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CLIMATE CHANGE IMPACTS ON AND ACTIONS FROM THE CONSTRUCTION INDUSTRY: PAST, PRESENT AND FUTURE

BY:

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Abstract:

Over the past 100 years, global temperatures have risen steadily. The construction industry contributes to global emissions immensely. New policies aim to curtail emissions to limit the continued global warming. The construction industry will need to change to adhere to stricter emissions standards. Changes to construction materials, modifications to construction machinery, and the installation of greener building components and systems can reduce total emissions. Contractors' who embrace these changes will allow the construction industry to transition from a primary offender to a force for change, and the AGC has the opportunity to spearhead this evolution of the industry.

The construction industry accounts for 13.2% of global GDP (Roman 2022), yet the industry accounts for 38% of total emissions (Neill 2020). The construction market is expected to continue to grow year over year, however recent international agreements have put sustainability initiatives in place that are, frankly, unattainable with the current construction practices. While action has been taken to make the construction industry more sustainable, there is still significant change needed. It is going to take a collaborative effort between construction contractors, material production companies, and the contractor's clients to institute meaningful change that reduces the emissions, pollutants, and waste associated with construction projects. A building's construction can also be altered to increase the sustainability of the structures themselves over their lifespans.

At the turn of the 20th century, the construction methods in use today began to gain popularity. By this point, early reinforced concrete was already in use, and structural steel use grew rapidly in the beginning of the century (A Brief History of Steel Construction, 2018). Many of the heavy construction machines used in modern construction were invented around this time as well (The History of Heavy Construction Equipment, 2021). As the construction industry grew over the past 100 years, so did the use of these building materials and equipment, contributing to the rising carbon emissions over this time period.

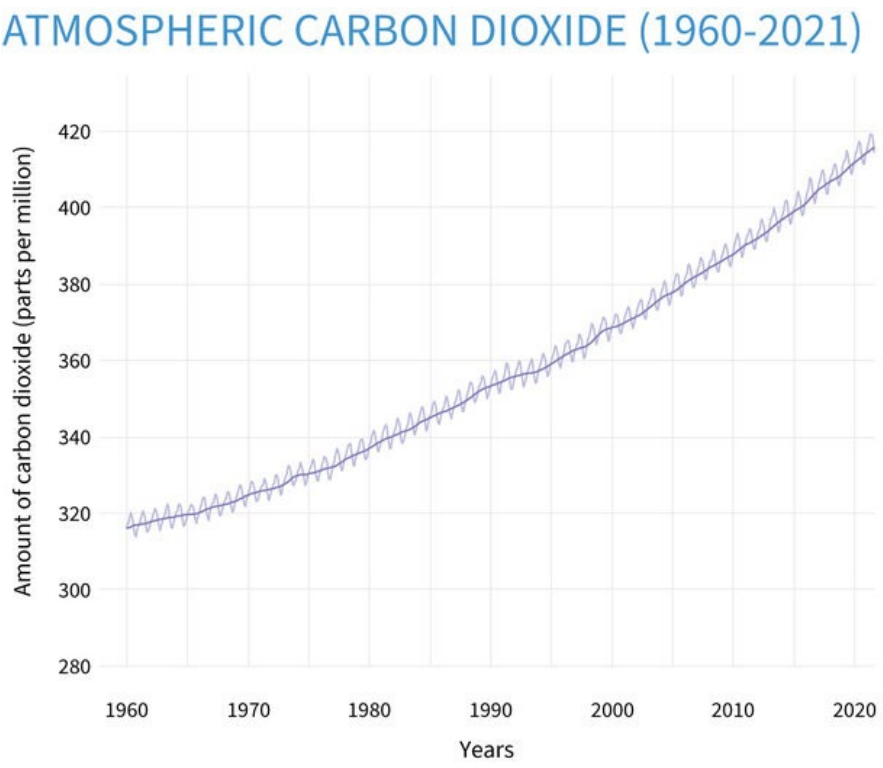

Figure 1: Record of atmospheric carbon dioxide levels recorded at Mauna Loa Observatory (Lindsey, 2022)

