Designing for the Future: Foreseeing climatic risk with model-based design

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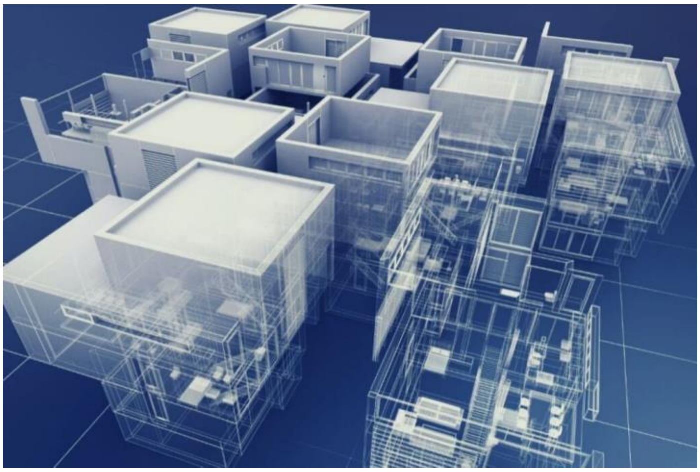
BIM technology is a modelling software where an accurate virtual model of a building is digitally constructed. Traditionally, BIM allows architects to predict potential construction hazards and prevent them by adjusting the design. This article suggests using BIM in the design and construction phase enables less wasteful construction and more sustainable operation and maintenance of the building.

Climate change is one of the most pressing issues of the 21st Century. Australia's ever-expanding population brings with it a construction boom which has seen a record amount of construction activity to appease the growing demand for infrastructure. Accounting for about 9% of Australia's Goss Domestic Product (GDP), with a projected 2.4% increase over the next five years, the construction sector is a key economic driver in Australia and for good measure, is also a significant contributor of greenhouse gas emissions. Greenhouse gas emissions are gases emitted during human activities such as burning fossil fuels or solid waste which trap heat in the atmosphere and consequently, raise global temperatures resulting in ecological consequences. In Australia, the construction sector contributes almost a quarter of the national carbon footprint and the housing market boom will see this figure increase in the coming years.



Source: Dormakaba

HONOURING A COMMITMENT: ALL EYES ON THE CONSTRUCTION SECTOR

As a signatory to the Paris Climate Change Agreement, Australia has committed to achieving a 1% global carbon budget by 2050, as set by the Australian Climate Change Authority. In order to stay within this recommended budget, Australia must address one of the biggest greenhouse gas emitting industries in the country – the construction industry. Historically, the construction industry has had little appetite to adapt their processes to the challenges of climate change. The barriers to uptake of sustainable methods and design in construction is multifactorial and includes issues such as a lack of government leadership in passing legislative requirements, perceived high costs, and maintenance of the status quo.

However, with the intensity and variability of climatic conditions increasing, pressure is mounting on the industry to adopt a more environmentally-conscious focus at all stages of the construction life-cycle. Extreme heat, wind, droughts, excessive rainfall, and flooding are all risks that are exacerbated by climate change. These risks not only disrupt the construction process due to delays caused by, for example, heat stress experienced by labourers and upending the supply chain but, without careful consideration of these risks during the design phase of a project, buildings are susceptible to becoming inefficient and structurally obsolete leading to higher costs and wasteful demolitions. Addressing the sustainability of construction projects during the design stage enables infrastructure to be built for future conditions thereby preserving its viability of use in the long-term and reducing overall greenhouse gas emissions.

BIM: DESIGNING WITH THE FUTURE IN MIND

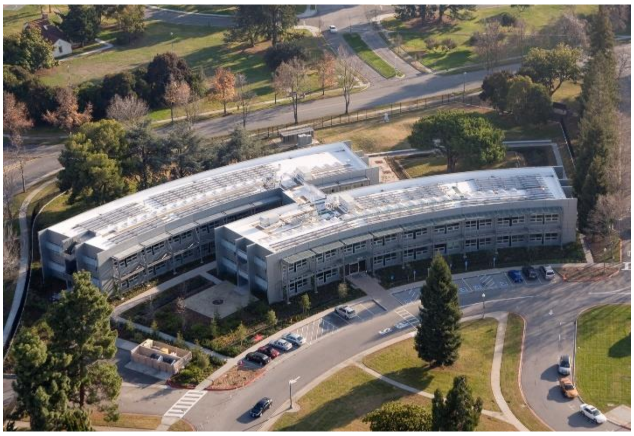
Infrastructure that is durable and sustainable reduce greenhouse gas emissions because they have been adapted to the climatic conditions for which they are built and perform at greater efficiency by harnessing the energy of natural resources. Sustainable projects rely heavily on configuring the design of a project to the environment with consideration of not only current climatic conditions but also future climatic conditions.

