easy to understand and prepare. The following step-by-step approach, nearly identical to the approach outlined in the June, 1981 ASCE paper "Setting Highway Construction Contract Duration" by Donn E. Hancher, and James E. Rowings, is offered as a suggested method of determining contract time, using the work items and dependencies of the Indiana bridge project shown in Figure 3.14.

Step 1. The first step in determining the amount of time necessary for completing a particular project is to examine all project drawings, specifications, and contract documents. In order to determine all of the necessary work activities which must be completed on the project, the person establishing the contract duration must become familiar with the existing conditions, the scope of work, and any special requirements or procedures which are incorporated in the contract. This step will help determine the type of

contractor that is expected to bid the job, thereby indicating the range of anticipated productivity rates for the project.

Step 2. Once there is a full understanding of all project requirements, significant and controlling work activities must be identified. These activities should be numbered and listed as close to chronological order as possible on a worksheet such as that shown in Figure 5.3. The corresponding quantities for each bid item or work activity should be listed in the third column of this worksheet. Consideration should be given to significant material procurement periods, as well as time periods necessary for such things as shop drawing submittals/approvals, or concrete curing.

Step 3. After all salient work activities have been identified and listed, the project logic must be established. This involves the identification of those activities that must precede the activity in question. These dependencies should be listed in the sixth column of Figure 5.3.

Not all logic is based on starting an activity immediately following the completion of a preceding activity; there are a few varying relationships that may occur, such as minimum or maximum time periods specified between start-to-start, start-to-finish, or finish-to-finish activity times. The variation that is most common, and of most importance to

CONTRACT TIME DETERMINATION WORKSHEET

(1) No.	(2) Work Item	(3) Quantity	(4) Daily Productivity	(5) Dur.	(6) Act. Depend.	(7) Start Time	(8) Finish Time

Figure 5.3 Contract Time Determination Worksheet

the individual determining contract time, is the start-to-start relationship. This case has many occurrences in construction. For example, in a new road construction project, paving may begin if it is started a certain distance (or time period) behind roadway preparation operations, or forms may be stripped from concrete slabs a certain number of days after the concrete is poured but before it has finished curing. This relationship can be indicated on the worksheet by showing the number of days between activity start times in work days placed in parentheses after the activity listed in column 6. An advantage to this step is that it helps to identify work activities that may have been omitted from the original work item list, work items that need further breakdown to support the logic, and work items that may be grouped together without confusing the project logic.

Step 4. The next step is the establishment of activity durations. This is accomplished through tne use of anticipated productivity rates for each of the work activities. As discussed earlier in this report, average productivity rates should be based on historical data of the past 3 to 5 years, and reviewed and updated periodically to ensure reliability. Once the productivity rates are known for each of the work activities, they should be entered into the fourth column of Figure 5.3. Activity durations, located in column 5, are calculated by dividing the work item quantity in column 3 by the the daily productivity rate in

column 4. The resulting value, which should be rounded up to the nearest whole number, is the number of working days an individual work item requires for completion.

Step 5. With the project logic established, start and finish times for each activity may be determined. The assumption is made that the project starts on work day 0, and all activities that have no preceding activities which are depended upon have a start time of 0. This should be entered in column 7 of Figure 5.3. Finish times for these activities then are simply their durations, which are listed in column 5. Finish times should be placed in column 8. Next, the activities that have dependency relationships are considered. For each of the activities, a comparison must be made of the finish times of all preceding work items that the activity is dependent upon. The largest value of these becomes the start time and is entered in column 7. The finish time is then calculated by adding the activity duration to the start time. When considering activities that have start-to-start relationships, the number in the parentheses should be added to the start time of the preceding activity and compared with the finish times of any other preceding activities. This procedure is continued until start and finish times for all activities has been determined. The largest of the finish time values in column 8 is the contract time in work days. Any special considerations for contingencies may be added at this time.

Completion of steps one through five is all that is necessary in determining contract time for working day contracts. Figure 5.4 illustrates the manner in which these steps are taken and documented. As shown, not including any contingencies, contract time for this particular project is 90 working days.

If it is desired to express the contract time in calendar days, or as a calendar date, a work-day-calendar conversion chart based on location and project type should be used, similar to those used by South Carolina, as shown in Figures 4.14 and 4.15.

Step 6. To make full use of the information that has been tabulated up to this point, a time-scaled bar chart should be drawn. As discussed earlier in this report, this is a valuable tool that assists in the visualization of the construction logic and the monitoring of construction progress. Figure 3.14 shows such a chart for the values found in Figure 5.4. A calendar day bar chart could just as easily be completed with consideration given to non-working weekends and holidays. When considering non-work day periods, activity durations for such items as concrete curing would have to be adjusted to account for curing during these time-frames.

There are numerous computer software programs on the market that have the capability of performing the steps described above, and much more. With only minimal effort,

CONTRACT TIME DETERMINATION WORKSHEET

(1) No.	(2) Work Item	(3) Quantity	(4) Daily Productivity	(5) Dur.	(6) Act. Depend.	(7) Start Time	(8) Finish Time
1	Move-In	--	--	5	--	0	5
2	Remove Existing Structure	--	--	5	1	5	10
3	Order & Deliver Piling	--	21	--	--	0	21
4	Construct Fill	8,000cy	500cy/day	16	2	10	26
5	Bent 1 Cofferdam	1 ea.	--	3	4	26	29
6	Bent 1 Piling	1,5001f	5001f/day	3	3,5	29	32
7	Bent 1 Form & Place Footing	10cy	10cy/day	1	6	32	33
8	Bent 1 Cure Footing	--	--	1	7	33	34
9	Dewater, Form & Place Bent 1 Stem	20cy	10cy/day	2	8	34	36
10	Bent 1 Cap	10cy	10cy/day	2	9	36	38
11	Bent 2 Cofferdam	1 ea.	--	3	5	29	32
12	Bent 2 Piling	15001f	5001f/day	3	6,11	32	35
13	Bent 2 Form & Place Footing	10cy	10cy/day	1	7,9,12	36	37
14	Bent 2 Cure Ftg.	--	--	1	13	37	38
15	Dewater, Form & Place Bent 2 Stem	20cy	10cy/day	2	9,14	38	40
16	Bent 2 Cap	10cy	10cy/day	2	15	40	42
17	North End Bent Drive Piling	10001f	5001f/day	2	12	35	37

FIGURE 5.4 Contract Time Determination Worksheet (Indiana Bridge Project)

CONTRACT TIME DETERMINATION WORKSHEET

(1) No.	(2) Work Item	(3) Quantity	(4) Daily Productivity	(5) Dur.	(6) Act. Depend.	(7) Start Time	(8) Finish Time
18	North End Bent Form & Place	30cy	10cy/day	3	15,17	40	43
19	N. End Bent Cure	--	--	4	18	43	47
20	South End Bent Drive Piling	10001f	5001f/day	2	17	37	39
21	South End Bent Form & Place	30cy	10cy/day	3	18,20	43	46
22	S. End Bent Cure	--	--	4	21	46	50
23	Order/Dlvr Beams	--	--	45	--	0	45
24	Set Beams	--	--	2	10,16, 19,22, 23	50	52
25	Form & Place Diaphrams	15cy	5cy/day	3	24	52	55
26	Cure Diaphrams	--	--	4	25	55	59
27	Form Deck&Coping	--	--	4	26(1)	56	60
28	Rebar	60,0001bs	20,0001b/day	3	27(2)	58	61
29	Place Deck W/O Support Cuttouts	150cy	150cy/day	1	28	61	62
30	Remove Bulkheads & Place Concrete	20 cy	10cy/day	2	29	62	64
31	Cure Deck	--	--	4	30	64	68
32	Form & Place Top Wall	3cy	15cy/day	2	31(3)	67	69
33	Cure Top Wall	--	--	4	32	69	73
34	Reinforced Conc. Approaches	180cy	30cy/day	6	32	69	75

FIGURE 5.4 (Continued)

CONTRACT TIME DETERMINATION WORKSHEET

(1) No.	(2) Work Item	(3) Quantity	(4) Daily Productivity	(5) Dur.	(6) Act. Depend.	(7) Start Time	(8) Finish Time
35	Cure Approaches	--	--	4	34	75	79
36	Place Compacted Aggregate	450tons	2000tons/day	1	34	75	76
37	Place Bituminous Mix	250tons	1300tons/day	1	36	76	77
38	Bridge Rail	8001f	6001f/day	2	33,35, 37	79	81
39	Guard Rail	12001f	6001f/day	2	37	77	79
40	Seeding&Sodding	5000sy	2500sy/day	2	37	77	79
41	Clean Up	--	--	9	38,39 40	81	90

FIGURE 5.4 (Continued)

the use of such programs can be mastered by state agency personnel, resulting in much less time and effort necessary in determining reasonable contract durations.

APPENDIX A
STANDARD PRODUCTION RATES FOR ESTIMATING WORK DAYS

TABLE A-1.a - STANDARD PRODUCTION RATES FOR ESTIMATING WORKING DAYS

WORK ITEM	ARKANSAS	FLORIDA	LOUISIANA	MARYLAND
Move-In	5 days	15-25 days (a)		10 days
Clean up	5 days			10 days
Clear & Grub	5 sta./day (b)	1-10 acres/day	1.5 acres/day	
	10 sta./day (c)			
Seeding		15000 sy/day (e)		
Sodding				
Pence			500-1000 lf/day	
Curb & Gutter		300-700 lf/day	700 lf/day	
Severs/Pipe		100-400 lf/day (m)	200 lf/day (<36")	
Mhls,Jnctn Bxs,CBs			2/day, adj.-6/day	
Shldr Underdrains			1500 lf/day	
Edge Drains				
Traff.Striping			10 mi/day (A.C.Pvmt)	
			6mi/day (PCC Pvmt)	
Culverts				
Box Culverts				10-15 cy/day (s)
				60-75 cy/day (t)
Water Main				
Gas Lines				
Light Standards				
Traffic Signals				
Refl.Pvmt Mrkrs		500-1000/day (w,x)	1000-2000/day (y)	
OH Sign Struct.				
Guardrail		1500 lf/day (w)	500-1000 lf/day	1000 lf/day
Excavation	600 cy/day (Rdwy) (b)	uses curves	3000 cy/day (rural)	100-150 cy/day(Cl.III)
	100 cy/day (Rdwy) (c)		1000 cy/day (urban)	
Borrov	600 cy/day	uses curves		
Mucking			3500 cy/day (lrg.proj)	
			1000ft-1/2mi/day(dtch)	
Trenching			1000 lf/day	
Subbase & Sel.Sub.				
Subgr.Undrct&Bckfl				
Scarify/Cmpct Rdbd			1 mi/day	
Shape Roadbed			1 mi/day	
Stabilized Roadbed		5000 sy/day (bv)		
Subbase Trtmnt.	5 days (b)		8000 sy or 1 mi/day	
	600 tons/day (c)			

Notes begin on page 112

TABLE A-1.b - STANDARD PRODUCTION RATES FOR ESTIMATING WORKING DAYS

WORK ITEM	MICHIGAN	MINNESOTA	NEW JERSEY	NORTH CAROLINA (cc)
Move-In	10 days	8 days	10 days	
Clean up	10 days or 20 sta./day			
Clear & Grub	2 acres/day		4-10 acres/day (bw)	1/4-10 acres/day (d)
Seeding	10 acres/day	10 acres/day	10000 sy/day	1-3 acres/day (f)
Sodding	2500 sy/day	2500 sy/day		
Fence	1200 lf/day (g)	4000 lf/day (g)	400 lf/day (h)	300-2000 lf/day (i)
	500 lf/day (h)	2000 lf/day (h)		
Curb & Gutter	2500 lf/day (k)	2000 lf/day	200-500 lf/day (l)	100-1000 lf/day (ca)
Sewers/Pipe	40-120 lf/day (n)	300 lf/day (<=24")	50-120 lf/day (bx)	50-300 lf/day (o)
		150 lf/day (>=30")		
Mhls,Jnctn Bxs,CBs	3-4/day	40 lf/day (48"diam.)		
Shldr Underdrains				
Edge Drains		4000 lf/day		
Traff.Striping				
Culverts	120 lf/day (p)	300 lf/day (<=24")		
	150 lf/day (q)	150 lf/day (>=30")		
	5 days/unit (r)			
Box Culverts	5 days/pour			
Water Main	80-300 lf/day (u)			
Gas Lines	300 lf/day			
Light Standards	6 ea/day		4 units/day	
Traffic Signals		15 days/intrsctn.(v)	10 days/intrsctsn.(v)	
Refl.Pvmt Mrkrs				
OH Sign Struct.			5-7 days/unit	
Guardrail	750 lf/day	750 lf/day		50-1500 lf/day (z)
Excavation	800-12000 cy/day (ab)	2000-10000 cy/day (ac)	500-2000 cy/day (ae)	100-8000 cy/day (af)
		1.5 substruct./day(ad)		
Borrow		2000-10000 cy/day (aj)		
Mucking	2000 cy/day	2500 cy/day		
Trenching				
Subbase & Sel.Sub.	20 sta./day (<=24ft)		50-350 cy/day (by)	
	15 sta./day (>24ft)			
Subgr.Undrct&Bckfl	2000 cy/day			
Scarify/Cmpct Rdbd				
Shape Roadbed				
Stabilized Roadbed				
Subbase Trtmnt.				