The above graph illustrates atmospheric carbon dioxide, measured at Mauna Loa Observatory from 1960-2020. The graph illustrates a steady rise in atmospheric carbon dioxide which has increased by nearly 25% over the last 50 years. This rise in carbon dioxide in the atmosphere is a major driver of climate change. The potential consequences of a continued rise have been recognized, and attendees of the UN Climate Change Conference have acknowledged the need to curb emissions in order to minimize future impacts to both the environment and society (UNFCCC, 2016). The Paris Agreement, entered into force on 4 November 2016, aims to limit the warming of the planet, primarily through a focus on the implementation on low- and zero-carbon solutions to numerous emissions sources (UNFCCC, 2016).

The construction industry, like every market sector, is not immune to the need to implement such changes. The reduction of carbon emissions can be achieved through the implementation of newer, more sustainable construction materials, lower net carbon methods of producing current construction materials, and more efficient construction methods and machinery.

One of the most exciting prospects in the construction industry is the adoption of mass timber as a design choice in high-rise buildings. Research into mass timber has solidified its validity as a construction method, and research from Germany's Institute for Climate Impact Research suggests that mass timber can reduce the carbon footprint of urban areas as a whole. In a paper published in *Nature Sustainability*, an increase in the percentage of new buildings constructed with mass timber provides a carbon sink in urban areas. If 50% of new building construction worldwide utilizes mass timber, it is estimated that between 1 and 11 billion tons of carbon dioxide would be stored within the mass timber structures over 30 years, which is the time remaining for the industry to achieve net-zero emissions. With annual emissions currently totaling 35 billion tons of carbon dioxide (Lindsey, 2022), mass timber construction could counteract 1% of these emissions. Mass timber buildings also reduce the total carbon emissions associated with material production. 50% of new building construction being comprised of mass timber results in roughly a 26% reduction in total carbon emissions of all material manufacturing for buildings over the same time period (Churkina et al., 2020). This reduction in emissions is due to both the lower emissions of mass-timber production and the reduction in transportation demands and foundation size associated with a smaller total weight of building materials.

The comparative emissions of the current material usage and a 50% mass timber usage, as well as 10% and 90% mass timber usages, are shown below.

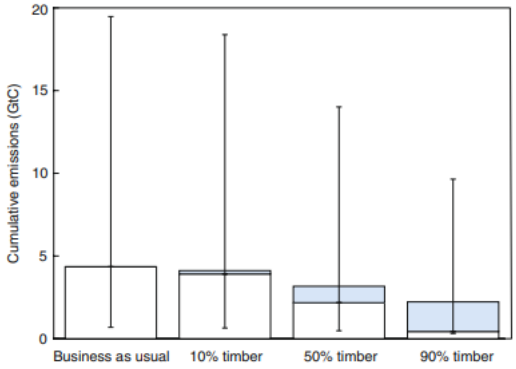

Figure 2: Total Carbon Emissions of material manufacturing with mass timber at various percentages of total construction (Churkina et al., 2020)

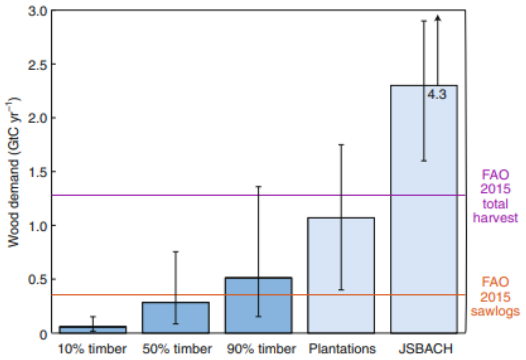

Figure 3: Comparison of wood demand at different percentages of total construction and available wood supply (Churkina et al., 2020)

While there are numerous benefits to mass timber from a net carbon perspective, the material demand must not exceed the supply of wood in the forests of the world. Managing the demand ensures that forest areas can be replenished at a sustainable rate while maintaining tremendous carbon sink these forests provide. As shown above, if 50% of new construction utilizes mass timber, the existing annual harvest of wood is sufficient to supply the material demand, assuming current allocations for fuel wood are redistributed into building material production as more sustainable heating practices are enacted (Churkina et al., 2020). While this forecast is on the global level, the United States has both the forest area and wood processing facilities to make mass timber a substantial portion of new building construction.

