

University of Arkansas, Fayetteville

ScholarWorks@UARK

---

Management Undergraduate Honors Theses

Management

---

5-2022

## Sustainability in Construction Practices as Emphasis on Environmental Investing in ESG Model Grows

Maddie Heal

*University of Arkansas, Fayetteville*

Follow this and additional works at: <https://scholarworks.uark.edu/mgmtuht>



Part of the [Business Law, Public Responsibility, and Ethics Commons](#), [Civil Engineering Commons](#), [Construction Engineering and Management Commons](#), and the [Environmental Engineering Commons](#)

---

### Citation

Heal, M. (2022). Sustainability in Construction Practices as Emphasis on Environmental Investing in ESG Model Grows. *Management Undergraduate Honors Theses* Retrieved from <https://scholarworks.uark.edu/mgmtuht/16>

This Thesis is brought to you for free and open access by the Management at ScholarWorks@UARK. It has been accepted for inclusion in Management Undergraduate Honors Theses by an authorized administrator of ScholarWorks@UARK. For more information, please contact [scholar@uark.edu](mailto:scholar@uark.edu), [uarepos@uark.edu](mailto:uarepos@uark.edu).

**Sustainability in Construction Practices as Emphasis on  
Environmental Investing in ESG Model Grows**

Maddie Heal

11 April 2022

Dr. Schubert

WCOB 499VH – Walton Honors College Thesis

## ABSTRACT

The purpose of this research is to emphasize the importance of growing investment on environmental initiatives in business ESG models in regard to sustainable practices in construction. The ESG acronym is known as the environmental, social, and governance efforts that businesses strive to incorporate in their models to increase the responsibility of operations.

Investors continue to seek out responsible businesses when choosing which ventures to pursue. The analysis of the current construction crisis, current investments in the right direction of Eco-friendly design regarding construction, and the threats and benefits incentivizing those investments elucidates the need to emphasize socially responsible investment behavior on “green” terms in the ESG model. Real world examples from businesses taking advantage of the benefits of building sustainably allow the reader to understand the growing popularity of the matter.

The different approach that each business has taken in regard to offsetting various wastes highlights that there are many avenues investors and corporations can take when approaching the challenge. The fear of money loss in initial adoption of new techniques is daunting, but in the long term the benefits of investing in green construction practices outweigh the costs. By gaining a better grasp on the crisis at stake, reinventing the wheel, and adoption of current sustainable measures, businesses and investors will see the need to emphasize socially responsible

investment behavior on “green” terms in the ESG model. Going green is not an easy task to take on but time is of the essence to take advantage of the level of knowledge and technological advancements at hand. In addition to the secondary research at hand, primary research was conducted to test the viability of various sustainable replacements in concrete mixtures. The research conducted contains various methods through customer discovery avenues as well as direct lab testing at the University of Arkansas Civil Engineering Research Center.

## LETTER OF TRANSMITTAL

Dear Reader,

I am writing this letter to you in regard to the decisions that led me to this topic. This thesis was a delight to work on as it expands on a topic that I am currently passionate about and am pursuing.

I have been conducting primary research through customer discovery interviews and conversations with industry leaders over the past year which have allowed me to gain a better understanding of the need to emphasize sustainable construction in our world. Over the past year,

I have participated in social innovation competitions, customer discovery programs, and am currently testing in our civil engineering lab exploring potential sustainable concrete mixtures to take to market! I included some of the interviews that I have conducted if you feel so inclined to hear from others on this topic.

Best,

Maddie Heal

# Table of Contents

Abstract	2
Letter of Transmittal	4
Introduction	7
If it Ain't Broke	9
I. Concrete	
II. Construction	
Current Investment in Eco-Friendly Technology	10
I. Materials	
II. CO2 Emissions	
Incentivizing Sustainable Construction	16
I. Threats	
II. Benefits	
My Research	18
I. Testing Plastic Aggregate as Replacement of Sand	
II. Potential of testing RHA as Replacement of	
Cement	
Conclusion of Primary Research	25

General Conclusion	26
Appendix	27
Works Cited	35

## INTRODUCTION

The expectation of meaningful progression behind industry growth has popularized over the past decade thus leading to a shift in business purpose. This shift in purpose has quite frankly harvested unrecognizable modern characteristics of business platforms seen prior to realignment of stakeholder models. The notion of maximizing shareholder value is finally dying and businesses are having to look at the results of their actions in a much deeper perspective. For decades, profit was in the driver's seat when it came to defining successful business models, however, times are changing and business impact on environmental, social, and governance levels holds precedence. Investors are thinking smarter and are looking for responsible business practices to put their big bucks into.

There are different priorities that come into play when ranking ESG initiatives for individuals and their companies, so it is a very interesting concept to grasp when analyzing industry practice and the decisions made. ESG practices range from conserving the amount of water buildings are using to broadening the participation with culturally ethnic employees now included in decision making processes. Today, the value of investment in ESG is “over \$14 million USD or around a quarter of all professionally managed assets around the world, and its rapid growth builds on the Socially Responsible Investment [SRI] movement that has been around much longer” (Kell).



While many individuals are making big moves on the social and governance fronts in ESG practice, the growing emphasis on environmental initiatives is creating buzz on a much larger scale than ever before. Eco-investing has gained significant traction as our world is depending on it, and one industry that is being forced to start thinking and acting more responsibly is the construction industry. For the majority of its life, the construction industry has been stuck in the way of an “if it ain’t broke don’t fix it” kind of mindset in terms of its practices and routines and has served as a leader in CO2 emission, waste production, water and air pollution, ecosystem disruption, etc. (TSC). The list goes on and the extent of its negative contribution is quite large. As our planet continues to warm and natural resources continue to deplete at exponential rates, emphasis on the E in ESG continues to rise, specifically in the construction industry. The extent to which companies and investors are focusing on sustainable activities depends on multiple factors such as level of involvement, passion, and position. Grasping a better understanding of our current construction crisis, current investments in the right direction of Eco-friendly design regarding construction, and the threats and benefits incentivizing those investments elucidates the need to emphasize socially responsible investment behavior on “green” terms in the ESG model.