Notes begin on page 112

TABLE A-1.c - STANDARD PRODUCTION RATES FOR ESTIMATING WORKING DAYS

WORK ITEM	NORTH DAKOTA	OKLAHOMA	WISCONSIN	WYOMING
Move-In		20-30 days		5-10 days
Clean up				
Clear & Grub			10 sta./day	
Seeding			20000 sy or 360 lb/day	40 acres/day
Sodding				5000-10000 sf/day
Fence			500 lf/day (g,h)	70-2000 lf/day (j)
Curb & Gutter			500 lf/day	500 lf/day
Sewers/Pipe			100 lf/day	200 lf/day
Mhls,Jnctn Bxs,CBs				1-2/day
Shldr Underdrains				
Edge Drains				
Traff.Striping				
Culverts				200-300 lf/day
Box Culverts				
Water Main				
Gas Lines				
Light Standards				
Traffic Signals				
Refl.Pvmt Mrkrs				
OH Sign Struct.				
Guardrail				(aa)
Excavation	1200-12800 cy/day (ag)	3000-10000 cy/day (ah)	300 cy/day (urban)	(ai)
			5000 cy/day (rural)	
Borrow			350-1000 cy/day (ak)	
Mucking				
Trenching				
Subbase & Sel.Sub.				
Subgr.Undrct&Bckfl		0.5 mi/day		
Scarify/Cmpct Rdbd				
Shape Roadbed		2 days/mi.		
Stabilized Roadbed				
Subbase Trtmnt.				

Notes begin on page 112

TABLE A-2.a - STANDARD PRODUCTION RATES FOR ESTIMATING WORKING DAYS

WORK ITEM	ARKANSAS	FLORIDA	LOUISIANA	MARYLAND
Lime Treatment			6000 sy/day (24 ft)	
			5000 sy/day (20 ft)	
Agg. Base Course	3000 tons/day	uses curves	6000 sy/day	
Agg.Surf.Course			300 cy/day	
Agg. Shoulder				
Base Course	600 cy/day(or tons)(b)	uses curves	1500 cy/day(non-stab.)	
	1000cy/day(or tons)(c)		1000 cy/day (Class I)	
Bit.Pavement	5 days (b)	uses curves	500-1000 tons/day (as)	
	600 tons/day (c)			
Cold Mix				
Bit.Shoulder			300 tons/day	
Bit. Curb			1000 ft/day	
Prime/Tack Coat	5 days (b) or		5000 gal/day	
	5000 gal/day (c)			
Seal Coat	5 days (shldr) (b) or			
	2500 gal/day(shldr)(c)			
Pntrt.Emuls.Concen				
Slurry Seal				
Surface Trtmnt.		200 cy/day		
Pfab.Coal Tar Memb				
Breaking Bit.Pvmt.			10000 lf/day	
Remov.Bit.Pvmt.			1 mi/day	
Mill Bit. Pvmt.		4000 sy/day (bb)	5000-10000 sy/day	
Conc. Pavement		5000 sy/day	2000 sy/day	
Sidewalk		300 sy/day		
Conc.Shldr/Median				
Conc.Med.Barrier			500 lf/day	
Epoxy Coating				150 sy/day
Remove Conc.Pvmt			500 sy/day	10-15 cy/day (deck)
Remove Curb				
Remove Conc.Median				
Retaining Wall				10-15 cy/day
Gabions				

Notes begin on page 112

TABLE A-2.b - STANDARD PRODUCTION RATES FOR ESTIMATING WORKING DAYS

WORK ITEM	MICHIGAN	MINNESOTA	NEW JERSEY	NORTH CAROLINA (cc)
Lime Treatment				
Agg. Base Course		3000 tons/day (rural)	50-350 cy/day or 250-2000 sy/day (al)	200-3000 tons/day (am)
Agg.Surf.Course				
Agg. Shoulder		2400 tons/day		
Base Course				300-600 tons/day (ap)
Bit.Pavement	40 sta./day (24ft) 10 sta./day (at)	1500-2400 tons/day(aq)	50-1000 tons/day (av)	200-1500 tons/day (bz)
Cold Mix				
Bit.Shoulder	25 sta./day(1sid./crs)	600 tons/day (3 ft) 1500 tons/day (10 ft)		
Bit. Curb				
Prime/Tack Coat				2000-10000 sy/day (ay)
Seal Coat				
Pntrt.Emuls.Concen				
Slurry Seal				
Surface Trtmnt.				
Pfab.Coal Tar Memb				
Breaking Bit.Pvmt.				
Renov.Bit.Pvmt.	200 lf/day 1500 lf/day (az)		150-1000 sy/day (ba)	
Mill Bit. Pvmt.		30000 sy-in/day (c) 12000 sy-in/day (bc)	1000-2500 sy/day (bd)	
Conc. Pavement	15 sta./day (be)	10000 sy/day (bf) 2000 sy/day (bg)	225-2500 sy/day (bh)	1000-5000 sy/day (bi)
Sidewalk	2000 sf/day (bl)	2500 sf/day	100-225 sy/day (bm)	
Conc.Shldr/Median	15 sta.or 1500sy/day	4000 sy/day		
Conc.Med.Barrier	1000 lf/day (k)	1200 lf/day (Pcst) 1500 lf/day (CIP)		
Epoxy Coating				
Remove Conc.Pvmt		2000 sf/day (deck)		
Remove Curb			250-500 lf/day (bo)	
Remove Conc.Median				
Retaining Wall	1 panel/day (bq)			
Gabions				

Notes begin on page 112

TABLE A-2.c - STANDARD PRODUCTION RATES FOR ESTIMATING WORKING DAYS

WORK ITEM	NORTH DAKOTA	OKLAHOMA	WISCONSIN	WYOMING
Lime Treatment				
Agg. Base Course	600-5000 tons/day (an)	500-1000 tons/day (ao)		2500-5000 tons/day
Agg.Surf.Course				
Agg. Shoulder				
Base Course		250-1000 tons/day (aq)	2000 tons/day	1000-6000tons/day (ar)
Bit.Pavement	600-2000 tons/day (aw)	250-1000 tons/day (ax)	500 tons/day (urban)	1500-2500tons/day(wrg)
			1000 tons/day (rural)	
Cold Mix	1 mi/day/lift (2"max)			1/2 mi/day
Bit.Shoulder			1500 tons/day	
Bit. Curb				
Prime/Tack Coat	2 mi/day			5 mi/day (2-lane)
Seal Coat	4 mi or 20000 gal/day			4-5 mi/day (2-lane)
Pntrt.Emuls.Concen				2 mi/day (2-lane)
Slurry Seal				1/2-1 lane mi/day
Surface Trtmnt.				
Pfab.Coal Tar Memb				400 sy/day
Breaking Bit.Pvmt.				
Remov.Bit.Pvmt.			1200 sy/day	
Mill Bit. Pvmt.	2000 tons/day			
Conc. Pavement	1/2 mi/day (rural)	400-2000 sy/day (bj)	1200 sy/day (urban)	1 mi/day (bk)
			5000 sy/day (rural)	
Sidewalk			500 sf/day (conc.)	675 lf/day or 100 sy
Conc.Shldr/Median	1 mi/day (10 ft)			
Conc.Med.Barrier				
				2000 lf/day (cb)
Epoxy Coating				
Remove Conc.Pvmt	1600-4300 sy/day (bn)			
Remove Curb				5000 lf/day (Bit.)
Remove Conc.Median				3000 lf/day (bp)
Retaining Wall				
Gabions				100-150 sy/day

Notes begin on page 112

TABLE A-3.a - STANDARD PRODUCTION RATES FOR ESTIMATING WORKING DAYS

WORK ITEM	ARKANSAS	FLORIDA	LOUISIANA	MARYLAND
BRIDGE WORK				
Remove Timb.Bridge			2 spans/day	
Remove Conc.Bridge				
Construct Bridge		uses charts	10-15 days/span (br)	
Conc. Footings				15 cy/day
Substructure				20-25 cy/day
Piling			500 ft/day	200 lf/day (CPI)
				0.5 ea/day (Cylinder)
				350 lf/day (H-piles)
Clmns,Caps,Abtmnts				
Struct. Steel				350-450 lf/day
Pstress.Conc.I-Bms				3-4 ea/day
Beam Erection				
Superstructure				35-50 cy/day
Sdwlk & Parapet				
Slp.Form Barrier				
Laytex Overlay				2.5 cy/day
Railing Reconstr.				
Replc.or Widn.Deck				
Overlay Deck				
Low Slump Overlay				
Mill Deck				
Clean Struct.Steel				6400 sf/day (by hand)
Paint			120000 sf/day or 13333 sy/day	6000-32000 sf/day (bu)
Sandblasting				12800 sf/day

Notes begin on page 112

TABLE A-3.b - STANDARD PRODUCTION RATES FOR ESTIMATING WORKING DAYS

WORK ITEM	MICHIGAN	MINNESOTA	NEW JERSEY	NORTH CAROLINA (cc)
BRIDGE WORK				
Remove Timb.Bridge				
Remove Conc.Bridge				
Construct Bridge			(bs)	
Conc. Footings	2 days/struct.			
Substructure	5 days/unit			
Piling	15/day (40 ft)	600 ft/day (ad)		15-25/day
Clmns,Caps,Abtmnts		4 day/struct. (ad)		
Struct. Steel	3 days/span			
Pstress.Conc.I-Bms				
Beam Erection		1 day/span (ad)		
Superstructure		9 days/span (ad)		
Sdwlk & Parapet	5 days/span			
Slp.Form Barrier	2 days/bridge			
Laytex Overlay				
Railing Reconstr.		30 lf/day		
Replc.or Widn.Deck		200 sf/day		
Overlay Deck	13-15 days (bt)			
Low Slump Overlay		8000 sf/day (ad)		
Mill Deck		8000 sf/day (1/4")		
Clean Struct.Steel				
Paint	5 spans/day	3 spans/day		2 spans/day
Sandblasting				

Notes begin on page 112

TABLE A-3.c - STANDARD PRODUCTION RATES FOR ESTIMATING WORKING DAYS

WORK ITEM	NORTH DAKOTA	OKLAHOMA	WISCONSIN	WYOMING
BRIDGE WORK				
Remove Timb.Bridge				2-3 days
Remove Conc.Bridge				3-5 days
Construct Bridge				
Conc. Footings				
Substructure			10 cy/day	
Piling				
Clmns,Caps,Abtmnts				
Struct. Steel			25000 lb/day	
Pstress.Conc.I-Bms				
Beam Erection				
Superstructure			10 cy/day	
Sdwlk & Parapet				
Slp.Form Barrier				
Laytex Overlay				
Railing Reconstr.				
Replc.or Widn.Deck				
Overlay Deck				
Low Slump Overlay				
Mill Deck				
Clean Struct.Steel				
Paint				800 sf/hr/gun
Sandblasting				2000 sf/day

Notes begin on page 112

NOTES FOR STANDARD PRODUCTION RATE TABLES

(a) 15 days (normal), 25 days (resurfacing)
(b) "Small" jobs
(c) "Large" jobs
(d) Major projects: 1-10 acres/day not to exceed 16 days
Grading/Paving projects: 1-8 acres/day not to exceed 16
Small rural widening projects: 1 acre/day
Small urban projects: 1/4-1 acre/day
(e) Not to exceed 15 days
(f) Major projects: 1-3 acres/day not to exceed 16 days
Grading/Paving projects same as major projects
Small rural widening & small urban projects: 1-2 ac/day
(g) Woven wire
(h) Chainlink
(i) Major projects: 1000-2000 lf/day
Grading/Paving projects: 500-1000 lf/day
Small rural widening & small urban projs: 300-500 lf/day
(j) 2000 lf/day (R/W fence), 640 lf/day (12ft snow fence-6wk delivery), 70-100 lf/day (screen fence w/6X6 posts-6wk delivery), 1200-1600 lf/day (filter fabric)
(k) Add 5 days cure time (minimum 7 days)

(l)

	Constr.	Reconstr.	Widen.	Resurf.	Intrsctn
Barr.Type	400lf/day	400	400	300	N/A
Vert.Type	500	400	400	300	200

(m) Municipal constr., includes pipe, inlets, manholes, etc.
(n) 120 lf/day (0-14ft up to 60"), 80 lf/day (0-14ft over 60"), 60 lf/day (14ft+ up to 60"), 60 lf/day (14ft+ over 60"), 40 lf/day (jacked in place)
(o) Major & Grading/Paving projects: 100-300 lf/day
Small rural widening projects: 100-200 lf/day
Small urban projects: 50-200 lf/day
(p) Rural highways
(q) Expressways
(r) Large headwalls
(s) Single cell
(t) Double/triple cell
(u) 80 lf/day (20"-42"), 300 lf/day (up to 16"), add 4-5 days for flushing, testing, and chlorination
(v) Installation time (does not include delivery time)
(w) When significant part of project
(x) 500/day (0-20000 ea), 1000/day (20000+ ea)
(y) 1000/day (traffic present), 2000/day (no traffic)
(z) Major projects: 500-1500 lf/day
Grading/Paving projects: 300-500 lf/day
Paving projects: 500-1500 lf/day
Small rural widening projects: 100-500 lf/day
Small urban projects: 50-300 lf/day
(aa) Remove (3000lf/day), remove corrugated beam (2000lf/day), Corrugated beam (single blocked out) (400lf/day), block out & add posts (750lf/day), Reset, block out and add posts to corrugated beam (single) (500lf/day), box beam (500-1000lf/day), posts (250-750 lf/day)
(ab) Freeway (12000 cy/day), grading (25 sta./day), embankment,lt-wt fill (800 cy/day), Reconstr. (5000 cy/day), widening (20 sta./day), gen. excav. for bridges (1000cy/day), excav. for footings (1day/unit)

(ac)

	Scraper	Truck	Reconstr.
Common exc.-plastic soils	8000cy	5000cy	2000cy/day
-gran. soils	10000cy	6000cy	2000cy/day
Subgrade excavation	6000 cy	4000cy	2000cy/day

(ad) For bridges over streams and three to four span grade separation units
(ae) Construction (2000 cy/day), reconstruction (500 cy/day)

