THE UNIVERSITY OF ALABAMA | Research & Economic Development
Alabama Transportation Policy Research Center

Overview of Highway Construction Cost Comparisons

POLICY REPORT ATPRC-2020-002

January 2020

ALABAMA TRANSPORTATION INSTITUTE

Cyber Hall Suite 3000 · Box 870288 · Tuscaloosa, AL 35487-0288 · 205-348-0741

This page is deliberately blank.

Table of Contents

Table of Figures

Overview of Highway Construction Cost Comparisons

Executive Summary

The Transportation Policy Research Center at the Alabama Transportation Institute, University of Alabama provides policymakers with background on current issues related to transportation and mobility. The purpose of this report is to share information specifically related to highway construction costs and establish peer states for future comparisons.

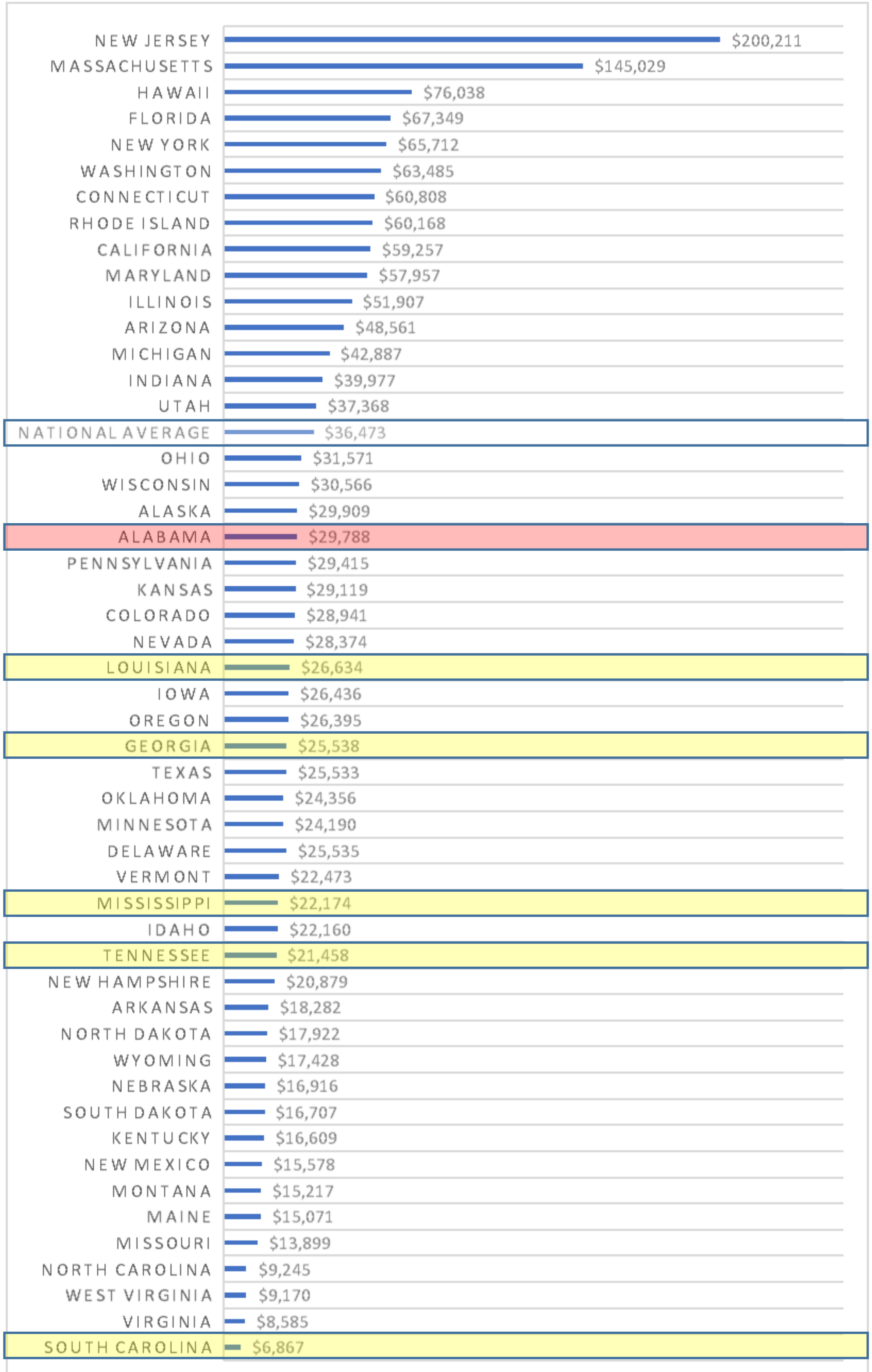
Comparing highway construction costs is complicated because no two highway projects are exactly alike and many factors contribute to the costs. Some of these factors are project length or size, materials used, type of roadway constructed, safety considerations, use and integration of technology, and the number of bidders on a project. Other variations may be caused by individual state laws or state agency standards, specifications, and contracting requirements.

One way to compare highway construction costs among states is to use the cost per mile, a figure calculated by using the dollar amount of bids awarded over time divided by the number of agency-administered lane miles. This method has shortcomings and users are cautioned against using it for projecting future costs; however, it is useful as a static measure for simple comparison. Using this method, Alabama ranks 19th among the states in cost per highway mile (Figure 1: Highway Construction Costs per Lane Mile. Midwest Economic Policy Institute, 2017) which puts it below the national average but above peer states. However, factors such as economies of scale, relative sizes of highway systems, and funding focus on large projects may not be adequately reflected.

Cost indices like the Producer Price Index (PPI) and the National Highway Construction Cost Index (NHCCI) are measures that accommodate inflation over time. There are no indices at anything less than a statewide level.

Identifying peer states for comparison with Alabama requires a review of soil types and climate along with consideration of population, economy, and other factors. When these factors are taken into account the resulting peer states recommended by this report for purposes of comparing state highway construction costs are Georgia, Louisiana, Mississippi, South Carolina, and Tennessee.

Figure 1: Highway Construction Costs per Lane Mile. Midwest Economic Policy Institute, 2017 and ATI



Overview of Highway Construction Cost Comparisons

1. Introduction

The Alabama Legislature, meeting in special session in 2019, passed several significant pieces of legislation addressing transportation issues[1]. These include House Bill 1 (HB 1), which revises the membership, operation, duties, and authority of the Permanent Joint Transportation Committee (JTC). Among other things, HB 1 authorizes the JTC to review the budget and plans of the Alabama Department of Transportation (ALDOT) and study a range of issues including costs related to highway construction.[2]

The purpose of this report is to provide the JTC with background on issues relevant to their work, specifically in the following areas:

1. An overview of highway construction costs and cost estimation issues.
2. Benchmarks to compare Alabama to at least four other states that are comparable based on climate and construction characteristics, including historical state-by-state review of the following cost factors:
    a. Direct input costs associated with highway construction
    b. Cost impacts from construction standards and requirements established in law
    c. Cost impacts from use of alternative methods of contracting and project management.
3. Factors specific to Alabama, if any, that contribute to cost differences.
4. Similarities or differences in the comparison states in their use of various materials to construct highways.

2. Highway Cost Factors

2.1. Highway Project Cost Contributors

A complicating factor in comparing highway construction costs is that no two highway projects are exactly alike. Historical data may not be a perfect indicator of future costs. A highway project requires many inputs; the inputs selected may themselves have an interaction or effect on the cost of other inputs.[3]

Differences in highway projects that affect overall project cost may include:[4],[5]

- Project length or size (economy of scale)
- Proximity to material supply locations and other construction projects
- Material selection, quantity and nature (e.g. use of recycled materials)
- Earthworks/excavation, soil stabilization, grade/slope
- Stream crossings
- Class of road (highway, arterial, collector, street)
- Work type (new construction, reconstruction, widening, surfacing)
- Safety and environmental (rain/runoff, permeability, banking/curve, shoulders, lighting)
- Bicycle, pedestrian, and aesthetic considerations
- Integration of technology (sensors, dynamic message boards, ramp controls, vehicle-to-infrastructure, accommodations for future technologies)
- Number of bidders
- Work schedule (daytime/nighttime, duration, time of year)
- Accommodation of social costs[6] (lane rental,[7] accelerated construction)
- Total contract price

In addition to the use of historical costs, modern estimation methods may be improved by the outcome of ongoing research in the field. Current technology applications include intelligent compaction and automated machine guidance.[8] Promising innovations such as the use of artificial neural networks[9] and improvements in using the cost of nearby projects for estimation purposes bring the potential for more accurate projections. Examples of such improvements include the identification of similar economic conditions using a variety of cost estimate location adjustment factors[10] like nighttime light satellite imagery.[11]

2.2. Construction Costs

The Midwest Economic Policy Institute created a comparison of state highway costs by averaging construction costs for state administered roadways from 1993 to 2015 and dividing by the number of state administered lane miles. This calculation resulted in Alabama being ranked 19th highest at $29,788 in construction costs per lane mile (2015 dollars), which is below the national average of $36,473.[12] The same study ranked Alabama 34th in right of way acquisition costs and 44th in engineering costs (Figure 2: Highway Construction Costs per State. Midwest Economic Policy Institute, 2017). Note that some researchers have concluded that using dollars per mile by highway type for future projections is unreliable due to variations in site conditions and other factors.[13] This approach may also not adequately reflect economies of scale; for example, South Carolina's highway system is 90,000 lane miles while Alabama's is 30,000.