## IF IT AIN'T BROKE

As stated above, the construction industry has been stuck in a “if it ain’t broke don’t fix it” kind of mindset. Now what does this mean? Construction has been around since the beginning of time when people started building civilizations with the natural resources they had at hand. As the level of knowledge and technology grew, so did the negative impact of construction practices at hand. Advances in technology and behavior regarding growth have changed, but basic practices have stayed the same to a large degree. Industry leaders in construction today are well aware of its negative environmental impacts; however, the majority of these leaders continue to stay stuck in a mindset of sticking to what works. Money is good and regulation is not fully hindering their ways, so why would they change?

*Concrete.* After water, concrete is the second most widely used substance on our planet, and it is the primary foundation found in any modern industry (Ramsden). The vast application of concrete in bridges, buildings, roads, and other integral construction means releases concerningly high amounts of CO<sub>2</sub> each year, roughly 4 billion tons annually. If concrete were a country, it would be the third-highest emitter of CO<sub>2</sub> (See Appendix B). Not only is it a leading emitter of carbon emissions, but concrete production leads to the depletion of natural resources and ecosystem disturbance.

*Construction.* Secondly, construction as a whole, serves as a big contributor to air and water pollution as well as landfill waste and climate change. According to a 2017 research blog on construction made by Bimhow, “the construction sector contributes to 23% of air pollution, 50% of the climatic change, 40% of drinking water pollution, and 50% of landfill wastes” (Bimhow). As our population continues to grow, the demand for construction continues to increase and that needs to be recognized on a much more proactive level. Strong economic growth is reflected in demand for construction and historically, profit has preceded environmental concerns. According to the U.S. Bureau of Economic Analysis, the value added by the construction industry as a percentage of GDP has steadily increased over a 10-year period resulting in a 1% increase in total value at 4.3% as of Q1 in 2021 (See Appendix A). Investors continue to invest in the ever-growing industry, but the environment, being a primary stakeholder in the ESG model, needs priority as a state of crisis encroaches.

#### CURRENT INVESTMENT IN ECO-FRIENDLY TECHNOLOGY

The adoption of green investing is still in its infancy as the number of innovators and early adopters continues to grow. The concept of green investing is multifaceted as there are many different levels within the supply chain of construction. Today, businesses and investors are looking at green construction on a much wider scale than what the narrow mind might initially consider. In the Business Roundtable “Statement on the Purpose of a Corporation” it

highlights the necessity of sharing a fundamental commitment to all stakeholders. In the statement, the individual businesses promise to “[Support] the communities in which we work. We respect the people in our communities and protect the environment by embracing sustainable practices across our businesses” (Class notes, “Statement on the Purpose of a Corporation”). As companies look towards emphasizing the environmental initiatives in their ESG models through construction, they are having to consider the different avenues available to them. Although green construction is still in its early stages, there are multiple entities taking that leap that need to be addressed. The term “sustainable” can be considered through many different avenues. While some companies are looking to incorporate green approaches from recycled material stances, others are approaching green construction by eliminating carbon emissions as its priority. There is no right or wrong approach when it comes to emphasizing environmental initiatives, it is more of the positive impact that these initiatives are making on our environment that matters. At the end of the day, the ultimate goal remains, creating a more sustainable building practice and at the very least starting to do so.

*Materials.* As environmental awareness continues to grow, decision making in putting green building as a priority is ultimately driven by the stakeholders: the clients. In the World Green Building Trend report, 40% of respondents said that client demands were the driver for their green building activity (Killough). Consumers, employees and tenants are not only

concerned with the sustainable practices of businesses, but they are hitting on the structural sustainability of their buildings themselves. This demand for sustainability is just one of the many reasons to invest in greener building practices in construction. The coined concept of the 3 R's; reduce, reuse and recycle integrates sustainable practices in various forms and businesses that are looking at incorporating recycled materials in their structures are heavily focusing on the reuse and recycle aspects. There are multiple businesses in the United States that have already hopped on this trend including entities such as Kum & Go and Starbucks.

In 2009, convenience store Kum & Go LLC was the first convenience store in Iowa to receive LEED certification. LEED is a global building certification program that focuses on the efforts of Leaders and their efficient use of Energy and Environmental Design. LEED serves as a points-based rating system that focuses on environmentally friendly design including energy and water efficiency, sustainable site development, material selection and indoor environmental quality. Ranking occurs at various levels including Certified, Silver, Gold and Platinum. In terms of green construction, Kum & Go LEED stores use 20% recycled materials such as steel and concrete. It currently has 12 stores with Gold certification, 57 have the Silver certification, and 31 others have been Certified (CSP). Kum & Go strives for growth and is receiving positive feedback and recognition in its continued efforts in green construction. Not only does Kum & Go

use recycled materials in its construction means, but its LEED buildings also use 20% less water and 30% less energy than typical stores of their size, said the company.

Another company that exemplifies the reuse and recycling of materials in green construction as a part of emphasis on the environmental aspect in ESG initiatives is Starbucks. In 2005, Starbucks opened up its first LEED certified building in Oregon. Since then, it continues to contribute to sustainable building practice in green design and construction. Green design is found in its cabinets and floor tiles that incorporate post-industrial waste and recycled materials. It does not stop there. As well as reusing material in building practices, Starbucks strives to reduce off-gas pollution by incorporating efficient lighting, low VOC paint and FSC-certified wood.

Although the current climate of reusing and recycling materials in construction is heavily encouraged in the United States, it is not required. This, however, is not the case for all nations. In 2015, India's government made it mandatory for plastic to be used in constructing roads located near large cities of more than 500,000 people. The plastic in these roads replaces a portion of a necessary aggregate, sand. The hefty demand of this primary aggregate in road construction in India has led to a depletion of the natural resource, creating a sand shortage thus leading to more incentive for a mandate. With India's extensive growth, construction with the utilization of recycled plastic in roads skyrockets its potential to incorporate sustainable

construction in its infrastructure and make a difference. The United States has yet to reach this crisis, however, that does not mean that the time for mandates regarding more sustainable construction in regard to material use is not near. Businesses and investors alike need to be proactive and make the conscious effort to incorporate recycled materials in their design. India's current efforts of incorporating recycled plastic in concrete show us that attainability is there.

*CO2 Emissions.* Businesses are looking beyond the reuse and recycling of materials in an effort to combat the negative effects found in the construction industry. There is recent growth in investment and attention geared towards the reduction aspect in the environmental initiative sector of the ESG model as well. Increased energy efficient techniques in breakthrough technologies have led to reductions in the carbon footprint of these construction practices as well as the businesses using these technologies. Corporations such as T-Mobile and Best Buy represent key players in the investment of reduction in their pollution and carbon emissions.

