

**Analysis of Liquidated Damages Provisions of Highway Standard  
Specifications in the USA**

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**Abstract**

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A construction schedule is a plan outlining the order and timing of the activities of construction in a project. Specifications may stipulate a course of action or penalties if the progress of work falls short of the defined Schedule.

To ensure uniform state-wide guidelines in construction, each Department of Transportation (DOT) developed a set of Standard Specifications throughout the United States of America. The analysis of Standard Specifications developed by DOTs in each State reveals stark differences in their implementation of schedule requirements and the consequences of non-conformance to the schedules.

This research work investigates the scheduling provisions implemented by all the state DOTs. Using content analysis and statistical analysis, the research objectives are to identify the various forms of schedule non-conformances, consequences of non-conformances, and Liquidated Damages as specified in all 50 Department of Transportation Standard Specifications. The data obtained from the review are analyzed and put into charts and tables to show how the states differed or agreed on the non-

conformances, LDs, and the impact of non-conformance. Descriptive and regression analyses of the states' liquidated damages are undertaken to show the various data points, the ranges of liquidated damages, and to uncover an LD model that captures the estimated LDs charges from aggregated states' LDs tables.

# TABLE OF CONTENTS

TABLE OF CONTENTS.....	1
LIST OF FIGURES .....	5
LIST OF TABLES .....	6
ACKNOWLEDGEMENTS.....	7
1 INTRODUCTION.....	8
2 LITERATURE REVIEW .....	12
2.1 Construction Schedules.....	12
2.2 Schedule Delays.....	12
2.2.1 Excusable vs Non-Excusable Delays.....	13
2.3 Liquidated Damages .....	14
2.3.1 Types of liquidated damages .....	15
2.3.2 Legal history .....	16
2.3.3 Standard features.....	17
2.3.4 Implementation .....	17
3 RESEARCH METHODOLOGY .....	19
3.1 Research Statement and Objectives .....	19
3.2 Research Data and Research methods .....	19
3.2.1 Content Analysis.....	19
3.2.2 Descriptive and Statistical Regression Analysis.....	20
4 CONTENT REVIEW AND ANALYSIS.....	21

4.1	Schedule submission .....	22
4.1.1	Required preconstruction .....	24
4.1.2	Different schedules .....	24
4.1.3	Format requirements .....	25
4.1.4	Computer software requirement .....	25
4.1.5	Requirement of updated Schedule .....	25
4.1.6	Payment Contingent on Schedule .....	27
4.1.7	Scheduled Meetings .....	28
4.2	States with Future bid submission clause .....	28
4.3	Payment Schedule .....	29
4.4	Positive Instances of Non-conformance .....	29
4.4.1	Expediting Work (Early Completion).....	30
4.4.2	Completing Work Early-Incentive Award.....	32
4.5	Liquidated Damages .....	34
4.5.1	Analysis of State Liquidated damages .....	34
4.5.2	Assessment of Liquidated damages .....	35
4.5.3	Value determination of LDs.....	38
4.5.4	LDs, Not Penalties .....	38
4.5.5	Calculation of LDs.....	38
4.5.6	Additional Types of liquidated damages .....	56
4.5.7	Liquidated Damages During Construction .....	58

4.6	Default/Suspension/Termination .....	60
4.6.1	Overview .....	60
4.6.2	Time of appeal .....	60
4.6.3	Unsatisfactory progress of work (specific work).....	61
5	LIQUIDATED DAMAGES MODEL.....	62
5.1	Tables Based on Calendar Days .....	63
5.1.1	Cluster Analysis and Box Plots.....	63
5.1.2	Regression Analysis.....	67
5.2	Tables Based on working Days.....	76
6	DISCUSSION AND CONCLUSION .....	78
6.1	SUMMARY .....	78
6.2	CONCLUSION.....	79
6.3	RESEARCH CONTRIBUTIONS .....	80
6.4	FUTURE RESEARCH .....	81
7	REFERENCES .....	82
8	APPENDIX .....	91
8.1	Appendix A Standard Specifications Review .....	91
8.2	Appendix B Liquidated Damages Table Based on Calendar Days .....	105
8.3	Appendix C Liquidated Damages Table Based on Working Days.....	108
8.4	Appendix C Cluster Analysis and Box Plot.....	110
8.5	Appendix D SPSS Output Calendar Days .....	114

8.6	Appendix D SPSS Output Working Days .....	119
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## LIST OF FIGURES

Figure 1 Schedule Submission Requirement .....	24
Figure 2 Requirement to Update Schedule .....	26
Figure 3 states with liquidated damages clauses.....	35
Figure 4 Start of liquidated Damages .....	36
Figure 5 Liquidated Damages based on Calendar/working days.....	37
Figure 6 Table of Liquidated Damages .....	40
Figure 7 Liquidated Damages table 2016 ILDOT Std Specs .....	40
Figure 8 Liquidated Damages charges per Contract size (Calendar Days & Contracts up to 10M).....	43
Figure 9 Liquidated Damages charges per Contract size (Calendar Days & Contracts up to 20M).....	44
Figure 10 Liquidated Damages charges per Contract size (Calendar Days & Contracts up to 50M).....	45
Figure 11 Liquidated Damages charges per Contract size (Calendar Days California) .....	46
Figure 12 Liquidated Damages charges per Contract size 1 (Calendar Days & Contracts up to 4M).....	47
Figure 13 Liquidated Damages charges per Contract size 2 (Calendar Days & Contracts up to 4M).....	48
Figure 14 Liquidated Damages charges per Contract size 3 (Calendar Days & Contracts up to 4M).....	49
Figure 15 Liquidated Damages charges per Contract size (Working Days) .....	50
Figure 16 Liquidated Damages charges per Contract size (Working Days & Contracts up to 4M).....	51
Figure 17 Sample of Clusters Analysis of tables based on Calendar Days .....	63

Figure 18 Box Plots of tables Based on Calendar Days .....	65
Figure 19 Sample box Plot of Cluster 7 .....	66
Figure 20 of Tables of 9 LDs Calendar Days Grouped Data.....	68
Figure 21 IMB SPSS Statistics Regression Analysis interface .....	69
Figure 22 All Contracts up to 10M Power Model with R-Squared .....	70
Figure 23 All Contracts up to 10M Inverse Model with R-Squared.....	70
Figure 24 Power Model All Contracts up to 5M .....	72
Figure 25 Power Model All contracts up to 10M .....	73
Figure 26 Power Model All contracts up to 20M .....	74
Figure 27 Power Model All contracts up to 50M .....	75
Figure 28 Power Model WD contracts .....	77

## LIST OF TABLES

Table 4-1 Non-conformance and consequences .....	22
Table 4-2 States with Payment Contingent on Schedule .....	27
Table 4-3 States with Scheduled Meetings .....	28
Table 4-4 States assessment of Liquidated Damages .....	39
Table 4-5 States With Other forms of Liquidated Damages.....	53
Table 4-6 States With Additional Liquidated Damages .....	56
Table 5-1 Example of a Box Plot (mimiss, 2016) .....	64
Table 5-2 Liquidated Damages Table with Extreme values in Red and Outliers in Blue .....	67
Table 5-3 Example of Table up to 50 Million R-Squared values based on Models .....	69
Table 5-4 R-Squared values of Grouped data based on CDs.....	71
Table 5-5 Working Days R-Squared values based on Models .....	76

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# 1 INTRODUCTION

A construction schedule is a fundamental part of project planning. A schedule outlines the timeline of events and tasks to be undertaken, the duration they will take, the teams responsible, and resources needed on a project. The goal of a schedule is to keep activities on track and prevent time and cost overruns.

Typical construction schedules include;

- The project deliverables
- Tasks required
- Dependencies between different tasks
- Deadlines and durations
- Budget and cost

Construction schedules are crucial for effective construction management. They help coordinate all tasks and personnel while tracking, informing, and reporting the project's progress.

The main construction scheduling methods utilized during construction include (Autodesk, 2022);

- i. Critical Path Method (CPM)
- ii. Line of Balance (LOB)
- iii. The Program Evaluation and Review Technique (PERT)
- iv. Q Scheduling.
- v. Resource-Oriented Scheduling.

- vi. Last Planner System® (LPS)
- vii. Gantt Chart.

Despite the varying scheduling approaches, the goals remain the same: To provide a timetable outlining the flow of events that allows managers to allocate labor, equipment, and materials appropriately, leading to effective resource management.

Non-conformance to construction schedules is when scheduled activities fall behind the Schedule, resulting in delays. Non-conformance may be unintentional or intentional.

To standardize Construction Schedules, the Department of Transportation (DOTs) throughout the U.S. established standard specifications. These Standard Specifications outline how each State handles Construction Schedules, the level of detail required, and the consequence of non-conformance to set schedules. A review of the different DOT's Standard Specifications reveals a significant degree of inconsistency in how each State handles the submission of construction schedules (whether required or not) and the results of non-conformance to the outlined schedules.

States such as Arkansas and Maine do not impose any schedule requirements on General Contractors within their jurisdictions (ARDOT,2014) (MEDOT, 2020), while states like California outline the Schedule for submission on a Construction Schedule, the format the Schedule should use, and even the level of detail based on the contract size (CADOT,2018). Unintentional non-conformance is generally dealt with through Extension of Time (EoT) clauses within the Standard Specification of most states, however, states like Delaware make no mention of such a clause (DeIDOT, 2016). Intentional non-conformance produces different outcomes depending on the State. Some states, such as Hawaii and Georgia, require their contractors to update their schedules monthly, reflecting the work they have already

undertaken, and linking the Payment of work packages to the submission of updated schedules (HIDOT, 2008) (GADOT, 2013). Others, such as Kentucky, impose a liquidated damages rate on failure to update Construction Schedules (KYDOT, 2008).

Intentional non-conformance triggers liquidated damage for the failure to complete a project within the stated timeframe, or failure to complete certain work packages by a specified date (HIDOT, 2008).

As the work begins to review various DOTs Standard Specification, certain key research questions begin to form;

- 1) What are the schedule requirements for each State?
- 2) How are these requirements enforced? Are there penalties for non-conformance?
- 3) Are these requirements applied in every State (frequency distribution)?
- 4) Does the state charge liquidated damages? What triggers these liquidated damages (specific non-conformances or just delays beyond project completion)?
- 5) How do the different liquidated damages from all the states compare? Is there an observable trend on how liquidated damages are applied, and can it be modeled into one table (Regression analysis)?

This research work examines these schedule practices implemented by all the state DOTs by performing a detailed review of the various forms of schedule non-conformance, consequences, and Liquidated Damages outlined in all the 51 Department of Transportation Standard Specifications. These documents were obtained from the different State DOT's websites or various online resources these governing bodies provide. These documents were reviewed and yielded both Qualitative (qualities or characteristics) and Quantitative (frequency distribution) data. The data is outlined and also analyzed in tables and charts.

Descriptive and regression analyses of the states' liquidated damages are undertaken to show the various data points, and the ranges of liquidated damages, and to uncover an LD model that captures how states charge LDs.

The next chapter will explore the existing literature on construction schedules and Liquidated damages. Chapter 3 will outline the research methods. Chapter 4 will go through the results of the Content review and Analysis. The liquidated damages model will be covered in chapter 5, and the conclusion and recommendations will follow.

## 2 LITERATURE REVIEW

The area to be reviewed next is the current literature on standard specifications, forms of non-conformance such as delays, and liquidated damages as a consequence of non-conformance.

These topics are the more covered subject matter in the literature and provide more knowledge on the causal effect of non-conformance to construction schedules.

### 2.1 Construction Schedules

A construction schedule is a plan outlining the order and timing of the activities of construction relating to the Project (Abdalla, 2015). In the construction industry, sizeable projects typically take 20 percent longer than scheduled to be completed (Agarwal, Chandrasekaran, & Sridhar, 2016). When schedules are included in specifications, they may also stipulate a course of action or penalties accrued if the progress of works falls short of the defined schedule milestones, i.e., monetary consequences such as liquidated damages, withheld payments, etc. These can be defined as delay damages. The purpose of these delay damages provisions is to return the owner to the same situation they would have been in had the contractor's delay not occurred (Assaad & Abdul-Malak, 2020). On the other hand, a penalty clause is intended to press the contractor to improve their performance through a financial obligation levied due to a contractual default (Assaad & Abdul-Malak, 2020).

### 2.2 Schedule Delays

From the outlined definition of a construction schedule, a clear example of a form of non-conformance is construction delays. A construction delay occurs when a planned activity cannot be completed on time.

A study by Janet K. Yates and Hala Elnagar concluded that project schedules are the main delay indicators leading to construction delays (Elnagar & Yates, 1997). Delays are caused by; Contractor delays, Owner intervention, Force Majeure or Act of God (adverse weather

conditions, Labor Problems, pandemics, etc.), or unforeseen site conditions (Assaad & Abdul-Malak, 2020).

When faced with a construction delay, the first course is to determine whether the day is critical or not. If the delay affects the project's completion date and/or important milestones on the project it's a critical delay (Scalisi, 2020). Once a critical delay is identified, it is categorized as either an excusable or non-excusable delay (Architects, 2022).

### **2.2.1 Excusable vs Non-Excusable Delays**

Both Excusable vs Non-Excusable Delays add to an extension of the contract completion date (Thomas, Smith, & Cummings, 1995).

Under the AIA form A201 "General Conditions" document, an excusable delay is described as follows:

"If a Contractor is behind schedule any time at start or development of the project by an action or failure of the Owner or representative, or an employee of either, or a separate contractor employed by the Owner; or by changes ordered in the Work; or by labor disputes, fire, unusual delay in deliveries, unavailable casualties or other causes beyond the Contractor's control; or by delay authorized by the Owner pending mediation and arbitration; or by other causes that the Architect determines may justify a delay, then the Contract Time shall be extended by Change Order for such reasonable time as the Architect may determine" (Architects, 2022).

A General Contractor typically causes Non-excusable delays. These tend to result in liquidated damages. Since General Contractors are in control of scheduling, subcontractors management, and the development of construction means and methods, inadequacies in any of these scopes are considered Non-excusable (Thomas, Smith, & Cummings, 1995).

When delays are attributable to both the owner and contractor they are known as Concurrent Delays (Thomas, Smith, & Cummings, 1995). In such a circumstance, the owner normally extends the completion date but no compensation is awarded to the General Contractor (Ibbs, Nguyen, & Simonian, 2011). When an owner however claims that the contractor is responsible for the delays, damages caused must be apportioned to both the owner and the General Contractor (Thomas, Smith, & Cummings, 1995).

If a delay affects a party, and that party has nothing to do with the cause of the delay, then they may be compensable for that day. This compensation can come in the form of either additional time, money, or both. These delays are known as Compensable delays (Scalisi, 2020).

### **2.3 Liquidated Damages**

Liquidated damages (L.D.s) clauses are standard in most construction projects. The Association for the Advancement of Cost Engineering International (AACE) defines these L.D.s as a sum of money specified in a Contract as the charge incurred by a contractor due to them failing to complete the work within the defined time(s) (AACE, 2022). They tend to be triggered when a contractor fails to meet a particular deadline for an item of work stipulated in the Contract or for project completion.

These damages are not paid as a penalty but are instead intended to indemnify the Owner for damages they incur due to work not being completed on time.

Delays are common in construction projects; however, for liquidated damages to be charged, the causes of the delay must be directly related to the General Contractor. These contractor-caused delays occur when the Contractor fails to honor contract deadlines and requirements in the stipulated manner due to their actions or situations. Delays can also be caused by; owner intervention, Force Majeure or Act of God (adverse weather conditions, Labor

Problems, pandemics, etc.), or unforeseen site conditions. These are past the General Contractor's control and are designated as excusable delays to which they are entitled to a time extension. Under the AIA form A201 "General Conditions" document, an excusable delay is described as follows:

"If the Contractor is delayed at any time in the commencement or progress of the Work by any act or neglect of the Owner or Architect, or of an employee of either, or a separate contractor employed by the Owner; or by changes ordered in the Work; or by labor disputes, fire, unusual delay in deliveries, unavailable casualties or other causes beyond the Contractor's control; or by delay authorized by the Owner pending mediation and arbitration; or by other causes that the Architect determines may justify a delay, then the Contract Time shall be extended by Change Order for such reasonable time as the Architect may determine" (Architects, 2022).

H. Randolph Thomas and Gary R. Smith wrote that the LDs clause generally limits the owner's recovery for delayed completion costs. They continued to state that this meant that actual delay damages are not recoverable. We can infer that liquidated damages are considered to be in lieu of actual damages (Thomas, Smith, & Cummings, 1995). The LDs clauses do not stop the owner from seeking compensation for damages resulting from negligence, poor workmanship, willful misconduct, termination, abandonment, or numerous other defaults by the contractor (Thomas, Smith, & Cummings, 1995).

Depending on the Contract, the Owner caused delays may also be compensable.

### **2.3.1 Types of liquidated damages**

Liquidated Damages are typically categorized as either traditional or reverse liquidated damages (McMillan, 2022). The distinction is made depending on the party being indemnified.

Traditional liquidated damages are paid to the Owner for every day (Calendar or Working) beyond the stipulated date; the work remains unfinished by the Contractor. This is the most common type and the focus of this discussion.

In contrast, the Owner pays to reverse liquidated damages to compensate for owner-caused delays to the Contractor. This clause is less common and may prove advantageous or disadvantageous to both parties. The advantage of these stipulated damages is that they may help avoid audits and disputes (McMillan, 2022). Inversely, owners may refuse this clause since it guarantees the Contractor a certain amount of money even if the actual damages are lower. Contractors may also oppose accepting them because the actual owner-caused damages may exceed the specified amount. California State uses the Reverse LD clause in public contracts (McMillan, 2022).

### **2.3.2 Legal history**

Liquidated damages are a common cause of disputes on construction projects. Though the last resort, litigation is a well-documented conflict resolution tool employed in such instances. Some literature is available on the legal framework around Liquidated damages. One such paper reviewed the development of L.D.s laws in several Commonwealth countries. The author's examination reviewed various cases and found hardly any differences among the different courts in each jurisdiction; each case had relied on common precedents (Twyford, 2007). One such case highlighted commonwealth law and stated that when a party does not fulfill their contractual duties, the indemnities (liquidated damages) are evaluated per two rules detailed in a well-known English contract law case, *Hadley v. Baxendale*. The first rule necessitates that the party suffering the damages be restored to the financial situation they would have been in had the Contract been satisfied. The second rule regards the valuation of

the damage. It states that the compensation paid should only be for those actions that could be realistically foreseen and occurred directly from the breach (Hadley & Anor v Baxendale & Ors, 1854) (Twyford, 2007).

More recently, a U.S. Court of Federal Claims sided with an Owner (the U.S. Coast Guard) when a contractor on a design-build project sought to render liquidated damages unenforceable (Michael C. Loulakis, 2011). This case enforced that in most cases, as long as the amount is sensible, courts will hold back from superseding the rate outlined in the Contract (Michael C. Loulakis, 2011).

### **2.3.3 Standard features**

Most standard specifications contain a Liquidated damages provision within them. These L.D.s typically have standard information in one or more of the following: “(1) Outlining a daily sum payable by a contractor due to their late Completion; (2) guaranteeing additional time compensating in lieu of excusable delays; (3) specifying the sums are not as a penalty; (4) defining the what the owner expenses represent; and (5) defining a schedule of L.D. rates as a based on the contract size.” (Crowley et al., 2008).

### **2.3.4 Implementation**

Liquidated damages are typically imposed every day a contractor fails to complete a contract on time. These days may be specified as working days (excluding weekends or holidays unless otherwise stipulated) or calendar days (every day, including weekends and holidays). The consensus is that L.D.s are generally put in to encourage compliance to time provisions stipulated. Crowley states that these damages are expressed as a monetary rate applied for every additional day required to complete the work after the actual substantial/final

completion date" (Crowley et al., 2008). The L.D.s compensate for added overheads related to overseeing, inspection, and engineering services required on the extra days. According to AACE, the assessment of L.D. Concludes at substantial Completion or when an owner occupies the project to their benefit" (AACE, 2022).

A review of each of the 51 states' L.D.s clauses introduces a degree of variance in how each State handles assessments. In terms of the actual calculation of this L.D.s cost, many states such as Florida assess L.D.s using a table referencing contract size to penalties per day, while other states such as Arkansas analyze L.D.s using a formula. Some states, such as Indiana, have a hybrid system, while Idaho does not outline an approach but instead leaves it at the discretion of the DOTs Engineer. Vague L.D. Clauses leave room for legal challenges to their enforcement. A paper looking into the State of practice for L.D.s surveyed 51 state DOTs, and of the 40 respondents, they found that six state agencies faced legal challenges on their provisions with mixed outcomes (Rogers, 2019).

The degree of discrepancy among these specifications necessitates further analysis to provide a framework for a universal standard specification.

## **3 RESEARCH METHODOLOGY**

### **3.1 Research Statement and Objectives**

A preliminary review of DOT standard specifications shows that there are differences among the states with regard to the consequences/impact if the contractor does not follow the contract requirements. The preliminary review also revealed that states have large differences when it comes to charging liquidated damages to contractors.

The research objectives are twofold:

1. Explore and identify non-conformity to construction schedules and the impact the states would have on the contractor for not complying with the construction schedule requirements.
2. Explore and identify how states define and manage their liquidated damages and identify if there is a statistical model that can explain the liquidated damages as charged by the states.

### **3.2 Research Data and Research methods**

To achieve the previously outlined research objectives, the research collected state documents that included, Standard specifications, construction manuals, and supplemental specifications.

The research methods included content analysis, descriptive analysis, and statistical regression analysis.

#### **3.2.1 Content Analysis**

The research data was obtained by conducting a detailed review of all the various schedule non-conformance, consequences, and Liquidated Damages outlined in all the Department of Transportation Standard Specifications, construction manuals, and supplemental provisions.

These documents were obtained from the different State DOT's websites or various online resources provided by these governing bodies. The data required is contained in the Prosecution and Progress chapter (section 1-08) of these standard specifications.

Prosecution and Progress details how the Contractor shall conduct their work. The chapter details Subcontracting, Prosecution of Work, Scheduling, Contract Time, Liquidated Damages, and Suspension and Termination of Contract.

The data obtained from this review yielded both Qualitative (qualities or characteristics) and Quantitative (e.g., liquidated damages rate schedules) data. The data was analyzed into tables and charts and a written narrative to explain the information.

### **3.2.2 Descriptive and Statistical Regression Analysis**

The Prosecution and Progress chapter, included in most state standard specifications, details how each State assesses liquidated damages. Most states determine these charges using a table of liquidated damages. A descriptive analysis of the states' liquidated damages was undertaken to show the statistical characteristics of LDs, such as minimum and maximum charges, and the range of liquidated damages. With states having different LD rate schedules, regression analysis was performed to uncover a model that would be used to explain how states assess or come up with the LD rates.

## 4 CONTENT REVIEW AND ANALYSIS

The content analysis of the DOT documents (Standard specifications, construction manuals, and supplemental specifications) revealed several areas that explain how non-conformances to schedule requirements were identified and managed by the states. These non-conformances were the result of a failure of contractors to meet certain conditions/requirements as outlined in the specifications.

These areas include the following list and are detailed below:

- Schedule submission
- Future bid submission clause
- Payment schedule
- Positive Non-conformance
- Liquidated Damages

General Requirements are contract conditions that when breached can be summed up as 'Failure to complete contract provisions' (ALDOT, 2018 ), and may lead to enforcement of Default/Suspension/Termination clauses. All non-conformances to schedule requirements are assessed as General Requirements. A summary of the findings is included in the Table below and discussed in the next sections.

Table 4-1 Non-conformance and consequences

<u>Non-conformance/Requirements</u>	<u>Consequence</u>	<u>States</u>
Schedule submission	General Requirement	47 states*
Updated Schedule Requirement	General Requirement	Forty (44) states
Updated Schedule Requirement	Withheld Progress Payments	Thirty-two (32) states
Payment schedule	General Requirement	Five (5) states
Unsatisfactory Progress	Barred from submitting future bids	Two (2) states, (Nebraska and Tennessee)
Early Completion	Allowed to Proceed	Twelve (12) states
Early Completion	Incentive Award	Four (4) states
Delays beyond project completion	Liquidated Damages	All
Non-Completion of Work-Parts	Liquidated Damages	Nine (9) states
Baseline Schedule and a baseline schedule narrative	Disincentive of one thousand dollars per week LDs	Utah DOT
Begin construction once a notice to proceed is given (in five (5) calendar days)	One hundred dollars (\$100) daily LDs	Indiana DOT

These requirements are discussed in more detail below.

#### **4.1 Schedule submission**

The opening requirement for this review was whether states require a schedule submission from general contractors. Of all the 51 documents reviewed, only four do not require schedule submissions (Arkansas, Mississippi, South Carolina, and South Dakota), which represents only 8% as shown in Figure 1. Arkansas outlines that the Engineer should issue a work order (AHTD, 2014), while Mississippi DOT states that they issue a contractor a

progress schedule established for determining contract time. The Contractor might submit their own proposed progress schedule for approval (MSDOT, 2017).

Given the cost associated with the preparation and updates to progress schedules, only seven (7) states (California, Delaware, Montana, North Dakota, Washington State, Wyoming, and Wisconsin) outline that their departments will pay the Contractor for the progress schedules.