Figure 2: Highway Construction Costs per State. Midwest Economic Policy Institute, 2017

State	Construction Costs Per Lane Mile (2015 Dollars)*	Rank	ROW Acquisition Costs Per Lane Mile (2015 Dollars)*	Rank	Engineering Costs Per Lane Mile (2015 Dollars)*	Rank	Distribution of Total Costs: Construction	ROW	Engineering
New Jersey	$200,211	1	$18,846	1	$25,046	2	82%	8%	10%
Massachusetts	$145,029	2	$4,980	7	$37,171	1	77%	3%	20%
Hawaii	$76,038	3	$16,606	2	$14,200	8	71%	16%	13%
Florida	$67,349	4	$13,986	3	$20,594	3	66%	14%	20%
New York	$65,712	5	$1,999	24	$13,630	9	81%	2%	17%
Washington	$63,485	6	$5,148	6	$19,109	5	72%	6%	22%
Connecticut	$60,808	7	$3,070	15	$15,157	7	77%	4%	19%
Rhode Island	$60,168	8	$3,285	14	$20,025	4	72%	4%	24%
California	$59,257	9	$6,811	4	$16,617	6	72%	8%	20%
Maryland	$57,957	10	$4,651	8	$10,483	10	79%	6%	14%
Illinois	$51,907	11	$1,971	25	$8,294	12	83%	3%	13%
Arizona	$48,561	12	$3,376	13	$4,708	22	86%	6%	8%
Michigan	$42,887	13	$1,802	28	$2,714	37	90%	4%	6%
Indiana	$39,977	14	$2,419	21	$2,787	36	88%	5%	6%
Utah	$37,368	15	$5,512	5	$4,776	21	78%	12%	10%
Ohio	$31,571	16	$1,728	30	$5,120	19	82%	4%	13%
Wisconsin	$30,566	17	$2,894	18	$5,498	17	79%	7%	14%
Alaska	$29,909	18	$2,004	23	$8,387	11	74%	5%	21%
Alabama	$29,788	19	$1,547	34	$1,926	44	90%	5%	6%
Pennsylvania	$29,415	20	$1,591	33	$3,757	26	85%	5%	11%
Kansas	$29,119	21	$1,335	37	$3,666	27	85%	4%	11%
Colorado	$28,941	22	$1,643	32	$5,081	20	81%	5%	14%
Nevada	$28,374	23	$3,834	9	$7,700	13	71%	10%	19%
Louisiana	$26,634	24	$1,935	26	$3,200	31	84%	6%	10%
Iowa	$26,436	25	$1,684	31	$3,977	25	82%	5%	12%
Oregon	$26,395	26	$1,825	27	$5,888	15	77%	5%	17%
Georgia	$25,538	27	$3,566	10	$3,133	32	79%	11%	10%
Texas	$25,533	28	$2,335	22	$3,427	28	82%	7%	11%
Oklahoma	$24,356	29	$2,900	17	$1,863	45	84%	10%	6%
Minnesota	$24,190	30	$2,561	19	$4,367	24	78%	8%	14%
Delaware	$23,535	31	$3,003	16	$6,178	14	72%	9%	19%
Vermont	$22,473	32	$1,001	41	$2,923	33	85%	4%	11%
Mississippi	$22,174	33	$3,463	12	$3,323	30	77%	12%	11%
Idaho	$22,160	34	$1,348	36	$5,184	18	77%	5%	18%
Tennessee	$21,458	35	$3,478	11	$5,587	16	70%	11%	18%
New Hampshire	$20,879	36	$2,559	20	$4,647	23	74%	9%	17%
Arkansas	$18,282	37	$846	42	$2,034	43	86%	4%	10%
North Dakota	$17,922	38	$394	49	$2,082	41	88%	2%	10%
Wyoming	$17,428	39	$282	50	$3,368	29	83%	1%	16%
Nebraska	$16,916	40	$662	46	$2,432	38	85%	3%	12%
South Dakota	$16,707	41	$719	44	$1,815	47	87%	4%	9%
Kentucky	$16,609	42	$1,126	39	$2,134	39	84%	6%	11%
New Mexico	$15,578	43	$454	48	$1,592	49	88%	3%	9%
Montana	$15,217	44	$1,034	40	$2,829	35	80%	5%	15%
Maine	$15,071	45	$716	45	$2,865	34	81%	4%	15%
Missouri	$13,899	46	$1,218	38	$2,129	40	81%	7%	12%
North Carolina	$9,245	47	$1,739	29	$1,716	48	73%	14%	13%
West Virginia	$9,170	48	$755	43	$1,833	46	78%	6%	16%
Virginia	$8,585	49	$1,362	35	$2,078	42	71%	11%	17%
South Carolina	$6,867	50	$495	47	$1,334	50	79%	6%	15%
National Average	$36,473		$3,090		$6,808		79%	7%	14%

* Cost Per Lane Mile calculated by dividing annual construction, right-of-way acquisition, and preliminary and construction engineering costs for state highway agency adminstered roadways (FHWA Table SF-4C), respectively, by total state highway agency administered lane miles (FHWA Table HM-81) for each state for every year between 1993 and 2015; values were then averaged to determine the final cost per lane mile. Annual construction costs were converted to 2015 dollars using Bureau of Labor Statistics CPI-U prior to the calculation.

2.3. Construction Cost Indices

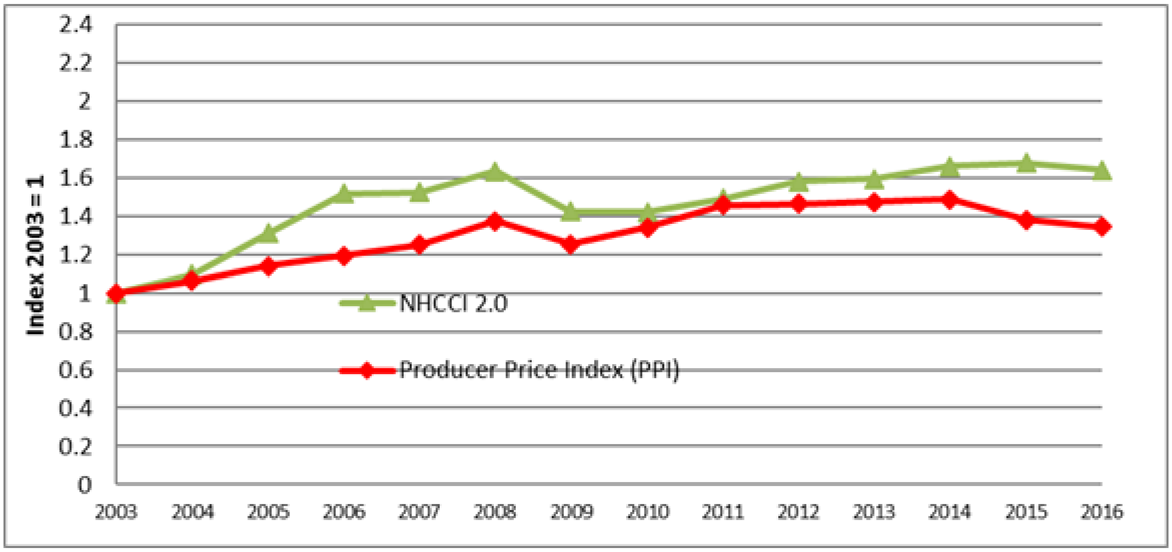
One way to measure construction costs over time is to use the Producer Price Index (PPI) generated by the U.S. Department of Labor's Bureau of Labor Statistics (BLS). BLS publishes a detailed PPI report monthly that provides prices for a wide variety of individual commodities and includes a category for inputs to highways and streets based on the U.S. Department of Commerce Bureau of Economic Analysis Input-Output Accounts Use of Commodities by Industry table as well as U.S. Census Bureau revenue data.[14] Prior to 2010, BLS aggregated data on certain materials into a highway and street construction cost index. These materials included fabricated structural metal, paving mixtures and blocks (emulsified asphalt, other liquid asphalt and tar paving materials and mixtures), and concrete products.[15] From 2010 to 2015 these were combined with other inputs into a nonresidential construction index; then the methodology changed to its current approach.