Located in Overland Park, Kansas, former Sprint headquarters now merged with T-Mobile, prides itself on its "green" foundation. T-Mobile claims itself to be among the most environmentally responsible campuses in the nation. It reduces its energy and water consumption through the use of solar panels for signage and recapturing systems that divert water for irrigation use. Alongside green building design, the T-Mobile HQ indirectly reduces CO2 emissions. Encouragement of responsible transportation is seen through the incorporation of

priority parking for hybrid vehicles and carpools as well as assistance programs that aid employees seeking alternative transportation. Before merging, Sprint opened a retail store in San Francisco that achieved LEED certification including energy efficient systems through lighting, equipment, and HVAC systems. In its 2020 Corporate Responsibility report, T-Mobile continues to incorporate green building and aims to source 25% of its retail stores with renewable energy (See Appendix C).

Not only is T-Mobile working towards a greener tomorrow but sustainable design efforts in construction are also seen with Best Buy. Best Buy may not be considered a likely candidate for seeking carbon reduction in its building design; however, that assumption stands corrected. In fact, Best Buy has been recognized for its efforts in green construction. Best Buy builds its stores in line with LEED Certifications made by the U.S Green Building Council standards. A key feature that sets Best Buy apart from others is its sustainable design implementing skylights that are equipped with sensors that automatically turn off interior lights when daylight is adequate. Through the use of these skylights, Best Buy is able to offset some of the negative carbon emitting activities by reducing its use of internal energy consumption with green building design

The direct and indirect approaches taken to offset unsustainable construction methods are endless and it is imperative to understand that there is no single “solution” when it comes to



choosing which environmentally friendly initiative to take. The term “sustainable construction practice” can range from the application of replacing basic materials incorporated in foundations up to how buildings function in more efficient ways. The exploration of these different approaches is necessary in order to address the emphasis of improving the environmental aspect in ESG models. Adoption of current models as well as innovation of new models when taking green leaps are crucial when making the right decisions in investing practices.

## INCENTIVIZING SUSTAINABLE CONSTRUCTION

There are many different drivers that need to be considered behind pushing a greener mindset in construction. There is always the pressing question of whether or not businesses are making these conscious efforts out of the good faith and character built within the values of their business or from outside pressures. Today, we are seeing certain regulations and incentives that are making the decisions a bit “easier” to go green.

*Regulation.* Unlike India, the United States is not facing as severe regulation in green construction, but there are some parameters that have been set in place regarding behavior in construction. One initiative that was set in 2015 to regulate carbon emissions is the Carbon Pricing Leadership Coalition. It set a goal of “putting in place effective carbon pricing policies that maintain competitiveness, create jobs, encourage innovation, and deliver meaningful emissions reductions” (IFC). The CPLC uses two carbon pricing mechanisms with construction

including shadow pricing and internal fees. Shadow pricing simulates the effect of an externally imposed tax on internal projects by adding a cost to the project while internal fees are imposed on specific business units based on their emission levels. Fees are centrally collected and reinvested, ideally in projects facilitating energy efficiency or carbon offsets (IFC). Carbon pricing and taxes allow businesses and construction companies to be more cognizant of the efficiency of their methods and emissions.

*Benefits.* Regulations can be daunting but there are also some benefits to building sustainably as well. Many corporations, including some of those mentioned earlier, are working towards LEED building certifications.

In addition to LEED building certifications, emission reduction credits, also known as ERC systems, are offered. Firms that fall in the parameters of offsetting certain amounts of greenhouse gasses below a predetermined level can receive credits. These credits can then be traded with parties who need to comply with emissions targets regulations or who wish to offset emissions to become carbon neutral. These credits can generate revenues, which may be reinvested in green initiatives, Encourage efficiencies within high-carbon sectors, and facilitate reporting of emissions reductions (IFC).

The LEED certification and ERC systems create a sense of competition and encourage investors and businesses to start thinking about sustainability goals shed in a more positive, rewarding light.

## MY RESEARCH

In regard to further exploration, the focus of primary research pertains to the material replacement aspect of sustainable construction methods in concrete. Research was conducted through multiple different avenues such as customer discovery and hands-on testing at the University of Arkansas Civil Engineering Research Facilities. Due to time constraints, only one test was run on an independent mixture to test the viability of replacing certain elements with waste byproducts in basic concrete mixtures, however, two separate material replacements were considered. The material tested in the mixture is recycled plastic as a partial replacement of sand aggregate and Rice Husk Ash was evaluated as a partial replacement of cement. The test followed the guidelines of a basic sidewalk mixture under the City of Fayetteville ASTM requirements. The purpose of this replacements is aimed at reducing waste in our landfills, decreasing the demand for a depleting natural resource, and minimizing carbon footprint. The goal of this research sought to answer three questions 1) is this mixture more structurally viable than previous compositions 2) is this mixture economically viable 3) is this mixture logistically

viable, taking all constraints into consideration. If there is a positive return in these questions, then a more sustainable mixture should be implemented.

The first mixture tested incorporates recycled plastic sourced from Marck Recycling as a partial replacement of sand aggregate. Sand is a primary aggregate in the current production mixture of concrete, and it is also a natural resource. Although the United States has not been faced with a sand shortage, India, for example has. India's current sand shortage has forced their country to introduce innovative sustainable solutions within the production of concrete. Innovators are incorporating ground plastics in their roadway, thus providing a solution to this growing issue.

Due to time constraints for this project, the testing of a second mixture was not possible, however, evaluation was considered on the incorporation of Rice Husk Ash, also known as RHA, as replacement of a portion of the cement. The concept of RHA replacement in building materials as a sustainable alternative to cement is relatively new and is novel, as it has not been explored and tested quite as much, however there is much potential. RHA is the byproduct of burning rice husk waste disposed from the rice production process. While there have been many uses found in rice husk alone such as animal feeds, insulation, and fertilizers, rice husk ash brings in much more potential. The property of rice husk ash is similar to cement in the way of its high silica content. RHA contains greater than 80% silica. Silica is also the second

largest quantity of cement ingredients with presence of about 17-25% (Constructor, 2021).