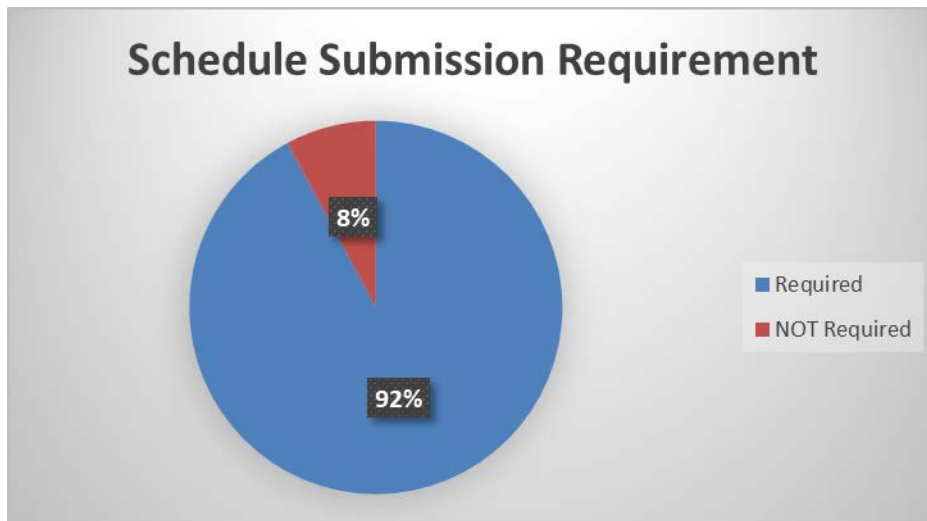
North Dakota addresses this by saying,

*" The Department will measure the CPM schedule as a complete unit, and the Department will pay as follows:*

*Pay Item Pay Unit Critical Path Method Schedule Lump Sum. The Department will pay the Contractor for the CPM schedule as follows:*

- 1. The Department will include 20 percent of the lump sum price in the progressive estimate following the Department's acceptance of the baseline schedule.*
- 2. The Department will pay the remaining 80 percent of the lump sum contract unit price in prorated amounts based on the following formula: Amount paid per update schedule submitted*
- 3. If the Contractor fails to submit an updated schedule on time, the Engineer will reduce the prorated amount for that update schedule, as shown in Table 108-01. Even if the Engineer reduces the prorated amount by 100 percent, the Contractor must submit the updated Schedule. = 80% x (Lump Sum contract unit price/number of update schedules anticipated during the life of the Contract)" (NDDOT, 2014).*

Figure 1 Schedule Submission Requirement



Addition requirements on the Schedule are further elaborated below.

#### **4.1.1 Required preconstruction**

This is where a contractor is obligated to hand in a progress schedule before the construction starts. Forty (40) states outline this requirement, with eleven (11) having no mention of this (Arkansas, Maryland, South Dakota, Mississippi, Connecticut, Montana, Oklahoma, South Carolina, Iowa, Utah, and Washington state). Utah swaps this preconstruction requirement and instead requires a baseline schedule pre-submittal meeting within fourteen calendar days of getting the Notice of Award (UTDOT, 2020). Maryland DOT requires a contractor to provide a "Progress Schedule" to the procurement officer presenting a suggested order of work and designating the necessary time for the completing o the work (MDOT, 2018).

#### **4.1.2 Different schedules**

Thirteen (13) of the 51 DOTs outline different types of schedules (California, Washington State, Oregon, Washington D.C., Wisconsin, Hawaii, Tennessee, Kentucky, New Jersey, Rhode Island, Texas, West Virginia, and Wyoming). These different schedules may be based on contract size; depending on the size of the Contract (less than one million and one hundred working days, less than one million over one hundred working days, 1M to 5M, or over 5M

(Caltrans, 2018)). They may also be based on the determination of the Engineer, as imposed by Kentucky; either a Written Narrative with an Activity Bar Chart or Critical Path Method schedule (KYTC, 2019)) or by duration (90 days, 90days to 24 Months, or over 24 Months (TNDOT, 2015).

#### **4.1.3 Format requirements**

Forty (40) states have specific formatting requirements for the schedules they require contractors to submit. Some like Alaska only require the Engineer to approve the format of the Schedule (AKDOT, 2020), while others, such as Arizona, outline the use of a CPM schedule, including interrelationships among the activities, projected workforce, unit quantities, equipment, and production rates (ADOT, 2008). Eleven (11) states do not have formatting requirements (Arkansas, South Carolina, Connecticut, Georgia, Vermont, Kansas, Maryland, Massachusetts, Pennsylvania, South Dakota, and Virginia).

#### **4.1.4 Computer software requirement**

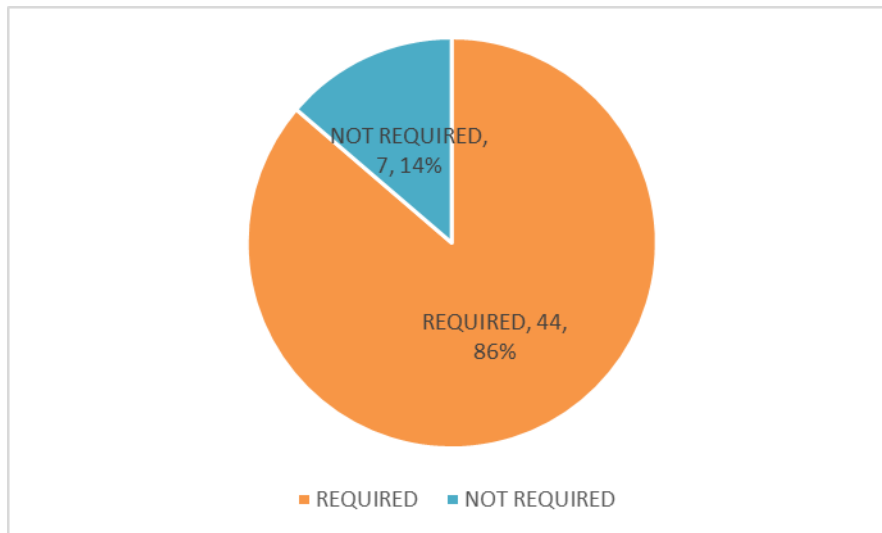
Fourteen (14) states require digitally developed schedules (Alabama, New Hampshire, California, New Mexico, Colorado, Washington D.C., Idaho, Minnesota, Montana, New Jersey, Rhode Island, Utah, Washington State, and West Virginia). Specific software for use may be outlined (CPM schedule developed on either Microsoft Project or Primavera (CODOT, 2019).

#### **4.1.5 Requirement of updated Schedule**

Forty-four (44) states require contractors to update their schedules. Only seven (7) states do not specifically outline this requirement in their specifications (Vermont, North Carolina, Oregon, Connecticut, South Carolina, Arkansas, and South Dakota). The updated Schedule may be based on a delay (The Contractor outlines that the progress is 14 calendar days behind the Schedule (ILDOT, 2016)). It may also be based on the requirement of the Engineer (if in

their opinion progress has been materially affected by changes to plans (INDOT, 2020) or at a given interval (every month where work is executed, a week before the end of the project's monthly estimate cycle (MDOT, 2018).

Figure 2 Requirement to Update Schedule



#### **4.1.5.1 Weekly Schedule Update**

Seven (7) states require weekly schedule updates (Arizona, Colorado, Delaware, Hawaii, Minnesota, Oregon, and Washington State).

#### **4.1.5.2 Final Project Schedule**

Five (5) states require the submission of a final project schedule on Completion of the Project (California, Washington D.C., Idaho, Texas, and Virginia). Virginia states that the Contractor should submit an As-built schedule, and the Engineer may withhold final Payment (VDOT, 2020).

#### **4.1.5.3 List of Changes to Schedule**

Two (2) states require a list of changes to an updated schedule. Idaho requires a written description narrating the project schedule, including the status, the critical path, and schedule revisions with the schedule update (ITD, 2018). Hawaii's document state that the Contractor should submit a report acceptable to the Engineer with every updated Schedule with a list of

changes to the progress schedule that occurred since the previous schedule submittal (HIDOT, 2020).

**4.1.5.4 Recovery Schedule**

Six (6) states (Nevada, Minnesota, Ohio, New Jersey, Pennsylvania, and Rhode Island) require a contractor to provide a Recovery Schedule outlining how they intend to make up for the delays to meet the project completion date. Rhode Island states that at a minimum, a Contractor should hand in a Recovery Schedule when the Project Schedule Update falls behind, by thirty (30) or more Days, any Milestone(s) designated in section 108.03 detailing the Milestones (RIDOT,2018).

**4.1.6 Payment Contingent on Schedule**

Thirty-two (32) states require that the contractors maintain and revise construction schedules, failure to which results in the state DOT withholding the contractor’s progress payment. These states are listed in the table below. For example, Louisiana DOT states that if the Engineer demands a revision of a Schedule, the Contractor should provide it within 14 days, or progress payments may be withheld (LaDOTD, 2016). This statement ties progress payments to schedule submission.

*Table 4-2 States with Payment Contingent on Schedule*

Alabama	Indiana	Montana	Pennsylvania
California	Iowa	Nebraska	Rhode Island
Hawaii	Kentucky	New Hampshire	Tennessee
Florida	Louisiana	New York	Virginia
Maryland	Georgia	North Dakota	Washington State
Colorado	Michigan	Ohio	West Virginia
Oklahoma	Minnesota	Idaho	Wyoming
Illinois	Mississippi	Oregon	Missouri

#### 4.1.7 Scheduled Meetings

Twenty-four (24) states outline that the Contractor and the Engineer should have scheduled meetings to assess work progress and review the Schedule. These states are listed in the table below. The failure of the contractor to schedule or attend these meetings presents a non-conformance to the DOT contracts. New Hampshire states under 'A.3.2 Project Schedule Updates' that the Contractor should conduct job site meetings with the Engineer to corroborate the Schedule's accuracy. It also states that these meetings should be held monthly or as required by the project's complexity." (NHDOT, 2016).

*Table 4-3 States with Scheduled Meetings*

Montana	Idaho	Colorado	Hawaii	California	Wisconsin
Kentucky	Kansas	Rhode Island	New Hampshire	Missouri	Arizona
Minnesota	New Jersey	West Virginia	Ohio	Utah	North Carolina
Pennsylvania	Oregon	Maine	North Dakota	Oklahoma	Indiana

#### 4.2 States with Future bid submission clause

Two states, Nebraska and Tennessee, have clauses that outline that unsatisfactory progress may lead to the contractors being barred from submitting future bids. Nebraska states that if a Contractor does not implement reasonable provisions to correct their Schedule and execution in seven days, their ability to submit future bids in future might be withheld pending the Contractor's Schedule, and execution showing the Contract will conclude in a time frame suitable for the Department." (NEDOT, 2017). Tennessee similarly outlines that if a Contractor fails to validate the unsatisfactory progress, the Department might remove the Contractor from the list of qualified bidders per section 102.01. It also adds that along with the Contractor, all affiliated/subsidiary companies, companies where the Contractor holds a substantial interest, and companies where the company officers or stockholders hold a

substantial interest will be removed from the list of qualified bidders. Finally, it states that the Department will offer timely written notification (TNDOT, 2015).

### **4.3 Payment Schedule**

Five (5) states (California, Colorado, Delaware, Washington D.C., and Maine) require that a contractor submit a payment schedule with estimates of all the payments they will require throughout the project. Delaware has this spelled out,

*"Monthly Payment Chart. Unless otherwise noted on the Plans submitted to the Engineer, as part of the PSC or CPM Schedule submittal, an estimate of the monthly payments expected to receive the Contract. This estimate will be referenced as the "Monthly Payment Chart". The Monthly Payment Chart can be generated by hand or by a word processor or spreadsheet. Include, as a minimum, columns showing estimated monthly payments for the duration of the Contract Time. The total of all estimated monthly payments must equal the Awarded Contract's total Bid Price. The Engineer may request an updated "Monthly Payment Chart" depending on the accuracy of the initial estimates and according to the overall needs of the Department. The Monthly Payment Chart is not binding on either the Department or the Contractor. The chart's purpose is to help the Department plan its budget so that Contractors can be paid each month as quickly as is practicable." (DelDOT, 2016).*

### **4.4 Positive Instances of Non-conformance**

Early completion could be considered as non-conforming with the schedule requirements, however, it could be considered to have a positive consequence if the Owners can accommodate that. States have addressed this by either inserting an Expediting Work and/or Completing Work Early-Incentive Award.

#### 4.4.1 Expediting Work (Early Completion)

Twelve (12) states (Hawaii, Massachusetts, Iowa, Maine, Nevada, Minnesota, Nebraska, Kansas, Utah, Washington State, Oklahoma, and Virginia) have clauses that explore early Completion. Most of these states allow contractors to submit schedules with early Completion but do not guarantee acceptance or additional allocation of department resources for contract administration. Nebraska, as an example, states that Department can assent to a schedule outlining an early completion date. However, it cannot pledge that it will provide its resources to meet the Contractor's fast-tracked Schedule. They also state that no supplementary payment shall be disbursed if the Contractor cannot meet their fast-tracked Schedule owing to the absence of Departmental resources. (NEDOT, 2017).

Maine goes into more detail by outlining,

*"Section 109.5.3 ( the title is on Early Completion Date and Delay Claims)*

*"Contractor's Early Completion Date" means a Project Completion date shown on the Contractor's initial Schedule of Work submitted under Section 107.4.2 -Schedule of Work Required that is earlier than the Contract's specified Completion date. The Department will not be liable for any claims or expenses related to the period between the Contractor's Early Completion Date and the Contract's specified Completion date unless the Contractor demonstrates, by clear and convincing evidence, that: (A) all requirements of Section 109.5.2(B) - Requirements for Entitlement are met, and (B) that the Contractor's Early Completion Date was reasonable at the time of Bid in light of the surrounding facts and circumstances, including the Contractor's available resources, and the requirements of the work."*

(MaineDOT, 2020).

Iowa State goes further and details conditions where the Department requires an accelerated schedule and how it would go about the same;

*"K. Accelerated Work Schedule.*

*1. A note may require an accelerated work schedule on the proposal. When required, the Contractor shall marshal the necessary forces, including but not limited to, extra crews, subcontractors, extra work hours, or other acceptable methods to ensure Completion of the Project, or various stages of the project, within the contract period and in compliance with the specifications.*

*2. A work plan shall be submitted to the Engineer for review before the commencement of work. Work will be permitted on 24-hour days basis and Sundays and holidays, though work may be restricted as identified in the contract documents. Credit will not be allowed for delayed or slow delivery of materials." (IowaDOT, 2020).*

Massachusetts outlines the remuneration it provides to contractors based on Engineer directed accelerations;

*"The contract work shall be expedited when the Engineer determines that the safety and/or the convenience of the public necessitates an earlier completion date for the performance of the work contained in the Contract.*

*Compensation for expediting the work shall be based on the actual added cost of direct labor as applied to the overtime labor cost only. The Contractor shall accept as full compensation for the actual added cost of expediting the contract work the following:*

*(a) The added overtime premium portion of the direct labor costs (the premium labor cost less [minus] the regular time labor cost);*

*(b) Plus the actual cost for payroll taxes associated with (a) above.*

*(c) Plus an overhead additive of 10% of the total of (a) and (b) above for related overhead.*

*(d) Plus any proportionate added cost for the surety bond." (massDOT, 2020).*

Utah stands from other states as it sets out conditions where a contractor can be compensated for an accelerated schedule. In section '1.13' early completion schedule, additional compensation for delays due to actions attributed to the Department may be due if the baseline schedule and baseline narrative show that the work was planned to be completed early. It refers the reader to Section' 00777' for additional information (UTDOT, 2020).

West Virginia is unique because it instructs contractors that early Completion should be used to define float time in the project. They state that should the Contractor's Schedule show an earlier date than the original date that the project was to be concluded as outlined by the Contract; this Schedule should delineate all positive float developed between the early date of completion and the original Contract date of Completion as part of the overall project float. They also state that it is known by the Contractor and the Department that positive float is shared by all parties and not for the select usage or advantage of a particular party. Either party has the full use of the positive float until it is depleted. (WVDOT, 2020).

#### **4.4.2 Completing Work Early-Incentive Award**

The incentive for an early completion clause is a contract provision intended to reward a contractor with an assured sum of funds for every day documented that critical scopes of work are finalized in advance of the Project Schedule (USDOT, 2022). Its use is mainly utilized in critical infrastructure jobs where any traffic problem or interruptions should be minimized. The sums awarded are centered on evaluations of scopes such as traffic maintenance, user safety, and road user delay costs (USDOT, 2022).

Four (4) states (Iowa, Kansas, Maine, and Oklahoma) mention early completion incentives in their specifications. Iowa state DOT outlines that the proposal form from the Department

could stipulate a completion bonus. However, a speeded-up work schedule is permitted for work essential to receive the bonus (IowaDOT, 2020).

Kansas is more detailed about early completion incentives as follows:

*"108.7 COMPLETING WORK EARLY-INCENTIVE AWARD*

*a. The Secretary may offer the Contractor an incentive award for completing some or all of the work before the specified hourly periods, working days, calendar days, or calendar completion date expires (incentive award).*

*b. Seek no additional money for completing a Project before the Contract Time unless the parties have agreed, in writing, to an incentive award under this subsection 108.7. Seek no additional money for completing parts of a Project before interim Contract Times unless the parties have agreed, in writing, to an incentive award under this subsection 108.7.*

*c. The Contractor may request the Secretary to add an incentive award to a contract. It is in the Secretary's sole discretion to include or add an incentive award to a contract.*

*d. The Secretary will pay the incentive award only if the Contractor completes the work early, according to the Contract Documents." (KDOT, 2018).*

Maine discusses both incentives and disincentives (I/D). Disincentives are defined as the amount withdrawn for every day a Contractor exceeds the incentives/Disincentives time (USDOT, 2022). This clause states that 'Completion Incentives/Disincentives' if outlined in a Contract, monetarily entices early Completion while simultaneously deters late Completion, which is summed to or withheld from monies payable to a Contractor. Incentives/Disincentives are distinct and separate from the L.D. clause and Supplemental L.D. clause (MaineDOT, 2020).

All 4 states are similar in that they require that Early Completion and associated Incentive Award be outlined in the contract. The difference lies in whether they are implemented by the State or negotiated by the Contractor.

## **4.5 Liquidated Damages**

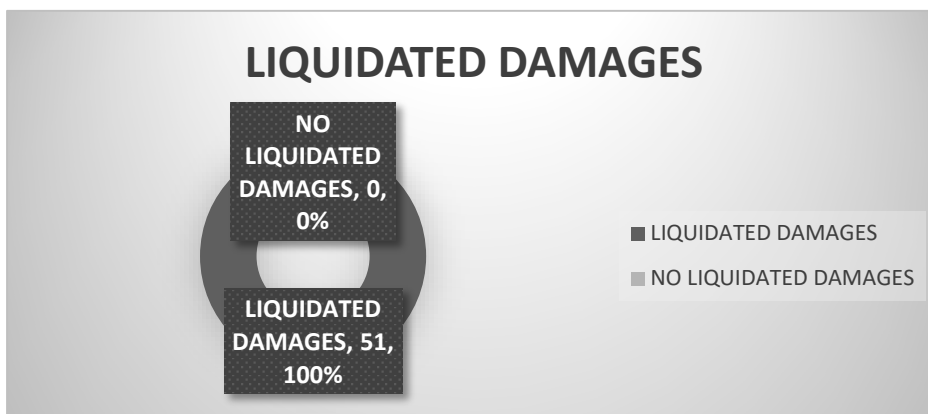
Liquidated Damages, as earlier discussed, are a sum of money specified in a Contract as the charge incurred by a contractor due to them failing to complete the work within the defined time(s) (AACE, 2022). LDs are one of the methods used by state DOTs to address nonconformity by a contractor, specifically non-conformity to the contract requirements detailing project timeliness and completion. They are intended to compensate the Departments for damages they incur due to work not being completed on time and not as a penalty. Colorado DOT Standard Specifications explain LDs by defining the non-conformity and the remedy, “Failure to Complete Work on Time. A daily charge will be made against the Contractor for each calendar day, including free time, that any work remains uncompleted after the elapse of contract time. This daily charge will be deducted from any money due to the Contractor.” (CODOT, 2019). The Document further specifies that it is not a penalty, “This deduction will not be considered a penalty but as liquidated damages. The schedule of liquidated damages set forth below is an amount, agreed to by the Contractor and the Department, as reasonably representing additional construction engineering costs incurred by the Department if the Contractor fails to complete performance within the contract time.” (CODOT, 2019).

### **4.5.1 Analysis of State Liquidated damages**

#### ***4.5.1.1 Current Liquidated Damages Clauses***

All 51 DOTs Standard Specifications include a liquidated damages (LD) clause. The specification documents published by the various DOTs define liquidated damages and outline the situations that can trigger them. Illinois DOT for example writes, “Time is of the

essence to the contract. Should the Contractor fail to complete the work within the working days stipulated in the contract or on or before the completion date stipulated in the contract or within such extended time, as may have been allowed, the Contractor shall be liable and shall pay to the Department the amount shown in the following schedule of deductions, not as a penalty but as liquidated damages, for each day of overrun in the contract time or such extended time as may have been allowed.” (ILDOT, 2016)



*Figure 3 states with liquidated damages clauses*

Fifty-one documents were compared, and specific references were made to assess the level of detail covered in the clauses. Each reference will be discussed in the following sub-headings.

## **4.5.2 Assessment of Liquidated damages**

### ***4.5.2.1 Reference Date for LDs***

Liquidated damages start to accrue when the original Contract Time expires and continue up until the project reaches the actual completion. Based on the analysis of states, the Contract Time at which the DOT begins to charge LDs may be either; at the Final Contract time (35), at the point of Substantial Completion (9), or a combination of both (7). At final completion time was the most common point among all the states. However, some states elected to use the substantial Completion as the reference line, and a small number of states can use both reference lines.

In addition to these LDs charged, some states using substantial Completion as the reference date charge separate LDs after the substantial Completion until contract completion. For example, MA changes ½ of the regular LDs after substantial Completion.

The states (7 states) that utilize both reference points are Alaska, South Dakota, Massachusetts, Michigan, North Dakota, Washington State, and Wyoming. The states that reference substantial Completion (9 states) are Arizona, Washington D.C., Hawaii, Idaho, New Hampshire, South Carolina, Utah, Vermont, and West Virginia.

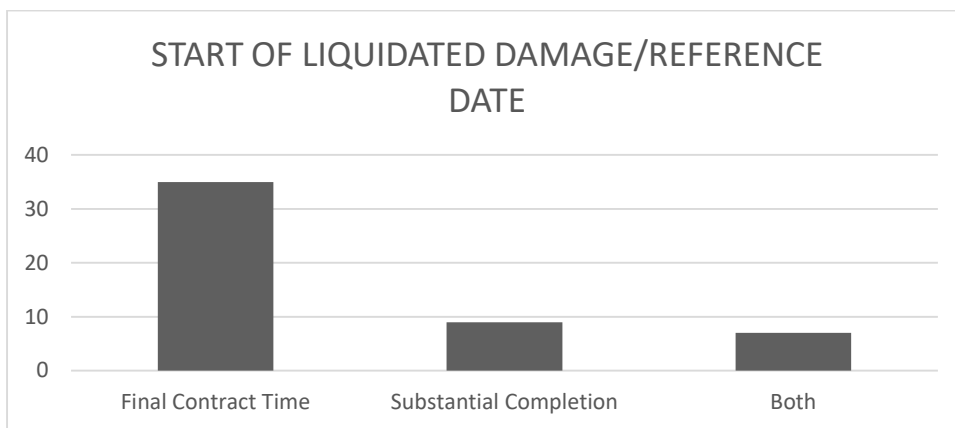


Figure 4 Start of liquidated Damages

#### 4.5.2.2 Reference Days for LDs

The analysis of states' standard specifications further shows that liquidated damages are charged based on one of three parameters. These parameters are either calendar days (CD) (24), working days (WD) (7), or a combination of both (19). Calendar days as the basis for charging liquidated damages are the most common and are used by 24 states (48%). These states are Florida, California, South Carolina, Colorado, Minnesota, Washington D.C., Massachusetts, Virginia, Kentucky, Iowa, Maine, Michigan, Indiana, North Carolina, Louisiana, Ohio, Connecticut, Oklahoma, New York, Oregon, Tennessee, and West Virginia. Working days were utilized by seven states (14%), including Hawaii, Nevada, New Jersey, Texas, Vermont, Washington State, and Wyoming. The other 19 (38%) states allowed the use of both calendar days and working days as the basis for LD. As will be explained later, some

of the 19 states that used both reference days provided different LD charges; the rate based on CD would be different from the rate based on WD.

The liquidated damages are assessed as a daily rate charged based on calendar days (24) or working days (7) or a combination of both (19). This indicates a shift from the contract time observed in a previous paper published that noted that 38 (72%) of their responding agencies use calendar days while 15 (28%) use calendar days of the 53 agencies. Nine (9) agencies also specified that another form of contract time is utilized in distinct specific project conditions (Crowley et al., 2008). The outcome of this is having a contract based on a specific reference day (calendar or working) does not necessarily get the LDs to use the same reference day.