The Federal Highway Administration (FHWA) produces the National Highway Construction Cost Index (NHCCI), a quarterly price index designed to show highway construction cost changes over time. A highway construction project may have hundreds of individual pay items;[16] each item itself may have multiple subcomponents. Washington State calculates a price per ton for asphalt concrete paving that includes the cost of all the ingredients that make up the asphalt, the cost to mix and prepare it for installation, the cost of delivery by truck to the job site, and the machinery and labor to place it on the highway and compact it to a finished product.[17] Texas tracks price changes in 34 items that are highly correlated to the highway construction industry but found that the items having the greatest impact on costs are roadway embankment, cement, surface treatment aggregate, hot mix asphaltic concrete, bridge rail, and bridge slab.[18]

NHCCI data is drawn from state reports of highway construction contract bidding for 31 elements. However, because the NHCCI combines these items into general expenditure categories to account for variations in cost items, it is an inexact tool for comparisons among states and does not compare state prices.[19]

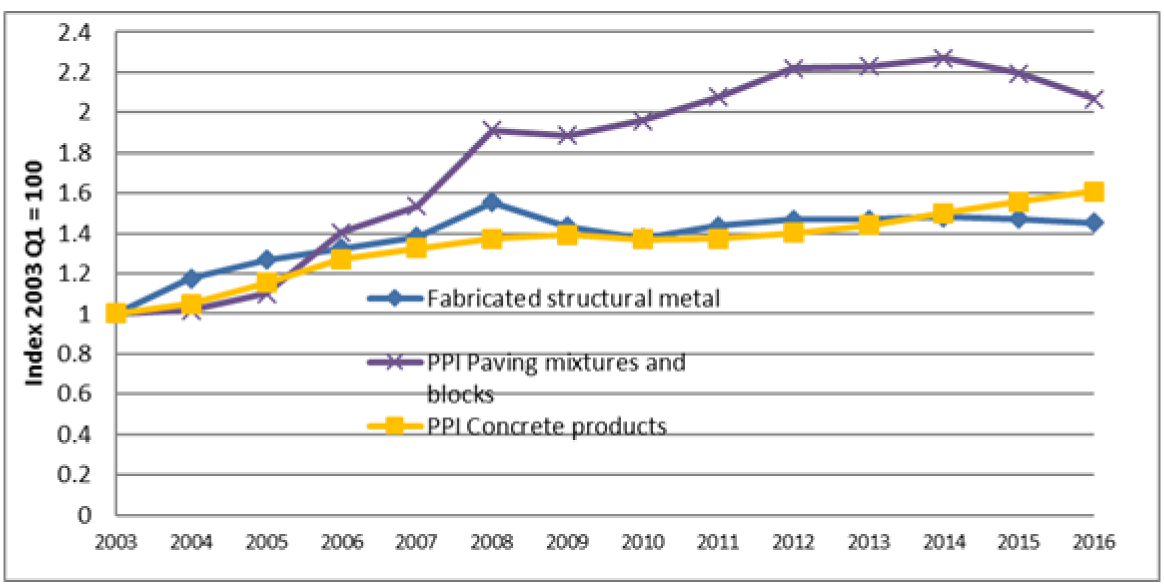
There is some variation between the PPI and the NHCCI, as shown in Figure 3: NHCCI 2.0 and PPI for All Commodities. Source: NHCCI 2.0 last modified November 14, 2017 and accessed July 5, 2019.

Figure 3: NHCCI 2.0 and PPI for All Commodities. Source: [NHCCI 2.0] last modified November 14, 2017 and accessed July 5, 2019



According to the FHWA, producer prices of major highway construction inputs have experienced much faster growth rates than the overall PPI which includes other commodities. Figure 4: PPI for Highway Construction Inputs. Source: NHCCI 2.0 last modified November 14, 2017 and accessed July 5, 2019 illustrates changes in highway construction input costs according to the FHWA.

Figure 4: PPI for Highway Construction Inputs. Source: [NHCCI 2.0] last modified November 14, 2017 and accessed July 5, 2019



A number of states maintain their own construction cost indices. Products tracked vary from state to state but typically include roadway excavation or earthwork, asphalt, concrete pavement, structural concrete, reinforcing steel, structural steel, and aggregates.[20] States with their own highway construction cost index or similar effort include California, Colorado, Florida, Iowa, Louisiana, Maryland, Minnesota, New Hampshire, Ohio, Oregon, South Dakota, Texas, Utah, and Washington State.[21] Some states maintain material price indices. Oklahoma has a monthly asphalt binder price index. Alabama publishes Asphalt and Construction Fuel indices.

The authors of this report have not identified any indices in the United States at a level smaller than a statewide index.

2.4. Other Factors Affecting Cost

When estimating future project costs, a number of states attempt to take into account current market conditions, project constructability, price-volatile materials, sequence of construction, contractor's familiarity with process, risk to contractors, and inflation.[22]

Almost every state uses historical bid data to prepare bid estimates, and about 80% of state DOTs have documented cost estimation procedures.[23] A 2015 FHWA study complimented Alabama on developing its own internal cost estimating guidance manual and a memo-based formalized process for meeting with low bidders.[24]

States can avail themselves of major project cost estimation guidance and non-regulatory cost estimation guidance from the FHWA and the American Association of State Highway and Transportation Officials (AASHTO)'s Practical Guide to Cost Estimating. However, the US DOT Office of Inspector General found in March 2019 that outdated guidance, the absence of training and limited federal oversight "could adversely impact the accuracy and reliability of the estimates that are used to evaluate bids."[25]

If a large proportion of a state's program in a given time frame is focused on constructing new lanes as opposed to resurfacing, as occurred with Alabama's Corridor X (I-22) from 1993 to 2015, the result could appear as a higher construction cost per mile. The relative size of states' revenue and highway systems could also affect the cost per mile calculation.

Several factors may vary on a state to state basis as a function of state laws or agency practices. Sources of such variation could include contracting laws and standard specifications found in agency rules. Note that in some cases the requirement or provision may originate in state law but the agency has expanded on the requirements; or they may be the result of a statutory requirement in some states but an agency rule in others. The following charts categorize the subject as statute or regulation based on how it is treated in Alabama.

2.4.1 State Contracting Laws

While state departments of transportation tend to have broad authority over contracting, statutes in a number of states require certain practices and provisions. These provisions may affect project costs. Examples include the areas of advertising requirements, performance bonds, and contract award. Other provisions such as Alabama's net worth requirements may be unique depending on states selected for comparison.

2.4.1.1 Advertising Requirements

State	Advertising Requirements: Provision of Law
Alabama	For contracts > $250,000, the Department must advertise for sealed bids. (39-2-2(j)). For projects > $50,000, the Department does not have to advertise for sealed bids if the project is listed on the Department's website for at least 7 days before entering into the contract, but the total cost of all projects not subject to advertising under this provision cannot exceed $1 million in the year. (39-2-2). The Department must advertise for sealed bids at least once each week for 3 consecutive weeks in a newspaper that is circulated where the construction is taking place. (39-2-2). Excluded from the bidding requirement are contracts to persons who do not engage in the actual construction. (e.g. project manager). (39-2-2).
Georgia	All construction contracts for $200,000 or more must be let by public bid, which includes posting a bid on the department's website. (32-2-64) The Department does not have to advertise bids for the procurement of business or professional services (e.g. project management). (32-2-61) Contracts let by public bid must be advertised for competitive bids for at least 2 weeks. The advertisement must appear in a newspaper once a week. The first appearance in the newspaper must be at least 2 weeks before the opening of bids and the next advertisement must be in the subsequent week. Alternatively, the department may place the advertisement on its website for the same amount of required time. (32-2-65)
Mississippi	Construction contracts must be competitively bid after advertisement is inserted once a week for 2 consecutive weeks in a newspaper and no letting can be less than 14 days nor more than 60 days after the publication of the 1st notice. (65-1-85) Purchases for < $5,000 allowed without advertising or requesting competitive bids. (31-7-13) Purchases between $5,000 and $50,000 may be made to the lowest and best bidder without publishing advertisement for bids if 2 competitive written bids were obtained. (37-7-13)
South Carolina	Construction contracts for > $10,000 must be advertised for at least 2 weeks in a daily newspaper and must be awarded to the lowest qualified bidder. (57-5-1620) In cases of emergency, the department can avoid the advertising requirement. (57-5-1620)
Tennessee	The department must advertise for bids for at least 2 weeks prior to the date set for receiving bids by publishing a written notice on the department's website. (54-5-114) The department may advertise for bids in a newspaper where the project is located. (54-5-114) The advertising requirements may be waived if there is a transportation system failure. (54-1-135)

State	Advertising Requirements: Provision of Law
Louisiana	Contracts for projects less than $150,000 (38:2212) but greater than $50,000 must be let according to the following: • the department must send out invitations for bids at least 10 calendar days before the date of public opening to at least 3 bona fide, qualified bidders and post notice of the bidding by electronic media available to the general public • Invitations for bids must contain complete plans, specifications and the quantity required, along with the time and place of delivery of the bid • Any qualified contractor who does not receive an invitation for bids must be sent bidding documents after the contractor makes a request for the documents • All bids must be publicly presented and publicly opened and read • The department may advertise for bids in the manner provided for projects with a cost equal to or greater than the contract limit (48:252) Contracts for projects with a cost equal to or greater than $150,000 ((38:2212) must be let according to the following: • When the plans and specifications have been approved, a request for bids must be published in the official journal of the state or through an electronic bid system approved by the department and made available to the general public, or both • The department must require alternate bids on selected highway projects based on life cost analysis and other engineering data where feasible. The department must make a quarterly report to the Joint Committee on Transportation, Highways and Public works detailing the bids put out by the department, whether the bid was an alternate bid, the award of the contract, and the basis therefor. • The advertisement for bids must be published at least once a week for 3 different weeks. No less than 21 days between advertisement and receipt of bid. • The department will charge a nonrefundable fee of $25 for each set of printed bid proposal documents provided to prospective bidders, but does not apply to bid proposal documents provided electronically through the department website. • Bidding documents cannot contain more than 3 additive alternates. If the bidding documents contain additive alternates, then the low bidder must be the lowest responsive bidder on the base bid. Additive alternates can only be accepted if acceptance does not change the status of the low bidder. • Any plan change outside the scope of the contact in excess of the contract limit must be let out for public bid. (48:252) In cases of emergency, no bids are necessary. (48:207).