Cement, the binder that glues together aggregate to form concrete, also happens to be one of the three major contributors to the energy cost of building construction (Henry, 2020). The partial replacement of cement with RHA could serve as an opportunity to produce renewable energy through the combustion of rice husk in controlled environments and reduce carbon footprint in construction by alleviating the demand for such quantities of cement production.

#### MIXTURE 1

The goal of this first mixture is aimed at reducing waste in our landfills, i.e., plastic, and decreasing the demand for a depleting natural resource, i.e., sand. Results of this initial test are below.

#### TEST RESULTS

Test results from replacement of sand with recycled plastic in sidewalk mixture

The minimum required compressive strength and mix design specifications for the sidewalks in the city of Fayetteville are shown in Table 1. These were taken from the Minimum Street Standards published by the City of Fayetteville, 2020 Edition.

**Table 1 City of Fayetteville Concrete Sidewalk Specifications**

Minimum Compressive Strength	3,500 psi
Air Content	4 – 7 %

Slump	1 – 4 inches
Maximum w/cm	0.44
Maximum Fly Ash Content	20%

A more sustainable concrete alternative was studied. Replacement of coarse aggregate by recycled plastic was investigated using a replacement rate of 20%. Ordinary Portland cement and Class C fly ash were utilized with a replacement rate of 20%. The maximum weight to volume ratio determined by Fayetteville was used. The mix design used for this project is shown in Table 2.

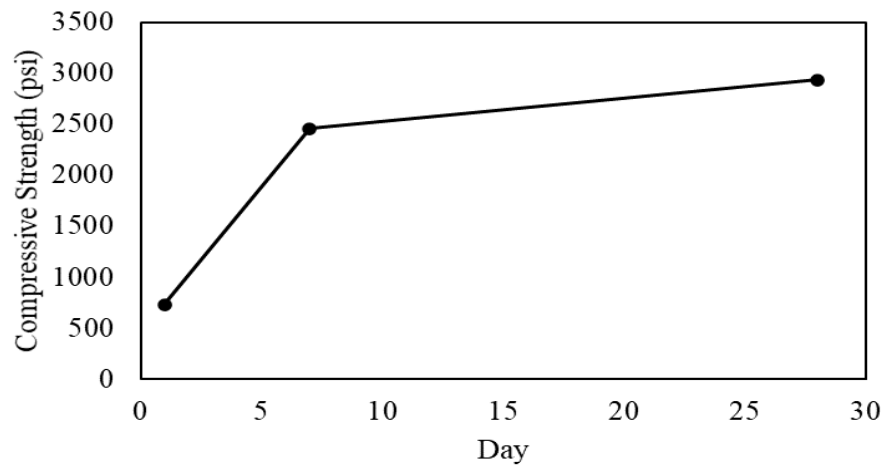
**Table 2 - Mix Design**

<b>Material</b>	<b>Weight (lb)</b>	<b>Volume (ft<sup>3</sup>)</b>	<b>Specific Gravity</b>
Cement	13.8	0.07	3.15
Fly Ash	2.29	0.01	2.5
Recycled Plastic	10.68	0.09	Unknown
Sand	59.5	0.36	2.65
Rock	56.89	0.35	2.613
Water	5.7	0.09	1
Air	0	0.04	-

The mix design described above was mixed on December 9, 2021. Slump content was taken after mixing and was determined to be 2 inches. The slump value fell between the required 1 – 4 inches proscribed by Fayetteville. Air content was not tested. Therefore, nine concrete cylinders were cast to be tested on day 1, 7, and 28. The compressive strength values are shown in Table 3 with a corresponding figure presented in Figure 1.

**Table 3 – Compressive Strength**

Cylinder	Day (psi)		
	1	7	28
1	720	2,366	2,561
2	703	2,550	3,113
3	769	2,463	3,132
<b>AVERAGE</b>	<b>731</b>	<b>2,460</b>	<b>2,935</b>



## Figure 1 – Compressive Strength

The compressive strength values on day 28 did not meet the minimum required compressive strength of 3,500 psi. Therefore, alterations of the mix design would be required. A high-range water reducer may be required to meet the required minimum compressive strength. If the minimum required compressive strength could be met, extensive freeze/thaw testing should be examined. Concrete mixtures using the mix design described in Table 2 without the inclusion of recycled plastic show much higher compressive strength on day 28. Therefore, the use of the recycled plastic greatly influenced the compressive strength of the concrete cylinders.

### CONCLUSION: MIXTURE 1

Test results from this initial test were not a promising start; however, the potential of alteration and restructuring of such mixes for future research and environmental as well as economic benefit should be explored. This mixture failed to answer the first question with promise. Before more testing of this concept, economic viability was explored a bit more to decide whether or not further time commitment behind this specific research should be implemented with the time constraints at hand. After further exploration, the viability behind supplying a steady supply of the correct number (type) of plastics needed for such mixtures on a large scale just does not line up logistically. As oil prices continue to remain very volatile, the price of plastics follow suit, which would not allow for steady projections. Additionally,



recycling programs are quite variable based on location and there is not much consistency in these programs, so the supply of plastics in such mixtures in a geographic sense may struggle to consistently find those resources at cost-efficient levels. In conclusion, although mixture 1 was not explored in depth by any means on the structural front, there needs to be a bit more maturity in recycling programs that allow for consistency within the supply chain of recycled plastics procurement.

## MIXTURE 2

The goal of this second mixture is aimed at reducing carbon footprint in cement. This is done through the replacement of a portion of cement in concrete mixtures with a waste byproduct, alleviating the immense demand for the material as well as producing a renewable energy out of the controlled burning of rice husk to obtain ash. The use of renewable energy through the controlled combustion of rice hull is relatively novel in the United States as there are only two companies taking on this practice. Agrilectric is one of the only companies in the United States that utilizes this biomass waste product, rice hulls, to produce energy. Although their main market is not geared toward the construction industry, there is a lot of room in the industry for breakthrough. This leads to a gap in supply of RHA as a cement replacement in the industry thus creating a great opportunity.

The testing and development of this second mixture was only considered to the extent of background research due to time constraints, however, there are many promising factors that should be considered in sustainable design regarding the replacement of a portion of cement with RHA.