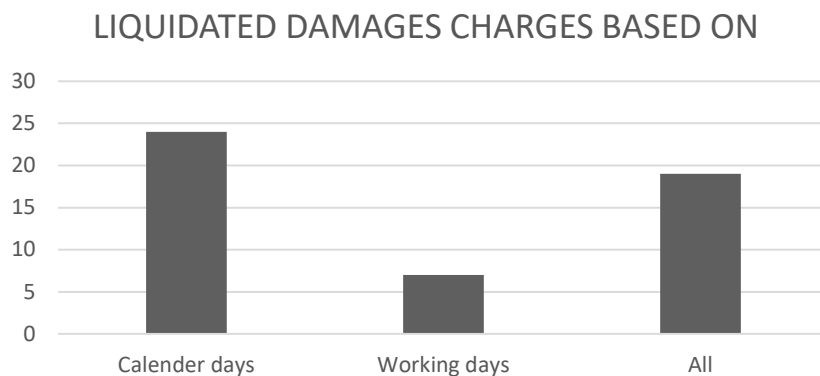


Figure 5 Liquidated Damages based on Calendar/working days

#### 4.5.2.3 LDs based on CD and based on WD

The analysis revealed that the LDs are charged differently based on whether they use Calendar or working days. The trend reveals that LDs based on WD tend to be higher than those based on CD. For example, the State of Wisconsin, for the average contract size of \$125,000, charges \$1850 for WD compared to \$925 for CD. On the other hand, some states like New Hampshire and Utah did not differentiate between the rates.

### **4.5.3 Value determination of LDs**

As explained below, most states have a table of dollar values for LDs based on contract sizes. However, most state standard specifications do not provide how the dollar values are obtained. West Virginia DOT division of Highways, Vermont Agency of Transportation, New Hampshire DOT, Missouri DOT, Etc., mentioned that these LDs were based on elements such as administrative costs (engineering, inspection, and supervision) of the DOT for managing the Contract after the substantial Completion, road user cost, inconvenience to the public, obstruction of traffic, and interference with business

Missouri is an example of a state that mentions administrative fees and user costs in section 108.8.1.1. They state that the L.D.s presented in the Contract should be itemized distinctly as project road user costs and/or contract administrative costs. It also states that when a grouping of projects is conferred as a sole contract, it will be assessed as a single unit to determine and estimate the administrative L.D.s. The road user costs are to be specified individually for each of the projects in the Contract (MODOT, 2011).

### **4.5.4 LDs, Not Penalties**

The review also reveals that most states mention that the daily charge is Liquidated Damages, not a penalty. Minnesota DOT states that because of the difficulty of determining the actual damages sustained, the Department will assess a daily charge to compensate for the additional costs incurred, not charged as a penalty but instead as L.D.s (MnDOT, 2018).

### **4.5.5 Calculation of LDs**

The analysis of the standard specifications reveals that LDs are imposed based on specific parameters. First, on the reference milestone (substantial Completion vs final Completion) and the reference day (Calendar Days Vs Working Days). Second, the rate charged as

Liquidated Damages is specified based on; a table of predefined dollar L.D.s or through a formula that considers the contract size, number of days necessary to finish the project, or a percentage charge (e.g. 6% to 20%), and finally others that specify a dollar sum per day. In summary, they include either of the following ways (single or combined):

- a) Table of Liquidated Damages
- b) Formula of Liquidated Damages
- c) Other forms of Liquidated Damages

	Number of States	Example of states
LDs Table	35	Alabama, Wyoming, New York, Arizona, Colorado, Washington D.C., Georgia, Vermont, Illinois, Oklahoma, Kansas, Tennessee, Kentucky, South Carolina, New Mexico, Louisiana, Montana, Massachusetts, New Hampshire, Minnesota, North Dakota, Michigan, Mississippi, Ohio, Pennsylvania, Utah, Indiana, Virginia, Florida, West Virginia, Delaware, Wisconsin, California, Wyoming, South Dakota, Alaska, Rhode Island
LDs Formula	3	Indiana, Nebraska, Oregon
LDs Other Form	12	Arkansas, Maryland, Connecticut, Hawaii, Idaho, Nevada, Missouri, New Jersey, Iowa, North Carolina, Texas, Washington State
Combination of the above two or more methods	6	Indiana, Massachusetts, Utah, Alaska, California, Pennsylvania

*Table 4-4 States assessment of Liquidated Damages*

#### 4.5.5.1 Table of Liquidated Damages

A total of 35 states assess L.D.s using tables.

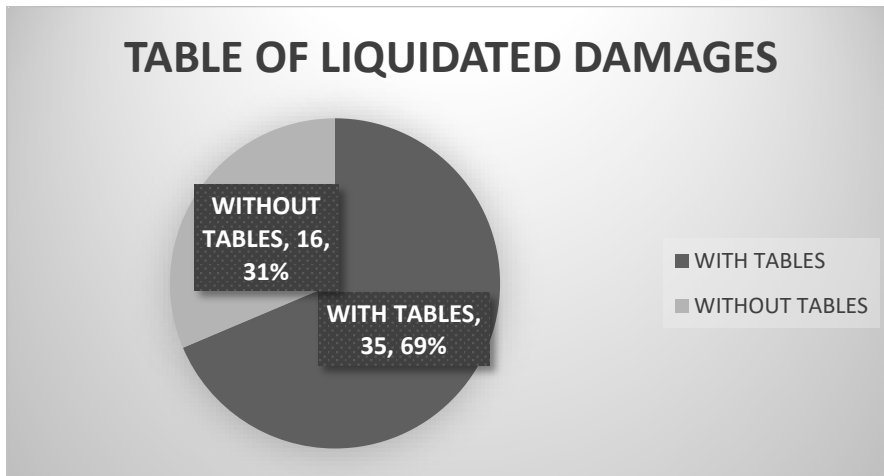


Figure 6 Table of Liquidated Damages

These tables assign a monetary rate of damages based on contract size.

Schedule of Deductions for Each Day of Overrun in Contract Time			
Original Contract Amount		Daily Charges	
From More Than	To and Including	Calendar Day	Work Day
\$ 0	\$ 100,000	\$ 475	\$ 675
100,000	500,000	750	1,050
500,000	1,000,000	1,025	1,425
1,000,000	3,000,000	1,275	1,725
3,000,000	6,000,000	1,425	2,000
6,000,000	12,000,000	2,300	3,450
12,000,000	And over	6,775	9,525

Figure 7 Liquidated Damages table 2016 ILDOT Std Specs

Given the difference in the assessment of liquidated damages, either based on calendar days or working days, data was analyzed based on those distinctions. Tables from this data refer to dollars charged per contract size. California and South Dakota DOT include two tables that define liquidated damages before substantial Completion and final acceptance.

#### **4.5.5.1.1 Analysis of Liquidated Damages**

A review of liquidated damages reveals that the rate charged for Working days is higher than the rate charged for calendar days for similar contract sizes. When determining how to plot the given tables, it was observed that these liquidated damages are charged depending on the contract size.

To be able to compare the LD rates of various states, it becomes important that the LD rate per contract size would need to be normalized. To this end, the research followed certain steps to normalize the rates:

- 1) For each state, the midpoint of each range of a contract size in a given LD table was determined to be a representative point of that range.
- 2) The LD rate associated with the relevant contract size range was then divided by the midpoint of the range, then the result was multiplied by 100 to make the result in terms of cents.
- 3) This converted each LD table into several contract size midpoints and relevant normalized LD rates, which were named 'cents per contract dollar'.
- 4) The LDs of each state were then charted in terms of the LDs (cents per contract dollar) against the contract size (mid points of ranges). This provided a curve for each state, making it possible to compare how they charge LDs for non-completion against each other.

Charts for states with LDs charged based on calendar days (CD) were developed separately from those based on working days (WD).

On average, when plotted in terms of cents per contract dollar vs contract size, all the liquidated damages tables follow a declining exponential rate. While the exact points plotted

on tables may vary, the trend seems similar. A separate table with the contract size limited to 4 million US dollars was plotted to observe the noted trend revealing a similar pattern.

The next two sections illustrate the LDs in a chart format that shows the declining exponential rates.

The charts include;

- a) Figure 8 LDs based on CD up to 10m
- b) Figure 9 LDs based on CD up to 20m
- c) Figure 10 LDs based on CD up to 50m

These represent the upper limit contract sizes of the state LDs tables reviewed. Grouping the tables allowed for clearer comparison by reducing the data being compared against each other. California was charted separately (Figure 11) since its upper contract size is 175M, far larger than all other states. While observing the data, it was noted that the declining exponential trend was more pronounced at the front end of the graphs, hence the data was charted up to 4M to display these observations. Finally, LDs based on WD is similarly charted.

#### 4.5.5.1.1.1 Charts based on calendar days

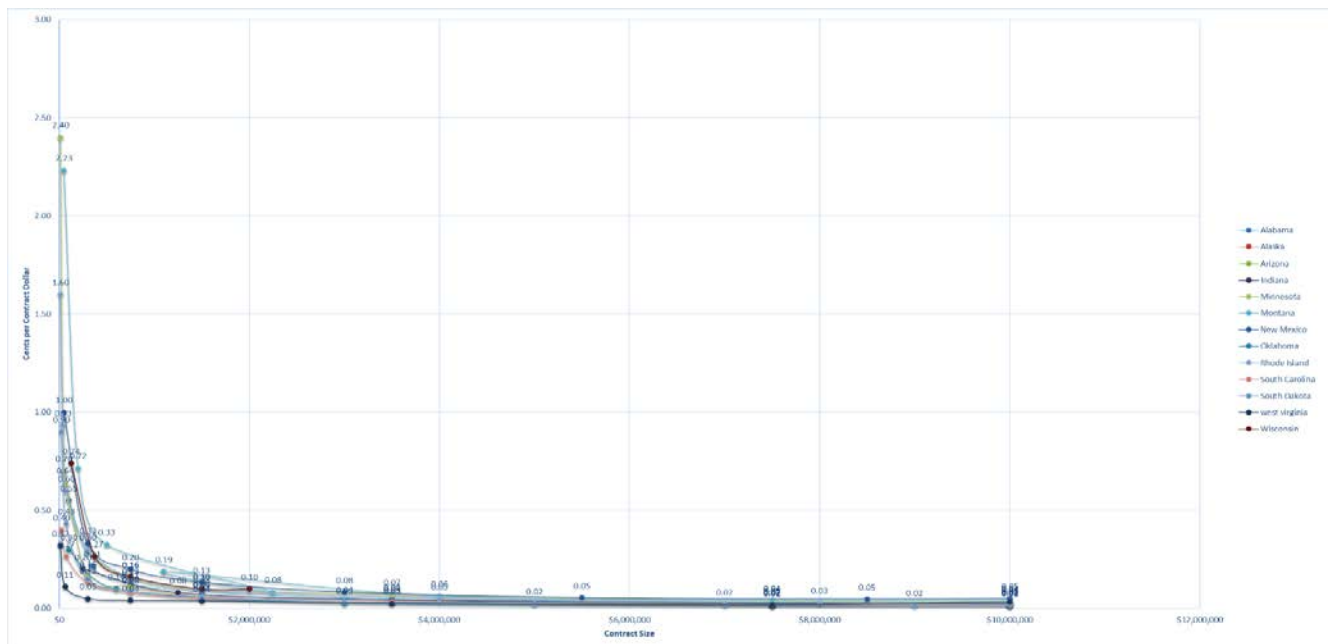


Figure 8 Liquidated Damages charges per Contract size (Calendar Days & Contracts up to 10M)

The chart above, Figure 8, denotes L.D.s data from states that have an upper limit contract value of up to 10M. This represented a total of 13 states. These states were Alabama (10M), Alaska (10M), Arizona (10M), Indiana (10M), Minnesota (10M), Montana (10M), New Mexico (10M), Oklahoma (10M), Rhode Island (8M), South Carolina (10M), South Dakota (9M), West Virginia (10M), and Wisconsin (2M). These charts followed a declining exponential rate as earlier noted. Most of the 13 states have a high L.D.s rate ranging between 8M to 10M, however, Wisconsin has the lowest contract size of 2M. It was noted that most of these states have an average rate of 0.19 to 0.08 for contract sizes between 1 and 3 million. Most of these states also have a steady low rate in the range of 0.05 or less for contract sizes above 4M to 10M.

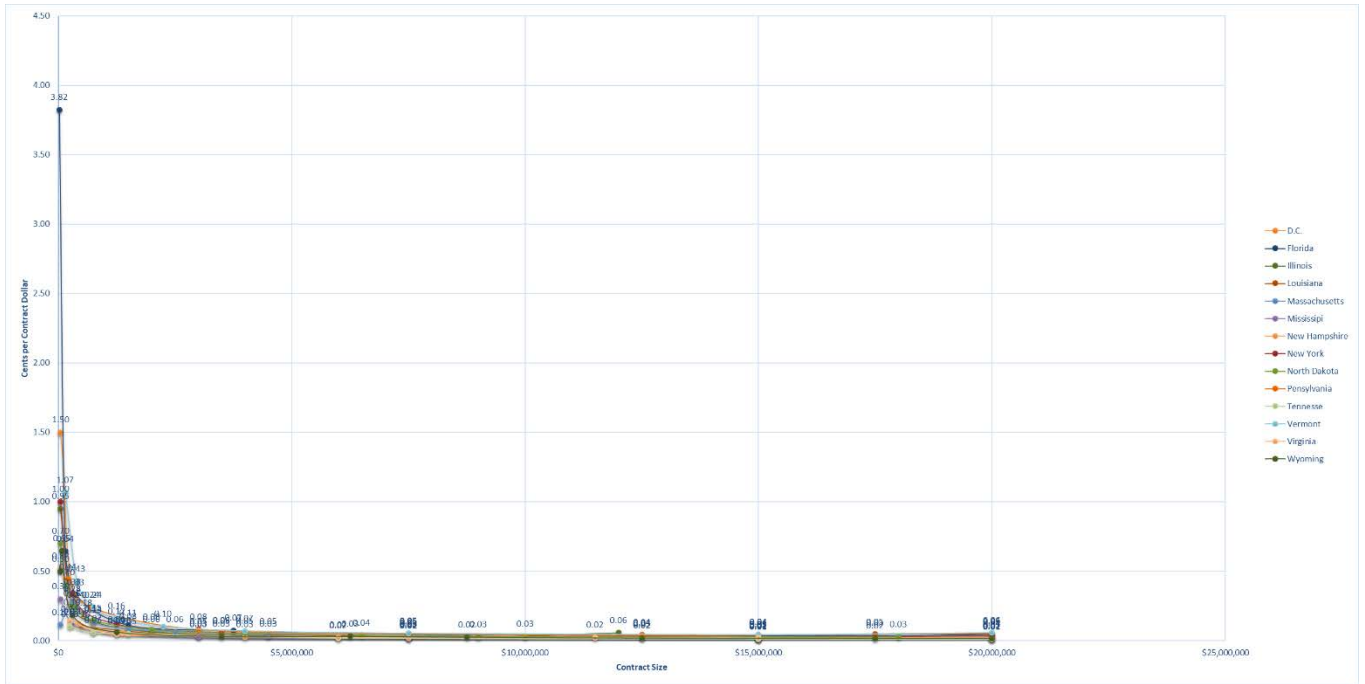


Figure 9 Liquidated Damages charges per Contract size (Calendar Days & Contracts up to 20M)

The chart above, Figure 9, denotes data from states that have an upper limit contract value of above 10M up to 20M. This represented a total of 14 states. These states were Washington D.C. (20M), Florida (20M), Illinois (12M), Louisiana (20M), Massachusetts (15M), Mississippi (10M), New Hampshire (20M), New York (20M), Pennsylvania (15M), Tennessee (20M), North Dakota (18M), Vermont (20M), Virginia (15), and Wyoming (20M). These charts followed a declining exponential rate as earlier noted. Most of the 14 states have an L.D.s rate ranging between 15M to 20M, however, Illinois has the lowest contract size of 12M. It was noted that most of these states have an average rate of 0.16 to 0.04 for contract sizes between 2 and 4 million. Most of these states also have a steady low rate in the range of 0.04 or less for contract sizes above 15M to 20M.

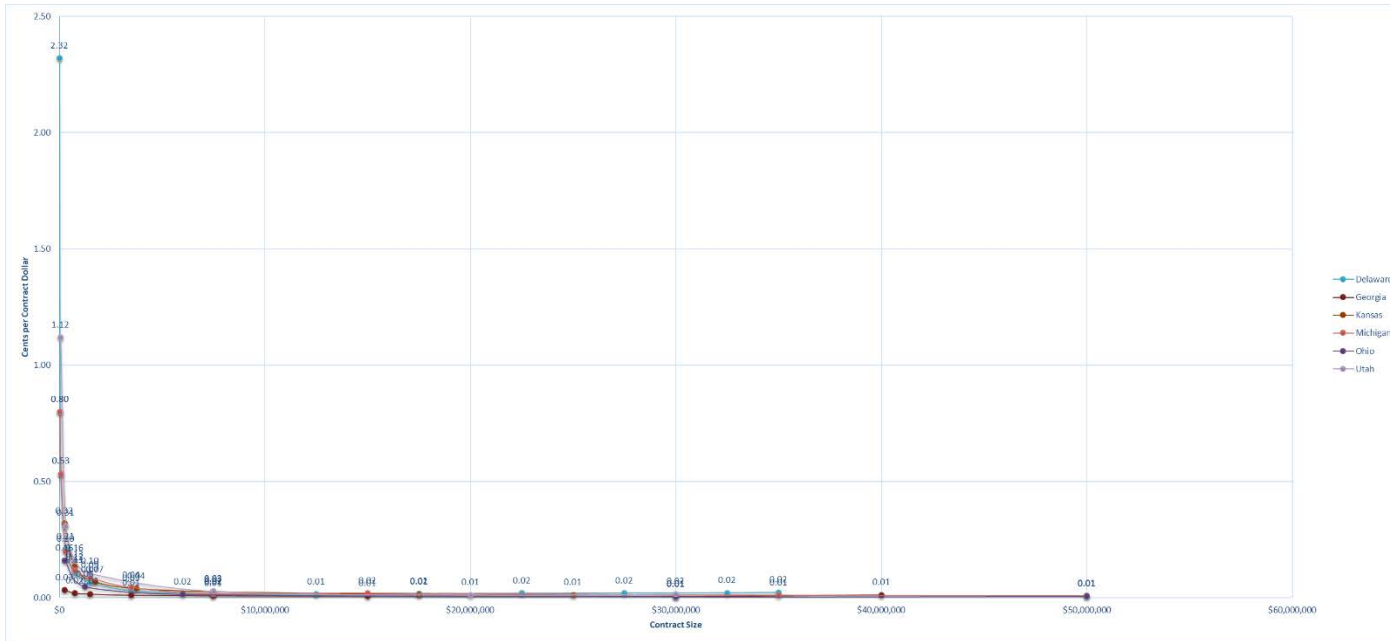


Figure 10 Liquidated Damages charges per Contract size (Calendar Days & Contracts up to 50M)

The chart above represents data from states that have an upper limit contract value of above 20M up to 50M. This represented a total of 6 states. These states were Delaware (35M), Georgia (40M), Kansas (25M), Michigan (50M), Ohio (50M), and Utah (30M). These charts followed a declining exponential rate as earlier noted. Five of these states have an L.D.s rate ranging between 30M to 50M, however, Kansas has the lowest contract size of 25M. It was noted that most of these states have an average rate of 0.10 to 0.02 for contract sizes between 2 and 8 million. Most of these states also have a steady low rate in the range of 0.02 or less for contract sizes above 20M to 50M.

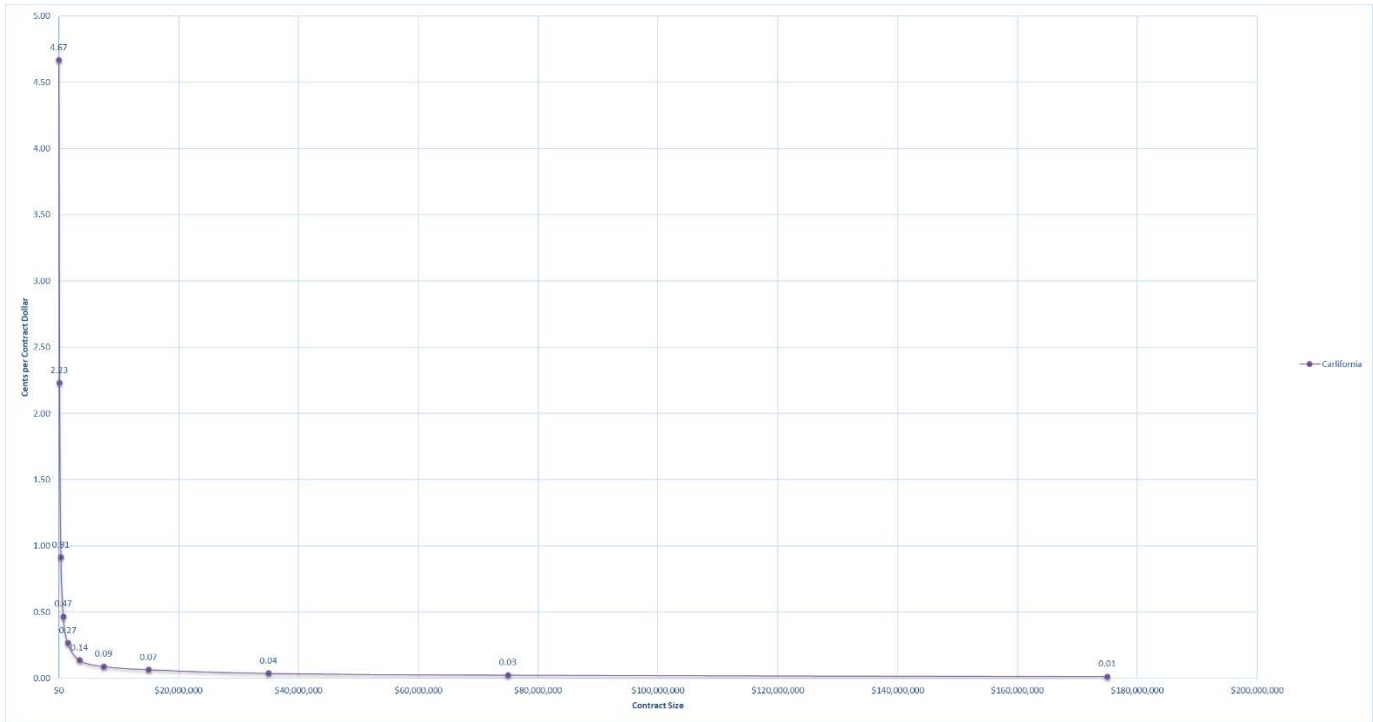


Figure 11 Liquidated Damages charges per Contract size (Calendar Days California)

As earlier discussed, California had to be charted separately given how large the upper contract size is (175M).

Visually inspecting these tables, it can be concluded that the significant portion of the negative exponential trend is more pronounced in the initial portions of the tabled values, between 0 and 4 million. The above charts (Figure 8 L.D.s 10M, Figure 9 L.D.s 20M, Figure 10 L.D.s 50M, Figure 11 California L.D.s) were narrowed down to 4 million to better observe this trend. Given the size of the data from all these tables, and to prevent too much clutter on one chart, the tables were charted on 3 separate charts.