2.4.1.2 Net Worth

State	Net Worth: Provision of Law
Alabama	Maximum amount of work awarded for one applicant cannot be more than 10x the applicant's net worth. (23-1-56)
Georgia	N/A
Louisiana	N/A
Mississippi	N/A
South Carolina	N/A
Tennessee	N/A

2.4.1.3 Performance Bonds

State	Performance Bonds: Provision of Law
Alabama	100% of contract bid price. (103.05)
Georgia	120% of contract bid price. (103.05)
Louisiana	100% of the contract amount. (103.05)
Mississippi	100% of contract bid price. (103.05.1)
South Carolina	100% of contract bid price, but cannot be less than $10,000. (103.5)
Tennessee	100% of contract bid price. (103.06)

2.4.1.4 Contract Award

State	Contract Award: Provision of Law
Alabama	Proposals are compared on the basis of the summation of the products of the approximate quantities shown in the bid schedule multiplied by the unit bid prices. (103.01) Awarded within 30 days of opening proposals. (103.02(a))
Georgia	Proposals are considered based on the sum of the products of the quantities shown in the Proposal multiplied by the Unit Prices Bid will be considered the amount of the Bid. (103.01) Awarded within 30 days after opening proposals. (103.02)
Louisiana	Proposals are compared based on the summation of the products of the quantities and the unit bid prices in the Schedule of Items. (103.01) Awarded within 45 days after the receipt of bids or within 20 days after the receipt by the Department of concurrence in award with all funding agencies or sources. (103.02)
Mississippi	Proposals are compared on the basis of the summation of the products of the quantities shown in the bid schedule and the contract unit prices bid. (103.01)_ Awarded within 60 days after opening proposals. (103.02)
South Carolina	Proposals are compared based on the summation of the extensions of the approximate quantities shown in the bid schedule multiplied by the unit bid prices. (103.1) Awarded within 30 days of opening proposals. (103.2)
Tennessee	Proposals are compared based on the summation of the products of the unit bid prices and the approximate quantities. (103.01) Awarded within 30 days after opening proposals. (103.04)

2.4.2 State DOT Standard Specifications

Many states have adopted their own standard specifications for highway construction and made those specifications available online. These adoptions are typically done at the state agency administrative level as opposed to being placed in statute. States adopting standards include the peer states:

- Alabama
- Georgia
- Louisiana
- Mississippi
- South Carolina
- Tennessee

A comparison of selected standard specifications follows.

2.4.2.1 Combination Bids

State	Combination Bids: Standard Specification
Alabama	"All or None" Combination Bid: the bidder must clearly designate the proposals that are being combined in a bid being submitted as an All or None combination bid and the Department will make awards to bids that are most advantageous to the State. (102.08). "Total Dollar Amount" Combination Bid: the bidder must clearly designate the proposals that are being combined in a bid being submitted as a "Total Dollar Amount" combination bid. The bidder must stipulate that the bid is for designated projects but must request to be awarded work that will not exceed the designated total dollar amount. (102.08). "Total Number of Contracts" Combination Bid: the bidder must clearly designate the proposals that are being combined in a bid being submitted as a "Total Number of Contracts" combination bid and must stipulate that the work will not exceed the designated number of contracts. (102.08). Combination bids will not be accepted on any projects wholly or partially financed by a city/county unless all the projects in the combination bid are city/county financed projects located in the same city/county. (102.08).
Georgia	Proposals may be issued for projects in combination and/or separately, so that bids may be submitted either on combination bids or separated bids to the best advantage of the Department. (102.11)
Louisiana	N/A
Mississippi	Combination bids must state one of the following: • The bidder is bidding on "All or None" of the work for designated proposals. • The reduction the bidder will make in the contract unit price of one or more of the items in any or all of the proposals. The bidder cannot reduce any contract unit price fixed by the Department. The bidder is bidding on multiple projects but desires to be awarded work not exceeding a specified total amount/number of contracts. (102.11)
South Carolina	N/A
Tennessee	N/A

2.4.2.2 Extra Work

State	Extra Work: Standard Specification
Alabama	If any alterations significantly change the character of the work under the contract, an adjustment, excluding anticipated profit, will be made to the contract. (104.02). If the cost of work does not change, the adjustment will be zero. (104.02). Before any extra work is started, a supplemental agreement must be executed that specifies the estimated quantities of extra work to be done and specifies the unit prices or lump sum agreed upon, or a written order must be issued for the work, stating that compensation will be on a force account basis. In an emergency the Engineer may direct the immediate start of extra work. (104.02).
Georgia	Whenever an alteration in character of work involves a substantial change in the nature of the design or in the type of construction or materially increases or decreases the cost of performance, a Supplemental Agreement acceptable to both parties must be executed before alteration work is started, except that in the absence of a Supplemental Agreement acceptable to both parties, the engineer may direct that the work be done by Force Account. Any Force Account Agreement must be in writing, specifying the terms of payment, signed by the State Construction Engineer and agreed to in writing by the Contractor. The engineer has unlimited authority to increase or decrease quantities of Pay Items. The engineer has the authority to extend or reduce the total length or total cost of the project by as much as 20% (104.03)
Louisiana	The Department reserves the right to order such alterations in quantities and plans, within the general scope of the contract, including alterations in grade and alignment, as deemed necessary or desirable in order to complete the work as contemplated. Pay items affected by such alterations must be performed in accordance with the project specifications and payment will be made at the same unit prices as other parts of the work. The Department reserves the right to order changes in details, including changes in materials, processes and sequences, whenever such changes are in the best interests of the public or are necessary or desirable to satisfactory completion of the work. Such changes in details must be performed in accordance with the specifications and as directed, and payment will be made as provided in 109.04. (104.02.5) When necessary or desirable to complete the project, the engineer may direct the contractor to perform unforeseen work for which there is no pay item or unit price in the contract by issuing, when appropriate, a Notice of Extra Work to the contractor. The Department will pay for such work through an approved change order. (104.02.5)
Mississippi	A significant change in the character of the work must occur for an alteration to be considered. The character of the work, as altered, must differ materially from the original proposed construction. Minor alterations are valued at less than $10,000 (104.02.3)
South Carolina	The quantity of any contract item may be altered. If the quantity increases or decreases by less than 25% of the original quantity, there is no change in the unit price. If the quantity increases or decreases by more than 25% of the original quantity, the RCE will determine if unit prices may be adjusted. (104.2)
Tennessee	If the alterations or changes in quantities significantly change the character of work, the department will make appropriate Contract adjustments, excluding loss of anticipated profits, in accordance with 1-0.06 and 109.04 as applicable. (104.03)

2.4.2.3 Prequalification Requirements

State	Prequalification Requirements: Standard Specification
Alabama	Applicants must file for prequalification at least 14 days before the date the bid opens. (102.02). Bids for 100% State funded projects will not be accepted from a corporation organized in another State if the bidder does not submit a valid Certificate of Existence issued by the Alabama Secretary of State. (102.02). Bids for federally funded projects will be accepted from a corporation organized in another State, but award of the contract is contingent upon the receipt of the Certificate of Existence from the Alabama Secretary of State. (102.02).
Georgia	Applicants with a bid greater than $500,000 are not required to prequalify. The aggregate total amount that a non-prequalified applicant may have under contract cannot exceed $2,000,000. (102.01)
Louisiana	If the estimated project cost is greater than $50,000, the contractor must show his license number, if required, on the bid envelope unless the contractor submits the bid via the Department approved electronic bidding process. If a subcontract amount is $50,000 or more, both the contractor and subcontractors are subject to the rules and regulations of the State Licensing Board for Contractors. (102.02)
Mississippi	For bids greater than or equal to $50,000 and financed 100% with State funds, the bidder must be prequalified. (102.01)
South Carolina	Applicants must file a Prime Contractor Prequalification Questionnaire. (102.1)
Tennessee	Applicants must file a Prequalification Questionnaire. (102.01)