(af) (Unclassified, drainage ditch, Undercut, borrow)
Major project: 6000-8000 cy/day (Rock : 500-2000cy/day)
Grading/Paving project: 2000-6000 cy/day
Small rural widening projects: 200-400 cy/day
Small urban projects: 100-500 cy/day

(ag) 0-20000cy: 1 scraper @ 150 yds/hr @ 8 hrs.= 1200 cy/day
20000-50000cy: 2 scrapers @ 180 yds/hr @ 8 hrs = 2880 cy/day use 2900 yds/day
50000-100000cy: use 3 scrapers @ 200 yds/hr @ 8 hrs.= 4800 yds/day
100000-250000cy: use 4 scrapers @ 200 yds/hr @ 8 hrs.= 6400 yds/day
250000-500000cy: use 5 scrapers @ 200 yds/hr @ 8 hrs.= 8000 yds/day
500000-1000000cy: use 6 scrapers @ 200 yds/hr @ 8 hrs.= 9600 yds/day
1000000-2000000cy: use 8 scrapers @ 200 yds/hr @ 8hrs.= 12800 yds/day

(ah) Class "D" unclassified excavation

Under 200,000cy	use 3,000 cy/day
200,000-300,000cy	use 3,500 cy/day
300,000-400,000cy	use 4,000 cy/day
400,000-500,000cy	use 4,500 cy/day
500,000-600,000cy	use 5,000 cy/day
600,000-700,000cy	use 5,500 cy/day
700,000+cy	use 6,000 cy/day
Extra large proj.	use 10,000 cy/day

(ai)

Route	
0.5 mi	use 7,000-10,000 cy/day
up to 1000 ft	use 400 cy/hr/unit
1000-2000 ft	use 100 cy/hr/unit
Rock excavation	use 2,000-3,000cy/day
Solid rock exc.	use 500 cy/day

(aj)

	Scraper	Truck	Reconstruction
Plastic soils	8000 cy	5000 cy	2000 cy/day
Granular soils	10000 cy	6000 cy	2000 cy/day

(ak) 1000 cy/day/unit (T-pull), 350 cy/day/unit (truck)

(al)

(6" thick)	Constr.	Reconstr.	Widening	Intersctns
	350cy/day	250cy/day	150cy/day	50cy/day
or	2000sy/day	1500sy/day	1000sy/day	250sy/day

(am) Major projects: 1000-2500 tons/day(mainline), 500-1200 tons/day(Y-lines & ramps)
Grading/Paving projects: 1000-3000 tons/day
Paving projects: 1000-2500 tons/day(mainline, if tot.qty. > 40,000 tons), 500-1200 tons/day (Y-lines & ramps)
Small rural widening projects: 300-500 tons/day
Small urban projects: 200-500 tons/day
(SOIL TYPE)
Major projects: 2000-3000 cy/day
Grading/Paving projects: 1000-2000 cy/day
Paving projects: 2000-3000 tons/day
Small rural widening projects: 300-500 cy/day
Small urban projects: 200-500 cy/day

(bh) Construction (2,500 sy/day), reconstruction (1,000 sy/day), widening (750 sy/day), intersections (225 sy/day)
(bi) All projects (3,000-5,000 sy/day), Ramps (1,000-1,500 sy/day + 2 days for turnout tapers)
(bj) Municipal paving (400 sy/day), rural paving (800-1,000 sy/day), large four-lane (2,000 sy/day)
(bk) One-lane, 24ft. X 8in.
(bl) For sidewalk patching use 700 sf/day
(bm) Concrete, construction (225 sy/day), reconstruction & widening (175 sy/day), resurfacing (150 sy/day), intersections (100 sy/day)
(bn) Rural (4,300 sy/day or 1500 lf/day), urban (1,600 sy/day)
(bo) Reconstruction (500 lf/day), widening, resurfacing, intersections (250 lf/day)
(bp) 4ft. wide, 4in. thick, with curbs
(bq) 10 days minimum
(br) Based on 20ft. span (CIP)
(bs) See Figure A.1 on page 118
(bt) Entire deck, traffic removed (15 days), 1/2 deck with traffic interference (13 days)
(bu) 4-man crew, brush (6,000-8,000 sf/day/coat), roller (8,000-16,000 sf/day/coat), airless spray (32,000 -48,000 sf/day/coat), conventional spray (16,000 -32,000 sf/day/coat)
(bv) Not to exceed 10 days
(bw) Construction and reconstruction (4 acres/day), widening and resurfacing (10 acres/day)
(bx) Includes one structure. Construction (200 lf/day), reconstruction (100 lf/day), widening and intersections (50 lf/day)
(by) Construction (350 cy/day), reconstruction (250 cy/day), widening (150 cy/day), intersections (50 cy/day)
(bz) Major projects and paving projects: 800-1500 tons/day (mainline), less than 800 tons/day for ramps and Y-lines
Grading/Paving projects: 300-1,000 tons/day
Small rural widening projects: 200-600 tons/day
Small urban projects: 200-500 tons/day
(ca) Major projects and paving projects: 500-1,000 lf/day (mainline), 200-400 lf/day (Y-lines)
Grading/Paving projects: 100-500 lf/day
Small rural widening and small urban projects: 100-300 lf/day
(cb) Temporary
(cc) North Carolina describes Major projects as "Major Urban and Rural Projects" with grading in excess of 1,000,000 cy, and Grading/Paving projects as those type projects with less than 1,000,000 cy of grading

(an) 0-5,000 tons use 4 trucks @ 15 t/load @ 10 loads/day = 600tons/day
5,000-10,000 tons use 6 trucks @ 15 t/load @ 10 loads/day = 900 tons/day
10,000-25,000 tons use8 trucks @ 18 t/load @ 10 loads/day = 1,440 tons/day
25,000-50,000 tons use 8 trucks @ 18 t/load @ 14 loads/day = 2,000 tons/day
50,000-100,000 tons use12 trucks @ 18 t/load @ 14 loads/day = 3,000 tons/day
100,000-200,000 tons use 16 trucks @ 18 t/load @ 14 loads/day = 4,000 tons/day
200,000 tons and up use 20 trucks @ 18 t/load @ 14 loads/day = 5,000 tons/day

(ao) Stabilized Aggregate Base
Under 40,000 tons use 500 tons/day
40,000-75,000 tons use 750 tons/day
Over 75,000 tons use 1,000 tons/day
Soil Asphalt Bases, 8" use 4 mi/day, 6" use 3 mi/day, add 1 day for each 2,000-2,500sy of material hauled.
PC Treated Base (Shoulders), 1 day/2,000-2,500sy

(ap) Sand asphalt

(aq) Bituminous Base-Fine or Course Aggregate
Under 15,000 tons use 250 tons/day
15,000-30,000 tons use 500 tons/day
30,000-75,000 tons use 750 tons/day
Over 75,000 tons use 1,000 tons/day

(ar) Plant mix base (4,000-6,000 tons/day), streets (1,000 tons/day), 1.5 mi. haul (2,000-3,000 tons/day)

(as) Large project (1,000 tons/day), overlay (500-800 tons/day), friction course-60lb/sy (7,000-10,000 sy/day), widening one-side (50 sta./day)

(at) 16ft. wide ramps, add 5 days cure time-minimum 7 days

(au) Rural or minimum degree of difficulty: Leveling course (2,000 tons/day), base course (2,400 tons/day), Binder course (2,000 tons/day), Wearing course (>1" use 2,000 tons/day, <=1" use 1,500 tons/day)

(av) Construction, widening, resurfacing (1,000 tons/day), reconstruction (750 tons/day), intersections (50 tons/day)

(aw)

	Hot Bit.	Recycled HBP
0-20,000 tons(100t/hr)	800 tons/day	600 tons/day
20,000-40,000 tons(150t/hr)	1200tons/day	900 tons/day
40,000-80,000 tons(225t/hr)	1800tons/day	1350 tons/day
80,000 tons and up(250t/hy)	2000tons/day	1500 tons/day

(ax) Under 15,000 tons use 250 tons/day
15,000-30,000 tons use 500 tons/day
30,000-75,000 tons use 750 tons/day
Over 75,000 tons use 1,000 tons/day

(ay) Bituminous surface treatment-small urban projects use 2,000-5,000 sy/day, all other projects use 5,000 -10,000 sy/day

(az) For recycling (24 ft)

(ba) Reconstruction & widening (1,000 sy/day), resurfacing (500 sy/day), intersections (150 sy/day)

(bb) Not to exceed 20 days

(bc) Urban reconstruction

(bd) Up to 2" thick, Reconstruction, widening, resurfacing (2,500 sy/day), intersections (1,000 sy/day)

(be) 24ft wide, add 5 days cure time, minimum 7 days

(bf) Standard width

(bg) Non-standard width

CONTRACTOR PRODUCTIVITY IN WORKING DAYS FOR BRIDGES

SIZE OF BRIDGE	TYPE 1 CONSTRUCTION	TYPE 2 REPLACEMENT	TYPE 3 SUPERSTRUCTURE	TYPE 4 DECK	TYPE 5 OVERLAY
ONE SPAN					
2 LANES	100	120	50	45	30
4 LANES	120	150	60	55	35
6 LANES	130	170	70	60	40
TWO SPANS					
2 LANES	130	160	60	55	35
4 LANES	150	180	70	65	40
6 LANES	160	190	80	75	45
FOR EACH ADDITIONAL SPAN, ANY NUMBER OF LANES	10/Span	5/Span	5/Span	5/Span	5/Span
COFFERDAMS	20	20	N/A	N/A	N/A
PILES	10	10	N/A	N/A	N/A

NOTES:
1. For two bridges add 50%, for each additional bridge add 25%
2. For stage construction, consider each stage to be a separate bridge
3. For bridges over water or railroads add 30 days, except for Type 5 for which no adjustment is necessary.

TYPE 1 = New construction on new alignment
TYPE 2 = Remove existing and construct new at same location
TYPE 3 = Replace deck and beams including minor substructure repair
TYPE 4 = Replace deck
TYPE 5 = Deck patching and LMC overlay (subtract 10 days if overlay is bituminous concrete)

Figure A.1 Productivity Rates for Bridges (New Jersey)

APPENDIX B
FDOT SPECIFICATIONS

1-7 Calendar Day.

Every day shown on the calendar, ending and beginning at Midnight.

1-11 Contract Time.

The number of work days or calendar days allowed for completion of the contract, including authorized time extensions.

In case a calendar date of completion is stipulated in lieu of a number of work or calendar days, the contract shall be completed by such calendar date.

5-8 Contractor's Supervision.

5-8.1 Prosecution of Work: The Contractor shall give the work the constant attention necessary to assure the scheduled progress and he shall cooperate fully with the Engineer and with other Contractors at work in the vicinity.

5-8.2 Contractor's Superintendent: The Contractor shall at all times have on the work as his agent, a competent superintendent capable of thoroughly interpreting the plans and specifications and thoroughly experienced in the type of work being performed, who shall receive the instructions from the Engineer or his authorized representatives. The superintendent shall have full authority to execute the orders or directions of the Engineer and to supply promptly any materials, tools, equipment, labor and incidentals which may be required. Such superintendence shall be furnished regardless of the amount of work sublet.

5-8.3 Supervision for Emergencies: The Contractor shall have a responsible person available at or reasonably near the work site on a 24-hour basis, seven days a week, in order that he may be contacted in emergencies and in cases where immediate action must be taken to maintain traffic or to handle any other problem that might arise. For compliance with this requirement outside of working hours, the furnishing of the telephone number where such person can be reached will suffice.

5-10 Final Construction Inspection.

5-10.1 Maintenance until Final Acceptance: The Contractor shall maintain all work in first-class condition until it has been completed as a whole and has been accepted by the Engineer under the provisions of 5-11, provided that on non-Federal-Aid projects the work may be accepted in sections as designated by the Engineer, and the Contractor relieved of maintenance of such sections after acceptance.

5-10.2 **Semifinal Inspection:** The Engineer will make a semifinal inspection within seven days after notice from the Contractor of presumptive completion of the entire project. If, at the semifinal inspection, all construction provided for and contemplated by the contract is found completed to the Engineer's satisfaction, such inspection shall constitute the final inspection, as prescribed below. If, however, at any semifinal inspection any work is found unsatisfactory, in whole or in part, the Engineer shall give the Contractor the necessary instructions as to replacement of material and performance or reperformance of work necessary and prerequisite to final completion and acceptance, and the Contractor forthwith shall comply with and execute such instructions. Upon satisfactory replacement of material and performance or reperformance of such work, another inspection shall be made, which shall constitute the final inspection if the required material is found to have been replaced and the work completed satisfactorily.

5-10.3 **Final Inspection:** Whenever all materials have been furnished, all work has been performed, and the construction contemplated by the contract has been satisfactorily completed, the Engineer will make the final inspection.

5-12 Claims by Contractor.

Where the Contractor deems that extra compensation is due him for work or materials not clearly covered in the contract or not ordered by the Engineer as extra work, as defined herein, the Contractor shall notify the Engineer in writing of his intention to make claim for extra compensation, before he begins the work on which he bases the claim. If such notification is not given, and the Engineer is not afforded proper opportunity for keeping strict account of actual cost, as defined for force account, then the Contractor thereby agrees to waive the claim for such extra compensation. Such notice by the Contractor, and the fact that the Engineer has kept account of the cost as aforesaid, shall not in any way be construed as establishing the validity of the claim. In case the claim, after consideration by the Engineer, is found to be valid, it shall be allowed and paid for as an extra as provided herein. Nothing in this Article shall be construed as establishing any claim contrary to the terms of 4-3.

SECTION 8
PROSECUTION AND PROGRESS

8-1 Subletting or Assigning of Contracts.