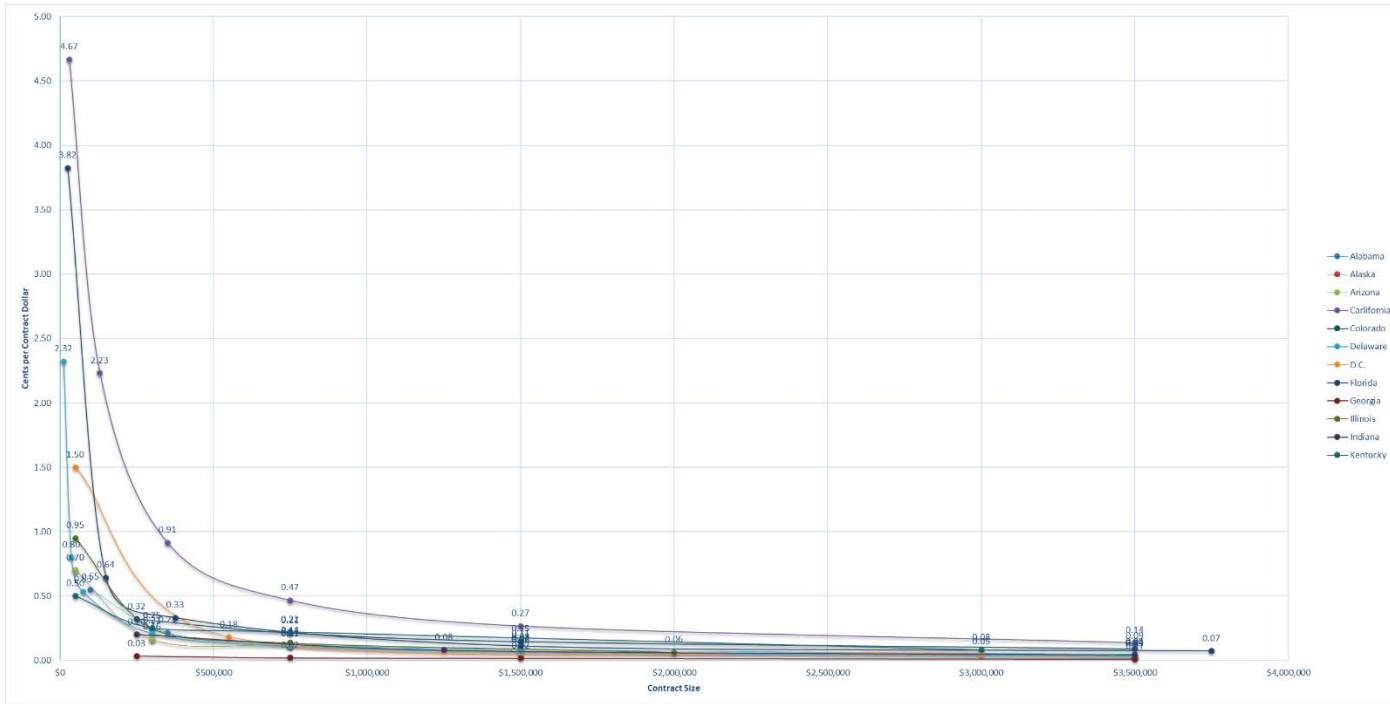


Figure 12 Liquidated Damages charges per Contract size 1 (Calendar Days & Contracts up to 4M)

The first of these charts (Figure 12) contains L.D.s data up to 4M from calendar day tables from Alabama, Alaska, Arizona, California, Colorado, Delaware, Washington D.C., Florida, Georgia, Illinois, Indiana, and Kentucky. In these states, the L.D.s rates up to 1 million are seen to be higher in the range of up to two million dollars. The upper curve that stands out represents California state L.D.s, with most of the other states in a small narrow range lumped together for contract sizes under \$500,000.

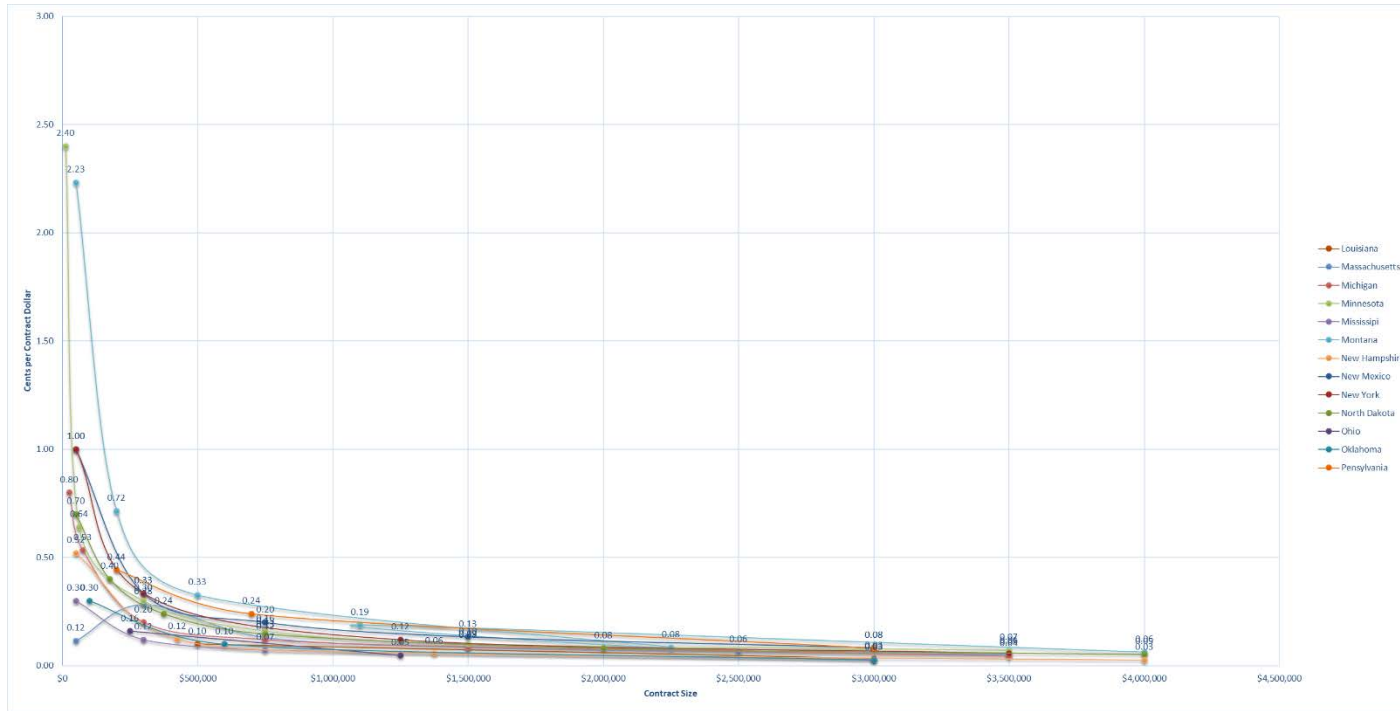


Figure 13 Liquidated Damages charges per Contract size 2 (Calendar Days & Contracts up to 4M)

The second of these charts, represented in the figure above (Figure 13), contains L.D.s data up to 4M from calendar day tables from Louisiana, Massachusetts, Michigan, Minnesota, Mississippi, Montana, New Hampshire, New Mexico, New York, North Dakota, Ohio, Oklahoma, and Pennsylvania. Similar to the previous chart, these states also have a higher L.D.s rate up to 1 million in the range of up to two million dollars. These states are mostly lumped together with a range of 0.33 to 0.10 at the \$500,000 mark.

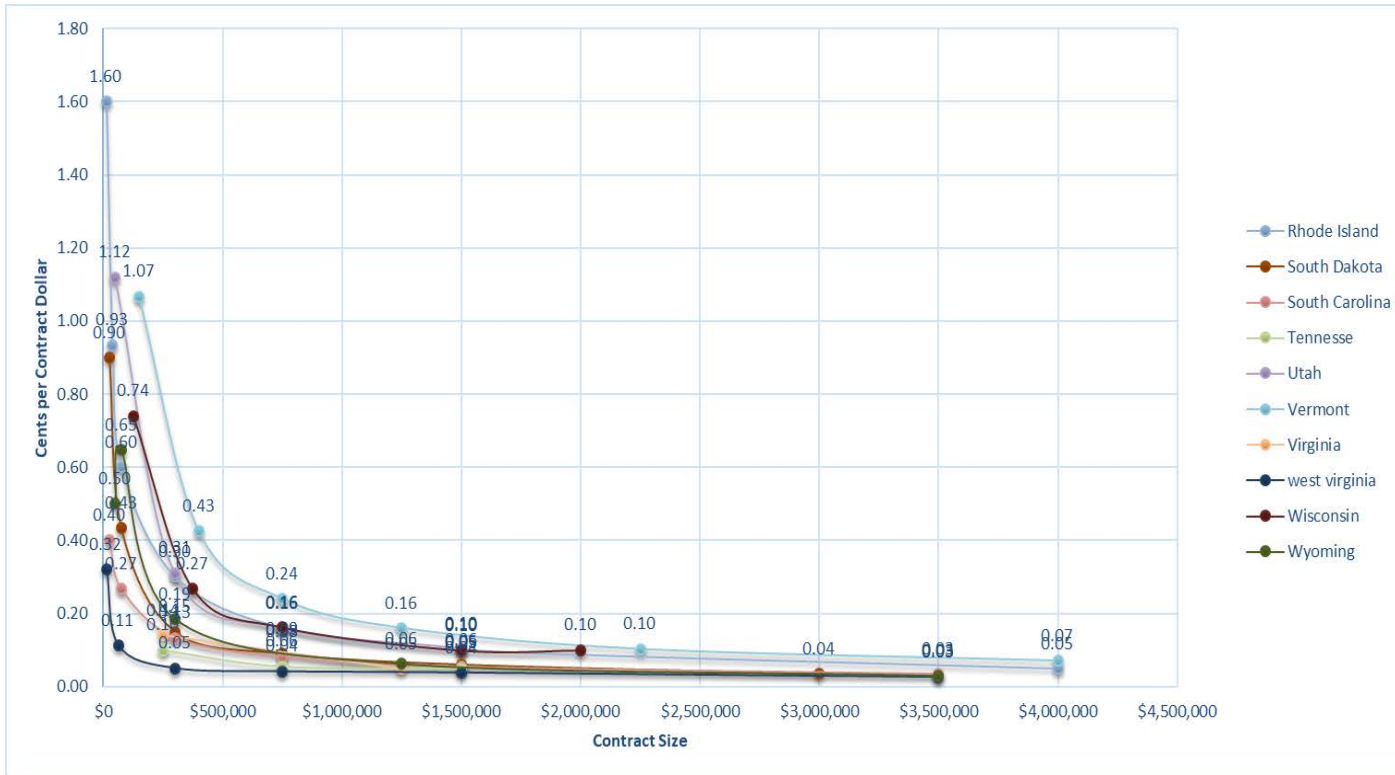


Figure 14 Liquidated Damages charges per Contract size 3 (Calendar Days & Contracts up to 4M)

The last of the tables, represented in the figure above (Figure 14), contains L.D.s data up to 4M from calendar day tables from Rhode Island, South Dakota, South Carolina, Tennessee, Utah, Vermont, Virginia, West Virginia, Wisconsin, and Wyoming. Like the previous charts, these states also have a higher L.D.s rate up to 1 million in the range of up to two million dollars. These states are mostly lumped together with a range of 0.24 to 0.40 at the \$750,000 mark.

#### 4.5.5.1.1.2 Charts based on working days

All the tables based on working days were plotted together on one chart and are represented below.

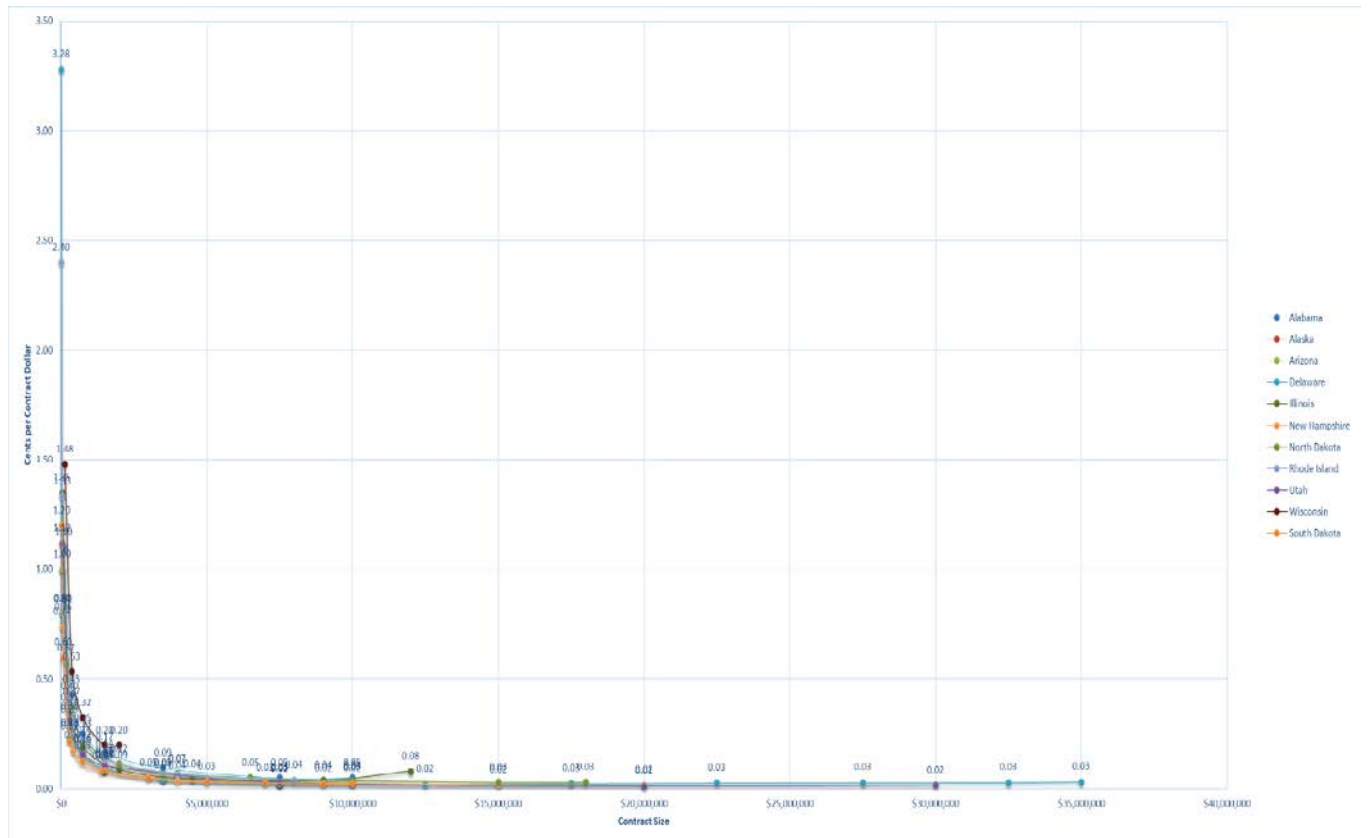


Figure 15 Liquidated Damages charges per Contract size (Working Days)

Figures 15 and 16 portray L.D.s for states that are based on Working Days. These two charts are made up of 11 states including Alabama (10M), Alaska (10M), Arizona (10M), Delaware (35M), Illinois (12M), New Hampshire (20M), Utah (30M), North Dakota (18M), Rhode Island (8M), Wisconsin (2M), and South Dakota (10M). These states have similar ranges with only a few points on the graph standing out against the rest such as Illinois with a rate of 0.08 against the majority of the other states in a range of 0.02 at 12M.

The same tables, as earlier done with the calendar day tables, were charted up to 4M to better visualize the trend of the data. Most of the data were clustered together for example the range of rates at 1.5M was 0.20 to 0.09. This table is shown in Figure 16 below.

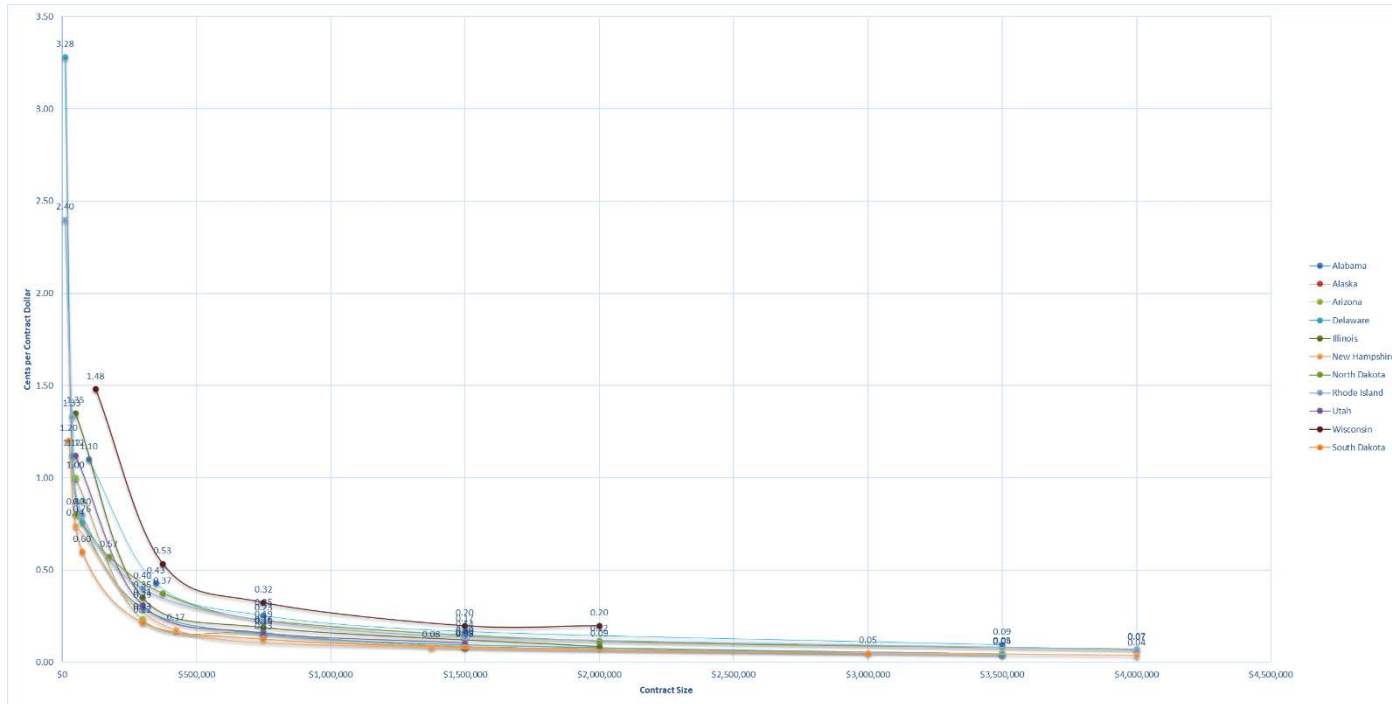


Figure 16 Liquidated Damages charges per Contract size (Working Days & Contracts up to 4M)

#### 4.5.5.2 Formula of Liquidated Damages

Of the documents reviewed, 4 make use of a formula to assign liquidated damages.

##### 4.5.5.2.1 Indiana

In addition to having a table for liquidated damages, Indiana DOT's standard specifications outline a formula for liquidated damages. This clause states that any changes to the contract payment regarding L.D.s should be included as an L.D.s pay item. The unit cost for this pay item they state will be one dollar (\$1.00) and that the quantity will be in dollars. They also state that the quantity is the total sum calculated according to the previously outlined Schedule (INDOT, 2020).

#### 4.5.5.2.2 Nebraska

Nebraska DOT's standard specifications outline a formula for liquidated damages.

This clause states that the Department will utilize a formula to calculate L.D.s if a contractor does not finish a project on time. They write that the rate of L.D.s defined in their formula as representing a part of the Department's expenses sustained due to the delay in winding up the project.

*"LIQUIDATED DAMAGES FORMULA*

$$LD = (R \times C)/T$$

*where:*

*LD = Liquidated damages per working day or calendar day (rounded to the nearest dollar).*

*C = Original contract amount (includes all work completed and unfinished).*

*T = Original number of calendar days or working days, whichever is specified in the Contract.*

*R = 0.06 for working day contracts.*

*R = 0.12 for calendar day contracts." (NEDOT, 2017)*

#### 4.5.5.2.3 Oregon

Oregon DOT's standard specifications outline a formula for liquidated damages.

This clause states that the L.D.s per day (Calendar) for failing to finish the project in time as needed by 00180.50(h) when a particular project Time is itemized as 00180.50(h) it is calculated with the subsequent formula;

*"The L.D.s per Calendar Day\* are 21.2 % of C divided by T as defined in this Section.*

*C = Contractor's Bid amount*

*T = total Calendar Days between the latest completion date or time listed under 00180.50(h)*

*in the Solicitation Documents and the Bid Opening that will result in the greatest value for T.*

*\* Calendar Day amounts are applicable when the Contract Time is expressed on the Calendar Day or fixed date basis." (ODOT, 2008)*

#### **4.5.5.2.4 Washington State**

Washington State's formula for assessing Liquidated Damages is 15% Total Cost /Working Days. WSDOT construction manual still can charge LDs based on the formula even though the formula itself is not referenced.

Although the formula varies, all 4 states' DOTs calculate LDs as a Function of Contract Size and Contract Time.

#### **4.5.5.3 Other forms of Liquidated Damages**

*Table 4-5 States With Other forms of Liquidated Damages*

Arkansas	This state Dot's document outlines that the sums to be deducted will be outlined in the proposal and subsequent Contract. The clause states that for every calendar/working day, as stated in the Contract, where the work remains incomplete beyond a stated contract time, the sum indicated in the proposal and Contract shall be subtracted from any sums payable to a Contractor, not charged as a penalty instead as L.D.s. It also states that should the amount owed to the Contractor be less than the totality of the L.D.s, the Contractor and their Surety are responsible for sums due to the Department for the deficiency (AHTD, 2014)
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Connecticut	The liquidated damages clause states that for every calendar day where any scope of work is unfinished once the Contract time passes, a per diem amount of L.D.s indicated in the Contract will be withheld from any sums owed to a Contractor. It also adds that if the final day of the original Contract date or the original Contract time outlined as Substantial Completion is ahead of the 1st of December in a particular year, L.D.s, as stated within the Contract, are evaluated against the Contractor based on Calendar day (this also includes all days during in a winter shutdown) till the point at which the project is assessed to be at substantial completion (CTDOT, 2020)
Hawaii	This State's document leaves a blank space to be filled in on a contract-to-contract basis. The specifications state that when a contractor fails to attain substantial Completion of the project for which L.D.s are quantified, in a contract time or any extra time, in addition to all other remedies directed for the breach that may be available to the State, the Contractor will also pay liquidated damages to the State, amounting to "\$ _____" per working day (HIDOT, 2020)
Idaho	The clause states that the Engineer will decide the working days for assessing liquidated damages, specified in section 108.02.B. It also adds that the State Engineer will not omit days (calendar) in December, January, and February in the project completion date. L.D.s shall be subtracted from sums owed to the Contractor or payable by the Contractor (ITD, 2018)
Iowa	This DOT document states that the final Payment will be suspended up to a time when a value for L.D.s is decided upon (IowaDOT, 2020)
Maryland	Liquidated Damages are addressed as follows in the state DOT specifications;  For every day that any work will is unfinished beyond the contract time specified, the Contractor and/or their surety shall be liable for L.D.s in the quantity indicated in the solicitation. It adds that any modification of the specified completion time for completing the project, as allowed by accepted change orders, will be accounted for (MarylandDOT, 2008).
Missouri	Liquidated Damages are addressed as follows in the state DOT specifications;  (In section 108.8.1.1) It states that L.D.s outlined in the Contract will be itemized individually as project road user costs and contract administrative costs. Separate jobs conferred as a sole contract will be assessed as a single unit to determine and evaluate the administrative L.D.s. The road user costs will be quantified individually for all of

	<p>the projects in the Contract and determined separately for each project not completed on time (MODOT, 2011).</p>
Nevada	<p>Liquidated Damages are addressed as follows in the state DOT specifications;</p> <p>When a contractor does not finish the project in the stated time or within the additional duration they may have been allowed by increases in the Contract or by an officially approved extension granted by the Department, the Department will deduct from any money or sums that are due or that may become due, the sum outlined in the project Special Provisions for every day (working) that the project remains unfinished. This sum will be considered and treated not as a charged penalty but as L.D.s owed to the State; due to the public inconvenience, the additional cost of engineering, administration, and any supplementary items that will cause extra expenditure of public funds owing to them not completing the work within the contract time (NEDOT, 2017).</p>
New Jersey	<p>The document states that both parties acknowledge that interruptions to project Time lead to damages to the Department. It also states that this includes the consequence of the interruptions on the usage, convenience of the public, economic growth, and other added expenses incurred by the authority for engineering, administration, plus inspection. The document goes on to say that it is challenging to precisely assess the damages suffered and that all the principles approve that if the Contractor does not conclude the project or part of the project in the designated project time, they will reimburse the Department the L.D.s stated in the Special Provisions (NJDOT, 2007).</p>
North Carolina	<p>Liquidated Damages are addressed as follows in the state DOT specifications;</p> <p>They state that it is agreed that due to the difficulty of making accurate assessments of such damages, an amount of money specified and leveled against the Contractor based on the contract for the duration that the work remains incomplete after the stated dates indicated in the Contract, not charged as a penalty but as L.D.s (NEDOT, 2017).</p>
Texas	<p>The document states that the dollar sum stated in the Contract will be subtracted from any sums owed or what will be owed to the Contractor for every day (working) the project remains unfinished. This amount is not be evaluated as a penalty but as L.D.s. The sum evaluated for non-site specific agreements shall be assessed from each work order's projected sum unless otherwise stated in the</p>

	Contract. This sum assessed will be as stated in the Contract (TXDOT, 2014).
Washington State	The document states that the Contractor approves to first pay the L.D.s stated in the Special Provisions for every working day after the Physical Completion. Secondly, it authorizes the inspection subtraction of these stated L.D.s from any sums owed to or about to be owed to the Contractor by the Engineer (WSDOT, 2021).