3. Alabama

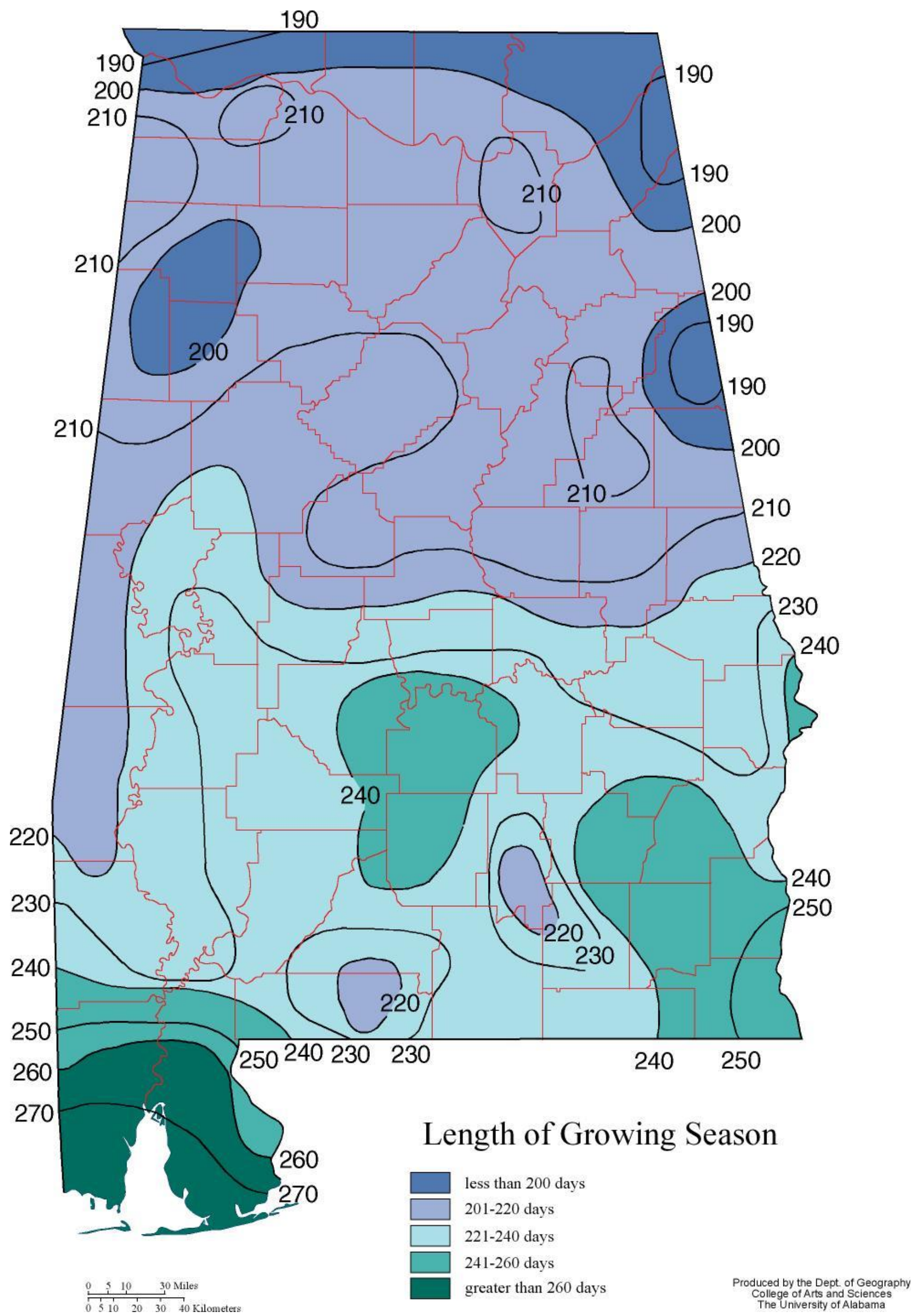
In his "History of Alabama," Dr. Albert Moore notes the state's rich diversity of topography, proclaiming "The Alabama country was highly favored in the creation, not merely with esthetic enchantment. It was given incalculable wealth in climate, soil, minerals, forest, fauna, flora, water power, and transportation facilities."[26] The extent of the diversity is such that he further notes "a thorough discussion of these resources would lead to a somewhat minute division of the State into physiographic sections…."[27]

Key components regarding the physical and climatological nature of Alabama include climate and soil types.

3.1 Climate

Alabama has a generally warm and humid climate, with four distinct seasons punctuated by turbulent weather patterns featuring tornadoes and hurricanes, providing mild winters, hot summers, and the potential for rain throughout the year. The northern half of the state tends to be slightly warmer than the southern half, with precipitation higher in the south than in the north.[28] One effect of this variation within the state is demonstrated by the length of the growing season, which varies from 190 days in the north to 270 days along the coast (Figure 5: Length of Growing Season). Temperatures in Alabama have not changed much in 50 years, but soils have become drier, annual rainfall has increased in most of the state, more rain arrives in heavy downpours, and sea level is rising about one inch every eight years.[29] The University of Alabama maintains an interactive online map with historical details for each weather station, as well as other maps showing tropical cyclones, tornadoes, and other natural phenomena.

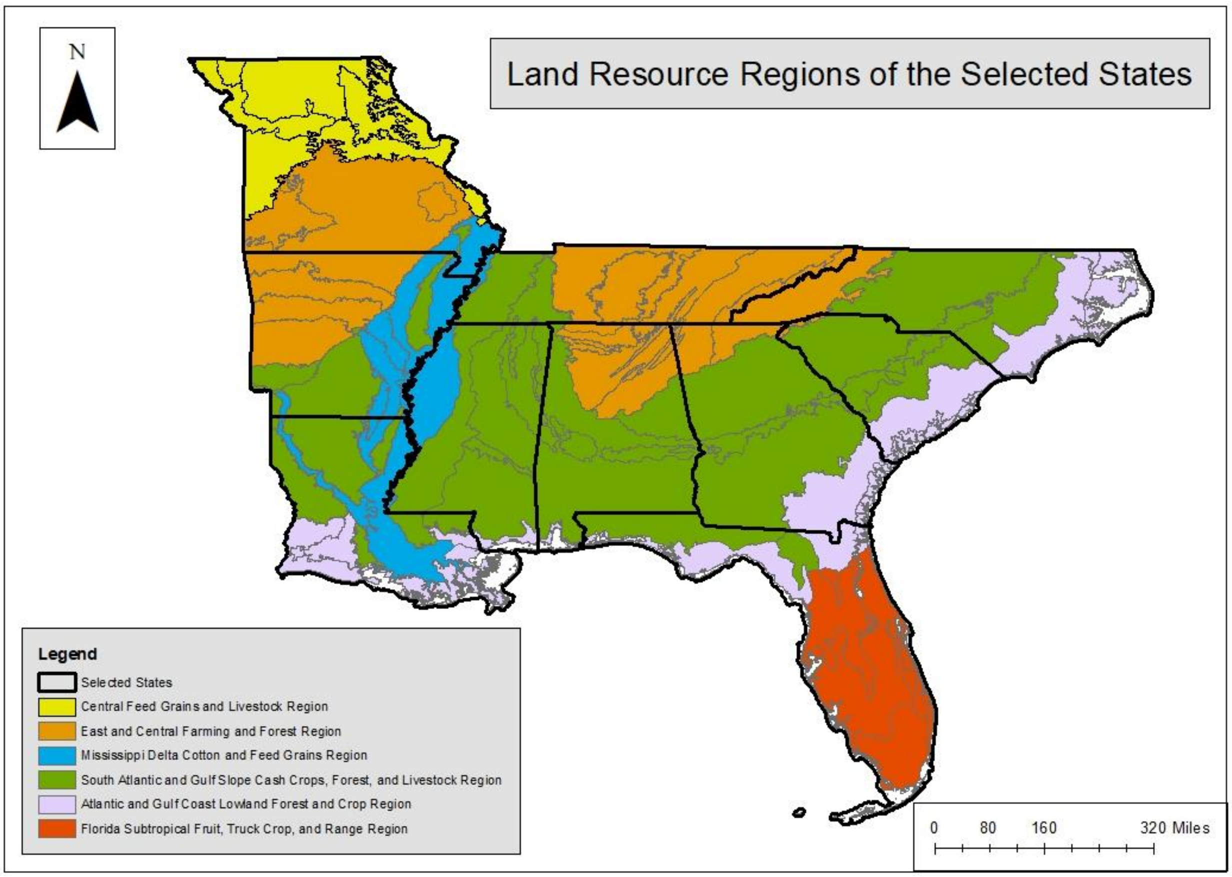
Figure 5: Length of Growing Season. Source: University of Alabama



3.2 Land Resources[30]

Alabama and nearby states share six land regions and 42 distinct land resource areas according to the USDA's Natural Resources Conversation Service (NRCS).[31] Land regions are grouped based on geographic landform and resource similarities. These geographic parallels are key when planning for infrastructure developments that occur on a regional or interstate level. Distinct land resource areas are a further classification of the land regions that focus on regional or state-wide similarities based on landforms, climate, and other environmental factors (Figure 6: Land Resource Regions of the Selected States. Source: ATI).

Figure 6: Land Resource Regions of the Selected States. Source: ATI



3.2.1 East and Central Farming and Forest Region

Highland Rim and Pennyroyal

This land resource area is located in three percent of Alabama, particularly concentrated near Athens. Dominant soil orders are Alfisols, Inceptisols, and Ultisols. Soils are moderately deep to very deep, well drained, and loamy or clayey. Most of this soil is used to support small to medium farms with some areas being used for urban development. Erosion caused by water runoff is the main concern with this type; however, construction and crop management also contributes to erosion issues.