#### CONCLUSION OF PRIMARY RESEARCH

There were many things that worked well throughout the primary research aspect of this project. Potential industry partner connections were formed, promising supply of the byproducts needed to produce sustainable mixtures was discovered, and genuine passion was developed.

The main issue that I ran into was the lack of movement toward a greener model as many industry leaders are comfortable in their processes and have not been faced with the need for change (quite yet).

In retrospect, if I were to go back and change my methods within this project, I would have focused more of my attention toward the latter mixture as mixture 1 did not provide enough promise. The issues found within various recycling programs would result in inconsistent supply thus creating an inconsistent model, however, rice hull is a bit different. The approach to burning rice hull and using its emissions as renewable energy while also using its byproduct RHA as a

cement replacement in concrete holds much more value and I will continue to pursue that project well after my time here at the university.

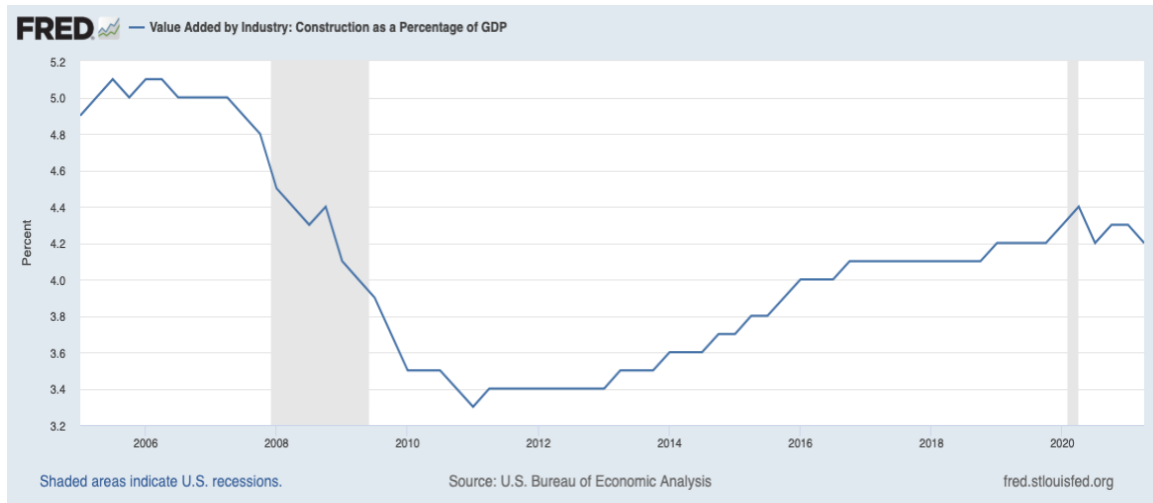
## CONCLUSION

Adoption and implementation of investing in more sustainable and environmentally friendly construction practices is not easy. The major cost that many argue is the biggest barrier to evolving practice is found within the implementation of new processes. These costs could include things like training employees, expense of new equipment and training on how to effectively use that new equipment. The fear of money loss in initial adoption of new techniques is daunting, but in the long term the benefits of investing in green construction practices outweigh the costs.

By gaining a better grasp on the crisis at stake, reinventing the wheel, and adoption of current sustainable measures, businesses and investors will see the need to emphasize socially responsible investment behavior on “green” terms in the ESG model. Going green is not an easy task to take on but time is of the essence to take advantage of the level of knowledge and technological advancements at hand.

## APPENDIX

### A. Value Added by Industry: Construction as a percentage of GDP

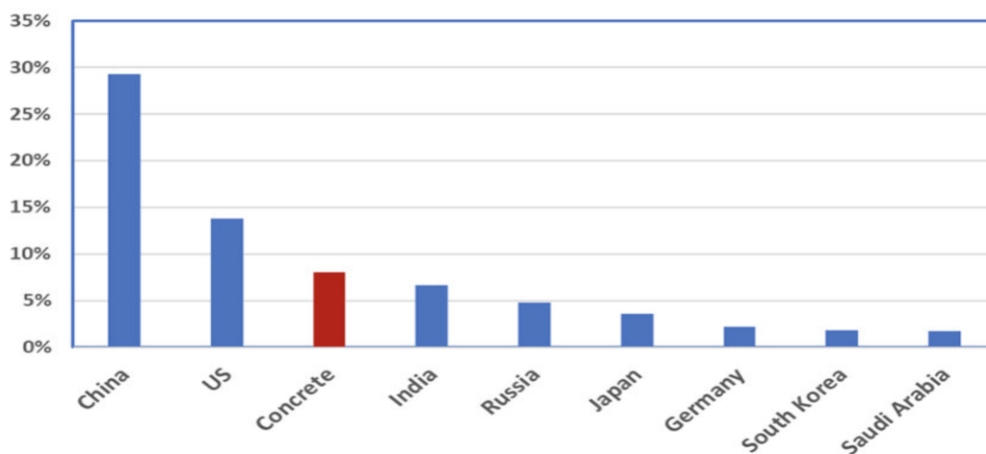


Source: (U.S. Bureau of Economic Analysis, Value Added by Industry: Construction as a Percentage of GDP [VAPGDPC], retrieved from FRED, Federal Reserve Bank of St. Louis; <https://fred.stlouisfed.org/series/VAPGDPC>, December 6, 2021.)

### B. Global Warming Has Concrete Problem When It Comes to CO<sub>2</sub>

#### **Global Warming Has Concrete Problem When It Comes to CO<sub>2</sub>**

October 04, 2019



Source: Graphics and text by ROGER WARBURTON/ecoRI News contributor

## C. T-Mobile 2020 Corporate Responsibility Report

### ACCELERATING CLIMATE ACTION

Tackling climate change and building a more sustainable future demands bold action from each of us. That's why we've led the U.S. wireless industry when it comes to setting science-based targets and investing in renewable energy.

In true Un-carrier style, we're leveraging our larger size and scale to double down on our commitments to reduce our carbon footprint and to source 100% of our electricity from renewable energy by end of 2021.

T-Mobile was the first in the industry to set two carbon reduction targets validated by the Science-Based Targets Initiative<sup>SM</sup>, a global initiative and a leading standard for setting targets to reduce greenhouse gas (GHG) emissions and prevent the worst effects of climate change. We also set an industry first by joining the RE100 pledge in 2018, committing to source renewable energy equivalent to 100% of our total electricity usage by the end of 2021. A few years and one historic merger later, we're still on track to meet these goals.