#### 4.5.6 Additional Types of liquidated damages

Table 4-6 States With Additional Liquidated Damages

Massachusetts	<p>Once substantial completion is achieved, the state DOT's document assigns a liquidated damages rate based on the given table.</p> <p style="text-align: center;"><i>Table 8.11-1: Schedule of Liquidated Damages</i></p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Project Value</th> <th>Liquidated Damages (per Day)</th> </tr> </thead> <tbody> <tr> <td>0 to \$100,000</td> <td>\$575.00</td> </tr> <tr> <td>\$100,000 to \$500,000</td> <td>\$850.00</td> </tr> <tr> <td>\$500,000 to \$1,000,000</td> <td>\$975.00</td> </tr> <tr> <td>\$1,000,000 to \$2,000,000</td> <td>\$1,250.00</td> </tr> <tr> <td>\$2,000,000 to \$3,000,000</td> <td>\$1,550.00</td> </tr> <tr> <td>\$3,000,000 to \$4,000,000</td> <td>\$1,800.00</td> </tr> <tr> <td>\$4,000,000 to \$5,000,000</td> <td>\$2,200.00</td> </tr> <tr> <td>\$5,000,000 to \$10,000,000</td> <td>\$2,400.00</td> </tr> <tr> <td>\$10,000,000 to \$15,000,000</td> <td>\$2,700.00</td> </tr> <tr> <td>Over \$15,000,000</td> <td>\$3,500.00</td> </tr> </tbody> </table> <p style="text-align: center;"><i>Figure 17 Figure 4 Liquidated Damages table 2020 MADOT Std Specs</i></p> <p>The clause states that if the Contract is project is open for traffic and is designated as substantially completed as instructed, by the Engineer (in writing), but not physical Completed from the delay due to small incomplete parts that hardly reduce the utility of the project, the elected figures for each day will be half the cost shown. On top of this day-to-day cost, the Contractor will settle (without compensation) the total cost of all officers (controlling traffic), railroad flagmen, along with any inspectors the department representative concludes to be crucial during the period past the contract time (massDOT, 2020).</p> <p>It adds that if physical Work incorporated is finished and approved in writing but any reports or other documents remain, according to the</p>	Project Value	Liquidated Damages (per Day)	0 to \$100,000	\$575.00	\$100,000 to \$500,000	\$850.00	\$500,000 to \$1,000,000	\$975.00	\$1,000,000 to \$2,000,000	\$1,250.00	\$2,000,000 to \$3,000,000	\$1,550.00	\$3,000,000 to \$4,000,000	\$1,800.00	\$4,000,000 to \$5,000,000	\$2,200.00	\$5,000,000 to \$10,000,000	\$2,400.00	\$10,000,000 to \$15,000,000	\$2,700.00	Over \$15,000,000	\$3,500.00
Project Value	Liquidated Damages (per Day)																						
0 to \$100,000	\$575.00																						
\$100,000 to \$500,000	\$850.00																						
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\$2,000,000 to \$3,000,000	\$1,550.00																						
\$3,000,000 to \$4,000,000	\$1,800.00																						
\$4,000,000 to \$5,000,000	\$2,200.00																						
\$5,000,000 to \$10,000,000	\$2,400.00																						
\$10,000,000 to \$15,000,000	\$2,700.00																						
Over \$15,000,000	\$3,500.00																						

	<p>Contract provisions, to be given to the Department by the Contractor, the Contract is not considered acceptably finished within the implications of the General Laws (Section 39G of Chapter 30) up to the provision any such items to the Department, but the selected amount throughout that period will be nil (massDOT, 2020).</p>
Utah	<p>The State DOT assigns given rates on certain contract items.</p> <p>It states that the Contractor should achieve physical Completion within thirty calendar days of receiving their <b>final punch list</b>. \$560 per day, paid as a disincentive, will be deducted from any sums owed for every calendar day beyond the 30 calendar days before physical Completion (UTDOT, 2020).</p> <p>Another paragraph says that the Contractor should achieve contract completion within thirty calendar days of receiving notification of <b>physical Completion</b>. It states that the Department will subtract \$100 per day as a disincentive from any sum owed for each calendar day beyond the thirty calendar days after receiving their notification of physical Completion where the final documents punch list or other Contract obligation under remains unsatisfied Contractor (UTDOT, 2020).</p>
Alaska	<p>In addition to a table of liquidated damages, Alaska details a rate for liquidated damages once substantial Completion is achieved.</p> <p>The clause states that for every day (calendar) the project is complete (substantial completion), but the project remains incomplete, beyond the end of the allotted duration, the Engineer will subtract twenty percent (20%) of the day-to-day charge matching to the damages presented in Table 108-1 from progress payments (ALDOT, 2018 ).</p>
California	<p>This State charges a rate for when the entire project is finished except for the plant establishment and the permanent erosion control work.</p> <p>The clause states that when the entire project is finished except for the plant establishment and the permanent erosion control, but all the days (working) have elapsed, L.D.s will be \$950 each day (Caltrans, 2018).</p>
Pennsylvania	<p>In addition to a schedule of liquidated damages outlined in a table, Pennsylvania DOT has these additional statements;</p> <p><i>"(b) Road Users Liquidated Damages. When indicated in the proposal, Road Users Liquidated Damages will be charged for each day that the roadway is not opened to unrestricted traffic after the specified Milestone Date. The sum per day will be deducted from the money due or to become due. This deduction will not be a penalty but as Road Users Liquidated Damages.</i></p>

	<p><i>If the Contractor is declared in default, as specified in Section 108.08, Road Users Liquidated Damages will be charged in the amount indicated. If the total amount chargeable as Road Users Liquidated Damages exceeds the amount payable to the Contractor or the surety, the excess is to be paid to the State by the Contractor or the surety.</i></p> <p><i>(c) Work Zone Liquidated Damages. A sum of no less than \$1,000 per 24-hour period will be charged as work zone liquidated damages for failure to comply with Maintenance and Protection of Traffic requirements and drawings or other contract traffic control requirements. This deduction will not be as a penalty but as work zone liquidated damages.</i></p> <p><i>(d) Erosion and Sedimentation Control (E&amp;S) Noncompliance Liquidated Damages. Begin work to correct any non-compliance with Section 107.28 (Erosion and Sediment Pollution Control Plans and Permits) within 24 hours of notification by the Representative of the noncompliance. At the time of notification, the Representative will provide the Contractor with a copy of the visual site-inspection report or the report from DEP or their designee or other regulatory agency that identifies the noncompliance. A \$1,500 per 24-hour period will be charged as E&amp;S noncompliance liquidated damages for failure to begin work within 24 hours of notification of-compliance and for each subsequent 24-hour period until E&amp;S compliance is attained. This deduction will not be as a penalty but as E&amp;S noncompliance liquidated damages. (PennDOT, 2020)"</i></p>
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#### **4.5.7 Liquidated Damages During Construction**

##### **4.5.7.1 Baseline Schedule Disincentive**

The General Contractor must provide a baseline schedule and a baseline schedule narrative in the Utah DOT standard specifications. They have a weekly disincentive that is charged until the conditions are met to enforce this requirement.

The extract of the SS reads that a disincentive of one thousand dollars per week may be assessed starting from sixty days after a Notice to Proceed is granted until the Contractor submits a Baseline Schedule (with a baseline schedule narrative). However, the disincentive

period starts fourteen days after a Notice to Proceed if a preliminary schedule is required to be submitted (UTDOT, 2020).

#### ***4.5.7.2 Commencement Liquidated Damages***

In Indiana, the DOT sets a daily rate for the failure of the General Contractor to begin construction once a notice to proceed is given out. The clause states that if a Contractor does not commence work in five (5) calendar days after receiving the notification, one hundred dollars (\$100) will be charged as L.D.s, and not as a penalty, but as compensations for each day (calendar) beyond the five that the job is not started (INDOT, 2020).

#### ***4.5.7.3 Liquidated Damages for Non-Completion of Work-Parts***

This clause, present in 9 DOTs document, prescribes damages arising from not completing specific work parts in time. California DOT outlines in its clause that the damages assessed should not be equivalent to the daily sum stated as L.D.s for the whole project. In contrast, others either prescribe that the rate be outlined in the special provisions or the L.D.s clause in standard specifications (Caltrans, 2018).

##### **8-1.10B Failure to Complete Work Parts within Specified Times**

The Department may deduct specified damages from payments for each day needed to complete a work part in excess of the time specified for completing the work part.

Damages for untimely completion of work parts may not be equal to the daily amount specified as liquidated damages for the project as a whole, but the Department does not simultaneously assess damages for untimely completion of work parts and for the whole work.

Damages accrue starting the 1st day after a work part exceeds the specified time through the day the specified work part is complete.

##### **8-1.10C Failure to Complete Work Parts by Specified Dates**

The Department may deduct specified damages from payments for each day needed to complete a work part in excess of the specified completion date for the work part.

Damages for untimely completion of a work part may not be equal to the daily amount specified as liquidated damages for the project as a whole, but the Department does not simultaneously assess damages for untimely completion of a work part and the whole work.

Damages accrue starting the 1st day after an unmet completion date through the day the work part is complete.

*Figure 18 2018-CALTRANS Std Specs work-parts clause*

## **4.6 Default/Suspension/Termination**

### **4.6.1 Overview**

All states have Default/Suspension/Termination clauses. These govern how a state stops a contractor from progressing with work due to non-conformance and ultimately ending their Contract prematurely. The power to find the Contractor in default and subsequently suspend or terminate the Contract lies mainly with the state Engineer, who administrates the Contract. Alabama, for example, outlines that the Engineer maintains the capacity to stop the project entirely or partly through a written directive to the Contractor; the stoppage may be for such a duration as they may deem fit due to either of the following explanations. A failure to carry out instructions provided or a failure to complete any provision in the Contract and therefore the period will be charged, and they will receive no time extension (ALDOT, 2018 ).

"Failure to carry out instructions or complete contract provisions" is the statement to note. It defines the failure of a contractor to adhere to the contract provisions (our outlined non-conformances) results in the Contractor being held in default of the Contract leading to suspension/termination if no action is taken to remedy the situation.

### **4.6.2 Time of appeal**

Most states (45 states) overtly stipulate the period within which a contractor can comply with the State's notice and remedy the noted defects, failure to which triggers the State to terminate their Contract. This period ranges from Five (5) days in California to fourteen (14) days in Iowa. The only states without this distinction were D.C., Massachusetts, New York, Ohio, Pennsylvania, and Tennessee.

Wisconsin's specification addresses this by stating that if the Contractor or their surety, in ten calendar days after the notice, does not progress acceptably in accordance to withe Agreement; the Department can remove the project from the Contractor or their surety. And

to utilize all the appropriate materials and equipment available, enter into privity with other parties, or use other procedures that the Department necessitates to finish the project (WisDOT, 2021).

#### **4.6.3 Unsatisfactory progress of work (specific work)**

Twenty-three states (23) outline that unsatisfactory progress of work, i.e. failure to meet certain intermediate milestones, scopes of work, or during a review of the percentage of work done, can trigger default/suspension/termination of the Contract. Alabama, Michigan, Arkansas, Arizona, Illinois, Louisiana, Colorado, Florida, Delaware, Idaho, Kansas, Georgia, Indiana, D.C., Kentucky, Iowa, Maryland, Connecticut, Massachusetts, California, Minnesota, Alaska, and Mississippi.

Delaware states frames this by stating that if a Contractor fails to continue with the work acceptably to the Department." (DelDOT, 2016).

Connecticut states the condition is if the Contractor discontinues appropriate progress of the work for over 72 hours, excluding weekends and holidays, without any written approval to do so from the Engineer (CTDOT, 2020).

## 5 LIQUIDATED DAMAGES MODEL

The next part of the analysis focuses on the states with tables of liquidated damages.

As discussed in the previous sections, particularly the charts of LDs against contract sizes, it becomes apparent that the L.D.s data follows a negative exponential pattern or a trend. Could this trend be used to explain how states, from a statistical standpoint, determine the L.D.s they charge? Could a pattern or a model be identified to describe the LDs in each state? To answer these questions, a descriptive and statistical regression analysis of the L.D.s table data was undertaken to investigate whether a model could be used to describe how states assess or come up with the LD rates.

Thirty-five (35) states assess liquidated damages using tables of liquidated damages, as discussed in section 4.5.5.1 Table of Liquidated Damages. These tables were plotted as cents per contract dollar (*Figure 8 Liquidated Damages charges per Contract size*). All these states assessed these LDs based on Calendar Days; however, a few also had tables for contracts based on Working Days.

This data was used to perform a descriptive analysis of these LDs. The goal of this analysis was to show the various data points, such as the ranges of liquidated damages, needed to perform statistical data analysis (through regression analysis), to model the data into a standardized chart, forming a standard table of liquidated damages.

The following section (5.1) details the work for obtaining the model for the CD data while the succeeding section (5.2) details the model for the working days data.

## 5.1 Tables Based on Calendar Days

### 5.1.1 Cluster Analysis and Box Plots

All 35 states had tables based on calendar days. Given that the L.D.s rates and intervals did not match from state to state, it was necessary to group this data to allow for easier comparison of the data. The data in these tables were grouped into 15 clusters (based on the average size of the contract ranges used by the 51 states) using Statistica. The software determined these clusters were based on the contract sizes and put close data-sets within a given contract size from the various tables together.

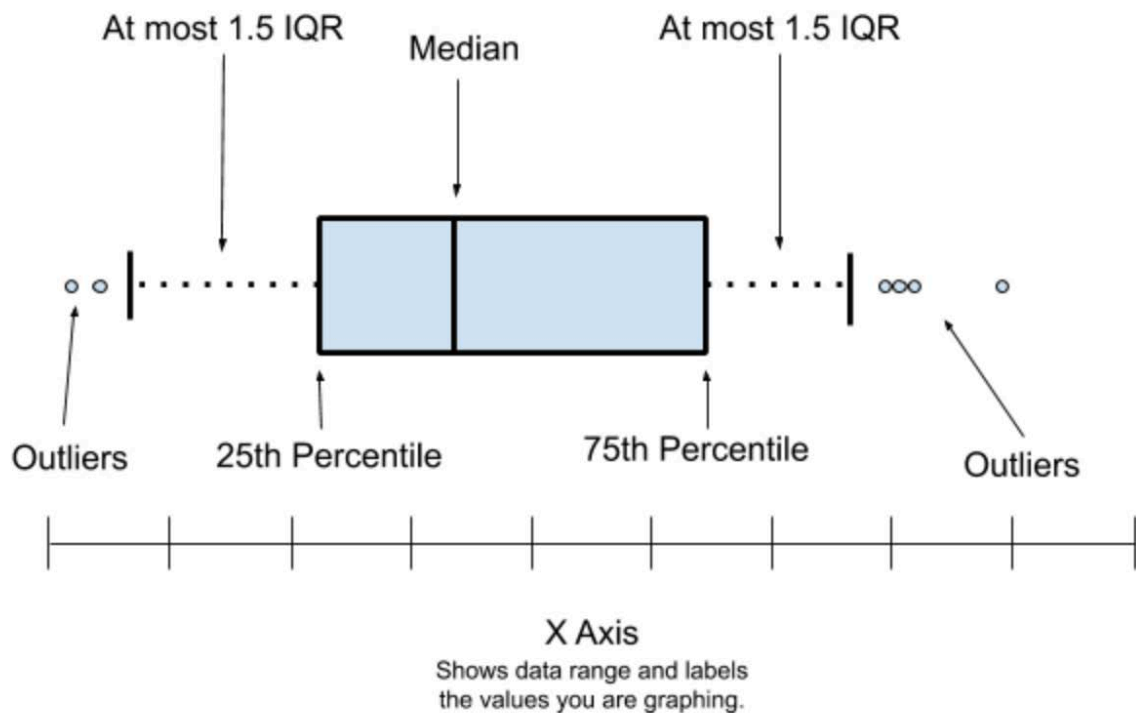
These clusters were vital since the contract sizes to cents per contract dollar vary from one state to another. The software allowed for similar contract sizes to be grouped for easier analysis of the data.

Cluster 1		Cluster 2		Cluster 3		Cluster 4		Cluster 5		Cluster 6		Cluster 7	
LDs	C Size	LDs	C Size	LDs	C Size	LDs	C Size	LDs	C Size	LDs	C Size	LDs	C Size
Var7	Var8	Var9	Var10	Var11	Var12	Var13	Var14	Var15	Var16	Var17	Var18	Var19	Var20
0.7000000	50,000	0.5500000	100,000	0.0336000	250,000	0.2000000	500,000	0.1366667	750,000	0.0800000	1,250,000	0.0666667	1,500,000
2.3200000	12,500	0.3000000	100,000	0.3200000	250,000	0.1223529	425,000	0.2392857	700,000	0.1878182	1,100,000	0.0833333	1,500,000
2.4000000	12,500	0.7400000	125,000	0.2000000	250,000	0.1000000	500,000	0.1266667	750,000	0.1200000	1,250,000	0.0606667	1,500,000
1.6000000	12,500	2.2307692	130,000	0.1600000	250,000	0.3258000	500,000	0.1120000	750,000	0.0480000	1,250,000	0.0606667	1,500,000
0.3200000	12,500	0.6426667	150,000	0.1000000	250,000	0.1818182	550,000	0.1120000	750,000	0.1600000	1,250,000	0.2666667	1,500,000
3.8240000	25,000	1.0666667	150,000	0.1400000	250,000	0.1000000	600,000	0.4666667	750,000	0.0480000	1,250,000	0.1466667	1,500,000
0.8000000	25,000	0.4000000	175,000	0.1633333	300,000			0.2133333	750,000	0.0620000	1,250,000	0.1110000	1,500,000
0.4000000	25,000	0.7150000	200,000	0.1633333	300,000			0.1093333	750,000	0.0567273	1,375,000	0.0164667	1,500,000
0.9000000	25,000	0.4425000	200,000	0.2100000	300,000			0.0201333	750,000			0.0833333	1,500,000
4.6666667	30,000			0.2500000	300,000			0.2200000	750,000			0.0866667	1,500,000
0.8000000	37,500			0.2500000	300,000			0.1300000	750,000			0.1000000	1,500,000
0.9333333	37,500			0.2833333	300,000			0.1200000	750,000			0.1333333	1,500,000
0.7000000	50,000			0.2000000	300,000			0.1600000	750,000			0.1000000	1,500,000
1.5000000	50,000			0.3000000	300,000			0.0720000	750,000			0.0533333	1,500,000
0.9500000	50,000			0.1200000	300,000			0.2000000	750,000			0.0493333	1,500,000
0.5000000	50,000			0.3333333	300,000			0.1466667	750,000			0.1046667	1,500,000
0.1150000	50,000			0.3333333	300,000			0.1600000	750,000			0.0380000	1,500,000
0.3000000	50,000			0.3000000	300,000			0.0800000	750,000			0.0990000	1,500,000
2.2320000	50,000			0.1333333	300,000			0.0560000	750,000			0.1200000	1,500,000
0.5200000	50,000			0.3100000	300,000			0.1600000	750,000			0.0600000	1,500,000
1.0000000	50,000			0.0500000	300,000			0.2400000	750,000			0.0637500	2,000,000
1.0000000	50,000			0.1850000	300,000			0.0413333	750,000			0.0800000	2,000,000
0.7000000	50,000			0.1500000	300,000			0.1620000	750,000			0.0992500	2,000,000
1.1200000	50,000			0.2142857	350,000			0.0900000	750,000			0.0843556	2,250,000
0.5000000	50,000			0.9142857	350,000							0.1022222	2,250,000
0.6400000	62,500			0.3309333	375,000							0.0620000	2,500,000
0.1120000	62,500			0.2400000	375,000								
0.5333333	75,000			0.2666667	375,000								
0.5333333	75,000			0.4250000	400,000								
0.6000000	75,000												
0.2666667	75,000												
0.6466667	75,000												
0.4333333	75,000												

Figure 17 Sample of Clusters Analysis of tables based on Calendar Days

These clusters of data were then plotted onto box and whisker plots. Representing this data graphically allows for easier interpretation of data. Box and whisker diagrams (known as box plots) are used to graphically demonstrate the distribution of groups of numerical data (locality, median, minimum, maximum, and skewness) through their quartiles (Dutoit, 2012).

Table 5-1 Example of a Box Plot (mimiss, 2016)



The 25<sup>th</sup> and the 75<sup>th</sup> percentiles denote the lower and upper ends of the data points. The median shows the typical observation from the data. The distance between the 25<sup>th</sup> and the 75<sup>th</sup> percentiles is called the interquartile range (IQR). The arms (whiskers) extend no more than 1.5 times the IQR (mimiss, 2016). An outlier is a data point that is numerically distant from the majority of the data; more than 1.5 IQR. In a box plot, outliers are located outside the whiskers of the boxplots (McLeod, 2019). Extreme values are more than 3.0 IQR. Extreme values and outliers lead to compressed box plots that are difficult to read. These compressed plots are difficult to estimate and the distribution of data is hard to distinguish

(Mary Rose Sibayan PPD, 2016). Removing these outliers and extreme values yield data that is more statistically significant to be used for analysis such as regression analysis.

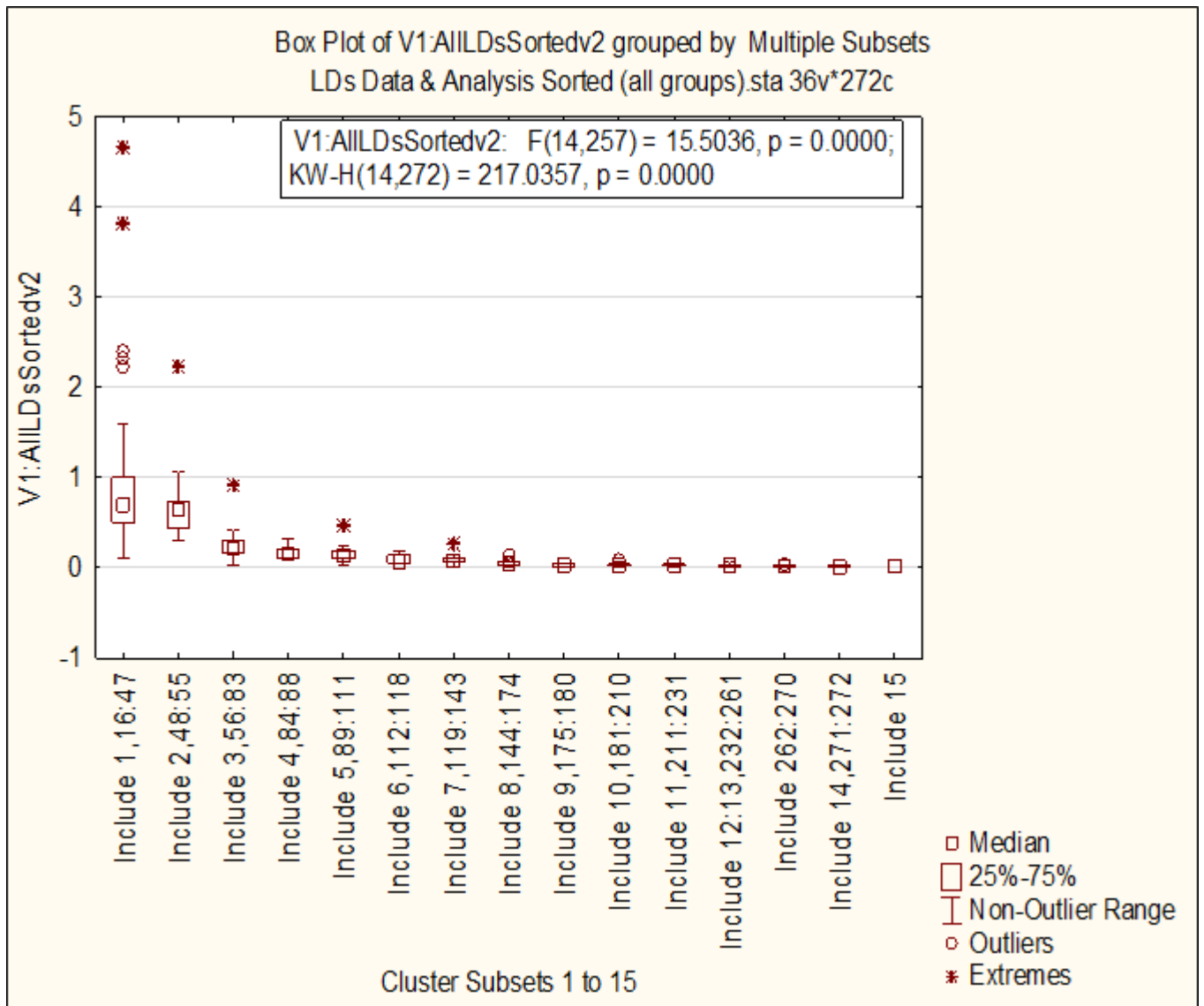


Figure 18 Box Plots of tables Based on Calendar Days

The figure above represents the contract size clusters on the x-axis and the cents per contract dollar on the y-axis.

Studying these box plots showed the data distribution within the whiskers and revealed outlier and extreme values in the data points.

