ALABAMA TRANSPORTATION INSTITUTE
TRANSPORTATION POLICY RESEARCH CENTER

To: Senator Clyde Chambliss, Jr.

From: Steven Jones, PhD
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Executive Director, Alabama Transportation Institute

Re: Alabama Transportation Institute (ATI) Report on the Impact of Heavier Truck Loads on Alabama's Bridges and Roads

EXECUTIVE SUMMARY

The Alabama Transportation Institute (ATI) at the University of Alabama conducted an independent review of the Alabama Department of Transportation's (ALDOT) analysis regarding the impact of proposed legislation (SB110) that would increase the allowable weight on truck axles in Alabama. **ATI's findings confirm ALDOT's conclusion that heavier axle loads will result in increased damage to Alabama's bridges and roadways.**

KEY FINDINGS

Impact on Alabama's Bridges:

- **Increased Internal Forces:** Heavier axles generate greater stress on bridge components (such as girders, decks, piers), potentially **exceeding design limits** and requiring additional load posting, strengthening, or redesign.

- **Excessive Deflections:** Bridges may experience greater deflection (bending), **increasing the risk of concrete cracking and misalignment** of bearings, especially on older bridges.

- **Accelerated Fatigue Damage:** Repeated exposure to higher axle weights significantly **increases the risk of fatigue-related damage**, which could shorten the lifespan of steel and concrete bridge components. ALDOT's load rating analysis does not explicitly account for cumulative fatigue damage, so the consequences of this long-term damage will be in addition to an increase in the number of weight restricted bridges.

ALDOT's analysis determined that the number of load-posted bridges would increase from 1 to 8 on state highways and from 787 to 1,135 on county roads if SB110 becomes law. **ATI concluded that ALDOT's methodology follows industry standards, and ALDOT's findings are valid and reliable.**

Impact on Pavements:

- ATI's review confirmed that pavement damage is not linked to total vehicle weight but rather to the weight of axles. **Heavier axles increase pavement damage exponentially**, following the "fourth power law," meaning even small increases in axle weight will cause significantly greater damage.

- ALDOT's analysis indicates that maintaining pavement integrity under heavier axle loads would **require more frequent resurfacing or additional asphalt thickness, both of which increase costs to taxpayers**. Interstate highways may require an estimated 0.7 inches of added asphalt, while state, county, and local roads may require even greater thicknesses due to their lower structural capacity.

CONCLUSION

ATI's independent review determined that **ALDOT's analysis is technically sound, well-supported by established engineering practices, and accurately highlights the increased risks and costs** associated with heavier truck loads. While ALDOT's study did not fully explore long-term fatigue damage on bridges, ATI notes that such damage is a legitimate concern that warrants additional monitoring and research.

APPENDICES

- A1 – ATI analysis of impact to State bridges

- B1 – ATI analysis of impact to State pavements

The Alabama Transportation Institute (ATI) at The University of Alabama supports faculty-led efforts to forge innovative, data-driven and cost-effective solutions that advance Alabama's economy, safety and quality of life through transportation. ATI has *established itself as a nationally recognized transportation institute and serves as a resource for research and economic development in the state of Alabama.*

Appendix A – ATI analysis of impact to State bridges

Section 1. General effect of truck loads heavier than current allowable maximums

Truck loads exceeding the current allowable maximums potentially lead to the following technical effects:

- **Increased internal forces**: Axles heavier than the allowable maximums increase internal forces, such as bending moments, shear forces, and stresses, in bridge components (girders, decks, piers), potentially exceeding design capacities and requiring load posting, strengthening, or redesign per AASHTO LRFD Bridge Design Specifications (LRFD) and Manual for Bridge Evaluation (MBE).
- **Excessive deflections:** AASHTO LRFD Section 2.5.2.6 specifies deflection limits to ensure user comfort and structural integrity—typically L/800 for vehicular loads on steel/concrete bridges (where L is the span length) and L/1000 with pedestrian use. Heavier axles amplify midspan deflections, potentially violating these criteria and leading to secondary effects like cracking in concrete decks or misalignment of bearings. For older bridges with less conservative designs, excessive deflections could trigger load posting or rehabilitation.
- **Accelerated fatigue damage**: Repeated overloads accelerate fatigue in steel and concrete elements. AASHTO LRFD Sections 5.5 (for concrete) and 6.6 (for steel) specify the fatigue design limits. A heavier axle can significantly increase stress ranges, accelerate fatigue damage, and reduce the fatigue life per the S-N (stress vs. number of cycles) curve.

Section 2. Review of ALDOT Testimony and Analysis Methodology for SB110 (Bridge)

Based on the ALDOT testimony document about bridge evaluation, including its Appendix A and other attached materials, ALDOT performed bridge rating analysis using three different methods, ASR, LFR, and LRFR, respectively, to different types of bridges (e.g., reinforced concrete, steel, wood, prestressed, etc.). ALDOT's evaluation method in general is technically sound. The conclusion of an increase in the number of bridges to be posted ("*On state routes and US routes, the current number of bridges that are currently load posted for 18-wheelers is **1 which would increase to 8** under SB110. On county routes, based on a detailed analysis of three counties with representative bridge inventories, the number of county bridges posted for 18-wheeler trucks would increase **from 787 to 1,135***") is reasonable and valid due to the increase of truck loads (see the general effect on bridges from Section 1).