Cumberland Plateau and Mountains

This land resource area is located in three percent of Alabama, concentrated near Huntsville. Most of the soils are Hapludults and are found along rolling terrain. These soils are moderately deep, well drained, and loamy formed in sandstone. Hapludult soils located along steep slopes are deep, well drained, and loamy formed in gravelly or stony colluvium derived from sandstone and/or shale. Most of this soil is used to support small to medium farms with large tracts used for coal or timber. Major land use issues include erosion, soil nutrient depletion, contamination, and sediment deposits.

Southern Appalachian Ridges and Valleys

This land resource area is located in 27 percent of Alabama, concentrated in the cities of Decatur, Huntsville, Hartselle, Scottsboro, Gadsden, Talladega, Birmingham, and Anniston. Urban development of this area is high and includes interstates such as I-20, I-59, and I-65. The soils in this area are mainly Udults and Udepts. Typically they are well drained, strongly acid and have a clay subsoil. They range from shallow on sandstone and shale ridges to very deep in valleys and on large limestone formations. Along the steep ridges are stony Dystrudepts that are shallow and shaly. Most of this soil is used to support small to medium farms; forested land is divided into lots. Erosion caused by slope and water movement is the main land issue and helped by buffer construction and contour farming.

Sand Mountain

This land resource area is located in 96 percent of Alabama, concentrated around the towns of Jasper, Cullman and Fort Payne. Major interstates serving this area are I-59 and I-65. Prominent soil types are Ultisols and Inceptisols. These soils are shallow to very deep, well drained, and loamy. On a smaller scale, Hapludults, Fragiudults, Dystrudepts, and Eutrudepts are located on hills, ridges, and plateaus and along the mountainsides. Land usage consists mostly of forested land that is privately, federally, or industrially owned. Poultry production is the major farming practice in the area. Soil issues that are common include erosion caused by water movement and nutrient depletion connected to livestock management.

3.2.2 South Atlantic and Gulf Slope Cash Crops, Forest, and Livestock Region

Southern Piedmont

This land resource area is located in seven percent of Alabama and is concentrated near the city of Auburn. The dominant soil types are Ultisols, Inceptisols, and Alfisols and are shallow to very deep, well drained, and loamy or clayey. Less common soil types in this area are Hapludalfs, Hapludults and Kanhapludults that are located on hills and ridges while Dystrudepts formed in alluvium are located on flood plains. Udults consist of old alluvium and are located on stream terraces. While most of the land usage comprises of small farms, there are large forested areas managed by industry. Erosion caused by water movement is the main land management concern. However, urban development is transforming farmland into urban areas which changes how the terrain reacts to erosion.

Southern Coastal Plain

This land resource area is located in 26 percent of Alabama, concentrated near the cities of Tuskegee, Eufaula, Selma, and Tuscaloosa. Interstates serving this area are I-20, I-59, and I-10. The dominant soil types are Ultisols, Entisols, and Inceptisols. These soils are very deep, excessively drained to poorly drained, and loamy. On hills and ridges are Hapludults and Kandiudults that formed in marine and alluvium sediments. Uplands and stream terraces consist of Fragiudults and Paleudults that formed in mixed marine and fluvial sediments. Fluvaquents and Endoaquepts are located in alluvium on flood plains while Paleaquults consisting of marine and fluvial sediments are located on terraces. The major land use occurs with timber management and crop production. Erosion caused by water movement is the main land use concern and managing surface water through artificial drainage is common.

Alabama and Mississippi Blackland Prairie

This land resource area is located in 53 percent of Alabama and concentrated near the towns of Demopolis, Uniontown, Montgomery, and Selma. Interstates serving this area are I-20 and I-59. The dominant soil types in this area are Inceptisols and Vertisols that are shallow to very deep, well drained to poorly drained, and loamy or clayey. Epiaquepts, Eutrudepts, Epiaquerts, and Hapludolls are located on floodplains and consist of clayey and/or loamy alluvium. Dystruderts, Hapluderts, Udorthents, and Paleudalfs formed in clayey sediments on uplands, ridges, and hills. Major land issues include erosion caused by water movement and widespread agriculture production. The majority of this area has been developed, through agriculture or urban development, and nutrient depletion in soil is a major concern in the area.

3.2.3 Atlantic and Gulf Coast Lowland Forest and Crop Region

Eastern Gulf Coast Flatwoods

This land resource area is located in nine percent of Alabama, concentrated near the city of Mobile. Major interstates serving this area are I-10, I-59 and I-65. The dominant soil types are Alfisols, Ultisols, Entisols, Spodosols, and Histosols and are deep, very poorly drained, and loamy or sandy. Alaquods formed in sandy marine sediments on flats and in depressions while Haplosaprists formed in organic deposits in swamps and depressions in marshes and swamps. Sulfaquents formed in saltwater and brackish water marshes while Psammaquents formed on dunes and in interdunal swales along barrier islands. Hydraquents are located on flood plains and Endoaquults, Paleaquults, and Paleudults were formed in marine sediments are located on flats and stream terraces. The major land management issue is erosion caused by water movement, surface compaction, and soil nutrition depletion.

3.3 Transportation Infrastructure

Alabama's 67 counties are served by and rely on a complex system of transportation infrastructure. Transportation infrastructure refers to aviation, waterways and ports, highways and bridges, railroads, and pipelines. These elements combine to provide mobility for two different "commodities" -- people and freight. The various modes complement each other, provide multiple avenues for disaster resilience, and compete for traffic with an ultimate goal of economic expansion to benefit Alabama, the nation, and the world.

Air, water, rail, and pipeline modes are primarily owned by private sector entities with regulation by the public sector but minimal public funding. Highways (a term used in this report to also include city streets, bridges, signals, and related structures and systems unless otherwise specified) are primarily publicly funded and support a mix of public and private uses including transit, passenger vehicles, and freight. Local (county and municipal) roads also support non-motorized vehicles and pedestrian activity.

Alabamians have invested and continue to invest their hard-earned money to construct and maintain the State's roadway system. Today's replacement cost of all the road and bridge assets is about $390 billion or about $210,000 per Alabama household. The replacement cost will be $630 billion over ten years or $1.0 trillion over 20 years.

The Alabama Department of Transportation maintains a detailed listing of planned projects, known as the Statewide Transportation Improvement Plan (STIP). As of this writing, the proposed new STIP is available in draft form on ALDOT's website.

Details about the condition, extent, and performance of Alabama highways are available in the recently issued report "Addressing Alabama's Transportation Infrastructure: Roads and Bridges."

Figure 7: Map of Alabama. Source: University of Alabama

4. Identifying Peer States

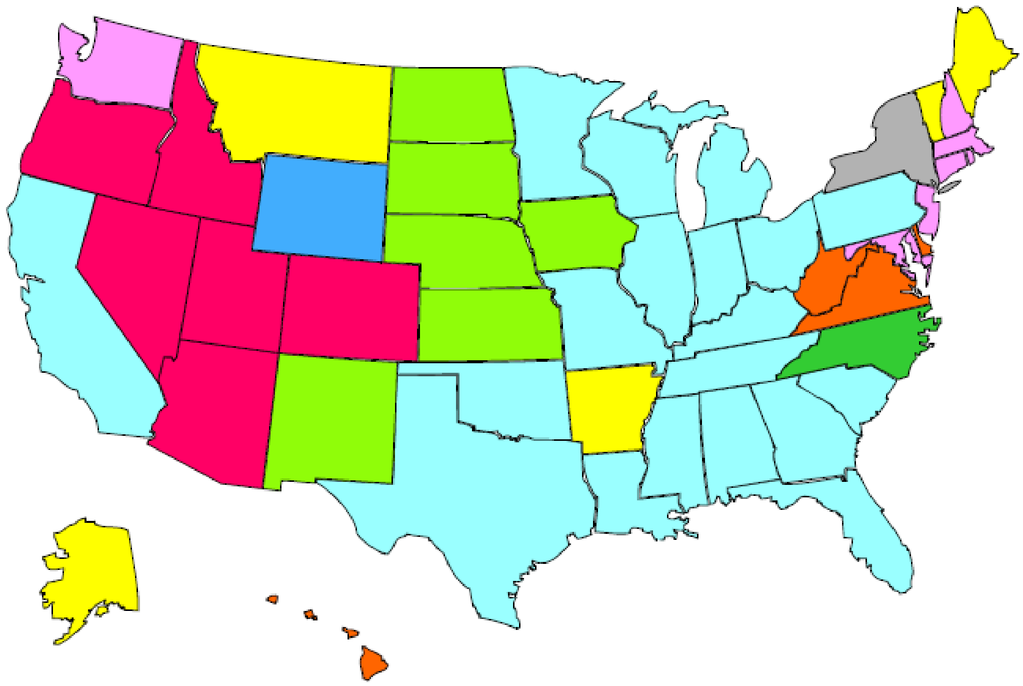
4.1. General Transportation Factors

Some factors affecting the cost of highway construction impact the states equally and so are excluded from this discussion. An example would be Buy America provisions of federal law, which can raise the direct cost of materials and indirect costs due to project completion delays.[32] Other provisions of federal law may not impact states equally (e.g. environmental, prevailing wage, disadvantaged business enterprises)[33] but are not within the scope of this document. Likewise, factors that could affect costs such as population density and design requirements are not addressed in this study due to time constraints. Also not addressed are future oriented design items that may depend on prediction and local decisionmaking such as infrastructure protection, smart roads/sensors, and resilience to sea level changes.