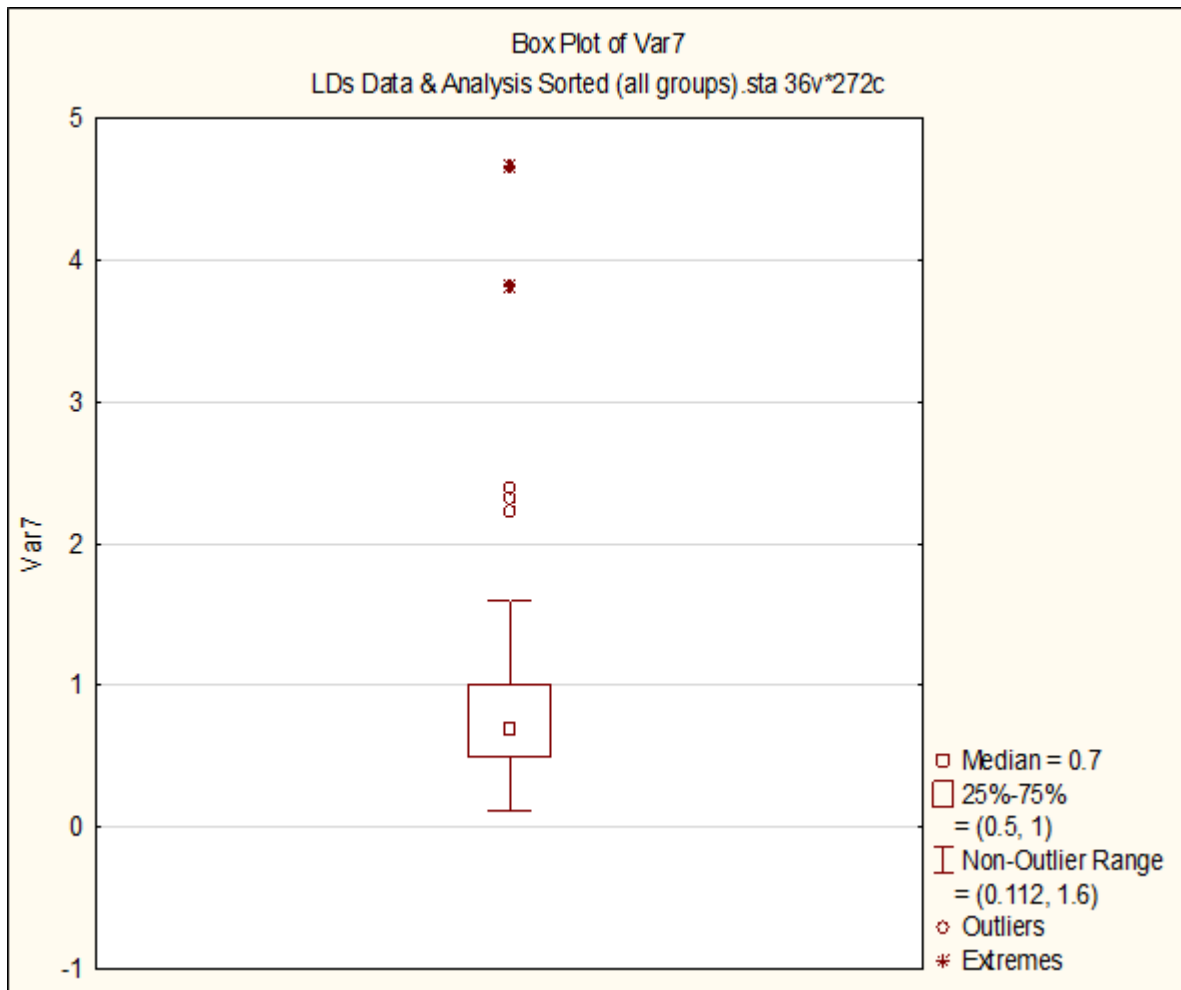


Figure 19 Sample box Plot of Cluster 7

Outlier and Extreme values are data points that deviate far from the other data points.

Identifying these values helps clean statistical data since their inclusion leads to increased error variance. These Outliers and Extreme values were removed from the table data ahead of the subsequent analysis step. California State DOT LD tables presented the most outlier and extreme values (Indicated in red below). These data points were removed to increase the accuracy of the model.

Table 5-2 Liquidated Damages Table with Extreme values in Red and Outliers in Blue

Calender days. Cents per contract dollar. Ccontract dollars are the mid points of the ranges in each LD table.														
Alabama	0.55	0.21	0.13	0.08	0.05	0.02	0.03							
	\$100,000	\$350,000	\$750,000	\$1,500,000	\$3,500,000	\$7,500,000	\$10,000,000							
Alaska	0.70	0.16	0.11	0.06	0.03	0.02	0.02							
	\$50,000	\$300,000	\$750,000	\$1,500,000	\$3,500,000	\$7,500,000	\$10,000,000							
Arizona	0.70	0.16	0.11	0.06	0.03	0.02	0.02							
	\$50,000	\$300,000	\$750,000	\$1,500,000	\$3,500,000	\$7,500,000	\$10,000,000							
California	4.67	2.2308	0.91	0.47	0.27	0.14	0.09	0.07	0.04	0.03	0.01			
	\$30,000	\$130,000	\$350,000	\$750,000	\$1,500,000	\$3,500,000	\$7,500,000	\$15,000,000	\$35,000,000	\$75,000,000	\$175,000,000			
Colorado	0.32	0.21	0.15	0.09	0.05	0.07								
	\$250,000	\$750,000	\$1,500,000	\$3,500,000	\$10,000,000	\$15,000,000								
Delaware	2.32	0.80	0.53	0.21	0.11	0.07	0.03	0.02	0.01	0.02	0.02	0.02	0.02	0.02
	\$12,500	\$37,500	\$75,000	\$300,000	\$750,000	\$1,500,000	\$3,500,000	\$7,500,000	\$12,500,000	\$17,500,000	\$22,500,000	\$27,500,000	\$32,500,000	\$35,000,000
D.C.	1.50	0.18	0.05	0.03	0.02	0.03								
	\$50,000	\$550,000	\$3,000,000	\$7,500,000	\$15,000,000	\$20,000,000								
Florida	3.82	0.64	0.33	0.11	0.07	0.05	0.04	0.03	0.05					
	\$25,000	\$150,000	\$375,000	\$1,500,000	\$3,750,000	\$7,500,000	\$12,500,000	\$17,500,000	\$20,000,000					
Georgia	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01						
	\$250,000	\$750,000	\$1,500,000	\$3,500,000	\$7,500,000	\$15,000,000	\$30,000,000	\$40,000,000						
Illinois	0.95	0.25	0.14	0.06	0.03	0.03	0.03	0.06						
	\$50,000	\$300,000	\$750,000	\$2,000,000	\$4,500,000	\$9,000,000	\$12,000,000							
Indiana	0.20	0.08	0.04	0.03	0.02									
	\$250,000	\$1,250,000	\$3,500,000	\$7,500,000	\$10,000,000									
Kentucky	0.50	0.25	0.22	0.08	0.04	0.03	0.02							
	\$50,000	\$300,000	\$750,000	\$3,000,000	\$7,500,000	\$15,000,000	\$20,000,000							
Louisiana	0.10	0.03	0.03	0.03	0.05	0.05								
	\$500,000	\$3,000,000	\$7,500,000	\$12,500,000	\$17,500,000	\$20,000,000								
Massachusetts	0.12	0.28	0.13	0.08	0.06	0.05	0.05	0.03	0.02	0.02				
	\$50,000	\$300,000	\$750,000	\$1,500,000	\$2,500,000	\$3,500,000	\$4,500,000	\$7,500,000	\$12,500,000	\$15,000,000				
Michigan	0.80	0.53	0.20	0.12	0.09	0.04	0.02	0.02	0.01	0.01				
	\$25,000	\$75,000	\$300,000	\$750,000	\$1,500,000	\$3,500,000	\$7,500,000	\$15,000,000	\$35,000,000	\$50,000,000				
Minnesota	2.40	0.64	0.30	0.16	0.10	0.07	0.04	0.04						
	\$12,500	\$62,500	\$300,000	\$750,000	\$1,500,000	\$3,500,000	\$7,500,000	\$10,000,000						
Mississippi	0.30	0.12	0.07	0.03	0.02	0.01	0.02							
	\$50,000	\$300,000	\$750,000	\$3,000,000	\$7,500,000	\$15,000,000	\$20,000,000							
Montana	2.23	0.72	0.33	0.08	0.19	0.06	0.04	0.04						
	\$50,000	\$200,000	\$500,000	\$2,250,000	\$1,100,000	\$4,000,000	\$7,500,000	\$10,000,000						
New Hampshire	0.52	0.12	0.06	0.03	0.02	0.01	0.01							
	\$50,000	\$425,000	\$1,375,000	\$4,000,000	\$7,500,000	\$15,000,000	\$20,000,000							
New Mexico	1.00	0.33	0.20	0.13	0.08	0.05	0.05	0.05						
	\$50,000	\$300,000	\$750,000	\$1,500,000	\$3,000,000	\$5,500,000	\$8,500,000	\$10,000,000						

### 5.1.2 Regression Analysis

Statistical modeling (mathematically representing data) through regression analysis allows observation of trends and commonalities in the data. Regression analysis is a series of statistical methods used to examine the correlation between two or more variables of interest.

In this case, regression analysis is utilized to model the statistical data into one table of best fit, by inferring the causal relationships between the independent (Contract size) and dependent variables (Cents per contract dollar). The regression achieves this by revealing the relationships in the fixed data set, the LDs tables.

IBM SPSS Statistics was used to run the regression analysis.

The table data was split into the groups based on contract sizes;

- 1) All contracts up to 5M
- 2) All contracts up to 10M

3) All contracts up to 20M

4) All contracts up to 50M

Grouping this data allowed researchers to run the regression analysis on several sets of data to track the accuracy of the findings. All the table data was used but was divided depending on the limit set, i.e. All contracts up to 20M represent data from all the states but only up to the 20 Million contract size.

Figure 20 of Tables of 9 LDs Calendar Days Grouped Data

DATA IN THESE GROUPS ARE BASED ON THE DATA LIMIT OF THE LD TABLES; a table would be repeated under several categories; FOR EXAMPLE DELAWARE WHICH HAS AN UPPER LIMIT OF 35M ON THE TABLE WOULD BE INCLUDE IN THE GROUP OF CONTRACTS 0-10

All Contracts		Contracts 0 TO 5 M		Contracts 0 TO 10 M		Contracts 0 to 20 M		Contracts 0-50 M	
<b>ALL CONTRACTS: tables would be repeated under several categories.</b>									
DATA IN THESE GROUPS ARE BASED ON THE DATA LIMIT OF THE LD TABLES; a table would be repeated under several categories; FOR EXAMPLE DELAWARE WHICH HAS AN UPPER LIMIT OF 35M ON THE TABLE WOULD BE INCLUDE IN THE GROUP OF CONTRACTS 0-10 (BUT ONLY TO THE DELAWARE DATA BETWEEN (0-10M), AND DELAWARE WOULD BE INCLUDED IN THE CONTRACT 10-20 BUT ONLY TO THE DATA UPTO 20M, AND FINALLY, DELAWARE WOULD BE INCLUDED IN THE CONTRACTS 20-50 M SINCE IT HAS DATA FROM 0-35M.									
0.70	\$50,000	0.55	100000.00	0.55	100000.00	0.55	100000.00	0.14	3500000.00
0.16	\$300,000	0.21	350000.00	0.21	350000.00	0.21	350000.00	0.09	7500000.00
0.11	\$750,000	0.13	750000.00	0.13	750000.00	0.13	750000.00	0.07	15000000.00
0.06	\$1,500,000	0.08	1500000.00	0.08	1500000.00	0.08	1500000.00	0.04	35000000.00
0.03	\$3,500,000	0.05	3500000.00	0.05	3500000.00	0.05	3500000.00	2.32	12500.00
0.02	\$7,500,000	0.70	50000.00	0.02	7500000.00	0.02	7500000.00	0.80	37500.00
0.02	\$10,000,000	0.16	300000.00	0.03	10000000.00	0.03	10000000.00	0.53	75000.00
0.91	\$350,000	0.11	750000.00	0.70	50000.00	0.70	50000.00	0.21	300000.00
0.47	\$750,000	0.06	1500000.00	0.16	300000.00	0.16	300000.00	0.11	750000.00
0.27	\$1,500,000	0.03	3500000.00	0.11	750000.00	0.11	750000.00	0.07	1500000.00
0.14	\$3,500,000	0.70	50000.00	0.06	1500000.00	0.06	1500000.00	0.03	3500000.00
0.09	\$7,500,000	0.16	300000.00	0.03	3500000.00	0.03	3500000.00	0.02	7500000.00
0.07	\$15,000,000	0.11	750000.00	0.02	7500000.00	0.02	7500000.00	0.01	12500000.00
0.04	\$35,000,000	0.06	1500000.00	0.02	10000000.00	0.02	10000000.00	0.02	17500000.00
0.32	\$250,000	0.03	3500000.00	0.70	50000.00	0.70	50000.00	0.02	22500000.00
0.21	\$750,000	0.14	3500000.00	0.16	300000.00	0.16	300000.00	0.02	27500000.00
0.15	\$1,500,000	0.32	250000.00	0.11	750000.00	0.11	750000.00	0.02	32500000.00
0.09	\$3,500,000	0.21	750000.00	0.06	1500000.00	0.06	1500000.00	0.02	35000000.00
0.05	\$10,000,000	0.15	1500000.00	0.03	3500000.00	0.03	3500000.00	0.03	250000.00
0.07	\$15,000,000	0.09	3500000.00	0.02	7500000.00	0.02	7500000.00	0.02	7500000.00
0.04	\$35,000,000	0.02	7,500,000	0.02	10,000,000	0.02	10,000,000	0.02	15,000,000
0.32	\$250,000	0.80	37500.00	0.14	3500000.00	0.14	3500000.00	0.01	3500000.00
0.21	\$750,000	0.53	75000.00	0.09	7500000.00	0.09	7500000.00	0.01	7500000.00
0.15	\$1,500,000	0.21	300000.00	0.32	250000.00	0.07	15000000.00	0.01	15000000.00
0.09	\$3,500,000	0.11	750000.00	0.21	750000.00	0.32	250000.00	0.01	30000000.00
0.05	\$10,000,000	0.07	1500000.00	0.15	1500000.00	0.21	750000.00	0.01	40000000.00
0.07	\$15,000,000	0.03	3500000.00	0.09	3500000.00	0.15	1500000.00	0.80	37500.00
		1.50	50000.00	0.05	10000000.00	0.09	3500000.00	0.53	75000.00
		0.18	550000.00	2.32	12500.00	0.05	10000000.00	0.20	300000.00
		0.05	3000000.00	0.80	37500.00	0.07	15000000.00	0.12	750000.00
		0.64	150000.00	0.53	75000.00	2.32	12500.00	0.09	1500000.00
		0.33	375000.00	0.21	300000.00	0.80	37500.00	0.04	3500000.00
		0.11	1500000.00	0.11	750000.00	0.53	75000.00	0.02	7500000.00
		0.07	3750000.00	0.07	1500000.00	0.21	300000.00	0.02	15000000.00
		0.03	250000.00	0.03	3500000.00	0.11	750000.00	0.01	35000000.00

This data was fed into IMB SPSS Statistics and analyzed using the regression function with several models; S, Linear, Power, Inverse, Cubic, Compound, Logistic, Exponential, Logarithmic, Quadratic Growth.

Each function represents a different method, with different sets of parameters, the software uses to run the estimation. Each model yields an R-Squared value that corresponds to how closely the model tracks (fits) with the data set. The closer the value is to 1, the more ideal the model.

Figure 21 IBM SPSS Statistics Regression Analysis interface

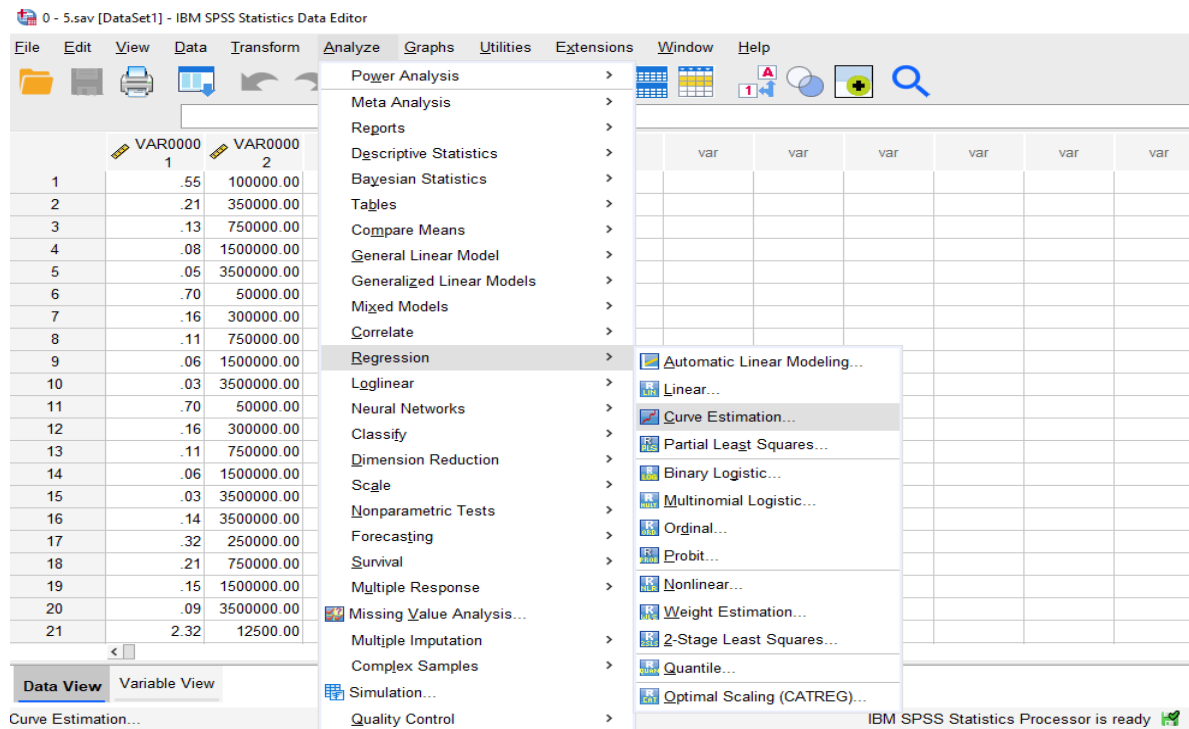


Table 5-3 Example of Table up to 50 Million R-Squared values based on Models

<b>Table up to 50 Million R-Squared values based on Models</b>	
<u>Model Equation</u>	<u>R-Square</u>
Linear	0.038
Logarithmic	0.363
Inverse	0.455
Quadratic	0.086
Cubic	0.128
<b>Power</b>	<b>0.802</b>
Compound	0.213
S	0.376
Logistic	0.213
Growth	0.213
Exponential	0.213

The Power Model performed the best among all the models by yielding an R-Squared value closest to 1 repeatedly compared to the rest. The model is a "good fit", as it passes through most plotted points.

Figure 22 All Contracts up to 10M Power Model with R-Squared

Equation	R Square	F	df1	df2	Sig.	Constant	b1
Power	.834	488.032	1	97	<.001	371.765	-.595

The independent variable is VAR00003.

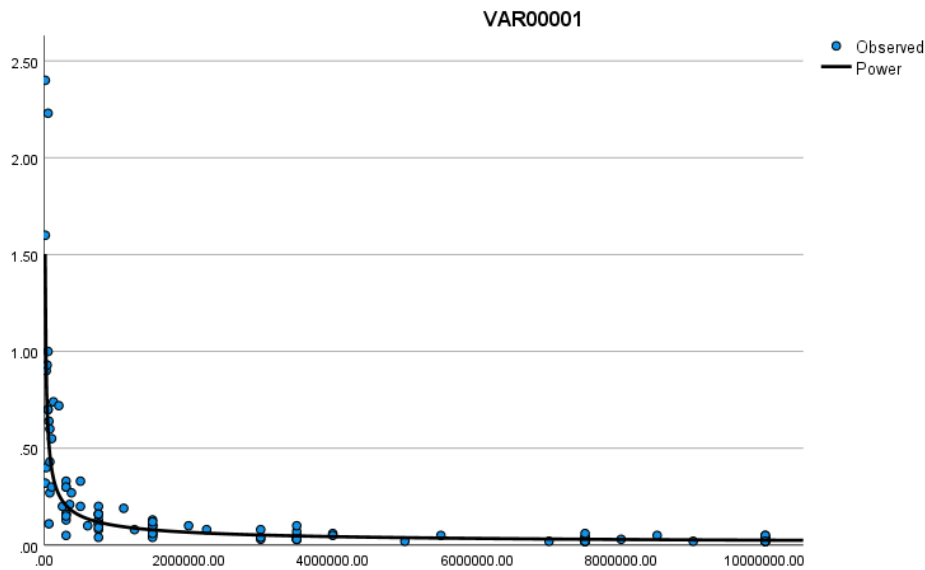
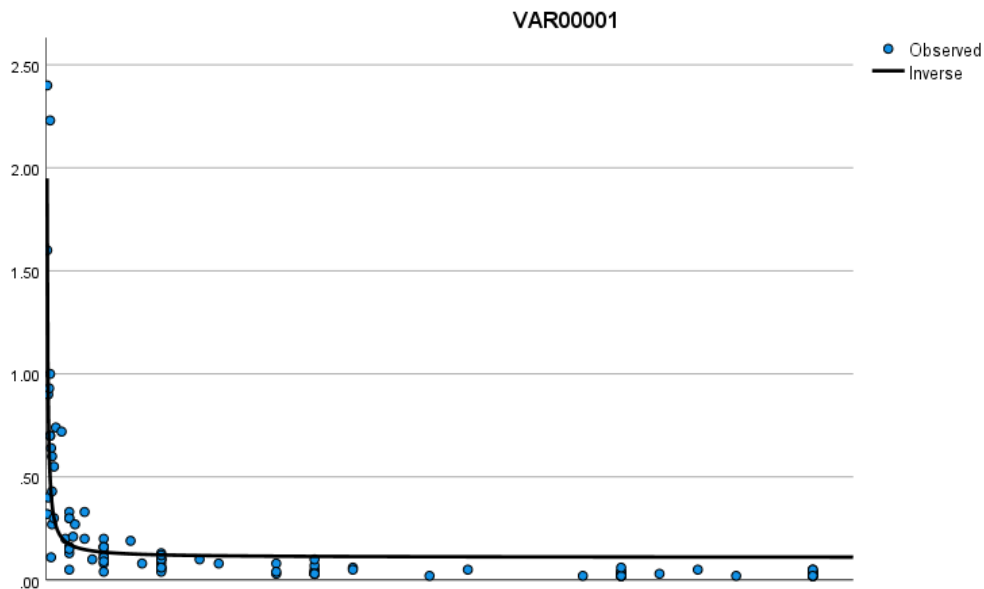


Figure 23 All Contracts up to 10M Inverse Model with R-Squared

Equation	R Square	F	df1	df2	Sig.	Constant	b1
Inverse	.540	113.841	1	97	<.001	.109	19387.520

The independent variable is VAR00003.



A Power Model is a function with an equation of  $y = ax^n$  or  $a/x^n$  (Education, 2022).

Regression analysis was run on the 4 sets of grouped data discussed above to model the data.

The results were as follows:

Table 5-4 R-Squared values of Grouped data based on CDs

<u>GROUP</u>	<u>MODEL</u>	<u>R-SQUARED</u>
All contracts up to 5M	Power	0.737
All contracts up to 10M	Power	0.802
All contracts up to 20M	Power	0.801
All contracts up to 50M	Power	0.812

An increase in contract size yielded a more accurate model, hence the **power model** from the **50M contracts** was selected.

The function obtained was  $y = 297.2894684214587 * x^{-0.5760117517472438}$

Y represents the cents per contract dollar and X the contract size. More details from the models are expounded on below.

### 5.1.2.1 Power Model All contracts up to 5M

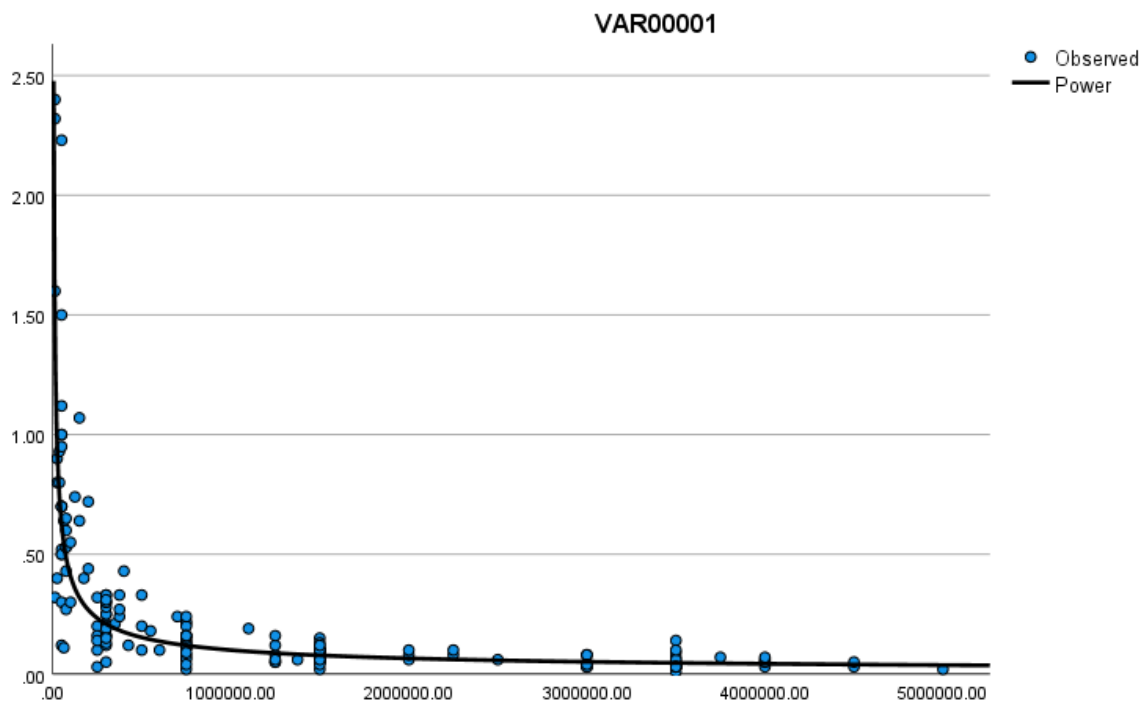
The power equation model yielded a function of  $y = 468.0384824124117 * x^{-0.6116160365002454}$

Y represents the cents per contract dollar and X the contract size.