8-1.1 **General:** The Contractor shall not sublet, sell, transfer, assign or otherwise dispose of the contract or contracts or any portion thereof, or of his right, title, or interest therein, without written consent of the Department. With the Engineer's written consent the Contractor will be permitted to sublet a portion of the work but shall perform with his own organization work amounting to not less than 50

percent of the total contract amount less the total amount for those contract items designed as "Specialty Work."

The total contract amount shall include the cost of materials, manufactured component products and their transportation to the project site. Off-site commercial production of materials and manufactured component products purchased by the Contractor and their transportation to the project shall not be considered subcontracted work.

If a part of a contract item is sublet, only its proportional cost shall be used in determining the percentage of subcontracted normal work.

All agreements to sublet work shall be in writing and must contain all pertinent provisions and requirements of the contract. Upon request, the Contractor shall furnish to the Department a copy of the subcontract. Subletting of work shall not relieve the Contractor or the surety of their respective liabilities.

A subcontractor shall be recognized only in the capacity of an employee or agent of the Contractor, and his removal may be required by the Engineer, as in the case of an employee.

8-1.2 Specialty Work: For normal road and bridge contracts Specialty Work is defined as work of a type not normally performed by road and bridge contractors with their own organizations.

The following work is specifically designated as Specialty Work for normal road and bridge construction. (Note: This listing does not apply to Federal Aid contracts. The Specialty Work for these contracts will be shown in the special provisions for the individual jobs.)

Grassing and Sodding Work.
Reworking Shoulders
Milling Existing Pavement
Removal of Buildings.
Fencing Work.
Painting.
Electrical Work.
Roadway and Bridge Lighting.
Navigation Lights.
Buildings, including Control House and Operator's House.
Sanitary Sewers.
Water Lines and Appurtenances.
Machinery and Castings for Movable Bridges.
Auxiliary Power Unit.
Pumping Equipment.
Riprap.
Landscaping Work.
Signalization System.
Installing Pipe or Pipe Liner, by jacking.
Installing Structural Plate Pipe Structures.
Roadway Signing and Pavement Marking.
Pit Scales.

Plugging Water Wells.
Vehicular Impact Attenuator.
Guardrail.
Temporary Traffic Control Devices.

When the major work under the contract is of a type not normally performed by road and bridge contractors, the above-listed work will be considered as Specialty Work only as so listed in the special provisions.

8.2 Work Permormed by Equipment-Rental Agreement.

The limitations set forth in 8-1, as to the amount of work that may be sublet, do not apply to work performed by equipment-rental agreement. However, for any work proposed to be performed by equipment-rental agreement the Contractor shall notify the Engineer in writing of such intention before using the rented equipment, and shall indicate whether the equipment is being rented on an operated or non-operated basis. The Contractor's written notice shall contain a listing and description of the equipment and a description of the particular work to be performed with such equipment. As an exception to the above requirements for a written notice to the Engineer, such notice will not be required for equipment to be rented (without operators) from an equipment dealer or from a firm whose principal business is the renting or leasing of equipment.

The operators of all rented equipment, whether rented on an operated or a non-operated basis, will be subject to all wage rate requirements applicable to the project. If equipment is being rented without operators the Contractor will be required to carry the operators on his own payroll. When equipment is rented on an operated basis the Contractor, when required by the contract or requested by the Engineer, shall furnish payrolls from the lessor with the names of the operators shown thereon.

Where rentals of equipment on an operated basis, from the same lessor, exceed $10,000, such lessor will be subject to any Equal Employment Opportunity requirements which may be applicable to the project.

8-3 Prosecution of Work.

8-3.1 Compliance with Time Requirements: The Contractor shall commence work in accordance with his approved working shedule and shall provide sufficient labor, materials and equipment to insure the completion of the work within the time limit set forth in the proposal. Should the Contractor fail to furnish sufficient and suitable equipment, forces and materials, as necessary to assure the progress of the work in accordance with the required schedule, the Engineer may withhold all estimates which are, or may become due, or may suspend the work until such deficiencies are corrected.

8-3.2 Submission of Working Schedule: Within 30 days after the contract has been awarded, the successful bidder shall submit to the

Department, on a prescribed form, a working schedule for the project, showing in detail the working day on which he expects to begin and complete each of the various major items of the work.

8-3.3 **Beginning Work:** The Contractor shall notify the District Engineer of his intention to begin work, not less than five days in advance of the date on which he proposes to begin and, upon the receipt of such notice from the Contractor, the District Engineer may give the Contractor notice to proceed, and may designate the point or points at which the work is to be started. In the notice to proceed the Engineer may waive the five-days advance notice from the Contractor and authorize him to begin immediately. The Contractor shall notify the Engineer in writing at least two days in advance of the date on which he expects to begin important features of the work. No work under the contract shall be commenced until after the notice to proceed has been issued. The notice to proceed will be issued within 30 days after execution of the contract by the Department.

8-3.4 **Provisions for Convenience of Public:** The Contractor shall schedule his operations so as to minimize any inconvenience to adjacent businesses or residences. Where necessary, the Engineer may require the Contractor to construct first the work in any areas along the project where restrictions caused by construction operations would present a more serious handicap, before beginning construction in the less-affected areas. In such critical locations, where there is no assurance of continuous effective prosecution of the work once the construction operations are begun, the Engineer may require that the work of removal of the existing (usable) facilities in such areas be delayed as is necessary and practicable.

8-3.5 **Preconstruction Conference:** Immediately after the Contract has been awarded, the Engineer will call a preconstruction conference to be held before any work is begun at a place designated by him, to go over the construction aspects of the project. The meeting will be between the Contractor, the Department, and the various utility companies which will be involved by the road construction. The Contractor shall have on hand for this meeting, a tentative working schedule for the project, in detail, showing his proposed operations for the various items of work which would affect or be affected by utility or railroad adjustments. The various utility or railroad companies will then establish their own working schedule under the direction of the engineer so as to coincide to the greatest degree practical with the schedule of the Contractor so that all work under the Contract may be diligently prosecuted. No work under the Contract shall be commenced until after the notice to proceed has been issued by the Engineer.

8-4 Limitations of Operations.

8-4.1 **Night Work:** In general, all work shall be performed during daylight hours. For special operations, night work may be done if so authorized in writing. No night work shall be performed unless adequate artificial lighting has been provided and has been approved.

8-4.2 **Sequence of Operations:** The Contractor shall not open up work to the prejudice of work already started, and the Engineer may require the Contractor to finish a section on which work is in progress before work is started on any additional section.

8-4.3 **Interference with Traffic:** The Contractor shall at all times conduct the work in such manner and in such sequence as to insure the least practicable interference with traffic. The Contractor's vehicles and other equipment shall be operated in such manner that they will not be a hazard or hinderance to the traveling public. Materials stored along the roadway shall be placed so as to cause as little obstruction to the traveling public as possible.

To prevent any open trench remaining after working hours where existing pavement is to be widened and stabilizing is not required the Contractor shall schedule his operations such that at the end of each work day the full thickness of the base for widening will be in place. Construction of the widening strips will not be permitted simultaneously on both sides of the road except where separated by a distance of at least one-fourth mile along the road, where either the work of excavation has not been started or the base has been completed.

8-4.4 **Coordination with other Contractors:** The Contractor shall arrange his work and dispose of his materials so as to not interfere with the operations of other contractors engaged upon adjacent work and to join his work to that of others in a proper manner, in accordance with the spirit of the plans and specifications, and to perform his work in the proper sequence in relation to that of other contractors, all as may be directed by the Engineer.

Each contractor will be held responsible for any damage done by him or his agents to the work performed by another contractor.

8-4.5 **Drainage:** The contractor shall so conduct his operations and maintain the work in such condition that adequate drainage will be in effect at all times. Existing functioning storm sewers, gutters, ditches, and other run-off facilities shall not be obstructed.

8-4.6 **Fire Hydrants:** Fire hydrants on or adjacent to the highway shall be kept accessible to fire apparatus at all times and no material or obstruction shall be placed within 15 feet of any such hydrant.

8-4.7 **Protection of Structures:** Heavy equipment shall not be operated close enough to pipe headwalls or other structures to cause their displacement.

8-4.8 **Fencing:** On all projects which include fencing and where the Engineer determines it to be necessary for maintaining the security of livestock or adjacent property, or for protection of pedestrians who are likely to gain access to the project from adjacent property, the Contractor shall erect permanent fence as a first order of business.

8.5 Qualifications of Contractor's Personnel.

The Contractor shall assure that all superintendents, foremen and workmen employed by him are competent, careful and reliable. All workmen must have sufficient skill and experience to properly perform the work assigned them. All workmen engaged on special work, or skilled work such as bituminous courses or mixtures, concrete bases, pavements, or structures, or in any trade, shall have had sufficient experience in such work to perform it properly and satisfactorily and to operate the equipment involved, and shall make due and proper effort to execute the work in the manner prescribed in the specifications, or the Engineer may take action as prescribed below.

Whenever the Engineer shall determine that any person employed by the Contractor is incompetent, unfaithful,intemperate, disorderly or insubordinate, such person shall, upon notice, be discharged from the work and shall not again be employed on it except with the written consent of the Engineer. Should the Contractor fail to remove such person or persons the Engineer may withhold all estimates which are or may become due, or may suspend the work until such orders are complied with. The Contractor shall protect, defend, indemnify and hold the Department, its agents, officials and employees harmless from any and all claims, actions or suits arising from such removal, discharge or suspension of employees.

8-6 Temporary Suspension of Work.

8-6.1 **Authority to Suspend Word:** The Engineer shall have the authority to suspend the work, wholly or in part, for such period or periods as may be deemed necessary, due to unsuitable weather or other conditions which are considered unfavorable for the prosecution of the work, or for such time as is necessary due to the failure on the part of the Contractor to carry out orders given or to comply with any or all provisions of the contract. Such suspension shall be ordered in writing, giving in detail the reasons for suspension.

8-6.2 **Prolonged Suspensions:** If for any reason it should become necessary to stop work for an indefinite period, the Contractor shall store all materials in such manner that they will not obstruct or impede the traveling public unnecessarily, nor become damaged in any way, and he shall take every reasonable precaution to prevent damage to or deterioration of the work performed, shall provide suitable drainage of the roadway by opening ditches, shoulder drains, etc., and shall provide any temporary structures necessary for public travel or convenience.

8-6.3 **Permission to Suspend Work:** The Contractor shall not suspend operations or remove equipment or materials necessary for the completion of the work without the permission of the Engineer.

8-6.4 **Contractor's Vacation:**

8-6.4.1 Length of Vacation: The Contractor will be allowed to suspend operations for a period not to exceed 14 days annually, in order to provide vacation time for his employees. These 14 days may be divided into no more than two separate periods of vacation time.

8-6.4.2 Automatic Time Suspension: Two periods of time are established for automatic time suspension. These periods are Thanksgiving, which includes Thanksgiving Day and the following Friday, Saturday and Sunday; and Christmas, which includes December 24th through January 1st. Vacation days other than provided at Thanksgiving and Christmas will require written request as specified in 8-6.4.3.

These automatic time suspensions may be approved verbally by the Project Engineer upon notification by the Contractor of his intent to shut down his operations for one or both of these periods. If the Contractor does not shut down his operations during these periods, contract time will be charged as usual.

8-6.4.3 Request for Vacations at Other Times: The Contractor shall submit written request to the District Engineer for permission to suspend operations, other than those specified in 8-6.4.2, at least 30 days in advance of the date of suspension.

8-6.4.4 Refusal of the Request: The Department reserves the right to refuse permission for a suspension (including automatic suspensions) when it might cause undue inconvenience to the traveling public or when, because of other factors, uninterrupted prosecution of the work is essential.

8-6.4.5 Minimum Staffing During Suspensions: The Contractor shall retain sufficient personnel at the job site to properly maintain all signs, warning devices and lights.

8-6.4.6 Contract Time Not Charged: Contract time will not be charged during the period of any approved suspension for vacation, as long as no work (with the exception of that specified in 8-6.4.5 is accomplished on the project.

8-7 Computation of Contract Time.

8-7.1 General: The Contractor shall perform fully, entirely and in accordance with the specifications, the contracted work within the contract time specified in the proposal, or as may be extended in accordance with the provisions hereinbelow.

The allowable contract time is calculated with consideration given that significant work is not normally accomplished on Saturdays, Sundays, State Legal Holidays and during seasonal inclement weather conditions with accompanying normal delays in prosecution of work on controlling items.

The effect on job progress of utility relocation and adjustments and the scheduling of construction operations required in order to adequately maintain traffic, as detailed in the plans and/or scheduled in the special provisions, has also been considered in the computation of the allowable contract time.

8-7.2 Date of Beginning of Contract Time: The date on which contract time will begin shall be either (1) the date of which the

Contractor actually begins work or (2) the date for beginning the charging of contract time as set forth in the proposal, whichever is earlier.

8-7.3 Adjusting Contract Time:

8-7.3.1 Increased Work: If the amount of the contract is increased due to net variations in estimated quantities or due to work added or extra work, then the contract time will be increased in the same proportion that the increased amount bears to the original contract amount.

8-7.3.2 Contract Time Extensions: The Department may grant an extension of the allowable contract time when a controlling item of work is delayed by factors determined to be beyond the Contractor's control which could not be reasonably anticipated at the time bids for the project were received. When failure by the Department to fulfill an obligation under the contract results in delays in the controlling construction operations, such delays will be considered as a basis for granting credit to the contract time. Extensions of contract time will not be granted for delays due to the fault or negligence of the Contractor.

Rains or other inclement weather conditions and related adverse soil conditions will be considered as the basis for granting of a time extension only when such conditions are unseasonable, provided that the project records indicate that they did in fact delay one or more controlling items of work.