We're meeting our targets through a combination of energy efficiency and renewable energy investments. In turn, we're reducing our dependence on fossil fuels, and future-proofing network infrastructure from the threats of a warming world. We're proud to have been recognized for our leadership in environmental ambition and climate action in the CDP A List 2020, Green America's Wireless Scorecard, and the EPA Green Power Partnership<sup>SM</sup>.



**TARGET**  
Reduce combined absolute Scope 1 and Scope 2 GHG emissions 95% by 2025 from a 2016 base year

**PROGRESS**  
23.4%  
Combined Scope 1 and Scope 2 emissions decreased by 22.2% since 2016

**TARGET**  
Reduce Scope 3 GHG emissions 15% per customer by 2025 from a 2016 base year

**PROGRESS**  
97.0%  
Scope 3 emissions intensity decreased by 14.5% per customer since 2016

#### OUR 2020 EMISSIONS PROFILE

8.95M  
metric tons (MT) CO<sub>2</sub>e\*

7.3%  
reduction in year-over-year scope 1 and 2 emissions

Scope 1: 53,180 MT CO<sub>2</sub>e  
Scope 2: (location-based): 2,755,796 MT CO<sub>2</sub>e  
Scope 2: (market-based): 1,858,206 MT CO<sub>2</sub>e  
Scope 3: 7,033,821 MT CO<sub>2</sub>e

**Scope 1:** Direct emissions generated from T-Mobile facilities including offices, retail stores, data centers, customer experience centers and network operations.

**Scope 2:** Indirect emissions from purchased electricity required to power all T-Mobile facilities.

**Scope 3:** Indirect emissions generated from upstream and downstream activities, including the products T-Mobile sells and the services it uses, including corporate travel.

\*CO<sub>2</sub>e is a measure used to compare the emissions from various greenhouse gases based upon their global warming potential (GWP) (Inventory of Statistical Terms... Carbon dioxide equivalent Definition)  
Calculations are based on the GHG Protocol methodology and the EPA Mandatory Greenhouse Gas Reporting Rule. Baseline year is 2016.  
As a result of the T-Mobile and Sprint merger in April 2020, we have included legacy Sprint environmental data in our historical results back to 2016, aligning data with T-Mobile data standards.

Source: T-Mobile. *Business.t-Mobile.com*. 1 Jan. 2020, [https://business.t-mobile.com/content/dam/t-mobile/assets/pdf/T-Mobile\\_CSR20\\_10921.pdf](https://business.t-mobile.com/content/dam/t-mobile/assets/pdf/T-Mobile_CSR20_10921.pdf)

## D. Test results from replacement of sand with recycled plastic in sidewalk mixture

The minimum required compressive strength and mix design specifications for the sidewalks in the city of Fayetteville are shown in Table 1. These were taken from the Minimum Street Standards published by the City of Fayetteville, 2020 Edition.

**Table 1 City of Fayetteville Concrete Sidewalk Specifications**

Minimum Compressive Strength	3,500 psi
Air Content	4 – 7 %
Slump	1 – 4 inches

Maximum w/cm	0.44
Maximum Fly Ash Content	20%

A more sustainable concrete alternative was studied. Replacement of coarse aggregate by rubber pellets was investigated using a replacement rate of 20%. Ordinary portland cement and Class C fly ash was utilized with a replacement rate of 20%. The maximum w/cm ratio determined by Fayetteville was used. The mix design used for this project is shown in Table 2.

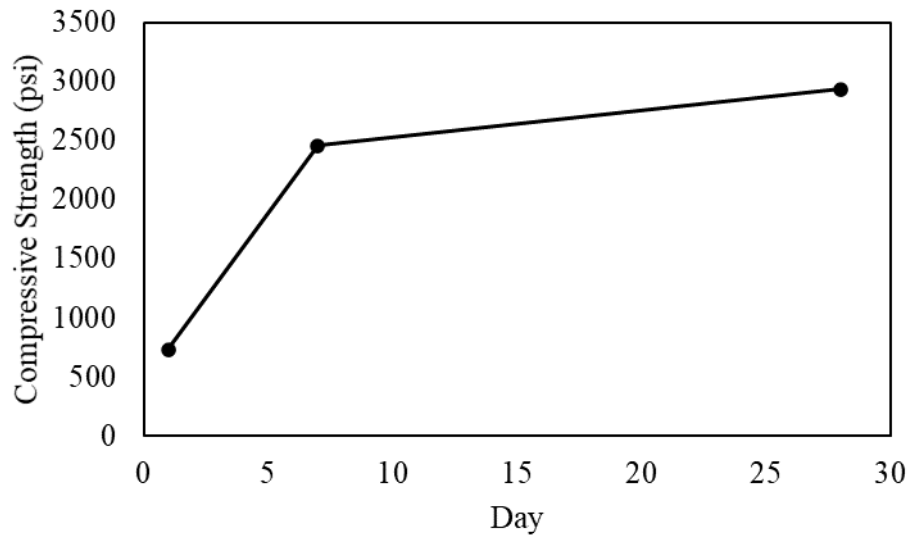
**Table 2 - Mix Design**

<b>Material</b>	<b>Weight (lb)</b>	<b>Volume (ft<sup>3</sup>)</b>	<b>Specific Gravity</b>
Cement	13.8	0.07	3.15
Fly Ash	2.29	0.01	2.5
Rubber Pellets	10.68	0.09	Unknown
Sand	59.5	0.36	2.65
Rock	56.89	0.35	2.613
Water	5.7	0.09	1
Air	0	0.04	-

The mix design described above was mixed on December 9, 2021. Slump content was taken after mixing and was determined to be 2 inches. The slump value fell between the required 1 – 4 inches proscribed by Fayetteville. Air content was not tested. Therefore, nine concrete cylinders were cast to be tested on day 1, 7, and 28. The compressive strength values are shown in Table 3 with a corresponding figure presented in Figure 1.

**Table 3 – Compressive Strength**

Cylinder	Day (psi)		
	1	7	28
1	720	2,366	2,561
2	703	2,550	3,113
3	769	2,463	3,132
<b>AVERAGE</b>	<b>730.7</b>	<b>2,459.7</b>	<b>2,935.3</b>



**Figure 1 – Compressive Strength**

The compressive strength values on day 28 did not meet the minimum required compressive strength of 3,500 psi. Therefore, alterations of the mix design would be required. A high-range water reducer may be required to meet the required minimum compressive strength. If the minimum required compressive strength could be met, extensive freeze/thaw testing should be examined.