The FHWA recommends a set of measures for use in comparing states. These include general measures such as land area, population, personal income, and gross state product; travel measures including annual vehicle miles of travel and lane miles of roads, and state highway agency-owned roadway system measures such as roadway miles and vehicle miles traveled split out by rural and urban. Current charts developed by the FHWA providing statistics for these items are available online at Table PS-1 – Highway Statistics 2017. The FHWA further cautions "There are many differences between States in their geography, economy, traffic growth, highway system size, etc. that need to be taken into account when comparisons are made between States."[34] Hendren and Niemeier used 42 variables from the categories transportation infrastructure, population, economy, growth, topography, and weather to identify a group of 19 peer states as shown in Figure 8: Peer States using Transportation Infrastructure, Population, Economy, Growth, Topography and Weather Factors. Transportation (2008) 35: 457. The 19 states are Alabama, California, Florida, Georgia, Illinois, Indiana, Kentucky, Louisiana, Michigan, Minnesota, Mississippi, Missouri, Ohio, Oklahoma, Pennsylvania, South Carolina, Tennessee, Texas, and Wisconsin.[35]

For the purposes of highway construction, key variables include climate and soils. These variables have a significant influence on highway construction costs and help us to narrow down the list of peer states.

Figure 8: Peer States using Transportation Infrastructure, Population, Economy, Growth, Topography and Weather Factors. Transportation (2008) 35: 457



4.2 Climate and Soils

The following conditions affecting climate and soils have been shown to influence the design, planning, choice of construction materials and maintenance of highway systems in the United States.[36]

- Temperature
- Precipitation intensity
- Extreme weather conditions such as storms, hurricanes, tornadoes, drought, etc.
- Soil type

In regions where climate conditions are unfavorable for roadway construction (such as extreme temperatures, high precipitation levels, and extreme weather events), construction costs may be higher due to the need for a complex construction site analysis, use of more resilient materials and identification of alternative ways for design, construction, and maintenance of transportation infrastructure. Additionally, unfavorable climate conditions may directly affect construction costs by complicating and delaying the construction process.

For each climate characteristic from the list above, we provide a separate table below to allow for comparison of Alabama to other southeastern states. In each table, the climate characteristics of selected states that are the most similar to Alabama's climate characteristics are highlighted in green.

4.2.1 Temperature[37]

State	Winter Temp (average low temp), ºF	Summer Temp (average high temp), ºF
Alabama	35-40	87-90
Florida	49-55	88-91
Georgia	37-43	85-90
Louisiana	40-48	87-92
Mississippi	36-44	88-91
North Carolina	31-37	84-87
South Carolina	35-41	87-90
Tennessee	30-37	85-88
Virginia	27-33	82-85

Prolonged intense temperatures may diminish the quality of highway systems.[38] Extreme heat causes extra stress on bridges due to thermal expansion and increased movement. Additionally, extreme heat is associated with an increased risk of highway closures due to wildfires. Furthermore, in areas with low levels of precipitation, high temperatures and exposure to ultraviolet (UV) radiation may cause oxidation (the process of light oils combining to form heavier oils) that may make asphalt brittle and more likely to crack. Extremely low temperatures, as well as a rapid temperature decrease, may lead to the contraction of pavement and development of cracks. In the southeastern states, extremely low temperatures are very rare. In this paper, winter average low temperatures (for the period December – March) and summer average high temperatures (for the period June-September) are used for comparison of temperature characteristics between states. Using the average low and average high temperature values allows accounting for extreme temperatures that may persist over time in a given region and may, therefore, reduce highway quality.

The state of Alabama is exposed to diverse air masses, including warm and humid air masses in the regions near the Gulf of Mexico and dry continental air masses that are cold in the winter and hot in the summer in more inland areas.[39] Therefore, Alabama's climate is characterized by mild winters and hot summers. In summer, Alabama's daytime average high temperatures reach 87-90° F. In winter, the average low temperatures fall in the range of 35-40° F. States with comparable summer and winter average temperature ranges include Georgia, Mississippi, South Carolina, and Tennessee,. Florida and Louisiana have similar ranges of average summer temperatures and slightly higher average winter temperatures.

4.2.2 Precipitation Intensity

State	Precipitation Type	Mean Annual Precipitation Level
Alabama	Rain Snow (up to 3 inches annually for the majority of the state; up to 6 inches in northern parts)	45-60 inches for the majority of the state; 60-90 inches in the southern part of Alabama
Florida	Rain Snow is extremely rare	45-60 inches for the majority of the state; 60-90 inches for the northwestern part of the state; second-highest level of precipitation in the country.
Georgia	Rain Snow (up to 3 inches for the majority of the state, up to 6 inches in northern parts)	45-60 inches
Louisiana	Rain Snow (up to 3 inches in central and northern parts).	45-60 inches; 60-90 inches for the southern and eastern parts of the state. The highest levels of precipitation in the nation.
Mississippi	Rain Snow (up to 3 inches annually for the majority of the state, up to 6 inches in northern parts)	45-60 inches; 60-90 inches in the south of the state
North Carolina	Rain Snow (up to 3 inches in southern parts, up to 6 inches in central parts, and up to 12 inches in northern parts) Occasional ice storms	45-60 inches; 30-45 inches for the northern part of the state
South Carolina	Rain Snow (up to 3 inches annually for the majority of the state, up to 6 inches in northern parts)	45-60 inches for the majority of the state
Tennessee	Rain Snow (up to 4-6 inches in southern parts, up to 10 inches in northern parts) Occasional ice storms	Varying levels; 45-60 inches for the majority of the state
Virginia	Rain Snow (up to 12 inches in southern parts, up to 24 inches for the majority of the state) Occasional ice storms	30-45 inches for the majority of the state

Intense precipitation and its aftermath (such as flooding) may lead to the damage to tunnels and culverts, road washouts due to landslides and slope failures, and pavement deterioration due to water puddling in pavement's deformed areas. Furthermore, higher levels of snow may be associated with an increased need for use of road salt and therefore, increased risk of infrastructure corrosion. Additionally, in winter, areas of snowfall and ice storms tend to see longer road construction seasons (thus, higher construction costs).

Alabama's levels of average annual precipitation are relatively high and reach 45 to 60 inches annually for the majority of the state, and 60-90 inches annually in the Gulf Coast areas. Alabama's precipitation levels are similar to Tennessee, Mississippi, Louisiana, Georgia, Florida, and South Carolina.[40]

4.2.3 Extreme Weather Events

State	Number of Severe Weather Days per Year (days with at least one tornado, wind and/or hail report within ~25 miles)	Types of Extreme Weather Events	Average Annual Tornadoes per 10K Square Miles
Alabama	12-20 in southern parts; 20-30 in northern parts	Tornadoes, hurricanes, drought	10
Florida	12-22	Thunderstorms, intense coastal storms, tornadoes, wildfires, drought, heat waves	10
Georgia	14-22	Thunderstorms, severe storms and flooding, tornadoes	5
Louisiana	12-20	Severe thunderstorms, flooding, extreme heat, tornadoes, ice storms, tropical cyclones	8
Mississippi	12-20 for the majority of the state; up to 36 in the central part	Severe thunderstorms, tornadoes, hurricanes, severe flooding, storms	10
North Carolina	Up to 20 in the coastal areas, up to 40 in the western part of the state	Tropical storms, hurricane, heat waves, drought, coastal flooding, landslide in the mountain regions, tornadoes	6
South Carolina	12-25 in the eastern part of the state; up to 35 in the central and western parts of the state	Severe storms, tornadoes, hurricane, droughts	8
Tennessee	20-30 for the majority of the state	Severe thunderstorms, flooding, extreme heat, tornadoes, cold waves and ice storms	8
Virginia	Up to 30 for the majority of the state	Severe thunderstorms, tornadoes, winter storms, hurricanes, droughts and heat waves	5

Extreme weather events may lead to the displacement of highway and bridge decks, flooding, and interruptions in the shipment of goods and materials. Higher frequency of extreme weather events is linked to higher costs of road construction projects due to infrastructure damage, choice of more resilient types of construction materials, longer construction periods and higher maintenance costs.

Tornadoes and hurricanes are considered to be the deadliest weather hazards in the state of Alabama. They may result in significant highway infrastructure damage from winds and flooding. Additionally, Alabama's soils have a relatively poor water-holding capacity. This frequently gives rise to short-term drought conditions that may also damage pavement. The average annual number of severe weather days fall between 12-20 for Alabama's southern areas and reaches 33 in the state's northern parts.[41] These numbers of severe weather days are comparable to Tennessee, Florida, Louisiana, Mississippi, and South Carolina. The average annual number of tornadoes in Alabama (10 tornadoes per 10,000 square miles per year) is comparable to Mississippi (10), Florida (10), Tennessee (8), Louisiana (8), and South Carolina (8).