Delays in delivery of materials or component equipment which affects progress on a controlling item of work will be considered as basis for granting a time extension if such delays are beyond the control of the Contractor or supplier. Such delays might be an area-wide shortage, an industry-wide strike or a natural disaster which affects all feasible sources of supply. In general, the Contractor shall furnish substantiating letters from a representative number of manufacturers of such materials or equipment clearly confirming that the delay in delivery was in no way the fault of the Contractor.

Requests for time extension due to delay in the delivery of custom manufactured equipment such as traffic signal equipment, highway lighting equipment, etc., will not be considered unless the Contractor furnishes documentation that his order for such equipment was placed in a timely manner, the delay was caused by factors over which the manufacturer could not be reasonably expected to exercise control and the lack of such equipment did cause a delay in progress on a controlling item of work.

The affect of utility relocation and adjustment work on job progress will be considered as the basis for granting a time extension only if all the following criteria are met:

1. Delays are the result of utility work not detailed in the plans or utility work detailed in the plans which is not accomplished

in reasonably close accordance with the schedule included in the special provisions.

2. Utility work actually affected progress toward completion of controlling work items.
3. The Contractor took all reasonable measures to minimize the effect of utility work on job progress including cooperative scheduling of his operations with the scheduled utility work at the preconstruction conference and providing adequate advance notification as given to utility companies as to the dates on which their operations must be coordinated with the Contractor's operation to avoid delays.

It is incumbent on the part of the Contractor to request any extension of the allowable contract time which he deems appropriate promptly after completion of the controlling work items which were delayed. Requests, if made after completion of the project, shall be submitted within 45 calendar days from the date of final acceptance of the project. The request must contain a detailed tabulation including dates and events fully describing the magnitude of the delays to controlling items of work caused by unanticipated factors beyond the control of the Contractor. The tabulation must consider overlapping periods of delay when there is more than one delaying factor.

8-7.3.3 Suspension Not Caused by Contractor: Whenever the work is suspended by the Engineer as provided in 8-6, for reasons other than the fault of the Contractor, allowance for any delay in completion of the work due to such suspension shall be made.

8-8 Failure of Contractor to Maintain Satisfactory Progress.

8-8.1 General: Time is an essential element of the contract and, as delay in the prosecution of the work will inconvenience the public, obstruct traffic, and interfere with business, it is important that the work be pressed vigorously to completion. Moreover, the cost to the Department for the administration of the contract, including engineering, inspection, and supervision, will be increased as the construction period is lengthened.

Chapter 337 of the Florida Transportation Code and Rules of the Department establish certain requirements pertaining to the suspension or revocation of a Contractor's certificate of qualification because of delinquency on a previously awarded contract.

8-8.2 Interpretation of Terms: Whenever in this Section the terms "delinquent" and "disqualified" appear, they are intended to mean disqualification only from bidding on other of the Department's contracts, and from approval as a subcontractor.

8-8.3 Regulations Governing Disqualification:

(a)A Contractor may be declared delinquent because of unsatisfactory progress on a contract with the Department, when the

contract time allowed has not been entirely consumed, but the Contractor's progress at any check period does not meet at least one of the following two tests:

(1) The percentage of dollar value of completed work with respect to the total amount of the contract is within ten percentage points of the percentage of contract time elapsed.
(2) The percentage of dollar value of completed work is within ten percentage points of the dollar value which should have been performed according to the Contractor's own progress schedule previously approved by the Engineer.

In lieu of the "ten percentage points" stipulated in the two preceding paragraphs, 20 percentage points may be allowed for a Contractor who, in the opinion of the Director, Division of Construction, has adequate organization, equipment, and financial resources to undertake other contract or subcontract work without conflict or delay in prosecuting work under existing contracts let by the Department.

(b) A Contractor will be declared delinquent because of unsatisfactory progress on the contract with the Department, under either of the following circumstances:

(1) The Contract time allowed has been consumed and the work has not been completed.
(2) The contract time allowed has not been entirely consumed, but the Contractor's progress at any check period does not meet either of the two tests described under the paragraphs headed (a) above.

(c) A Contractor declared delinquent under the provisions of 8.8 will be disqualified from further bidding and also will not be approved as a subcontractor so long as the delinquent status exists. Also, any individual, firm, partnership or corporation, affiliated with a delinquent Contractor to the extent that it is dependent upon the delinquent Contractor for either personnel, equipment or finances, shall likewise be disqualified.

(d) The Contractor may appeal to the Secretary of the Department for relief from his disqualification status. The Secretary will act upon any appeal within 30 calendar days after the filing thereof, and will promptly notify the appellant of the action taken.

(e) A Contractor disqualified under the requirements of this Article will be removed from such status upon receipt of evidence from the Department's District Engineer that his progress is no longer delinquent, provided the contract time has not elapsed.

(f) The principal progress check period will occur monthly, upon receipt in Tallahassee of the Contractor's monthly estimates. Postings will generally be completed by the first week of each month, and preliminary notices of delinquency will be sent to the Contractor by telegram immediately thereafter, and confirmed by certified mail.

(g) No Contractor given such a preliminary notice of delinquency will be finally declared delinquent until a period of ten calendar days after the preliminary notice has elapsed. During this ten-day period the affected Contractor may request any extensions of time, or other considerations which would affect his delinquency, which he feels he is entitled to.

(h) Final notification of delinquency will be made by telegram and certified mail after the expiration of this ten-day period, provided no extensions of time or other considerations are deemed proper by the Department, and provided the delinquency status has not been corrected.

(i) The Department may grant extensions of time during the prosecution of the work, as allowed under the Standard Specifictions and special provisions for the work, regardless of the Contractor's delinquency status.

8-9 Default and Termination of Contract.

8-9.1 Determination of Default: If the Contractor fails to begin the work under the Contract within the time specified in the "Notice to Proceed," or fails to perform the work with sufficient workmen and equipment or with sufficient materials to assure the prompt completion of the contract, or performs the work unsuitably or neglects or refuses to remove materials or to perform anew such work as may be rejected as unacceptable and unsuitable, or discontinues the prosecution of the work, or fails to resume work which has been discontinued within a reasonable time after notice to do so, or becomes insolvent or is declared bankrupt, or files for reorganization under the bankruptcy code, or commits any act of bankruptcy or insolvency, either voluntarily or involuntarily, or allows any final judgment to stand against him unsatisfied for a period of ten calendar days, or makes an assignment for the benefit of creditors, or fails to comply with contract requirements regarding minimum wage payments or EEO requirements, or for any other cause whatsoever, fails to carry on the work in an acceptable manner, or if the surety executing the bond, for any reasonable cause becomes unsatisfactory in the opinion of the Department, the Engineer will give notice in writing to the Contractor and his surety of such delay, neglect, or default.

If the Contractor, within a period of ten calendar days after the notice described above, shall not proceed to correct the conditions of which complaint is made, the Department shall, upon written certificate from the Engineer of the fact of such delay, neglect or default and the Contractor's failure to correct such conditions, have full power and authority, without violating the contract, to take the prosecution of the work out of the hands of the Contractor and to declare the contract in default.

8-9.2 Termination of Contract: The Department may by written notice, with the approval of the Federal Highway Administration where applicable, terminate the Contract or a portion thereof after determining that for reasons beyond either Department or Contractor control, he is prevented from proceeding with or completing the work as originally contracted for, and that termination would therefore be in the public interest. Such reasons for termination may include, but need not be necessarily limited to, executive orders of the President relating to prosecution of war or national defense, national emergency which creates a serious shortage of materials, orders from duly constituted authorities relating to energy conservation, and restraining order or injunctions obtained by third-party citizen action resulting from national or local environmental protection laws or where the

issuance of such order or injunction is primarily caused by acts or omissions of persons or agencies other than the Contractor.

When contracts, or any portion thereof, are terminated before completion of all items of work in the contract, payment will be made for the actual number of units or items of work completed, at the contract unit price, or as mutually agreed for items of work partially completed or not started. No claim for loss of anticipated profits will be considered.

Reimbursement for mobilization expenses (when not otherwise included in the contract) including moving equipment to the job, will be considered where the volume of work completed is too small to compensate the Contractor for these expenses under the contract unit prices; the intent being that an equitable settlement will be made with the Contractor.

Acceptable materials procured by the Contractor for the work, that have been inspected, tested, and approved by the Department, and that are not incorporated in the work, may be purchased from the Contractor at actual cost, as shown by receipted bills and actual cost records, at such points of delivery as may be designated by the Engineer.

Termination of a contract or a portion thereof, under the provisions of this Subarticle, shall not relieve the Contractor of his responsibilities for the completed portion, nor shall it relieve his surety of its obligation for and concerning any just claims arising out of the work performed.

8-9.3 Completion of Work by Department: Upon declaration of default the Department will have full power to appropriate or use any or all materials and equipment on the site which are suitable and acceptable, and may enter into an agreement with others for the completion of the work under the contract, or may use other methods which in the opinion of the Engineer are required for the completion of the work in an acceptable manner. All costs and charges incurred by the Department because of the Contractor's default, including the costs of completing the work under the contract, shall be charged against the Contractor. In case the expense so incurred by the Department is less than the sum which would have been payable under the contract if it had been completed by the defaulting Contractor, the defaulting Contractor shall be entitled to receive the difference. In case the expense exceeds the sum which would have been payable under the contract, then the Contractor and the surety shall be liable and shall pay the State the amount of the excess.

If after the ten-day notice period, and prior to any action by the Department to otherwise complete the work under the contract, the Contractor should establish his intent to prosecute the work in accordance with the Department's requirements, the Department may elect to permit the Contractor to resume the work, in which case any costs to the Department incurred by the delay, or from any reason attributable to the delay, will be deducted from any moneys due or which may become due under the contract.

8-10 Liquidated Damages for Failure to Complete the Work.

8-10.1 Highway Code Requirements Pertaining to Lidquidated Damages: The Florida Highway Code, Section 337.18, paragraph (2), requires that the Department shall adopt regulations for the determination of default and provides that liquidated damages be paid to the Department by the Contractor for any such default. These Code requirements shall govern, and are herewith made a part of the contract.

8-10.2 Amount of Liquidated Damages: Such liquidated damages are established in the following schedule:

Original Contract Amount	Daily Charge Per Calendar Day
$50,000 and under	$ 50
Over $50,000 but less than $250,000	$100
$250,000 but less than $500,000	$200
$500,000 but less than $2,500,000	$300
$2,500,000 but less than $5 million	$500
$5 million but less than $10 million	$750
$10 million but less than $15 million	$1,000
$15 million but less than $20 million	$1,250
$20 million and over	$1,250 plus 5/1000 of 1 percent per day for any amount over $20 million

8-10.3 Determination of Number of Days of Default: For all contracts, regardless of whether the contract time is stipulated in calendar days or working days, default days shall be counted in calendar days.

8-10.4 Conditions under which Liquidated Damages are Imposed: Should the Contractor or, in case of his default the surety fail to complete the work within the time stipulated in the contract, or within such extra time as may have been granted by the Department, the Contractor or, in case of his default, the surety shall pay to the Department, not as a penalty but as liquidated damages, the amount so due as determined by the Code requirements, as provided ablve.

8-10.5 Right of Collection: The Department shall have the right to apply as payment on such liquidated damages any money which is due to the Contractor by the Department.

8-10.6 Permitting Contractor to Finish Work: Permitting the Contractor to continue and to finish the work, or any part of it, after the expiration of the contract time allowed, including extensions of time granted to the Contractor, shall in no way act as a waiver on the part of the Department of the liquidated damages due under the contract.

8-10.7 Completion of Work by Department: In case of default of the contract and the completion of the work by the Department, the Contractor and his surety shall be liable for the liquidated damages under the contract, but no liquidated damages under the contract, but no liquidated damages shall be chargeable for any delay in the final

completion of the work by the Department due to any unreasonable action or delay on the part of the Department.

8-11 Termination of Contractor's Responsibility.

The contract will be considered complete when all work has been completed and has been accepted by the Department. The Contractor will then be released from further obligation except as set forth in his bond, and except as provided in 5-13.

APPENDIX C
CRITICAL PATH METHOD - ESSENTIAL ELEMENTS AND TECHNIQUES

CRITICAL PATH METHOD—ESSENTIAL ELEMENTS AND TECHNIQUES

THE CRITICAL PATH METHOD

During recent years the critical path method of planning, analyzing, and controlling a construction project has become a useful tool for engineers, architects, contractors, and others who are associated with construction. Many government and private agencies require the preparation and use of this method when planning the construction of a project.

In order to analyze a project by using the critical path method it is necessary to divide the project into activities. The number of units of work required to complete each activity should be determined. Then the time required to complete each activity, considering available equipment and labor, should be estimated in appropriate units, such as days, weeks, or months. Also, it is necessary to determine the time sequence in which the activities should be constructed. For example, concrete for a beam can not be placed until the forms have been erected and the reinforcing steel has been placed.

Each activity should be identified by a symbol or an appropriate description or both, and then listed in column form, with the duration of the activity, together with the activities which immediately precede and follow it, given. (This procedure is illustrated in Table 2-1.) Then the interrelationship of the activities can be indicated by a network or arrow diagram, in which each arrow represents an activity. Figure 2-1 illustrates an arrow diagram for a simple project involving five activities, designated by the letters, *A*, *B*, *C*, *D*, and *E*, for which the durations are estimated to be 4, 5, 3, 6, and 8 days, respectively.

Activities *A* and *B* can be started at the same time. Activities *C* and *D* cannot be started until *A* is completed. Activity *E* cannot be started until *B* and *C* are completed. An examination of Fig. 2-1

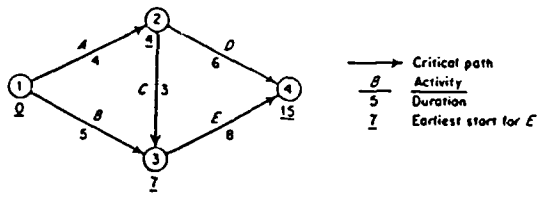


Fig. 2-1 Arrow diagram.

