Comparison of Cost and Environmental Impact of Concrete and Asphalt Roads

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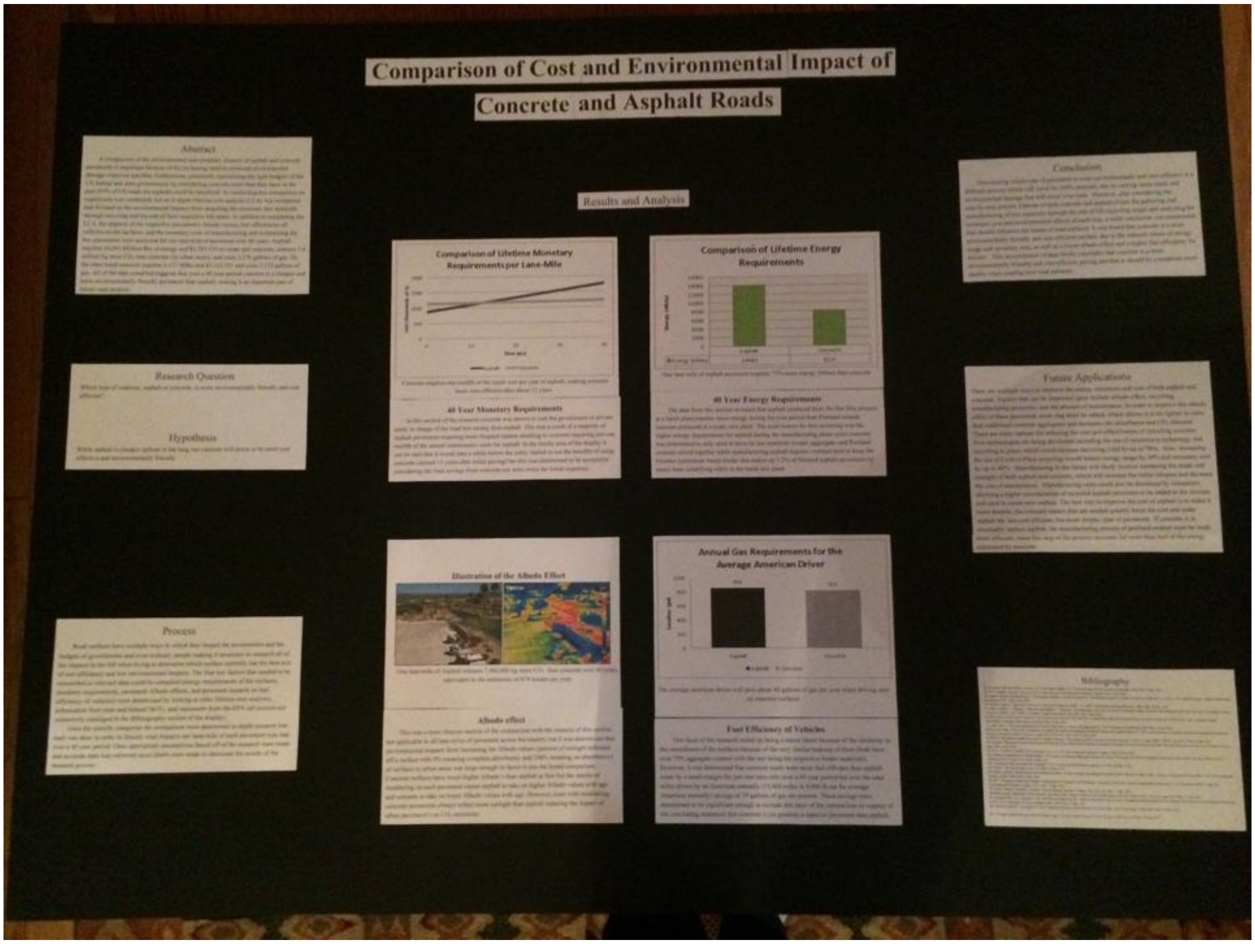


Research Question

Which type of roadway, asphalt or concrete, is more environmentally friendly and cost efficient?

Hypothesis

While asphalt is cheaper upfront in the long run concrete will prove to be more cost effective and environmentally friendly.