4.2.4 Soil Type

State	Dominant Soil Type
Alabama	**Ultisol** (majority of the state), **vertisol** (central part), **alfisol** (regions in central and northern parts)
Florida	Various types, **ultisol** (northern part)
Georgia	**Ultisol** (majority of the state), **alfisol** (regions in the central part), **spodosol** (south-east)
Louisiana	Various types, **ultisol** and **alfisol** (eastern and northern parts; **vertisol** (along the eastern border)
Mississippi	**Ultisol** and (eastern part of Mississippi), **vertisol** (regions in western, and eastern Mississippi) **alfisol** (northern, central and south-western parts)
North Carolina	**Ultisol** (majority of the state); **alfisol** (central part) and **inceptisol** (western and eastern parts)
South Carolina	**Ultisol** (majority of the state), **alfisol** (regions in northern and south-eastern parts)
Tennessee	**Ultisol** (central and southern parts of Tennessee); **alfisol** (eastern and central parts), **inceptisol** (western part)
Virginia	**Ultisol** (majority of the state), **alfisol** (regions in the central parts of the state) and **inceptisol** (along the western border)

Ultisol, **vertisol** and **alfisol** are the dominant soil types in Alabama. **Ultisol** is the most common soil type in Alabama.[42]

Ultisols are soils that have formed in humid areas and are intensely weathered. They typically contain a subsoil horizon that has an appreciable amount of translocated clay and are relatively acidic.[43]

Vertisols are clay-rich soils that contain a type of expansive clay that shrinks and swells dramatically. These soils shrink as they dry and swell as they become wet. The movement of these soils can crack building foundations and crack roads. Vertisols are highly fertile.[44]

Alfisols are similar to ultisols but are less intensely weathered and acidic. Alfisols are located in similar climatic regions as ultisols and tend to be more fertile than ultisols.[45]

4.3 Peer State Recommendation

Peer states comparable to Alabama based on soil structure:

- **Alfisol, ultisol, and vertisol are present in the following southeastern states:** eastern Mississippi, northern Louisiana.
- **Ultisol is a dominant soil type in the following southeastern states:** Georgia, South Carolina, northern Florida, southern/central Tennessee, North Carolina, and Virginia.

Using these criteria combined with climate considerations and limiting the selection to five states, these states could be considered peer states to Alabama for the purpose of comparing highway construction costs: Georgia, Louisiana, Mississippi, South Carolina, and Tennessee.

5. Conclusions

Comparing the costs of highway construction on a state by state basis is complex due to the unique nature of highway projects, the many factors and variables that affect project and construction costs, the amount and type of data available, and varying local conditions. Laws and administrative standard specifications vary from state to state and may also affect costs. There are no cost indices on less than a statewide level. Alabama's cost per mile are below the national average but above peer states of Georgia, Louisiana, Mississippi, South Carolina, and Tennessee.

6. Acknowledgments

This report was prepared by Olga Bredikhina, Justin Fisher, Gary Jordan, Bouran Mozayen, Steven Polunsky, and Melissa Wheeler for the Alabama Transportation Institute at the University of Alabama and produced by the Transportation Policy Research Center, a unit of the Alabama Transportation Institute.

ALABAMA TRANSPORTATION POLICY RESEARCH CENTER
atprc.ua.edu

Endnotes

---

[1] Policy Research Brief: Key Transportation Legislation of 2019. Alabama Transportation Policy Research Center, Tuscaloosa, Alabama, June 2019. accessed July 3, 2019.

[2] Act 2019-1, HB1. Accessed July 3, 2019.

[3] Baek, M. (2018). Quantitative Analysis for Modeling Uncertainty in Construction Costs of Transportation Projects with External Factors (Doctoral dissertation, Georgia Institute of Technology).

[4] Al-Zwainy, F. M. (2018). A State-of-the-Art Survey to Estimate Construction Costs in Highway and Bridge Projects: Analytical Diagnostic Study. International Journal of Civil Engineering and Technology, 9(5).

[5] Baek, M., & Ashuri, B. (2019). Analysis of the Variability of Submitted Unit Price Bids for Asphalt Line Items in Highway Projects. *Journal of Construction Engineering and Management*, *145*(4), 04019020.

[6] Gilchrist, A., & Allouche, E. N. (2005). Quantification of social costs associated with construction projects: state-of-the-art review. *Tunnelling and underground space technology*, *20*(1), 89-104.

[7] Lane Rental. Washington State Department of Transportation, accessed July 13, 2019

[8] Construction Technologies and Innovation. US DOT, updated June 27, 2017, accessed July 14, 2019.

[9] AL-Zwainy, F. M., & Aidan, I. A. A. (2017). Forecasting the cost of structure of infrastructure projects utilizing artificial neural network model (highway projects as case study). *Indian J. Sci. Technol*, *10*(20), 1-12.

[10] Migliaccio, G. C., Zandbergen, P., & Martinez, A. A. (2013). Empirical comparison of methods for estimating location cost adjustments factors. Journal of Management in Engineering, 31(2), 04014037.

[11] Zhang, S. (2016). Assessing the Utility of Nighttime Light Satellite Imagery for Adjusting Cost Estimate by Project Location.

[12] M Craighead, A Comparison of Highway Constructions Costs in the Midwest and Nationally. Midwest Economic Policy Institute, March 20, 2018.

[13] Wilmot, C. G., & Cheng, G. (2003). Estimating future highway construction costs. Journal of Construction Engineering and Management, 129(3), 272-279.

[14] PPI Detailed Report for May 2019, Table 13, Footnote 3, p. 170.

[15] National Highway Construction Cost Index (NHCCI) 2.0. Federal Highway Administration, November 14, 2017, accessed July 5, 2019.

[16] Validation of Project-level Construction Cost Index Estimation Methodology Draft Report. University of Colorado Denver, July 2017.

[17] Highway Construction Cost Comparison Survey, Final Report. Washington State Department of Transportation, April 2002.

[18] Highway Cost Index Estimator Tool Final Report. Texas Transportation Institute, March 2018.

[19] K. White and R. Erickson, New Cost Estimating Tool. FHWA, July/August 2011. Accessed July 7, 2019.

[20] Highway Construction Costs and Cost Inflation Study. Minnesota Department of Transportation, February 2018.

[21] Texas Transportation Institute, ibid.

[22] Synthesis on Construction Unit Cost Development: Technical Report. Texas A&M Transportation Institute, January 2009.

[23] National Review of State Cost Estimation Practice. U.S. Department of Transportation, February 2015.

[24] Ibid, p. 21.

---

[25] FHWA Lacks Adequate Oversight and Guidance for Engineer's Estimates. U.S. Department of Transportation, Office of Inspector General. March 2019.

[26] Moore, Albert B. History of Alabama (1934). *Tuscaloosa, Alabama* (1934): p. 2.

[27] Ibid.

[28] Chaney, P. Climate. Encyclopedia of Alabama. Updated June 12, 2013. Accessed July 9, 2019.

[29] What Climate Change Means for Alabama. U.S. Environmental Protection Agency, August 2016.

[30] NRCS, U. (2006). Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. *US Department of Agriculture Handbook, 296.*

[31] Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. 2006. Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin. Agricultural Handbook 296 digital maps and attributes. Available online. Accessed July3, 2019.

[32] Effects of Buy America on Transportation Infrastructure and U.S. Manufacturing, Congressional Research Service, July 2, 2019. Accessed July 7, 2019.

[33] "Federal Requirements for Highways May Influence Funding Decisions and Create Challenges, but Benefits and Costs Are Not Tracked," GAO-09-36, December 2008.

[34] Introduction – Highway Statistics 2017. Office of Highway Policy Information, Federal Highway Administration, December 6, 2018. Accessed July 3, 2019.

[35] Hendren, P. & Niemeier, D.A. Identifying peer states for transportation system evaluation & policy analyses. Transportation (July 2008) 35: 445. Accessed July 3, 2019.

[36] Meyer, M., Flood, M., Keller, J., Lennon, J., McVoy, G., Dorney, C., & Smith, J. (2014). *Strategic Issues Facing Transportation, Volume 2: Climate Change, Extreme Weather Events, and the Highway System: Practitioner's Guide and Research Report* (No. Project 20-83 (5)).

[37] Weatherbase. (n.d.) United States of America – Weather Averages. Accessed July 5, 2019.

[38] Farris, D. (2017) How Does Weather Affect Asphalt Pavement? [Web log post]. Accessed July 3, 2019.

[39] States Climate Summaries. NOAA National Centers for Environmental Information. (2019) Accessed July 3, 2019.

[40] NRCS, U. (2006).

[41] NOAA National Weather Service Storm Prediction Center. (2015) Severe Weather Days per Year from 2003-2012 Reports. Accessed July 3, 2019.

[42] University of Idaho. (n.d.) Dominant Soil Orders in the United States [map]. 1:7,500,000. Retrieved July 5,[h] 2019.

[43] Lindbo, D. (n.d.) Soil Types. Soil Science Society of America [Web log post]. Accessed July 5, 2019.

[44] Ibid.

[45] Ibid.

Alabama Transportation Policy Research Center