Concrete mixtures using the mix design described in Table 2 without the inclusion of rubber pellets show much higher compressive strength on day 28. Therefore, the use of the rubber pellets greatly influenced the compressive strength of the concrete cylinders.

### **Primary Resources**

**Madison Sutton** (Social Innovation Program Manager at the Office of Entrepreneurship and Innovation)

Mentor and guide through the research and interview process. Madison has connected me with leaders in various industries that have allowed me to learn and grow throughout this whole experience.

**Joe Daniels** (Engineer at the University of Arkansas, Real Estate Investor, Speaker, all in an effort to Build Community Through Love.)

This was the first interview that I conducted during this journey. Joe Daniels gave me a starting point and really good inspiration. I asked him “Is this idea even worth pursuing?” he answered “Any idea is worth pursuing. It doesn’t matter if you fail, it is the knowledge and experience gained that brings value.” I initially thought that this interview was going to give me more insight in the engineering field, however, Joe served as a guide and leader in setting up my journey with customer discovery and talking to humans.

**Sarah Goforth** (Executive Director of the Office of Entrepreneurship and Innovation at the University of Arkansas)

My conversation with Sarah allowed me to start thinking how an entrepreneur should. She gave me resources to explore ; “Talking to Humans” and “Testing with Humans” as well as connecting me with other leaders in the OEI program at the university such as Deb Williams. Sarah challenged me to explore the upcoming opportunities within the OEI program that could further my research and proposal goals. “One way to think about how to identify a path for a



NEW solution or product is to ask yourself, what factors are changing or are likely to change in the future that will create a stronger market demand? For example, sand is a limited resource and is likely to become more expensive over time, so if you could develop an innovation that cheaply replaces sand, the ability of potential customers to pay for such a product might grow over time. What other factors are changing? There is an analysis tool called STEEPL that can help with this. That could be a good framework to include in your project.” (Goforth)

**Richard Welcher** (Vice President & C.O.O., Adjunct Professor – University of Arkansas)

Richard was another faculty member at the UofA that pushed me forward on this journey. He gave me a light lecture on “concrete 101” and the logistics behind the production and distribution in the current industry. Richard also gave me a push when I was faced with some tough roadblocks. He cc'd me in an email with Andrew F. Braham, and stated , “Understand, she's just at the idea phase on this but I didn't see any glaring "There's no way you could even consider this and you're wasting your time" elements of her concept. I mean fly ash used to go straight to landfills until someone realized it had pseudo-cementitious properties and started trying to substitute it for Portland cement, right?” (Welcher)

**Andrew F. Braham** (forefront of sustainable design practices in Civil Engineering at the University of Arkansas)

I never had a one-on-one conversation with Andrew, however, he included some interesting next-steps in my discovery in this process. He stated in an email “I’m not sure if you are able to take an elective in Civil Engineering toward your degree, but I’d be happy for you to take CVEG4863, Sustainability in Civil Engineering. The content, unsurprisingly, is almost identical to the textbook that I had the privilege to co-author with one of my recently graduate doctorate students, Sadie Casillas. If you are interested in taking the course, I would make sure that you would not

be evaluated in the course on fundamental Civil Engineering concepts which you haven't taken the classes for but would instead look to you to open the Civil Engineering student's eyes to a completely different perspective on the topics that we'll cover. In addition, I encourage you to poke around on the following website (<https://rmrc.wisc.edu/>), which has some phenomenal resources on using recycled material in Civil Engineering applications. Each of the completed research reports have a nice summary that may help you sort through some of the content.”

(Braham)

**Michael Kraus** (Project Manager at Food Loops and Founder of Second Life Lumber)

In a conversation with Michael Kraus, I gained a lot of tactics and information regarding a start-up, specifically within sustainable development. His methods behind his start-up, Second Life Lumber, are very valuable tactics that I will take with me and will keep in my back pocket when considering the early beginnings of this project.

**Heather Ellzy & Taylor Gladwin** (Environmental Educators within Recycling and Trash Collection for the City of Fayetteville)

The interview with Heather and Taylor provided me more insight on the current plastics that are being recycled in Fayetteville. They provided me information regarding the recycled plastic market and informed me on the plastic classification scale. Heather also provided me with good contacts such as NWA Material, Material Depot, and Brightmark to connect with to discuss their current recycling plans.

**Christopher Swan** (Associate Professor of Civil and Environmental Engineering, Dean of Undergraduate Education, Tufts School of Engineering, Faculty, Jonathan M. Tisch College of Civic Life)

Christopher Swan is the Inventor of current patent #6669773B2. This patent is very similar to the mixture that I am pursuing regarding incorporating plastic and fly ash in concrete mixtures. I was able to arrange a conversation with him via zoom. He gave me insight on the status of the patent and its future. He was very keen on the idea of commercializing it and is looking forward to someone like me, passionate about pursuing and testing this idea. At the end of the day, he would like for this patent to be used to enhance sustainable design and development.

### **Helena True**

This conversation with Helena brought me to another subject of study regarding byproduct replacement in concrete mixtures. Years ago, True wrote her thesis on the benefits of replacing portions of cement with byproducts of burnt rice husk and coal, also known as RHA and fly ash. This conversation was very encouraging as it opened another opportunity for study and pushed me to explore another green alternative to the current concrete production method.

**Rilye Dillard** (PHD student at the University of Arkansas, Civil Engineering) **and Cameron Murray** (Assistant Professor | Department of Civil Engineering)

Contacts within the Civil Engineering Department at the University of Arkansas that allowed me access to facilities and assisted me in the testing of the two mixtures.

## Works Cited

Breckon, Robert. "Waste Plastic in Concrete Could Help Support Sustainable

Construction in India." *University of Bath*, 20 Dec. 2018,

[www.bath.ac.uk/announcements/waste-plastic-in-concrete-could-help-](http://www.bath.ac.uk/announcements/waste-plastic-in-concrete-could-help-support-sustainable-construction-in-india/)

[support-sustainable-construction-in-india/](http://www.bath.ac.uk/announcements/waste-plastic-in-concrete-could-help-support-sustainable-construction-in-india/). Accessed 7 Dec. 2021.