Process

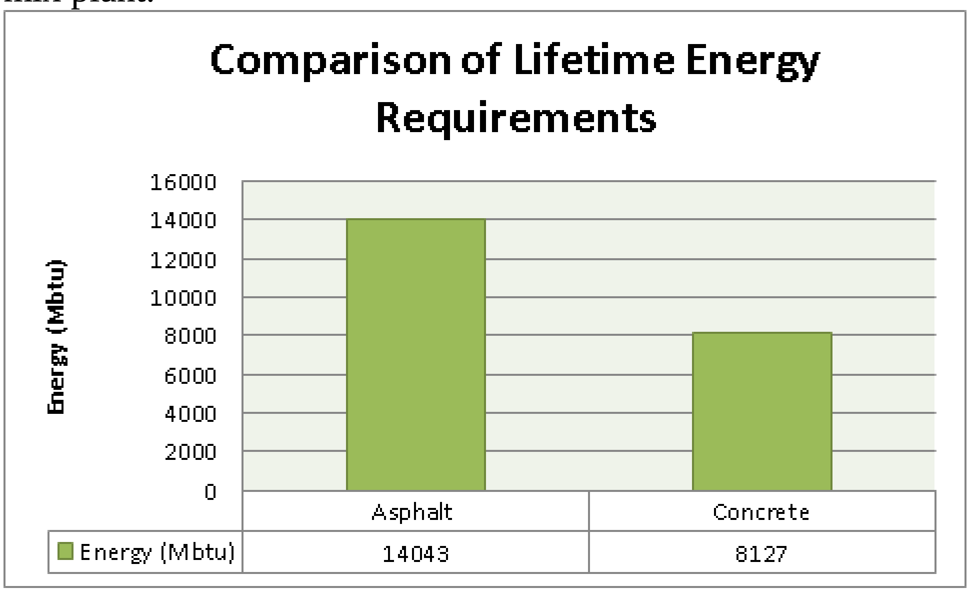
Road surfaces have multiple ways in which they impact the environment and the budgets of governments and even ordinary people making it necessary to research all of the impacts to the full when trying to determine which surface currently has the best mix of cost efficiency and low environmental impacts. The four key factors that needed to be researched so relevant data could be compiled (energy requirements of the surfaces, monetary requirements, pavement Albedo effects, and pavement impacts on fuel efficiency of vehicles) were determined by looking at other lifetime cost analyses, information from state and federal DOTs, and statements from the EPA (all sources are extensively cataloged in the Bibliography section of the display).

Once the specific categories for comparison were determined in depth research into each was done in order to discern what impacts one lane-mile of each pavement type had over a 40 year period. Once appropriate assumptions based off of the research were made and accurate data was retrieved excel charts were made to showcase the results of the research process.

Results and Analsysis

40 Year Energy Requirements

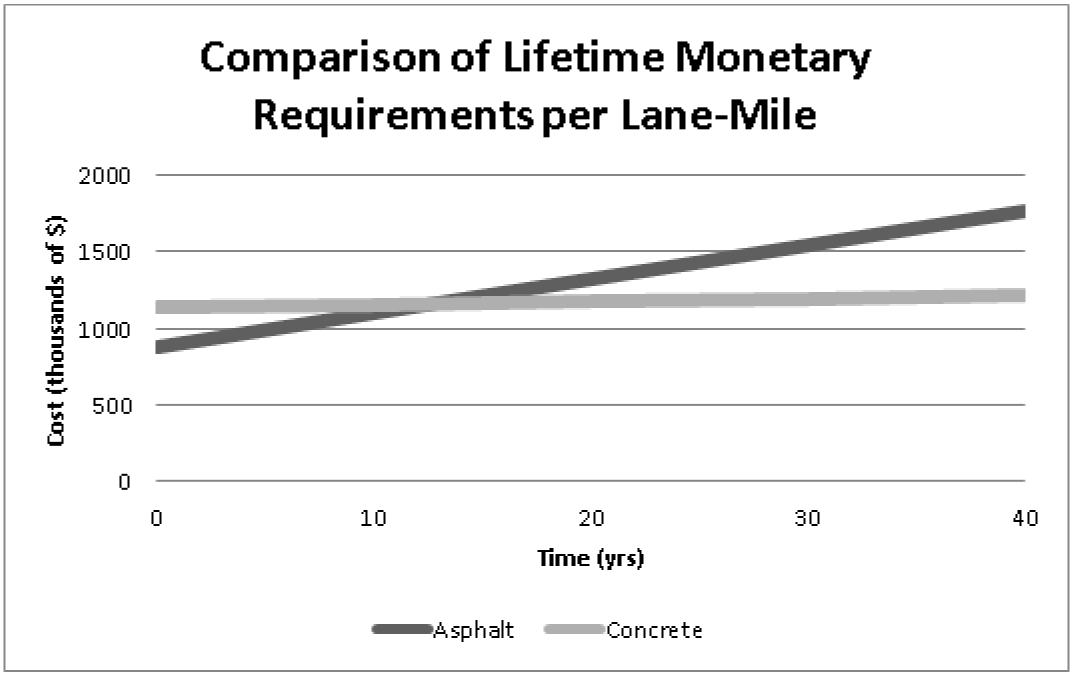
The data from this section revealed that asphalt produced from the Hot Mix process at a batch plant requires more energy during the year period than Portland cement concrete produced at a ready-mix plant. The main reason for this occurring was the higher energy requirements for asphalt during the manufacturing phase since concrete was determined to only need to have its raw materials (water, aggregate, and Portland cement) mixed together while manufacturing asphalt requires constant heat to keep the bitumen (petroleum based binder that makes up 5.2% of finished asphalt pavements by mass) from solidifying while at the batch mix plant.