Figure 24 Power Model All Contracts up to 5M

Equation	R Square	Model Summary				Parameter Estimates	
		F	df1	df2	Sig.	Constant	b1
Power	.737	448.583	1	160	<.001	468.038	-.612

The independent variable is VAR00002.



$$R^2 = 0.737$$

### 5.1.2.2 Power Model All contracts up to 10M

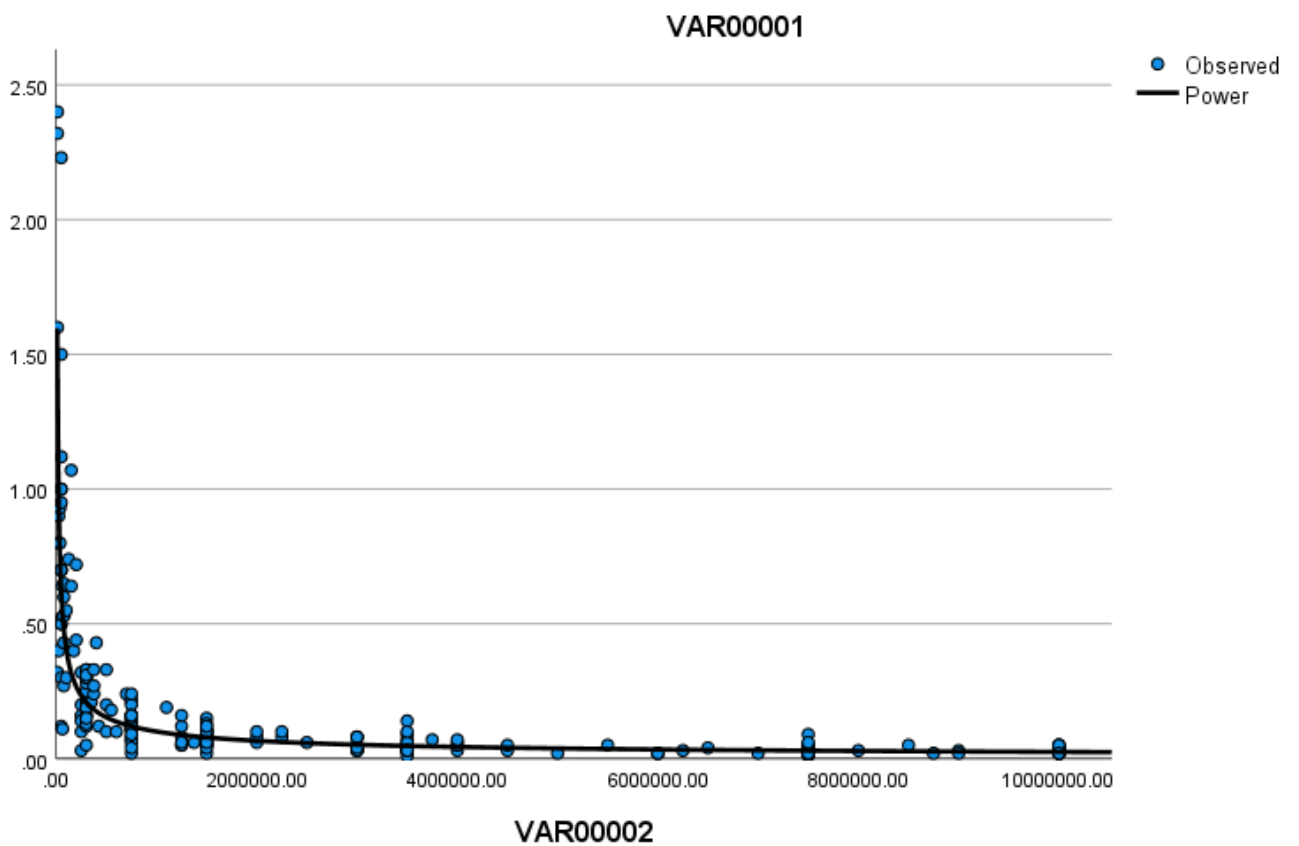
The power equation model yielded a function of  $y = 442.1881058433639 * x^{-0.6071627403932506}$

Y represents the cents per contract dollar and X the contract size.

Figure 25 Power Model All contracts up to 10M

Equation	R Square	Model Summary				Parameter Estimates	
		F	df1	df2	Sig.	Constant	b1
Power	.802	852.562	1	211	<.001	442.188	-.607

The independent variable is VAR00002.



$$R^2 = 0.802$$

### 5.1.2.3 Power Model All contracts up to 20M

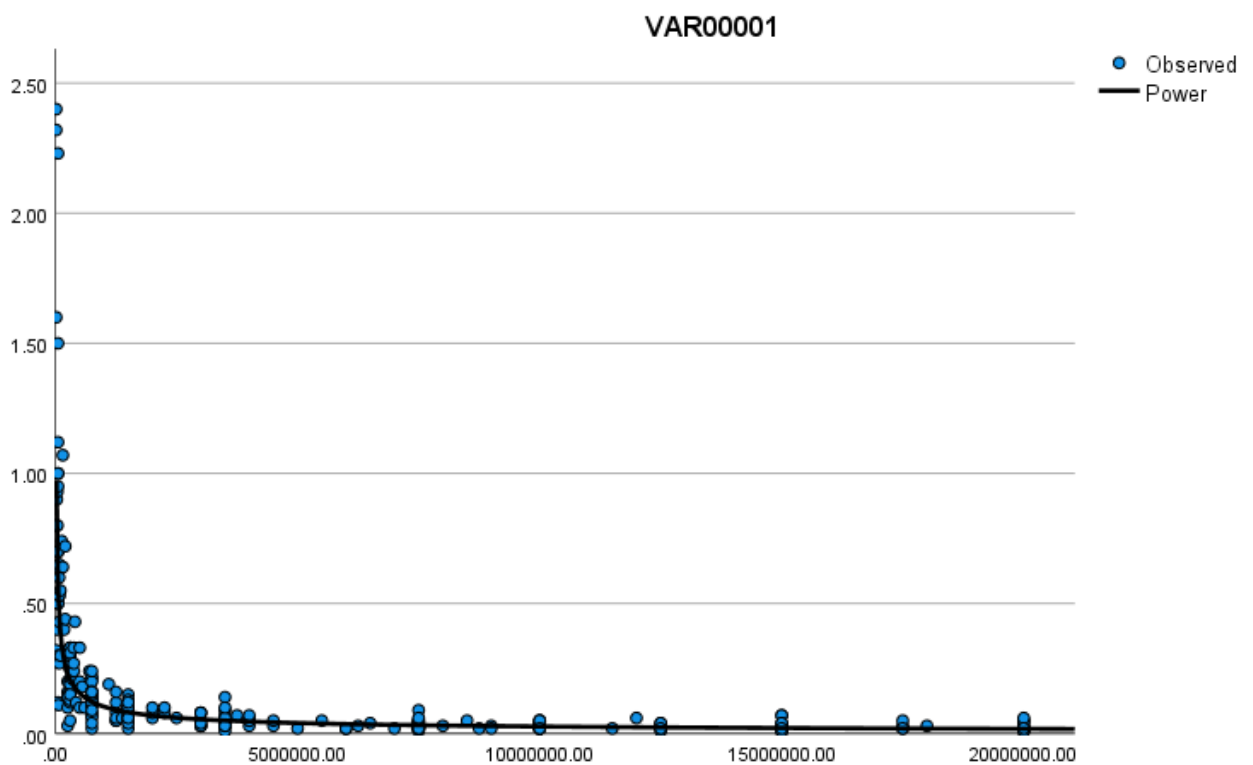
The power equation model yielded a function of  $y = 311.2295637551995 * x^{-0.579533935620663}$

Y represents the cents per contract dollar and X the contract size.

Figure 26 Power Model All contracts up to 20M

Equation	R Square	Model Summary				Parameter Estimates	
		F	df1	df2	Sig.	Constant	b1
Power	.801	1003.199	1	250	<.001	311.230	-.580

The independent variable is VAR00002.



$$R^2 = 0.801$$

### 5.1.2.4 Power Model All contracts up to 50M

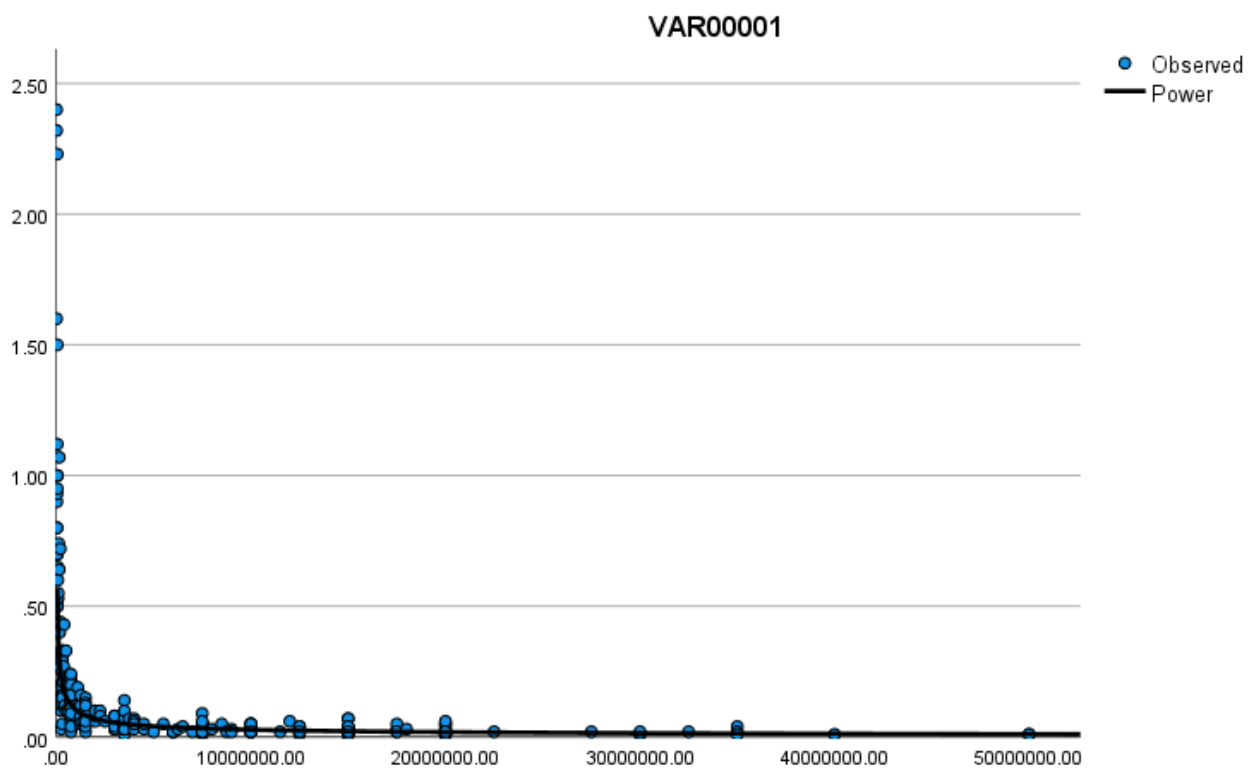
The power equation model yielded a function of  $y = 297.2894684214587 * x^{-0.5760117517472438}$

Y represents the cents per contract dollar and X the contract size.

Figure 27 Power Model All contracts up to 50M

Equation	R Square	Model Summary				Parameter Estimates	
		F	df1	df2	Sig.	Constant	b1
Power	.812	1129.873	1	262	<.001	297.289	-.576

The independent variable is VAR00002.



$$R^2 = 0.812$$

This model yielded the best R-Squared value for the calendar days models.

## 5.2 Tables Based on working Days

In addition to tables based on Calendar Days, ten (10) states have additional tables based on working days. These states include; Alabama, Alaska, Delaware, Illinois, New Hampshire, North Dakota, Rhode Island, Wisconsin, and South Dakota. Given the smaller number of states, their data was directly loaded onto IBM SPSS Statistics and using the regression function analyzed based on the previous models outlined.

Table 5-5 Working Days R-Squared values based on Models

<b>Working Days R-Squared values based on Models</b>	
<u>Model Equation</u>	<u>R-Square</u>
Linear	0.139
Logarithmic	0.625
Inverse	0.868
Quadratic	0.251
Cubic	0.330
<b>Power</b>	<b>0.932</b>
Compound	0.433
S	0.453
Logistic	0.433
Growth	0.433
Exponential	0.433

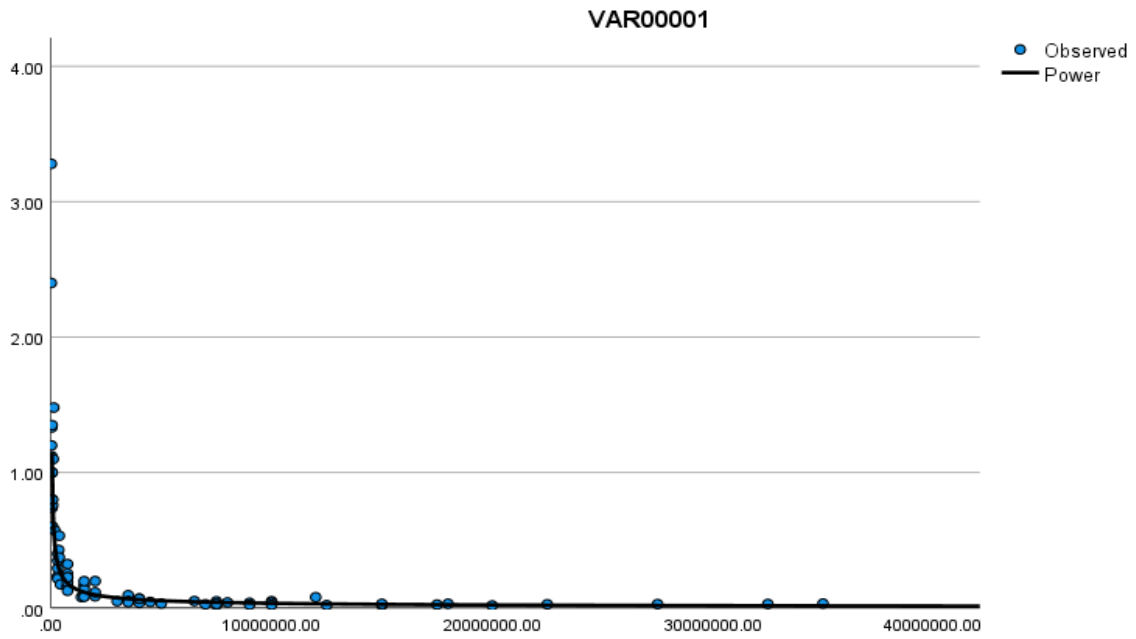
Like the Calendar Days models, the Power Model performed the best by yielding an R-Squared value closest to 1.

The power equation model yielded a function of  $y = 1058.739853417363 * x^{-0.6410201895879604}$

Figure 28 Power Model WD contracts

Equation	R Square	Model Summary				Parameter Estimates	
		F	df1	df2	Sig.	Constant	b1
Power	.932	1089.124	1	80	<.001	1058.740	-.641

The independent variable is VAR00002.



$R^2 = 0.932$

## 6 DISCUSSION AND CONCLUSION

### 6.1 SUMMARY

This research work began with the objectives of exploring and identifying non-conformity to construction schedules and the impact on the contractor for not complying with the construction schedule requirements. Additionally, the work also explored and identified how states define and manage their liquidated damages to identify whether there is a statistical model that can explain the liquidated damages.

The research reviewed Standard Specifications from all 51 DOTs in the United States to identify instances of non-conformance and Liquidated Damages. The research methods included content analysis, descriptive analysis, and statistical regression analysis of the data obtained.

The content analysis revealed contract requirements, based on the documents, and the consequences of non-conformance to them. Descriptive and statistical regression analysis on DOT Liquidated damages tables yielded tables of liquidated damages that showed the average trend of these Liquidated Damages.

The research revealed that non-conformances were the result of a failure of contractors to meet certain conditions/requirements. These conditions revolved around schedule submissions, Future bid submission clauses, Payment schedules, Positive Non-conformance, and Liquidated Damages. The consequences of non-conformances to these requirements were found to be: (a) enforcing default/Suspension/termination clauses of the general requirements, (b) Withheld Progress Payments, (c) being barred from submitting future bids, (d) Early Completion, (e) Incentive Award, and (f) Liquidated Damages.

All the states assess liquidated damages when contractors fail to meet contract milestones (final/substantial Completion). These damages are typically assessed using a table of liquidated damages (35). A few states (15) determine other forms of determining their liquidated damages as previously outlined. Even fewer states (5) use a formula for liquidated damages.

Focusing on the liquidated damages model, the LDs tables were grouped into two categories based on the contract days (Calendar vs Working Days). LDs based on WD were found to be higher than those based on CD. Using quantitative methods previously outlined in chapter 5 (Liquidated Damages Model), two equations and subsequent tables of liquidated damages using regression analysis were developed to indicate the average trend based on the states' data. The Power Model was selected since it performed the best compared to the rest of the models. These formulae are;

I. Calendar days: ( $R^2 = 0.812$ )  $y = 297.2894684214587 * x^{-0.5760117517472438}$

II. Working days: ( $R^2 = 0.932$ )  $y = 1058.739853417363 * x^{-0.6410201895879604}$

'X' representing the contract size and 'Y' the cents per contract dollar charged for each day, either contract or calendar day.

## 6.2 CONCLUSION

From the information revealed by this research, the general scheduling conditions enforced on contractors and consequences of non-conformance by state DOTs are similar. These conditions revolved around the requirement to submit a Schedule, progress payments being tied to schedule updates, and enforcement of Liquidated Damages, with only a few states being the exception. Non-conformance to these requirements results in enforcing of default/Suspension/termination clauses of the general requirements, withheld Progress Payments, being barred from submitting future bids, Early Completion, Incentive Award,

and/or Liquidated Damages. However, as the level of detail in each Standard Specification document is reviewed, several different and unique clauses are outlined by the various DOTs. The results from this research present these findings and provide an avenue for states to learn from each other to improve their documents.

Based on this review, Tables of Liquidated damages were the most widespread method of enforcing liquidated damages hence this research focused on reviewing these tables. These tables were separated based on whether assessed based on calendar days or working days and subsequently analyzed using various statistical methods and modeled using regression.

During this analysis, California's L.D.s table stood out and deserves further scrutiny given that the majority of the outliers and extreme values were obtained from this table. Once these values and the few others from the other tables were identified and set aside, regression analysis yielded two models. These models based on the power function closely matched the given data and represent the average of all the charges enforced.

The strength of this research is the analysis of the current contents of the Prosecution of work section DOT standard specification. However, more research is required to understand the rationale behind the DOTs' specific requirements and consequences for non-conformance to them as outlined in their Standard Specifications. Similarly, the Power Models obtained represent the average Liquidated Damages change by States. However, more research is required to ascertain how these charges were determined by the States DOTs.

### **6.3 RESEARCH CONTRIBUTIONS**

This research demonstrates the similarity and differences between states' treatment of non-conformances. This summary provides a basis of comparison where states can compare their documents against other states and possibly address any shortcomings or ambiguity in their

documents. This research work adds to the current body of knowledge and serves as a data point for future uniform standards Specifications.

Given the significant variation in tables of liquidated damages, the power models developed are an excellent resource for state DOTs and future researchers. The Liquidated damages models combine all the states' data into a normalized curve that can be used to compare against the national average.

Ultimately this work serves in the short term as a valuable benchmark for future revisions of state DOT Specifications and potential a long-term data point for future standardized specifications.

#### **6.4 FUTURE RESEARCH**

Given that this work narrowed down to studying DOT documents and modeling the data, the next step would be to interview the DOT staff. This could allow researchers to find out the criteria used to determine the charges for Liquidated Damages outlined in their standard specifications, and other consequences for non-conformance. These interviews could help shed light on the rationale behind the similarities and differences observed among DOT standard specifications. Additionally, a survey of General Contractors and Engineering Management firms could provide insight into the current implementation of these clauses on State highway projects.

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## 8 APPENDIX

### 8.1 Appendix A Standard Specifications Review

State	Count	Count		Alabama		
Reference	Yes/FCT/CD	No/SC/WD	BOTH/ALL	SS 2018	CM 2000	
Schedule submission	47	4		YES		
Required preconstruction	40	10		YES		
Diferrent schedules (eg. Based of contract size)	13	36		NO		
Format requirements	40	11		YES		
Computer software requirement	14	36		YES		
Requirement of updated schedule	44	7		YES		
Weekly schedule Update	7	44		NO		
Final Project Schedule	5	46		NO		
List of changes to schedule	2	49		NO		
Recovery Schedule				NO		
Payment contingent on schedule	32	19		YES		
Scheduled Meetings	24	27		NO		
Payment schedule	5	45		NO		
Payment for schedule	7	43		NO		
Future bid submission clause	2	49		NO		
Expediting Work (Early Completion)	12	39		NO		
Completing Work Early-Incentive Award	4	47		NO		
Liquidated Damages	51	0		YES		
Baseline schedule disincentive	1	50		NO		
Commencement liquidated damage	1	50		NO		
Non completion of work parts within specific time	9	42		NO		
Table of liquidated damages	35	16		YES		
Multiple tables	2	49		NO		
Formular of liquidated damages	5	46		NO		
Other Form of liquidated damage determination	15	36		NO		
Liquidated damages from the schedule update delays	5	46		NO		
Start of liquidated damage/Reference Date (final Contract	35	9	7	FCT		
Charges based on(Calendar days, working days)	24	7	19	ALL		
Default/Suspension/Termination	51	0		YES		
Time of appeal	45	6		YES		
Unsatisfactory progress of work(specific work)	23	28		YES		
Progress determination (special reviews) And disqualificati	7	44		NO		
"Failure to pursue Contract Provisions"	37	14		YES		

Alaska			Arizona			Arkansas			California			Colorado
SS 2020	CM 2019		SS 2008	CM 2015		SS 2014	CM		SS 2018	CM 2019		SS 2019
YES			YES			NO			YES			YES
YES			YES			NO			YES			YES
NO			NO			NO			YES			NO
YES			YES			NO			YES			YES
NO			NO			NO			YES			YES
YES			YES			NO			YES			YES
NO			YES			NO			NO			YES
NO			NO			NO			YES			NO
NO			NO			NO			NO			NO
NO			NO			NO			NO			NO
NO			NO			NO			YES			YES
NO			YES			NO			YES			YES
NO			NO			NO			YES			YES
NO			NO			NO			YES			NO
NO			NO			NO			NO			NO
NO			NO			NO			NO			NO
NO			NO			NO			NO			NO
YES			YES			YES			YES			YES
NO			NO			NO			NO			NO
NO			NO			NO			NO			NO
NO			NO			NO			YES			NO
YES			YES			NO			YES			YES
NO			NO			NO			NO			NO
NO			NO			NO			NO			NO
YES			NO			YES			YES			NO
NO			NO			NO			NO			NO
BOTH			SC			FCT			FCT			FCT
ALL			ALL			ALL			CD			CD
YES			YES			YES			YES			YES
YES			YES			YES			YES			YES
YES			YES			YES			YES			YES
NO			NO			NO			NO			NO
NO			NO			YES			YES			NO



	Georgia			Hawaii			Idaho			Illinois		
	SS 2013	CM 2019		SS 2005	SP 2017		SS 2018	CM 2017		SS 2016	CM 2020	
	YES			YES			YES			YES		
	YES			YES			YES			YES		
	NO			YES			NO			NO		
	NO			YES			YES			YES		
	NO			NO			YES			NO		
	YES			YES			YES			YES		
	NO			YES			NO			NO		
	NO			NO			YES			NO		
	NO			YES			YES			NO		
	NO			NO			NO			NO		
	YES			YES			YES			YES		
	NO			YES			YES			NO		
	NO			NO			NO			NO		
	NO			NO			NO			NO		
	NO			NO			NO			NO		
	NO			YES			NO			NO		
	NO			NO			NO			NO		
	YES			YES			YES			YES		
	NO			NO			NO			NO		
	NO			NO			NO			NO		
	NO			YES			NO			NO		
	YES			NO			NO			YES		
	NO			NO			NO			NO		
	NO			NO			NO			NO		
	NO			YES			YES			NO		
	NO			NO			NO			NO		
	FCT			SC			SC			FCT		
	ALL			WD			ALL			ALL		
	YES			YES			YES			YES		
	YES			YES			YES			YES		
	YES			NO			YES			YES		
	NO			NO			NO			NO		
	YES			YES			NO			YES		