The reduction in carbon footprint of mass timber can help offset the emissions of conventional building materials as production methods are updated to be more sustainable.

Mass timber provides a sustainable alternative to steel and concrete construction for buildings, but there are many other areas of the construction industry that will still necessitate the need for these conventional materials. Even with a reduction in total demand, existing production methods have extremely high emissions. Cement, a crucial component in concrete, is the single largest contributor to carbon emissions, accounting for 8% of total global emissions (Ramsden, 2020). There are several ideas that have been proposed to reduce the net output of cement production. Some of these ideas are carbon valorization, which is the process of converting waste CO_2 into valuable products, or the sequestration of the CO_2 into solid forms to keep it out of the atmosphere (Ramsden, 2020). One of the most interesting developments in concrete is the invention of greener alternatives to traditional cement. Solidia, a New Jersey based company, has made significant innovations in cement and concrete. Solidia has patented a method of cement and concrete production that utilizes a more efficient cement formula with a smaller energy demand, which cuts greenhouse gas emissions by roughly a third. This cement is then mixed with aggregate, but is cured using CO_2 in under 24 hours, rather than water curing which takes nearly a month. This curing method sequesters CO_2 in the concrete and drastically reduces the water demand of concrete curing (Solidia, 2020). Below is a graphic illustrating the difference in Solidia's proprietary method vs the traditional method of curing concrete, as well as the numerous benefits this new method provides.

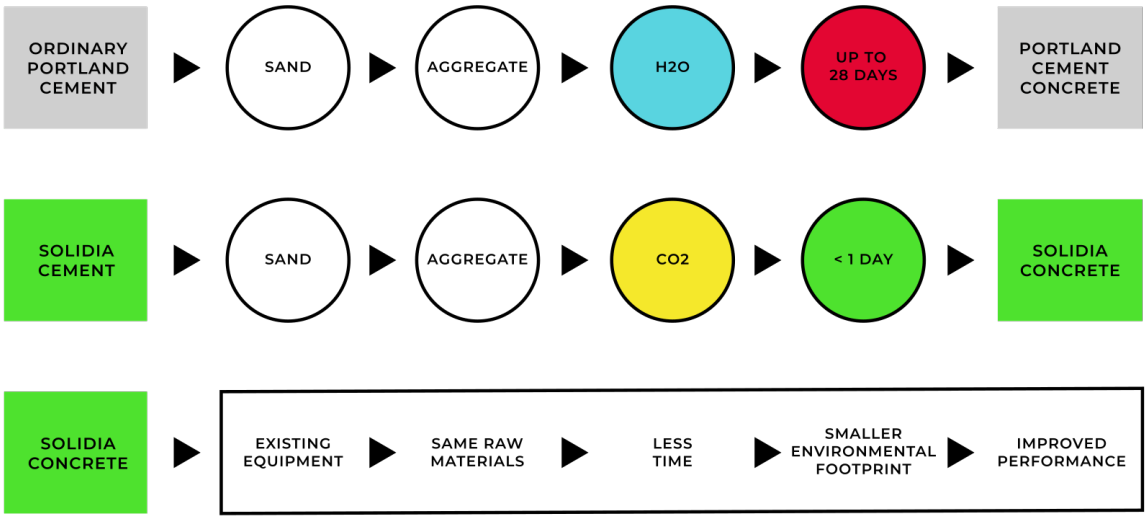

Figure 4: Comparison of Concrete Production Methods and the Benefits of Solidia Concrete (Solidia, 2020)

In addition to changes to the construction materials, construction machinery can be retrofitted to reduce emissions associated with the construction process. Clean Construction USA, a program launched by the EPA, was formed to advocate for such retrofitting and other changes that could reduce emissions from these machines. The program encourages the installation of Diesel Particulate Filters and Diesel Oxidation Catalysts on construction machinery to reduce the emissions from their engines. Other recommended practices include reducing idling, switching to cleaner fuels (i.e. biodiesel, natural gas), and the replacement of older engines with newer ones that are cleaner and more efficient. The EPA, as well as state and local governmental bodies, offer grants or tax incentives to motivate contractors to implement these changes (Environmental Protection Agency, 2022).