Table 2-1 List of activities, durations, and precedences

Activity	*Duration*	*Activities which immediately* *precede*	*follow*
A	3	None	*B, C, D*
B	5	*A*	*E*
C	4	*A*	*F, G*
D	6	*A*	*G, H*
E	4	*B*	*I*
F	5	*C*	*J*
G	3	*C, D*	*K*
H	6	*D*	*L*
I	5	*E*	*N*
J	7	*F*	*O*
K	4	*G*	*P*
L	5	*H*	*M, Q*
M	3	*L*	*P*
N	4	*I*	*S*
O	5	*J*	*S, T*
P	6	*K, M*	*T*
Q	4	*L*	*R*
R	4	*Q*	*T*
S	5	*N, O*	*U*
T	4	*O, P, R*	*U*
U	3	*S, T*	None

reveals that the minimum total time required to complete the project is the sum of the durations of activities *A*, *C*, and *E*, which is equal to 15 days. This is the critical path for the network.

If the project illustrated in Fig. 2-1 is modified by eliminating activity *C*, with the condition that activity *E* cannot be started until activities *A* and *B* are completed, a method must be used to indicate

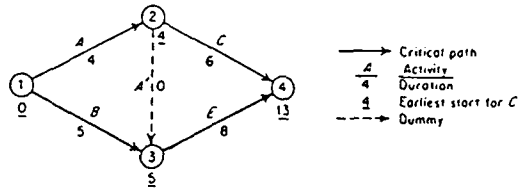


Fig. 2-2 Arrow diagram.

this requirement in the network. Since activity *C* does not appear in the network, it must be replaced with a dummy arrow, as illustrated in Fig. 2-2. A dummy is not a true activity, and it requires no time for completion. The critical path now lies along activities *B* and *E*.

DEFINITIONS OF TERMS AND SYMBOLS

Because terms and symbols are used in analyzing a project and constructing the arrow diagram, it is necessary to define these items.

Activity An activity is the performance of a specific task, such as placing reinforcing steel. It requires time to perform an activity.

Event An event represents the completion of an activity. It requires no time in itself. It is usually indicated on the arrow diagram by a number enclosed in a circle.

Arrow An arrow is drawn to represent each activity included in the network for a project, joining two events. An arrow is designated by two numbers, one at the tail and one at the head, with the number at the head always larger than the number at the tail. The length of the arrow has no relation to the duration of the activity which it represents.

Network This is an arrow diagram drawn to represent the relations of the activities and events. It is common practice to start time and the first arrow or arrows at the left end of the network and to proceed to the right.

Dummy A dummy is an artificial activity, represented on the arrow diagram by a dotted line, which indicates that an activity following the dummy cannot be started until the activity or activities preceding the dummy are completed. A dummy activity does not require any time.

Duration This is the estimated time, expressed in any desired unit, required to perform an activity.

Earliest start: ES This is the earliest time that an activity can be started.

Earliest finish: EF This is the earliest time that an activity can be finished. It is the earliest starting time plus the duration of an activity: $EF = ES + D$.

Latest start: LS This is the latest time that an activity may be started without delaying the completion of a project: $LS = LF - D$.

Latest finish: LF This is the latest time that an activity can be finished without delaying the completion of a project: $LF = LS + D$.

Total float: TF This is the amount of time that the start or finish of an activity can be delayed without delaying the completion of a project: $TF = LF - EF = LS - ES$. In Fig. 2-1 the earliest time for event 3 is the sum of the durations for activities *A* and $C = 4 + 3 = 7$ days. Because activity *B* has a duration of only 5 days, it can be completed 2 days prior to event 3. Thus its total float is $7 - 5 = 2$ days. If the start or finish of activity *B* is delayed 2 days, it will not delay the completion of the project.

Free float: FF This is the amount of time that the finish of an activity can be delayed without delaying the earliest starting time for a following activity. $FF = ES$ (following activity) $- EF$ (of this activity).

Critical path The critical path is the series of interconnected activities through the network for which each activity has zero float time. The critical path determines the minimum time required to complete a project.

The uses of these terms and symbols are illustrated more fully in the examples which appear below.

Persons who wish more comprehensive information on this subject may obtain such information from books devoted to the treatment of the critical path method.

STEPS IN CRITICAL PATH SCHEDULING

For persons who wish to apply the critical path method of scheduling the construction of a project it is suggested that the following steps be used.

1. Prepare a list of activities for the project.
2. Estimate the duration of each activity.
3. Determine which activity or activities immediately precede each activity.
4. Determine which activity or activities immediately follow each activity.
5. Draw a network with the activities and events properly interconnected.
6. Assign numbers to the events, being sure that the number at the head of each arrow is larger than the number at the tail of the arrow.
7. Prepare a chart with vertical columns and horizontal lines on which to list each activity with an appropriate designation: duration, earliest start, earliest finish, latest start, latest finish, and total float. A column for free float may be included, if this information is desired.
8. Determine which activities lie on the critical path.

DEVELOPING A CRITICAL PATH SCHEDULE

The following example illustrates a method of scheduling a project by the critical path method. Table 2-1 illustrates a form that can be used to tabulate the activities, together with the estimated durations, and the activities that immediately precede and follow each activity. Although the activities are designated by letters in this example, it is desirable in actual practice to designate each activity by appropriate descriptive words. Thus this example is intended to demonstrate how an arrow diagram and the related information are developed. This table provides the information specified in steps 1 through 4 of the preceding section.

Steps 5 and 6 are illustrated by Fig. 2-3. In this figure it will be noted that there are four dummies. The dummies C' and D' indicate that activities C and D, respectively, must be completed before activity G can be started. If activity G is drawn directly from event 4, without dummy C', it will be necessary to draw dummy D' from event 5 to event 4. This then will indicate that activity F cannot be started until activity D is completed, which is not true. Thus the two dummies O' and O'' are required for the same reasons.

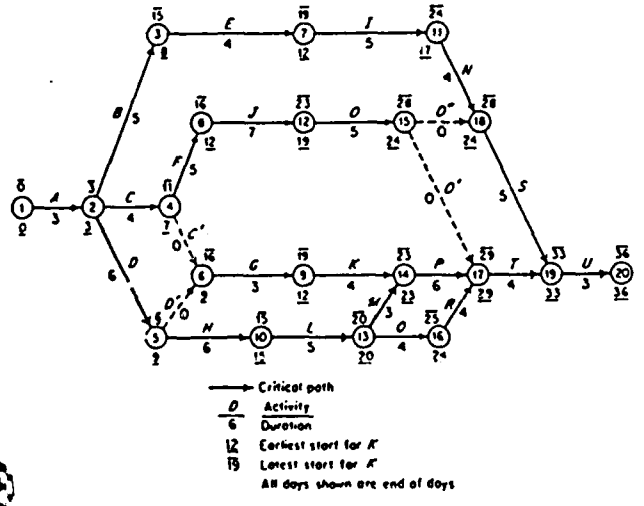


Fig. 2-3 Arrow diagram.

In the figure the heavy lines representing activities A, D, H, L, M, P, T, and U lie on the critical path. The estimated time required to complete the project is 36 working days.

Table 2-2 lists the activities, events, durations, starts, finishes, total floats, and free floats. Numbers appearing in the events columns should be taken from the arrow diagram after it is completed and the events numbered thereon.

Perhaps the easiest method of completing this table is to determine and record the earliest start time and finish time for each activity, including the dummies. The earliest start time for an activity is the controlling earliest finish time for the one or more immediately preceding activities. If two preceding activities have earliest finish times of 12 and 16 days, respectively, the 16 days will determine the earliest start time for the following activity.

Table 2-2 List of activities and related information

Activity	Events		D	ES	EF	LS	LF	TF	FF
A*	1	2	3	0	3	0	3	0	0
B	2	3	5	3	8	10	15	7	0
C	2	4	4	3	7	7	11	4	0
C'	4	6	0	7	7	16	16	9	2
D*	2	5	6	3	9	3	9	0	0
D'	5	6	0	9	9	16	16	7	0
E	3	7	4	8	12	15	19	7	0
F	4	8	5	7	12	11	16	4	0
G	6	9	3	9	12	16	19	7	0
H*	5	10	6	9	15	9	15	0	0
I	7	11	5	12	17	19	24	7	0
J	8	12	7	12	19	16	23	4	0
K	9	14	4	12	16	19	23	7	7
L*	10	13	5	15	20	15	20	0	0
M*	13	14	3	20	23	20	23	0	0
N	11	18	4	17	21	24	28	7	3
O	12	15	5	19	24	23	28	4	0
O'	15	17	0	24	24	29	29	5	0
O''	15	18	0	24	24	28	28	4	0
P*	14	17	6	23	29	23	29	0	0
Q	13	16	4	20	24	21	25	1	0
R	16	17	4	24	28	25	29	1	1
S	18	19	5	24	29	28	33	4	4
T*	17	19	4	29	33	29	33	0	0
U*	19	20	3	33	36	33	36	0	0

* These activities are on the critical path.
Note: All days shown are the ends of days.

After the minimum time required to construct the project is determined, 36 days for this project, the latest finish times for each activity can be determined by working backward from the 36 days. For example, the latest finish times for activities S and T are determined by subtracting the duration of activity U, namely 3 days, from 36 to give 33 days. The latest start time for activity S is its latest finish time minus the duration of S, namely 5 days, to give a value of 28 days. This procedure is applied along each path of activities.

The symbol *19* appearing under event 12 in Fig. 2-3 indicates that 19 days is the earliest finish time for activity J and the earliest start time for activity O. The symbol 23 appearing above event 12 indicates that 23 days is the latest finish time for activity J and the latest start time for activity O.

DETERMINING TOTAL FLOAT

The total float of an activity is the number of days or other appropriate units of time that the start or finish of an activity may be delayed without delaying the completion time for the overall project. Referring to Fig. 2-3 it will be noted that the earliest finish date for activity B is the end of the eighth day, while the latest finish time is the end of the fifteenth day. Thus there is a leeway of $15 - 8 = 7$ days for completing activity B. This is the total float designated in Table 2-2. The total float of 7 days may be allocated to any one of the activities along the path B, E, I, N, or it may be allocated in parts to more than one activity, provided the total delays do not exceed 7 days.

APPENDIX D
SUMMARY OF CONTRACT TIME DETERMINATION - MISSISSIPPI

SUMMARY OF CONTRACT TIME DETERMINATION—MISSISSIPPI

The Mississippi State Highway Department uses a progress schedule (bar chart) both to establish and to charge contract time.The progress schedule is published in the proposal so that a bidder can identify the items and rates of work that were considered in determining the time and thus reasonably estimate resources; i.e., personnel, equipment, etc., required to complete the work within the allotted time.

The progress schedule is developed by applying production parameters to the contract work items. Allied or similar work items are grouped into phases that are positioned on a bar chart in logical sequence. The positioning allows for mobilization and transition among the various phases. Additionally, applicable seasonal limitations are taken into consideration. The resulting chart indicates the number of productive days (termed time units) that are considered necessary for the work.

Contracts are let on a completion-date basis. To establish the completion date, a monthly allotment of time units is used (see Table E-1). This table was formulated by a review of monthly contractor estimates for the various types of projects and is indicative of the contractors' ability to earn money in any given month according to previous performance.

These monthly divisions are graphically indicated on the bar chart form. The work phase bars are entered on the chart in their proper calendar position oriented to the beginning of construction date. The end result after positioning the bars establishes the specified completion date.

As previously stated, the contracts are let on a completion-date basis. However, in recognition that abnormal weather conditions may occur within the life of a contract that could prevent the timely completion of the work, the contractor is guaranteed access to the number of time units determined by the state as necessary to do the work. If, on the completion date, the contractor has not been afforded the time units, the contract is automatically extended daily until the required time units have occurred.

The progress schedules govern the daily assessment of contract time and, as uniformity is vital, they are all prepared in the central office of the Construction Division where consistent oversight can be more easily exercised.

It is recognized that the actual management of a project rests with the contractor. In order not to mandate the sequence of operations, the contractor is given the option of either accepting the state's progress schedule or submitting his own. He may not, however, modify the specified completion date.

Examples of production parameters, a progress schedule that shows the grouping of work items into phases and bar interrelationships, and instructions relative to the daily time assessments follow.