One lane mile of asphalt pavement requires 73% more energy (Mbtu) than concrete

40 Year Monetary Requirements

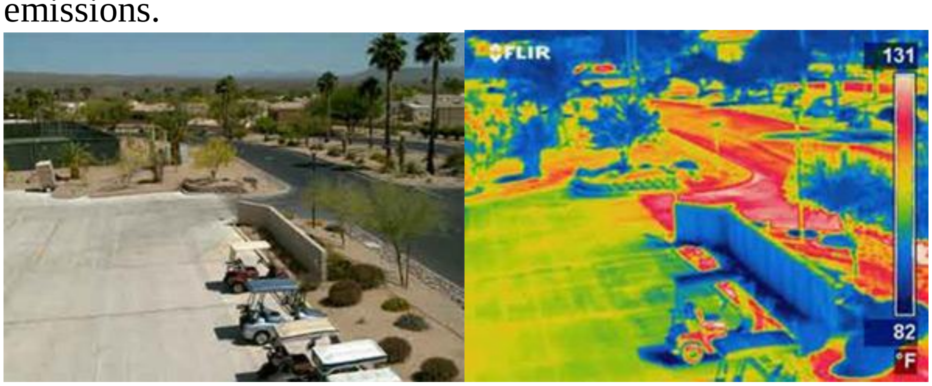
In this section of the research concrete was shown to cost the government or private entity in charge of the road less money than asphalt. This was a result of a majority of asphalt pavements requiring more frequent repairs resulting in concrete requiring just one twelfth of the annual maintenance costs for asphalt. In the results area of the display it can be seen that it would take a while before the entity started to see the benefits of using concrete (around 13 years after initial paving) but this was determined to be acceptable considering the final savings from concrete use were twice the initial expenses.



Concrete requires one twelfth of the repair cost per year of asphalt, making concrete more cost-efficient after about 13 years.