The materials and machinery used during construction account for the emissions associated with the construction industry. While the construction process is a contractor's primary concern, there are additional decisions contractors can make to increase the sustainability of the structures they work on. LEED is a grading system that evaluates the sustainability of buildings, from environmental, social, and economic perspectives, based on the installation of various features. There have been numerous innovations in various building components to reduce emissions and increase the efficiency of buildings. Most high-rise buildings have facades composed mostly of windows, and newer windows offer numerous advantages in energy efficiency. When constructing building layouts, the size and location of windows can be arranged to maximize this natural light which reduces the total energy need for internal lighting. Modern window panels can be double glazed and/or double paned, which reduces heat loss and limits additional heating from solar radiation, without compromising this natural light (Zhigulina and Ponomarenko, 2018). Some construction projects are replacing traditional building systems with more innovative designs that maximize efficiency. A high-rise in Guangzhou China replaced the majority of air conditioning ventilation ductworks with a system integrating into the floor which circulates chilled liquid, cooling the building more efficiently. The building also has an integrated heating system and dehumidifier within ventilation shafts that run between panes of glass on the building façade (Zhigulina and Ponomarenko, 2018). These integrated shafts increase efficiency without the need for additional costly machinery.

If a contractor lacks the specialized knowledge needed to implement new and innovative systems such as the ones discussed above, traditional building systems can be modified to increase efficiency. When rainfall drainage is installed, the inclusion of a rainfall collection and filtration system creates an auxiliary water supply for a buildings cooling system, reducing the total municipal water demands of the structure. Automated light dimming systems and shading systems can balance the reducing of lighting and cooling demands with the maximizing of natural light. Additionally, renewable energy systems can be installed on a building to reduce the overall energy demand on the power grid without actually increasing the efficiency of traditional systems (Al-Kohmany, 2022).

The most significant obstacle to the widespread adoption of any of these changes is increased cost. It is hard to expect contractors to include more sustainable components and practices when these alterations raise the overall construction cost. While the plethora of changes necessary to adhere to climate change policies is a daunting and expensive undertaking, changes can be made incrementally, spreading the additional cost over years, if not decades. Addressing climate change is also more than a strictly financial issue. A more holistic, long-term perspective can reduce a contractor's aversion to implementing change. Taking a greener approach to construction results in a net benefit for the entire community, and contractors can take pride in the progress they are making to foster a more sustainable and environmentally conscious society. Contractors can also convey this focus on sustainability to the owner, and clients are more likely to approve a more expensive budget so long as the benefits to the community and the environment are well explained.

In addition, federal climate change policies will continue to get stricter as we approach the Paris Agreement's goal of net-zero carbon emissions by 2050. An early adoption of sustainable materials and practices will allow contractors to familiarize themselves with this new style of construction, creating an advantage in the industry if competitors are slower to adopt.

While some contractors may have a conscious aversion to change, ignorance can pose a similarly significant obstacle to addressing climate change. The AGC has the means and access to inform a myriad of contractors of the effect climate change policy has and will continue to have on the construction industry. The emissions standards enumerated by the Paris Agreement will only get more restrictive, and making contractors aware of the constraints their business will face will allow contractors to adjust both their immediate and long-term operations accordingly. Contractors will then be able to institute company policies that ensure they are equipped to continue to operate while adhering to government regulations. Advance notice of future regulation reduces the likelihood that contracting companies encounter financial difficulties while instituting change. Smaller firms are especially at risk, as they are on smaller margins and have less free capital, which makes them less able to invest in sustainable practices rapidly. Through conferences, seminars, and the Constructor Magazine, the AGC can both inform contractors of current and impending sustainability and emissions standards and explain what changes can be made to meet these standards. It will take a collective effort across industries to mitigate the already mounting effect of climate change, and contractors are uniquely able to implement meaningful, lasting change that will preserve the environment for generations to come.

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