TABLE E-1
TIME UNITS

MONTH	COLUMN A	COLUMN B	COLUMN C	COLUMN D
January	5	5	6	7
February	5	6	7	8
March	9	9	11	13
April	13	14	14	17
May	17	19	19	19
June	19	20	22	19
July	21	22	23	18
August	21	22	23	18
September	20	20	22	17
October	15	17	17	15
November	10	11	11	12
December	5	5	5	7
Calendar Year	160	170	180	170

Column A: Grading and Drainage Projects
Column B: Base and Paving Projects
Column C: Bridge or Specialized Projects
Column D: Widening and Overlay (Asphalt) Projects

PRODUCTION PARAMETERS

		Small Projects 0-750 M	Medium Projects 750-1, 500 M	Large Projects 1,500 M-Greater	Overlay Projects
1.	Mob.	10 TU	12 TU	14 TU	15 TU
2.	C & G	5 TU (lead)	8 TU (lead)	10 TU (lead	
3.	Small Struct.	5 TU (lead)	8 TU (lead)	10 TU (lead)	
4.	Unclass. Exc.	2500-400 CY/TU	3500-600 CY/TU	6000-12000 CY/TU	
5.	Embankment (CF)	1500-3000 CY/TU	2000-3500 CY/TU	2500-5000 CY/TU	
6.	In-Gr. Mod.	10000 SY/TU	10000 SY/TU	10000 SY/TU	
7.	Lime Treat A	8000 SY/TY (+20 TU)	8000 SY/TU (+20 TU)	8000 SY/TU (+20 TU)	
8.	Lime Treat B	8000 SY/TU (+20 TU)	8000 SY/TU (+20 TU)	8000 SY/TY (+20 TU)	
9.	Lime Treat C	10000 SY/TU	10000 SY/TU	10000 SY/TU	
10.	Lime Treat D	15000 SY/TU	15000 SY/TU	15000 SY/TU	
11.	Cement Treat	8000 SY/TU	8000 SY/TU	8000 SY/TU	
12.	Gran. Mat. (CF)	1000-2000 CY/TU	1500-2500 CY/TU	2000-3000 CY/TU	
13.	Top Soil	500 CY/TU	1000 CY/TU	1500 CY/TU	
14.	Plating Mat.	500 CY/TU	1000 CY/TU	1500 CY/TU	
15.	EC	22,200 SY/TU	39,000 SY/TU	56,000 SY/TU	0.5 MI/TU
16.	HB Base	700 Tons/TU	850 Tons/TU	1000 Tons/TU	700 Tons/TU
17.	HB Leveling				500 Tons/TU
18.	Trench & Widen				1 Mile ea. side/TU
19.	Grout. Slabs				150-300 holes/TU
20.	Rem. RCP				250 SY/TU
21.	Clean & Seal Jts.				2000 FT/TU
22.	Prelim. Rolling				2 MI/TU
23.	HB Binder	700 Tons/TU	700 Tons/TU	850 Tons/TU	700 Tons/TU
24.	HB Surface	500 Tons/TU	500 Tons/TU	700 Tons/TU	500 Tons/TU
25.	DBST	0.5 MI/TU (2 Lane)	0.5 MI/TU (2 Lane)	0.5 MI/TU (2 Lane)	0.5 MI/TU (2 Lane)
26.	SBST	1.0 MI/TU (2 Lane)	1.0 MI/TU (2 Lane)	1.0 MI/TU (2 Lane)	1.0 MI/TU (2 Lane)
27.	Sho. Mat.				500 CY/TU
28.	RC Curb	100 FT/TU (min. 5 TU)	200 FT/TU (min. 5 TU)	300 FT/TU (min. 5 TU)	100 FT/TU (min. 5 TU)
29.	HB Curb	500 FT/TU	500 FT/TU	500 FT/TU	500 FT/TU
30.	Curb & Gutter	100 FT/TU (min. 5 TU)	200 FT/TU (min. 5 TU)	300 FT/TU (min. 5 TU)	100 FT/TU (min. 5 TU)
31.	Traffic Stripe	4 MI (of stripe)/TU (min. 5 TU)	4 MI/TU (min. 5 TU)	4 MI/TU (min. 5 TU)	2 MI/TU (min. 5 TU)
32.	Detail Stripe	2000 FT/TU	2000 FT/TU	2000 FT/TU	2000 FT/TU
33.	Legend Paint	500 SF/TU	500 SF/TU	500 SF/TU	500 SF/TU
34.	Conc. Base	5000 SY/TU	8000 SY/TU	8000 SY/TU	
35.	CP (Plain)	5000 SY/TU	8000 SY/TU	8000 SY/TU	
36.	RCP	5000 SY/TU	8000 SY/TU	8000 SY/TU	
37.	CRCP	5000 SY/TU	8000 SY/TU	8000 SY/TU	

FHWA C&B-606

PROGRESS SCHEDULE NO. 2

FOR USE WITH COLUMN "B" IN THE TABLE OF TIME UNITS

PROJECT NUMBER TQF-019-2(11)/09-0019-02-011-10

COUNTY Yalobusha

	WORK PHASE NO.	DESCRIPTION	CONTROLLING QUANTITY	IBM NUMBERS	PHASE VALUE	NO.	AVTU
	1	MISCELLANEOUS		1-4,56-58, 68,69,76,			
	2	DRAINAGE STRUCTURES & RIP-RAP		9,41-50, 75,			
	3	EXCAVATION & GRANULAR MATERIAL		5-8,26,27,			
	4	ASPHALT, SOIL, CEMENT, CURB AND GUTTER		25, 28-34,36,			
	5	CONCRETE PAVING		35-40,			
	6	EROSION CONTROL, MED. & ISLAND PAVEMENT, & GUARD RAIL		10-24, 51-53,55,			
	7	PERMANENT TRAFFIC STRIPE, DELINEATORS & RAISED MARKERS		59-67, 70-74			
		LET: Feb.27,1979 NTP: April 2, 1979 BCT: May 1, 1979 SCD: June 12, 1980 TIME UNITS: 195					

5 CALENDAR DAY INCREMENTS													
MONTH	MAY	JUNE	JULY	AUGUST	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APRIL	MAY	JUNE
TIME UNITS PER MONTH	19	20	22	22	20	17	11	6	6	6	9	14	19	20
CUMULATIVE TIME UNITS														

170 TIME UNITS PER YEAR

HORIZONTAL SCALE-1"=20 TIME UNITS

REVISED DUE TO LATE NOTICE TO PROCEED

FORM C80-000

YEAR 1980 **PROGRESS SCHEDULE** NO. 1 YEAR 1981

FOR USE WITH COLUMN "B" IN THE TABLE OF TIME UNITS

PROJECT NUMBER 97-0008-04-035-10

COUNTY Yazoo

WORK PHASE NO.	DESCRIPTION	CONTROLLING QUANTITY	IBM NUMBERS	PHASE VALUE
1	MISCELLANEOUS		3-5, 27, 51-81,	
2	CLEARING & GRUBBING		1, 2,	
3	STRUCTURE		8, 33-50,	
4	EXCAVATION		6, 7,	
5	EROSION CONTROL		9-22	
6	GRANULAR MATERIAL		24,	
7	PAVEMENT		23, 25, 26 28-32	
	YEAR 1982			
1	MISCELLANEOUS		3-5, 27, 51-81,	
2	CLEARING & GRUBBING		1, 2,	
3	STRUCTURE		8, 33-50,	
4	EXCAVATION		6, 7,	
5	EROSION CONTROL		9-22,	
6	GRANULAR MATERIAL		24,	
7	PAVEMENT		23, 25, 26, 28-32	

NO.	AVIU

5 CALENDAR DAY INCREMENTS																								
MONTH	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUGUST	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUGUST	SEPT	OCT	NOV	DEC
TIME UNITS PER MONTH	5	6	9	14	19	20	22	22	20	17	11	5	5	6	9	14	19	20	22	22	20	17	11	5
CUMULATIVE TIME UNITS																								

170 TIME UNITS PER YEAR

HORIZONTAL SCALE-1"=20 TIME UNITS

LET: August 26, 1980
ATP: September 19, 1980
BCT: October 20, 1980
SCD: September 30, 1982
TIME UNITS: 329

DAILY REPORT OF TIME UNIT ASSESSMENT

EXAMPLE

(1) No.	(2) Work Phase Description	(3) AVTU	Ratio to Daily Total (5)	(6) Work Condition Sat.	(6) Work Condition Uns.	(7) Hours Worked	Productive Hours Available (8)	Adjusted Productive Hours (9)
2	Excavation	5,935	.55	X		4	4	2.2
3	Granular Mat'l & Prime	3,030	.28	X		7	8	2.2
5	Minor Dr Str, Etc	1,429	.13	X		10	10	1.3
8	Erosion Control Items	392	.04	X		0	8	0.3
	Daily Total (4)	10,786					(10)	6.0

÷8= 0.7* (11)

\+

Previously Assessed Time Units 69.9

\-

Cumulative Time Units Assessed To Date 70.6

(1) This is a list of all the controlling phases of work that should be in progress on the date shown. The phase numbers are as they are shown on the Progress Schedule.

(2) This is a plain language description of each phase, also from the Schedule.

(3) This is the Average Value per Time Unit (AVTU) to the closest dollar for the phases shown. This value is determined by dividing the total value of all contract items in a phase by the total number of time units allotted to the phase.

(4) This is the AVTU total for all phases that should be in progress this day.

(5) This is the ratio of the individual AVTU to the total-- (3)÷(4).

(6) These columns are where the Project Engineer must exercise unbiased judgement when making entries. If soil and weather conditions are satisfactory for any part of the day, enter an X under Sat. by each of the phases for which conditions were satisfactory for work even if for only part of the day. If conditions were unsatisfactory during the entire day, enter an X under Uns.

(7) This column is self-explanatory, it is the hours actually worked on a phase.

(8) This is another column where the Project Engineer must depend upon his judgement to make an entry. It shows the total number of productive hours that the Contractor could work on each phase. The hours for each phase should not exceed 8 unless the Contractor actually worked more than 8 hours. If he works more than 8 productive hours, the entry is to be the hours actually worked. If the productive hours available are shown to be less than the hours worked, the Project Engineer should make a note of explanation on the front sheet of the diary.

(9) This column shows the adjusted productive hours for each phase. The adjusted productive hours for each phase is determined by multiplying the ratio under (5) by the productive hours available shown under (8).

(10) This figure is the total Adjusted Productive Hours for the day or the sum of the Adjusted Productive Hours for each phase.

(11) This figure is the number of time units to charge for the day. It is the quotient of (10) ÷ 8. For contracts awarded in and after June 1975, this figure is not to exceed 1.0 time unit per day.

* Round down to nearest tenth

APPENDIX E
CONTRACT TIME DETERMINATION - WYOMING

CONTRACT TIME DETERMINATION—WYOMING

After completion of contract plans and determination of a letting date, the Highway Department determines the contract date of completion using the critical path method.

Contract time is determined independently by two individuals. Production factors and anticipated adverse weather days are considered. The critical path is based on expectations of the contractor's work methods. The time determination (contract completion date) of each analysis is reviewed by a staff engineer who compares the analyses, reconciles any differences, and determines the contract completion dates to be used in the contract documents.

Two independent analyses, the engineer's review, and the final time determination on a construction project in Wyoming are presented here.

CONTRACT TIME DETERMINATION

District 3

Project - SCPF-012-1(27) Letting Date July 11, 1980

Road - Kemmerer By-Pass Award Date July 19, 1980

County - Lincoln Starting Date August 18, 1980

Determination Made by Al Tooker Date May 30, 1980

Node	Description	Working Days
1-2	Mobilization	10
2-4	Stripping Pits 58,000 C.Y. @ 3500 C.Y./day	17
2-3	Crushing Mtl. 278,860 Tons @ 2500 T./day	112
2-5 = 10 5-6 = 122	Uncl. Excl. 2,373,200 C.Y. @ 18,010 C.Y./day 10 122	132
6-7	Crusher Run Sub-Base 163,600 Tons @ 5100 T./day	32
7-8	Cr. Base 72,000 Tons @ 2500 T./day	29
9-10	H.R. Mix Bit. Pvmt., Type I 49,100 Tons @ 2000 T./day	20
10-11	P.M. Wearing Course, Type A 6425 Tons @ 1500 T./day	4
8-9	Concrete Pvmt. 7400 Sq. Yds. @ 1500 Sq. Yds./day	5
2-20	Pipe Culverts 18" to 60" 4420 L.F. C.M.P. 24" 154 L.F. @ 150 L.F./day	30
18-26	Guard Rail, Box Beam 1032 L.F. @ 300 L.F./day	3
21-22	Fence, 32" WW 2 BW 37,000 L.F. @ 1800 L.F./day	21
20-21	Cattleguards, 16' 2-Each @ 2-days Ea.	4

CONTRACT TIME DETERMINATION

District 3

Project - SCPF-012-1(27) Letting Date July 11, 1980
Road - Kemmerer By-Pass Award Date July 14, 1980
County - Lincoln Starting Date August 18, 1980

Determination Made by Al Tooker Date May 30, 1980

Node	Description	Working Days
	SIGN STRUCTURE & SIGN LIGHTING — 2-LOCATIONS	
10-25	DRILLED SHAFT FOUNDATIONS, 30" 100 L.F. @ 50 L.F./day	2
	— STR. STEEL DELIVERY TIME — 4 MONTHS = DEC. 18, 1980 —	
11-12	SET STR. STEEL 2-LOCATIONS @ 5-days EA.	10
12-13	SIGN LIGHTING, ELECTRICAL CONNECTIONS, ETC.	5
14-15	PAINT STR. STEEL	5
	STEEL BREAK-AWAY SIGNS — 7-LOCATIONS	
23-24	DRILLED SHAFT FOUNDATIONS, 24" 112 L.F. @ 50 L.F./day	2
	— STR. STEEL DELIVERY TIME — 4 MOS. = 12-18-80 —	
	SET STR. STEEL & SIGN INSTALLATIONS 7-LOCATIONS @ 2-DAYS EA.	14
		16
	ROADWAY LIGHTING SYSTEM —	
	DRILLED SHAFT FOUNDATIONS, 30" 104 L.F. @ 50 L.F./day	2
	PULL BOXES, CONCRETE 25 EACH @ 5 per day	5
	TRENCHING & BACKFILLING 4000 L.F. @ 300 L.F./day	13
5-23	SERVICE POINTS 3-EACH @ 1 per day	3
	— DELIVERY TIME - STEEL STDS. — 6-MONTHS = FEB. 18, 1981 —	
	STEEL STDS, TYPE VI 13-EACH @ 2 per day	7
	ELECTRICAL CONNECTIONS, ETC.	10
		40
		18

CONTRACT TIME DETERMINATION

District 3

Project - SCPE-012-1(27) Letting Date July 11, 1980
Road - Kemmerer By-Pass Award Date July 19, 1980
County - Lincoln Starting Date August 18, 1980