Indiana			IOWA			Kansas			Kentucky			Louisiana
SS 2020	CM		SS (2020)	CM (2020)		SS 2015	CM 2014		SS 2019	CM 2009		SS 2016
YES			YES			YES			YES			YES
YES			NO			YES			YES			YES
NO			NO			NO			YES			NO
YES			YES			NO			YES			YES
NO			NO			NO			NO			NO
YES			YES			YES			YES			YES
NO			NO			NO			NO			NO
NO			NO			NO			NO			NO
NO			NO			NO			NO			NO
NO			NO			NO			NO			NO
YES			YES			NO			YES			YES
YES			NO			YES			YES			NO
NO			NO			NO			NO			NO
NO			NO			NO			NO			NO
NO			NO			NO			NO			NO
NO			YES			YES			NO			NO
NO			YES			YES			NO			NO
YES			YES			YES			YES			YES
NO			NO			NO			NO			NO
YES			NO			NO			NO			NO
NO			NO			YES			YES			NO
YES			NO			YES			YES			YES
NO			NO			NO			NO			NO
YES			NO			NO			NO			NO
NO			NO			NO			NO			NO
NO			YES			NO			NO			NO
NO			NO			NO			YES			NO
FCT			FCT			FCT			FCT			FCT
CD			CD			ALL			CD			CD
YES			YES			YES			YES			YES
YES			YES			YES			YES			YES
YES			YES			YES			YES			YES
NO			NO			NO			NO			YES
YES			NO			YES			YES			YES

	Maine			Maryland			Massachusetts			Michigan
CM 2017	SS 2020	CM 2003		SS 2018	CM 2008		SS 2020	CM2020		SS 2012 (as
	YES			YES			YES			YES
	YES			NO			YES			YES
	NO			NO			NO			NO
	YES			NO			NO			YES
	NO			NO			NO			NO
	YES			YES			YES			YES
	NO			NO			NO			NO
	NO			NO			NO			NO
	NO			NO			NO			NO
	NO			NO			NO			NO
	NO			NO			NO			NO
	NO			YES			NO			YES
	YES			NO			NO			NO
	YES			NO			NO			NO
	NO			NO			NO			NO
	NO			NO			NO			NO
	YES			NO			YES			NO
	YES			NO			NO			NO
	YES			YES			YES			YES
	NO			NO			NO			NO
	NO			NO			NO			NO
	YES			NO			NO			NO
	YES			NO			YES			YES
	NO			NO			NO			NO
	NO			NO			YES			NO
	NO			YES			NO			NO
	NO			NO			NO			NO
	FCT			FCT			BOTH			BOTH
	CD			ALL			CD			CD
	YES			YES			YES			YES
	YES			YES			NO			YES
	NO			YES			YES			YES
	NO			YES			YES			NO
	YES			YES			YES			YES

	Minnesota			Mississippi			Missouri			Montana
CM 2012	SS 2018	CM (as of		SS 2017	CM 2017		SS 2020	CM (not		SS 2020
	YES			NO			YES			YES
	YES			NO			YES			NO
	NO			NO			NO			NO
	YES			YES			YES			YES
	YES			NO			NO			YES
	YES			YES			YES			YES
	YES			NO			NO			NO
	NO			NO			NO			NO
	NO			NO			NO			NO
	YES			NO			NO			NO
	YES			YES			YES			YES
	YES			NO			YES			YES
	NO			NO			NO			NO
	NO			NO			NO			YES
	NO			NO			NO			NO
	YES			NO			NO			NO
	NO			NO			NO			NO
	NO			NO			NO			NO
	NO			NO			NO			NO
	NO			NO			NO			NO
	YES			YES			NO			YES
	NO			NO			NO			NO
	NO			NO			NO			NO
	NO			NO			YES			NO
	NO			NO			NO			YES
	FCT			FCT			FCT			FCT
	CD			CD			ALL			ALL
	YES			YES			YES			YES
	YES			YES			YES			YES
	YES			YES			NO			NO
	YES			YES			NO			NO
	YES			YES			YES			YES

	Nebraska		Nevada		New Hampshire		New Jersey	
CM not	SS 2017 (as	CM 2029	SS 2014	CM 2017	SS 2016 (as of	CM 2016	SS 2019	Const
	YES		YES		YES		YES	
	YES		YES		YES		YES	
	NO				NO		YES	
	YES		YES		YES		YES	
	NO				YES		YES	
	YES		YES		YES		YES	
	NO		NO		NO		NO	
	NO		NO		NO		NO	
	NO		NO		NO		NO	
	NO		YES		NO		YES	
	YES		NO		YES		NO	
	NO		NO		YES		YES	
	NO		NO		NO		NO	
	NO		NO		NO		NO	
	YES		NO		NO		NO	
	YES		YES		NO		NO	
	NO		NO		NO		NO	
	YES		YES		YES		YES	
	NO		NO		NO		NO	
	NO		NO		NO		NO	
	NO		NO		NO		YES	
	NO		NO		YES		NO	
	NO		NO		NO		NO	
	YES		NO		NO		NO	
	NO		YES		NO		YES	
	NO		NO		NO		YES	
	FCT		FCT		SC		FCT	
	ALL		WD		ALL		WD	
	YES		YES		YES		YES	
	YES		YES		YES		YES	
	NO		NO		NO		NO	
	NO		NO		NO		NO	
	YES		YES		YES		YES	

	New Mexico			New York			North Carolina			North Dakota
	SS 2019	CC (NO)		SS 2020	CC		SS 2018	CC (as		SS 2014
	YES			YES			YES			YES
	YES			YES			YES			YES
				NO			NO			NO
	YES			YES			YES			YES
	YES			NO			NO			NO
	YES			YES			NO			YES
	NO			NO			NO			NO
	NO			NO			NO			NO
	NO			NO			NO			NO
	NO			NO			NO			NO
	NO			NO			NO			NO
	NO			YES			NO			YES
	NO			NO			YES			YES
	NO						NO			NO
	NO			NO			NO			YES
	NO			NO			NO			NO
	NO			NO			NO			NO
	NO			NO			NO			NO
	NO			NO			NO			NO
	YES			YES			YES			YES
	NO			NO			NO			NO
	NO			NO			NO			NO
	YES			YES			NO			NO
	YES			YES			NO			YES
	NO			NO			NO			NO
	NO			NO			NO			NO
	NO			NO			NO			NO
	NO			NO			YES			NO
	NO			NO			NO			NO
	FCT			FCT			FCT			BOTH
	ALL			CD			CD			ALL
	YES			YES			YES			YES
	YES			NO			YES			YES
	NO			NO			NO			NO
	NO			NO			YES			NO
	YES			YES			YES			NO

	Ohio			Oklahoma			Oregon			Pensylvania
CC 2020	SS 2019	cc 2017		SS 2019	CC (No)		SS 2021	CC 2017		SS2020
	YES			YES			YES			YES
	YES			NO			YES			YES
	NO			NO			YES			NO
	YES			YES			YES			NO
	NO			NO			NO			NO
	YES			YES			NO			YES
	NO			NO			YES			NO
	NO			NO			NO			NO
	NO			NO			NO			NO
	YES			NO			NO			YES
	YES			YES			YES			YES
	YES			YES			YES			YES
	NO			NO			NO			NO
	NO			NO			NO			NO
	NO			NO			NO			NO
	NO			NO			NO			NO
	NO			YES			NO			NO
	NO			YES			NO			NO
	YES			YES			YES			YES
	NO			NO			NO			NO
	NO			NO			NO			NO
	NO			NO			NO			NO
	YES			YES			NO			NO
	NO			NO			NO			NO
	NO			NO			YES			NO
	NO			NO			NO			YES
	NO			NO			NO			NO
	FCT			FCT			FCT			FCT
	CD			CD			CD			CD
	YES			YES			YES			YES
	NO			YES			YES			NO
	NO			NO			NO			NO
	NO			NO			NO			NO
	NO			YES			YES			NO





		WA			W Virginia			Wisconsin			Wyomng	
CC 2016		SS 2021	CC 2020		SS 2017 with	CC 2020		SS 2021	CC2020		SS 2021	cc 2020
		YES			YES			YES			YES	
					YES			YES			YES	
		YES			YES			YES			YES	
		YES			YES			YES			YES	
		YES			YES			NO			NO	
		YES			YES			YES			YES	
		YES			NO			NO			NO	
		NO			NO			NO			NO	
		NO			NO			NO			NO	
		NO			NO			NO			NO	
		YES			YES			NO			YES	
		NO			YES			YES			NO	
		NO			NO			NO			NO	
		YES			NO			YES			YES	
		NO			NO			NO			NO	
		YES			YES			NO			NO	
		NO			NO			NO			NO	
		YES			YES			YES			YES	
		NO			NO			NO			NO	
		NO			NO			NO			NO	
		YES			NO			NO			NO	
		NO			YES			YES			YES	
		NO			NO			NO			NO	
		NO			NO			NO			NO	
		YES			NO			NO			NO	
		YES			NO			NO			NO	
		YES			NO			NO			NO	
		BOTH			SC			FCT			BOTH	
		WD			CD			ALL			WD	
		YES			YES			YES			YES	
		YES			YES			YES			YES	
		NO			NO			NO			NO	
		NO			NO			NO			NO	
		YES			YES			NO			NO	

## **8.2 Appendix B Liquidated Damages Table Based on Calendar Days**



	\$25,000	\$75,000	\$300,000	\$750,000	\$1,500,000	\$3,500,000	\$7,500,000	\$10,000,000						
Tennessee	0.10	0.06	0.05	0.02	0.01	0.01								
	\$250,000	\$750,000	\$1,500,000	\$6,000,000	\$15,000,000	\$20,000,000								
Vermont	1.07	0.43	0.24	0.16	0.10	0.07	0.05	0.04	0.06					
	\$150,000	\$400,000	\$750,000	\$1,250,000	\$2,250,000	\$4,000,000	\$7,500,000	\$15,000,000	\$20,000,000					
Virginia	0.14	0.05	0.02	0.02	0.02									
	\$250,000	\$1,250,000	\$6,000,000	\$11,500,000	\$15,000,000									
West Virginia	0.32	0.11	0.05	0.04	0.04	0.03	0.02	0.03						
	\$12,500	\$62,500	\$300,000	\$750,000	\$1,500,000	\$3,500,000	\$7,500,000	\$10,000,000						
Wisconsin	0.74	0.27	0.16	0.10	0.10									
	\$125,000	\$375,000	\$750,000	\$1,500,000	\$2,000,000									
Wyomng	0.50	0.65	0.19	0.06	0.03	0.03	0.02	0.02	0.02	0.02				
	\$50,000	\$75,000	\$300,000	\$1,250,000	\$3,500,000	\$6,250,000	\$8,750,000	\$12,500,000	\$17,500,000	\$20,000,000				
USDOT	0.20	0.12	0.10	0.06	0.05									
	\$500,000	\$1,500,000	\$3,500,000	\$7,500,000	\$10,000,000									
South Dakota	0.90	0.43	0.15	0.09	0.06	0.04	0.02	0.02	0.02	0.02	Table A			
	\$25,000	\$75,000	\$300,000	\$750,000	\$1,500,000	\$3,000,000	\$5,000,000	\$7,000,000	\$9,000,000	\$10,000,000				

### **8.3 Appendix C Liquidated Damages Table Based on Working Days**

**Working days: Cents per contract dollar. Contract dollars are the mid points of the ranges in each LD table.**

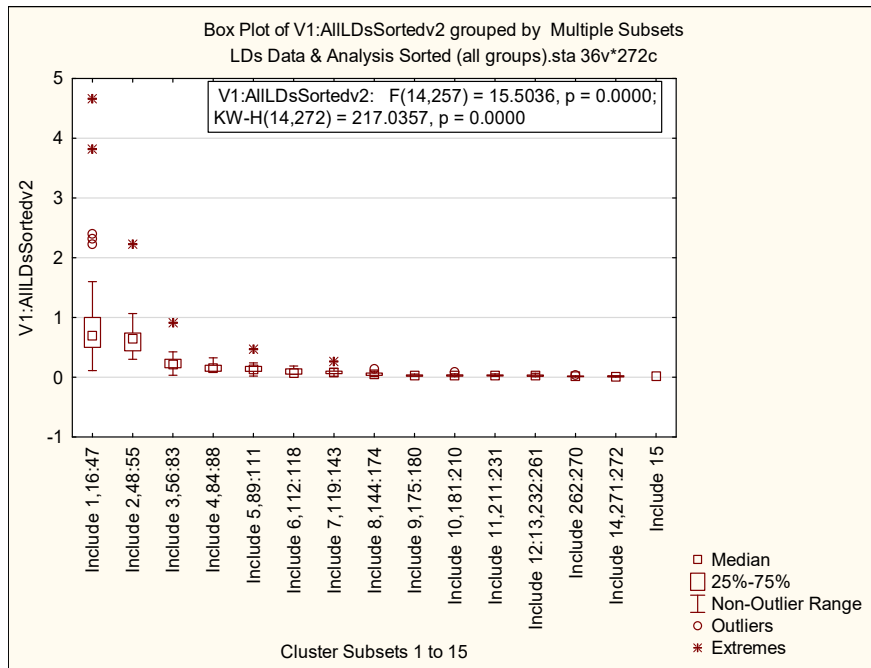
Alabama	1.10	0.43	0.25	0.17	0.09	0.05	0.05								
	\$100,000	\$350,000	\$750,000	\$1,500,000	\$3,500,000	\$7,500,000	\$10,000,000								
Alaska	1.00	0.23	0.16	0.09	0.05	0.03	0.03								
	\$50,000	\$300,000	\$750,000	\$1,500,000	\$3,500,000	\$7,500,000	\$10,000,000								
Arizona	1.00	0.23	0.16	0.09	0.05	0.03	0.03								
	\$50,000	\$300,000	\$750,000	\$1,500,000	\$3,500,000	\$7,500,000	\$10,000,000								
Delaware	3.28	1.12	0.76	0.29	0.15	0.09	0.04	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03
	\$12,500	\$37,500	\$75,000	\$300,000	\$750,000	\$1,500,000	\$3,500,000	\$7,500,000	\$12,500,000	\$17,500,000	\$22,500,000	\$27,500,000	\$32,500,000	\$35,000,000	
Illinois	1.35	0.35	0.19	0.09	0.04	0.04	0.08								
	\$50,000	\$300,000	\$750,000	\$2,000,000	\$4,500,000	\$9,000,000	\$12,000,000								
New Hampshire	0.74	0.17	0.08	0.04	0.03	0.02	0.02								
	\$50,000	\$425,000	\$1,375,000	\$4,000,000	\$7,500,000	\$15,000,000	\$20,000,000								
Utah	1.12	0.31	0.16	0.10	0.03	0.01	0.02								
	\$50,000	\$300,000	\$750,000	\$1,500,000	\$7,500,000	\$20,000,000	\$30,000,000								
North Dakota	0.80	0.57	0.37	0.23	0.12	0.07	0.05	0.04	0.03	0.03					
	\$50,000	\$175,000	\$375,000	\$750,000	\$2,000,000	\$4,000,000	\$6,500,000	\$10,000,000	\$15,000,000	\$18,000,000					
Rhode Island	2.40	1.33	0.80	0.40	0.23	0.14	0.07	0.04							
	\$12,500	\$37,500	\$75,000	\$300,000	\$750,000	\$1,500,000	\$4,000,000	\$8,000,000							
Wisconsin	1.48	0.53	0.32	0.20	0.20										
	\$125,000	\$375,000	\$750,000	\$1,500,000	\$2,000,000										
South Dakota	1.20	0.60	0.22	0.13	0.08	0.05	0.03	0.03	0.02	0.02					
	\$25,000	\$75,000	\$300,000	\$750,000	\$1,500,000	\$3,000,000	\$5,000,000	\$7,000,000	\$9,000,000	\$10,000,000					

## 8.4 Appendix D Cluster Analysis and Box Plot

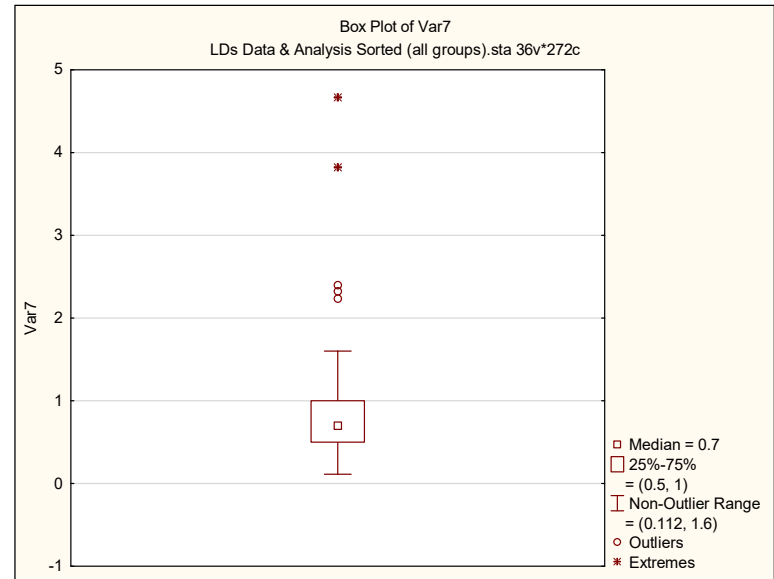




Summary Plot



This Plot is the first one in the summary plot



## 8.5 Appendix E SPSS Output Calendar Days

## Curve Fit

### Notes

Output Created	17-FEB-2022 14:11:26	
Comments		
Input	Active Dataset	DataSet0
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	264
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Cases with a missing value in any variable are not used in the analysis.
Syntax	<pre> CURVEFIT /VARIABLES=VAR00001 WITH VAR00002 /CONSTANT /MODEL=POWER /PLOT FIT. </pre>	
Resources	Processor Time	00:00:03.62
	Elapsed Time	00:00:01.26
Use	From	First observation
	To	Last observation
Predict	From	First Observation following the use period
	To	Last observation
Time Series Settings (TSET)	Amount of Output	PRINT = DEFAULT
	Saving New Variables	NEWVAR = NONE
	Maximum Number of Lags in Autocorrelation or Partial Autocorrelation Plots	MXAUTO = 16
	Maximum Number of Lags Per Cross-Correlation Plots	MXCROSS = 7
	Maximum Number of New Variables Generated Per Procedure	MXNEWVAR = 60

### Notes

Maximum Number of New Cases Per Procedure	MXPREDICT = 1000
Treatment of User-Missing Values	MISSING = EXCLUDE
Confidence Interval Percentage Value	CIN = 95
Tolerance for Entering Variables in Regression Equations	TOLER = .0001
Maximum Iterative Parameter Change	CNVERGE = .001
Method of Calculating Std. Errors for Autocorrelations	ACFSE = IND
Length of Seasonal Period	Unspecified
Variable Whose Values Label Observations in Plots	Unspecified
Equations Include	CONSTANT

[DataSet0]

### Model Description

Model Name		MOD_1
Dependent Variable	1	VAR00001
Equation	1	Power <sup>a</sup>
Independent Variable		VAR00002
Constant		Included
Variable Whose Values Label Observations in Plots		Unspecified

a. The model requires all non-missing values to be positive.

## Case Processing Summary

	N
Total Cases	264
Excluded Cases <sup>a</sup>	0
Forecasted Cases	0
Newly Created Cases	0

a. Cases with a missing value in any variable are excluded from the analysis.

## Variable Processing Summary

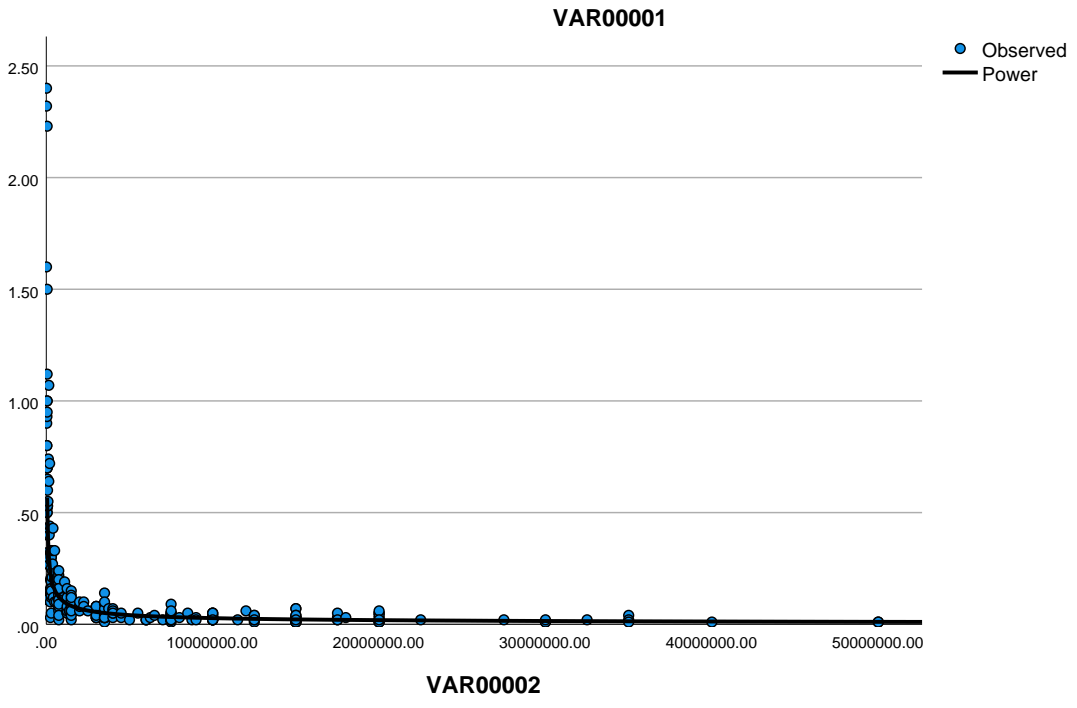
	Variables	
	Dependent VAR00001	Independent VAR00002
Number of Positive Values	264	264
Number of Zeros	0	0
Number of Negative Values	0	0
Number of Missing Values	User-Missing	0
	System-Missing	0

## Model Summary and Parameter Estimates

Dependent Variable: VAR00001

Equation	R Square	Model Summary				Sig.	Parameter Estimates	
		F	df1	df2	Constant		b1	
Power	.812	1129.873	1	262	<.001	297.289	-.576	

The independent variable is VAR00002.



## 8.6 Appendix F SPSS Output Working Days

## Curve Fit

### Notes

Output Created	19-NOV-2021 14:51:38	
Comments		
Input	Active Dataset	DataSet0
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	82
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Cases with a missing value in any variable are not used in the analysis.
Syntax	<pre> CURVEFIT /VARIABLES=VAR00001 WITH VAR00002 /CONSTANT /MODEL=POWER /PLOT FIT. </pre>	
Resources	Processor Time	00:00:03.56
	Elapsed Time	00:00:01.64
Use	From	First observation
	To	Last observation
Predict	From	First Observation following the use period
	To	Last observation
Time Series Settings (TSET)	Amount of Output	PRINT = DEFAULT
	Saving New Variables	NEWVAR = NONE
	Maximum Number of Lags in Autocorrelation or Partial Autocorrelation Plots	MXAUTO = 16
	Maximum Number of Lags Per Cross-Correlation Plots	MXCROSS = 7
	Maximum Number of New Variables Generated Per Procedure	MXNEWVAR = 60

### Notes

Maximum Number of New Cases Per Procedure	MXPREDICT = 1000
Treatment of User-Missing Values	MISSING = EXCLUDE
Confidence Interval Percentage Value	CIN = 95
Tolerance for Entering Variables in Regression Equations	TOLER = .0001
Maximum Iterative Parameter Change	CNVERGE = .001
Method of Calculating Std. Errors for Autocorrelations	ACFSE = IND
Length of Seasonal Period	Unspecified
Variable Whose Values Label Observations in Plots	Unspecified
Equations Include	CONSTANT

[DataSet0]

### Model Description

Model Name		MOD_1
Dependent Variable	1	VAR00001
Equation	1	Power <sup>a</sup>
Independent Variable		VAR00002
Constant		Included
Variable Whose Values Label Observations in Plots		Unspecified

a. The model requires all non-missing values to be positive.

## Case Processing Summary

	N
Total Cases	82
Excluded Cases <sup>a</sup>	0
Forecasted Cases	0
Newly Created Cases	0

a. Cases with a missing value in any variable are excluded from the analysis.

## Variable Processing Summary

	Variables	
	Dependent VAR00001	Independent VAR00002
Number of Positive Values	82	82
Number of Zeros	0	0
Number of Negative Values	0	0
Number of Missing Values	User-Missing	0
	System-Missing	0

## Model Summary and Parameter Estimates

Dependent Variable: VAR00001

Equation	R Square	Model Summary				Parameter Estimates	
		F	df1	df2	Sig.	Constant	b1
Power	.932	1089.124	1	80	<.001	1058.740	-.641

The independent variable is VAR00002.