B.V. Venkatarama Reddy, K.S. Jagadish

Embodied energy of common and alternative building materials and  
technologies

*Energy Build.*, 35 (2003), pp. 129-137

Class Notes.CSP Framework & Foundations Folder. "Statement on the

Purpose of a Corporation." Business Roundtable. August, 2019. Pp.1

"Construction: Resources." *Global Edge*, 2021,

[globaledge.msu.edu/industries/construction/background](http://globaledge.msu.edu/industries/construction/background). Accessed 7 Dec.

2021.

"Construction Site Safety Inspections and Audits." *Safety Consulting Training and*

*Equipment*, 2021, [www.totalsafety.org/site-safety-services/construction-site-](http://www.totalsafety.org/site-safety-services/construction-site-safety-audits/)

[safety-audits/](http://www.totalsafety.org/site-safety-services/construction-site-safety-audits/). Accessed 7 Dec. 2021.

Eccles, Robert G., and Svetlana Klimenko. "The Investor Revolution." *Harvard*

*Business Review*, June 2019, [hbr.org/2019/05/the-investor-revolution](http://hbr.org/2019/05/the-investor-revolution).

Accessed 7 Dec. 2021.

"Greening Construction Full Report." *IFC*, 2018,

[www.ifc.org/wps/wcm/connect/4a3fce61-a95b-4944-8059-](http://www.ifc.org/wps/wcm/connect/4a3fce61-a95b-4944-8059-62b9f9f450ea/201905-Greening-Construction-Full-Report.pdf?MOD=AJPERES&CVID=mH6grRT)

[62b9f9f450ea/201905-Greening-Construction-Full-](http://www.ifc.org/wps/wcm/connect/4a3fce61-a95b-4944-8059-62b9f9f450ea/201905-Greening-Construction-Full-Report.pdf?MOD=AJPERES&CVID=mH6grRT)

[Report.pdf?MOD=AJPERES&CVID=mH6grRT](http://www.ifc.org/wps/wcm/connect/4a3fce61-a95b-4944-8059-62b9f9f450ea/201905-Greening-Construction-Full-Report.pdf?MOD=AJPERES&CVID=mH6grRT). Accessed 7 Dec. 2021.

Kell, Georg. "The Remarkable Rise of ESG." *Forbes*, 11 July 2018,

[www.forbes.com/sites/georgkell/2018/07/11/the-remarkable-rise-of-](http://www.forbes.com/sites/georgkell/2018/07/11/the-remarkable-rise-of-esg/?sh=3b6d5da16951)

[esg/?sh=3b6d5da16951](http://www.forbes.com/sites/georgkell/2018/07/11/the-remarkable-rise-of-esg/?sh=3b6d5da16951). Accessed 5 Dec. 2021.

Killie, Leighton Walker. "Does Governmental Incentives or Economic Growth

Stimulate Green-Building Construction?" *The Journalists Resource*, 9 July

2013, [journalistsresource.org/environment/governmental-incentives-green-](http://journalistsresource.org/environment/governmental-incentives-green-building-construction/)

[building-construction/](http://journalistsresource.org/environment/governmental-incentives-green-building-construction/). Accessed 7 Dec. 2021.

Killough, Dawn. "Demand for Green Construction Doubles Every Three Years."

*Green Building Elements*, 23 Nov. 2015,

[greenbuildingelements.com/demand-for-green-building-doubles-every-three-](http://greenbuildingelements.com/demand-for-green-building-doubles-every-three-years/)

[years/](http://greenbuildingelements.com/demand-for-green-building-doubles-every-three-years/). Accessed 4 Dec. 2021.

Lee, Chermaine. "Future Planet." *BBC*, Mar. 2021,

[www.bbc.com/future/article/20210302-could-plastic-roads-make-for-a-smoother-ride](http://www.bbc.com/future/article/20210302-could-plastic-roads-make-for-a-smoother-ride). Accessed 7 Dec. 2021.

Lockwood, Charles. "Building the Green Way." *Harvard Business Review*, June 2006,

[hbr.org/2006/06/building-the-green-way](http://hbr.org/2006/06/building-the-green-way). Accessed 7 Dec. 2021.

Musulin, Kristin, editor. "5 Key Ways to Reduce GHG Emissions in Building

Construction." *Smart Cities Dive*, 11 Oct. 2019,

[www.smartcitiesdive.com/news/5-key-ways-to-reduce-ghg-emissions-in-building-construction/564707/](http://www.smartcitiesdive.com/news/5-key-ways-to-reduce-ghg-emissions-in-building-construction/564707/). Accessed 7 Dec. 2021.

Quiang, Christine Zhenewei, et al. "Global Investors Shift Focus to Sustainability amid

Push for a Green Recovery." *World Bank Blogs*, 15 June 2021,

[blogs.worldbank.org/psd/global-investors-shift-focus-sustainability-amid-push-green-recovery](https://blogs.worldbank.org/psd/global-investors-shift-focus-sustainability-amid-push-green-recovery).

R. Singh, T.P. Ojha, R.C. Maheshwari

Development of a husk fired furnace *J. Agric. Eng. Res.*, 25 (2) (1980),

pp. 109-120

Sikra, Sonya. "How Does Construction Impact the Environment." *GoContractor*, 21

June 2021, [gocontractor.com/blog/how-does-construction-impact-the-environment/](https://gocontractor.com/blog/how-does-construction-impact-the-environment/). Accessed 7 Dec. 2021.

"6 Reasons to Invest in a Greener Building." *Sustainable Tourism 2030*, 2021,

[www.sustainabletourism2030.com/6-reasons-to-invest-in-a-greener-building/](https://www.sustainabletourism2030.com/6-reasons-to-invest-in-a-greener-building/). Accessed 7 Dec. 2021.

T-Mobile. "T-mobile 2020 Corporate Responsibility Report." *T-mobile*, 1 Jan. 2020,

[www.t-mobile.com/content/dam/t-mobile/assets/pdf/T-Mobile\\_CSR20\\_10921.pdf](https://www.t-mobile.com/content/dam/t-mobile/assets/pdf/T-Mobile_CSR20_10921.pdf). Accessed 7 Dec. 2021.