Albedo effect

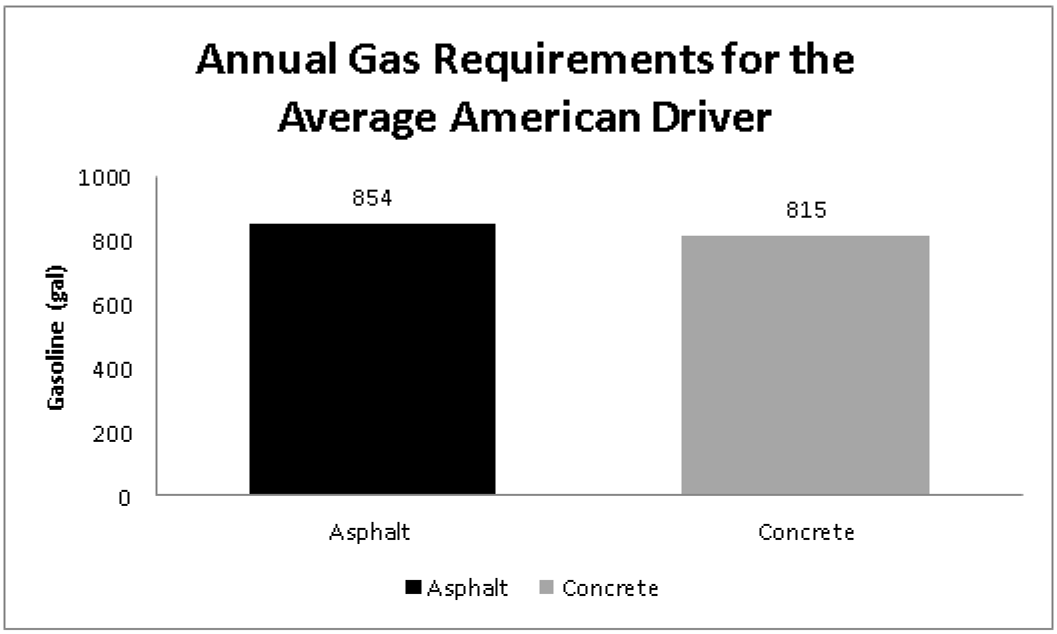
This was a more obscure section of the comparison with the impacts of this section not applicable to all lane-miles of pavement across the country but it was determined that environmental impacts from increasing the Albedo values (percent of sunlight reflected off a surface with 0% meaning complete absorbency and 100% meaning no absorbency) of surfaces in urban areas was large enough to factor it into the broad comparison. Concrete surfaces have much higher Albedo's than asphalt at first but the results of weathering on each pavement causes asphalt to take on higher Albedo values with age and concrete to take on lower Albedo values with age. However, even with weathering concrete pavements always reflect more sunlight than asphalt reducing the impact of urban pavement's on CO_2 emissions.



One lane-mile of Asphalt releases 7,400,000 kg more CO_2 than concrete over 40 years, equivalent to the emissions of 674 houses per year.

Fuel Efficiency of Vehicles

This facet of the research ended up being a minor factor because of the similarity in the smoothness of the surfaces because of the very similar makeup of them (both have over 75% aggregate content with the rest being the respective binder materials). However, it was determined that concrete roads were more fuel efficient than asphalt roads by a small margin for just one lane-mile over a 40 year period but over the total miles driven by an American annually (15,000 miles in 4,000 lb car for average American annually) savings of 39 gallons of gas are present. These savings were determined to be significant enough to include this facet of the comparison as support of the concluding statement that concrete is (in general) a superior pavement than asphalt.



The average American driver will save about 40 gallons of gas per year when driving only on concrete surfaces

Conclusion

Determining which type of pavement is more environmentally and cost effective is a difficult process which will never be 100% accurate, due to varying stress loads and environmental damage that will occur over time. However, after considering the step-by-step process lifetime of both concrete and asphalt (From the gathering and manufacturing of raw materials through the end of life/recycling stage) and analyzing the monetary cost and environmental effects of each step, a valid conclusion was constructed that should influence the future of road surfaces. It was found that concrete is a more environmentally friendly and cost efficient surface, due to the reduced values of energy usage and monetary cost, as well as a lower albedo effect and a higher fuel efficiency for drivers. This accumulation of data firmly concludes that concrete is a more environmentally friendly and cost efficient paving and that is should be considered more readily when creating new road surfaces.

Future Applications

There are multiple ways to improve the energy emissions and cost of both asphalt and concrete. Factors that can be improved upon include albedo effect, recycling, manufacturing processes, and the amount of maintenance. In order to improve the albedo effect of these pavements, more slag must be added, which allows it to be lighter in color than traditional concrete aggregates and decreases the absorbance and CO_2 released. There are many options for reducing the cost and effectiveness of recycling concrete. New technologies are being developed including the use of microwave technology and recycling in place, which could increase recycling yield by up to 70%. Also, increasing the use of Cold-In Place recycling would reduce energy usage by 50% and monetary cost by up to 40%. Manufacturing in the future will likely involve increasing the depth and strength of both asphalt and concrete, which will increase the initial lifespan and decrease the cost of maintenance. Manufacturing costs could also be decreased by companies allowing a higher concentration of recycled asphalt pavement to be added to the mixture and used to create new asphalt. The best way to improve the cost of asphalt is to make it more durable, the constant repairs that are needed quickly boost the cost and make asphalt the less cost efficient, but more simple, type of pavement. If concrete is to eventually replace asphalt, the manufacturing process of Portland cement must be made more efficient, since this step of the process accounts for more than half of the energy consumed by concrete.

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