Specifically, the following comments are made during the review:

1. The bridge analysis methodology conducted by ALDOT follows the AASHTO Manual for Bridge Evaluation (MBE). The analysis campaign covers 2,192 State and 1,488

County bridges using AASHTOWare Bridge Rating (BrR), the primary software developed by AASHTO for bridge load rating. Three different methods, ASR, LFR, and LRFR, were adopted in the analysis. In addition to the LRFR rating method, ASR and LFR are performed for bridges designed using legacy specifications (ASD and LFD). While a certain level of data insufficiency and uncertainty are always present in such an analysis, for example, accounting for section loss due to deterioration or uncertainty in member dimensions, ALDOT Maintenance Bureau analysis team has performed a comprehensive review of the available data, making every reasonable effort to mitigate uncertainties during their analysis with the available time and resources. It is considered that the analysis methodology is technically sound, and the conclusion obtained, therefore, is valid.

2. In Section 1, a notable impact from increased loads is the "accelerated fatigue damage". The load rating (for permit load evaluation) that ALDOT did so far can examine whether it is going to be safe when the "overload" truck cross the bridge – an operating level evaluation, but it cannot indicate if such trucks crossing the same bridge repeatedly (for years), what level of damage it will accumulate – this is answered by evaluating a fatigue design limit. While AASHTO LRFD specifies fatigue evaluation and design methods—as indicated in Section 1, such an analysis for all the bridges in the state (as ALDOT did for load rating) would be difficult to perform due to the lack of relevant data (e.g., strain levels and fatigue details). However, such an analysis could further highlight the potential long-term damage to bridges by overload trucks. Hope such impact can receive attention from ALDOT and spur discussions and research support for better bridge monitoring and bridge data collection.

Overall, the conclusion of an increase in the number of bridges to be posted was clearly stated in the testimony. The analysis method supporting this conclusion is reasonable and technically sound, and therefore, the obtained conclusion is considered valid. Although a fatigue damage evaluation can provide additional information on long-term bridge damage by overload trucks, it is currently considered infeasible to perform due to the lack of relevant data. Two specific comments are described above to further support this review statement.

References

AASHTO LRFD Bridge Design Specifications, 9th Edition (2020)

AASHTO Manual for Bridge Evaluation, 3rd Edition (2018)

Appendix B – ATI analysis of impact to State pavements

Review of ALDOT Testimony and Analysis Methodology for SB110 (Pavement)

Based on the ALDOT Testimony document and related Appendix B, ALDOT's evaluation method in general is technically sound. ALDOT correctly notes that damage in a pavement is not related to the overall truck weight, but rather the axle spacing and loads applied from each axle. The values of resilient modulus, traffic, lane distribution factors, and other parameters are either derived from direct measurements or are reasonable assumptions. The appendix also, correctly, notes that non-Interstate sections would suffer even greater loss of performance given that those designs are often conducted at lower levels of reliability to balance design performance and economics.

Following ALDOT's required design process of using DARWIN 3.1 to establish structural number requirements and then completing the analysis with AASHTO 93, the calculations are then completed with the known AADT and the associated load equivalency factors (LEFs) in various scenarios ranging from no 44-kip tandem axles up to 100% 44-kip tandem axles. There are several published methods to determine LEFs and the process that ALDOT used is appropriate and common as it is the method published in the AASHTO 93 design guide. While different design methodologies (i.e. AASHTO 93, PavementME, etc) may produce different reductions in service life, any analysis method would show a reduction. Furthermore, while ALDOT's inventory consists primarily of flexible pavements, any rigid pavement sections being loaded by the higher axle loads would also see a reduction in service life.

There have been several research studies in other states and countries that have also shown this effect (Rys et al. 2015, PIARC 2022). Generally, as noted in the main testimony, the damage increases at a 4th power rate with the increase in axle load. Specifically, from the PIARC report:

"The conclusion reached was that the pavement damage increases exponentially with the load with a power between 4 and 4.5 – this is also known as the "fourth power law", which implies for example that if 10% of overloading induces 46% more damage, 50% of overloading results in 5 times more damage."

Another way to put the values into perspective is to think about the LEF and the significant increase in the LEF from a typical truck to a truck with a 44-kip tandem axle. As noted in the ALDOT testimony, Appendix B, the increase in LEF from standard (LEF=2.451) to 44-kip tandem axle (LEF=3.638) is about 50%, or 1.5 times higher.

ALDOT's discussion notes that there are two ways to mitigate the impact of the heavier axles: more frequent resurfacing and/or additional thickness of the asphalt layer. While both methods can mitigate the increase in damage from the driving public perspective, the more frequent resurfacing will only act as a temporary fix to a fundamental overloading issue. Additional asphalt thickness can improve the surface life of the pavement section under heavier loads but this comes at a significant economic and user cost. It should be noted that ALDOT determined that approximately 0.7 inches of additional thickness would be needed but this extra thickness is only for the Interstate sections. It would be expected that state, county, and other local roads would need more than this amount of asphalt due to the lower initial structural capacities of those pavement types.

Overall, the conclusion of the pavement analysis section and the analysis method supporting this conclusion is technically sound. It is not about the total weight of the vehicle but how that total weight is applied to the pavement. Higher applied loads lead to higher levels of damage and a reduced service life that increase at a rate following the fourth power law.

References

AASHTO Guide for Design of Pavement Structures (1993)

Rys, D., Judycki, J., & Jaskula, P. (2015). Analysis of effect of overloaded vehicles on fatigue life of flexible pavements based on weigh in motion (WIM) data. *International Journal of Pavement Engineering*, *17*(8), 716–726. (available at: https://doi.org/10.1080/10298436.2015.1019493)

Overweight Vehicles: Impact on Road Infrastructure and Safety, PIARC Report, ISBN: 9782840606741. (2022)