Determination Made by Al Tooker Date May 30, 1980

Node	Description		Working Days	
	Structure — Sta. 76+44.39 — U.S. 30 By Pass	215' b-b Abuts.		
	Abut. 1 —			
	Spread Footings (4-Ea.)	Form = 4 / Pour = 2	6	
	Columns (4-Ea.)	Form = 4 / Pour = 2	6	
	Cap	Form = 3 / Pour = 1	4	
	Wall & Wingwalls	Form = 6 / Pour = 3	9	
	Abut. 2 —			
	Steel Piling	HP 10 x 42 434 L.F. @ 75 L.F./day	6	
	Cap	Form = 3 / Pour = 1	4	
5-18	Wall & Wing Walls	Form = 6 / Pour = 3	9	80
	Bent 1 —			
	Footings (3-Ea.)	Form = 3 / Pour = 1	4	
	Columns (3-Ea.)	Form = 6 / Pour = 3	9	
	Cap	Form = 4 / Pour = 1	5	
	Bent 2 —			
	Footings (3-Ea.)	Form = 3 / Pour = 1	4	
	Columns (3-Ea.)	Form = 6 / Pour = 3	9	
	Cap	Form = 4 / Pour = 1	5	
	Str. Steel Delivery = 6 Months = February 18, 1981 —			
	Set Str. Steel	7-Girders @ 2-days Ea.	14	
	Deck & Curbs	Form = 20 / Pour = 1	21	
18-19	Strip Deck Forms		5	61
	Approach Slabs	Form = 2 / Pour = 2	4	
	Br. Railing	487 L.F. @ 100 L.F./day	5	
	Slope Paving	1870 Sq.yds. @ 150 Sq.yd./day	12	
	Paint - Str. Steel		14	

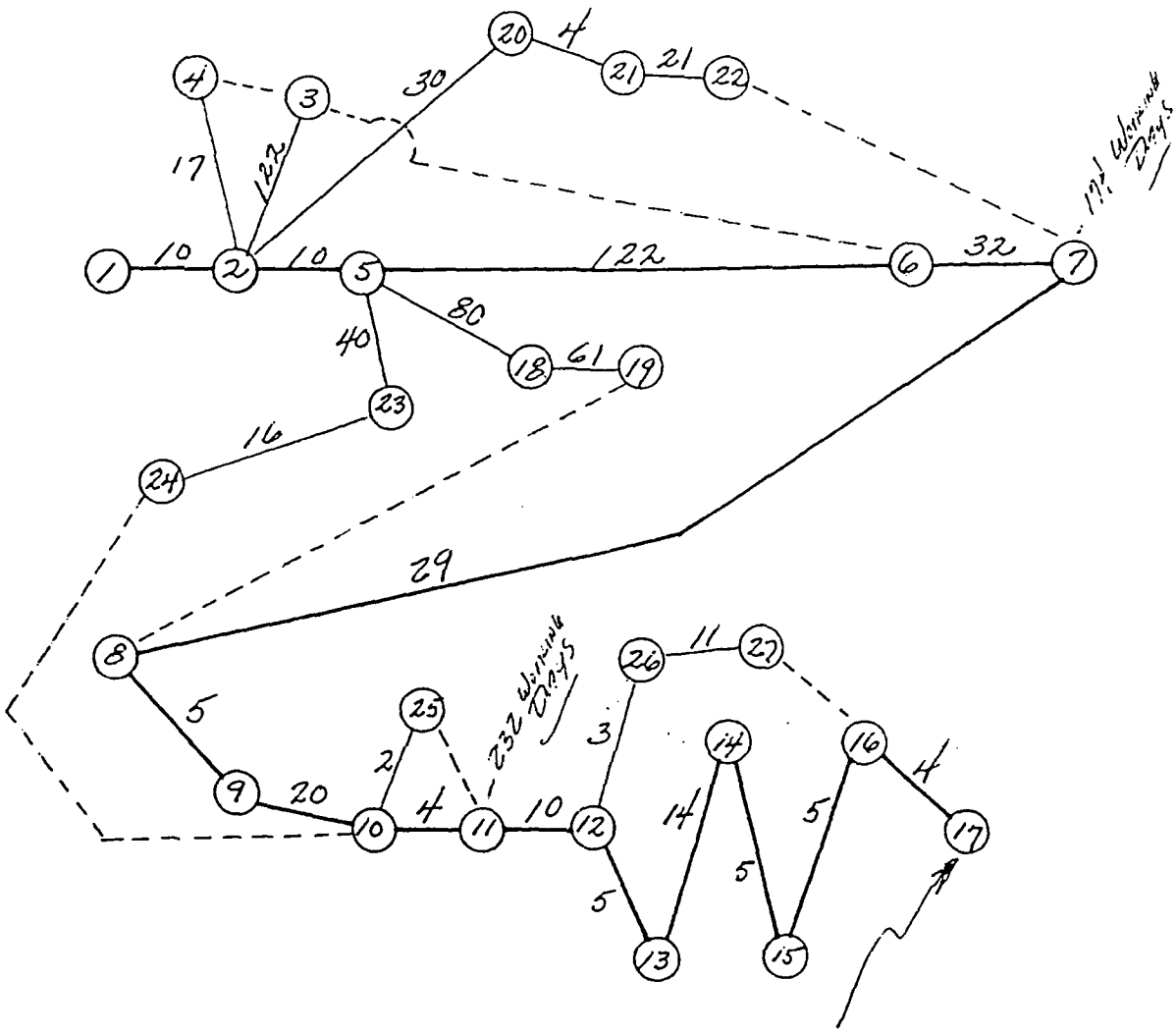
CONTRACT TIME DETERMINATION

District 3

Project - SCPE-012-1(27) Letting Date July 11, 1980
Road - Kemmerer By-Pass Award Date July 14, 1980
County - Lincoln Starting Date August 18, 1980

Determination Made by Al Tooker Date May 30, 1980

Node	Description	Working Days
15-16	Old Road Obliteration 2.3 Miles @ 0.5 Mi/day	5
26-27	Seeding (PLS) 2915 Lbs. @ 11 Lbs/Acre = 265 Ac. @ 25 A./day	11
16-17	Misc. & Cleanup Work	4
		672



275 Working Days

STAFF REVIEW & COMMENTS:

Adjust production rate on grading to 25,000 c.y./day for last 2.2 million yds. so node 5-6 is 88 working days. Parallel 16 days of crusher run subbase. Working days will be reduced to 275 - 40 - 16 = 219 DSL

CONTRACT TIME DETERMINATION

District 3

Project - SCPF-012-1(27) Letting Date July 11, 1980
Road - Kemmerer By-Pass Award Date July 14, 1980
County - Lincoln Starting Date August 18, 1980

Determination Made by Al Tooker Date May 30, 1980

Node	Description	Working Days			
		DAYS			
		Work	Weather	Avail.	Accu.
1980	Aug	10	1	9	
	Sep	19	4	15	24
	Oct	22	7	15	39
	Nov	20	10	10	49
1981	Apr	22	8	14	63
	May	21	6	15	78
	Jun	21	4	17	95
	Jul	22	2	20	115
	Aug	21	2	19	134
	Sep	21	4	17	151
	Oct	22	7	15	166
	Nov	17	10	7	173
1982	Apr	22	8	14	187
	May	20	6	14	201
	Jun	22	4	18	219
	Jul	22	2	20	239
	Aug	21	2	19	258
	Sep	21	4	17	275

Use July 31, 1982 JSSE

CONTRACT COMPLETION DATE = ~~September 30, 1982~~

5-30-80

CONTRACT TIME DETERMINATION

District 3

Project - SCPF-012-1(27) Letting Date 7-11-80
Road - Kemmerer Bip-Pass Award Date 7-19-80
County - LINCOLN Starting Date 8-15-80

Determination Made by Paul Buethuch Date 5-30-80

Node	Description	Working Days
1-2	Mobilization	10
2-3 3-4	Stripping - 58000 cy - 3000/day	19
3-5	Crushing - 285000 TON - 3000/day	95
2-2a 2a-11	Unc. Exc. - 2373200 cy - 15000/day	158
2-7	Pipe - 4644 L.F. - 200/day	23
2-8	Fence - 37000 L.F. - 2000/day	19
2-9 6-10	Cr. Run Sub-Base - 1636000 TON - 3000/day	54
10-12	Cr. Base - 72000 TON - 3000/day	24
12-13	Conc. Pvmt - 7400 sq yd - 1800/day	4
12-14	HPMB Pvmt - 40000 TON - 2500/day	16
14-15	PMWC - 6425 TON - 1300/day	5
14-16	Gr. Rail - Box Beam - 1032 L.F. - 400/day	3
15-17	Standards - 13 ea - 2/day	7 } 9
	Str. Steel (Overhead Signs) - 2 ea - 1/day	2 }
14-18	Str. Steel (Breakaway Signs) - 7 ea - 10/day	1
18-19	Painting Overhead Signs - 2 ea - 1/day	2
19-20	Haul Road Restoration	2
20-21	Lighting System - Final Hook-up	2
17-22	Seeding - 29515 lbs - 265 acres - 40/day	7
22-23	Testing & Misc. Clean-up	10
		463
	6 mos. delivery - Str. Steel	
	6 mos. delivery - Light Stds	
	4 mos. delivery - Sign Str.	

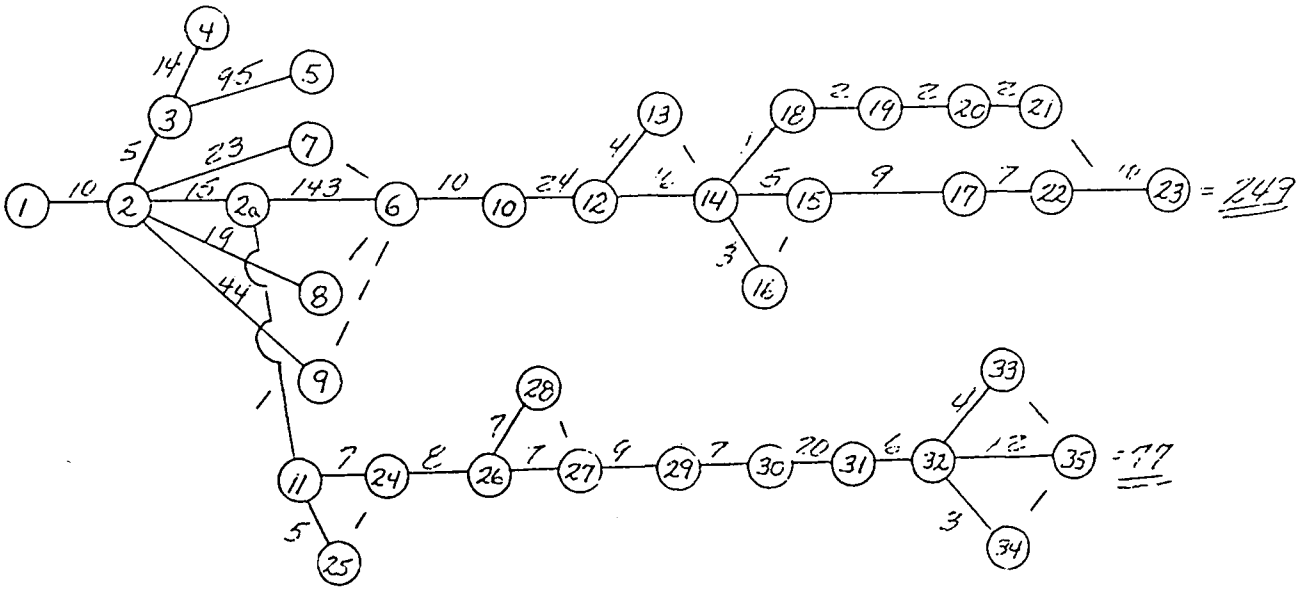
CONTRACT TIME DETERMINATION

District 3

Project - SCPF-012-1(27) Letting Date 7-11-80
Road - Kemmerer By-Pass Award Date 7-19-80
County - Lincoln Starting Date 8-18-80

Determination Made by Paul Duethman Date 5-30-80

Node	Description	Working Days
	Bridge - Sta. 76+44.39	
2a-11	Dry Exc.	1
11-25	Drive Piling - 434 L.F. - 80/day	5
24-26	Form & Pour Abut #1	8
11-24	Form & Pour Abut #2	7
26-27	Form & Pour Bent #1	7
26-28	Form & Pour Bent #2	7
29-30	Set Girders - 7ea. 1/day	7
30-31	Form & Pour Deck	20
27-29	Paint Slope Paving - 1820 sq yd - 200/day	9
31-32	Strip Deck	6
32-33	Appr. Slabs - 2days/ea	4
32-34	Br. Railing - 487 LF - 150/day	3
32-35	Paint Girders - 7ea. 1/day	7 } 12
32-35	Misc. & Clean-up	5 }
		96
	Total Working Days	559
	Staff Review & Comments	
	Reduce grading to 88 working days. Increase activity 6-10 paralleling only ½ of the crusher run subbase. Working days = 249-70+17 = 196 working days ~~Use~~	



Month	Work	Weather	Available	Accumulative
Aug	10	1	9	9
Sep	19	4	15	24
Oct	22	7	15	39
Nov	20	10	10	49
Apr	22	8	14	63
May	21	6	15	78
Jun	21	4	17	95
Jul	22	2	20	115
Aug	21	2	19	134
Sep	21	4	17	151
Oct	22	7	15	166
Nov	17	10	7	173
Apr	22	8	14	187
May	20	6	14	201
Jun	22	4	18	219
Jul	22	2	20	239
Aug	21	2	19	258

Use July 31, 1982 ~~August 31, 1982~~

Completion Date = ~~August 31, 1982~~

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