Modelling technologies of today have the ability to produce digital representations of designs with consideration to their suitability to changing climatic conditions. Research into the utilisation of BIM (Building Information Modelling) in sustainable design of the built environment is limited and policies and legislation are slow to encourage its uptake. However, leaders in the construction industry are risk-averse to the disruptions of volatile climatic conditions and are also opportunistic in adapting to new technologies where cost savings can be incurred. Modelling technologies such as BIM are widely utilised today within the design phase of a construction project. BIM's functionality is far-reaching and holds overwhelming potential to extend its capabilities into sustainable design. The ability to integrate weather-related data and produce simulations of adaptable building designs can inform decision-makers early in the construction phase of the optimal design for a project.

Source: Siemens

As weather becomes more extreme, there is a move towards greening the built environment and weather-proofing projects to withstand future climatic risks. Already used extensively during the design phase, BIM's capabilities of simulation are able to extend to modelling the use of emerging climate change technologies which adapt the components of a building to the variability of the climate. Examples include green roofs, vacuum windows, larger gutters to withstand more extreme rain events, and passive design which incorporates natural heating and cooling techniques.

Energy Efficiency: The prevalence and intensity of hot days and extreme temperatures are projected to increase in the future, and the negative impacts will create issues of concern in both the construction process and in post-construction. Rising temperatures impact the functionality of building designs by causing a higher demand for electricity to fuel cooling systems which drive up prices and cause blackouts. The Department of the Environment and Energy reports that Australian households are directly responsible for about 20% of Australia's greenhouse gas emissions. There is potential to greatly reduce this contribution by assessing energy efficient measures with BIM and other building simulation technologies. With energy simulations, BIM can provide an early indication of the projected energy efficiency of a project and forecast efficiency over time by adjusting the measures to expected climatic conditions. Location-specific weather data such as solar radiation, wind speed and direction, air humidity, and atmospheric pressure can inform decision-making in terms of heating and cooling, lighting, ventilation, wind systems and solar panels etc and assess their suitability and performance over time.



Nasa Lunar-Shaped Building, Silicon Valley.

Source: NASA

- Case study: Nasa's iconic lunar-shaped building located in Silicon Valley is one of the most prominent construction projects utilising BIM technology for sustainable design purposes. The distinguished building integrates energy efficient features that were tested in the early design stage to reduce consumption by designing it to be "native to place". Features include "a steel-frame exoskeleton, geothermal wells, natural ventilation, wastewater treatment, and a photovoltaic roof that provides 30% of the building's power."

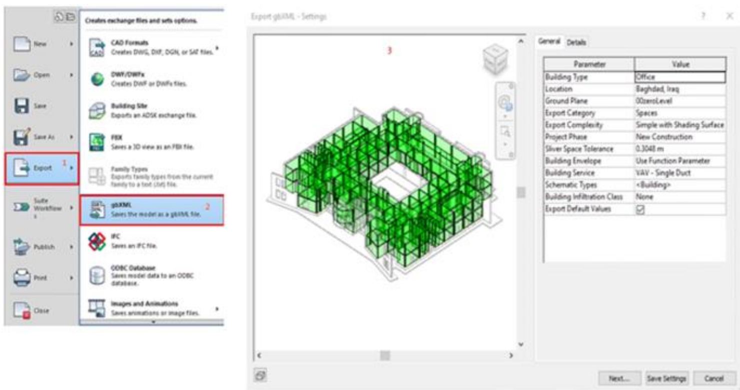
  Built in 2009, the 'sustainability base' was somewhat of a novelty whose sustainable features served to highlight the innovative advances of green technology applied on a large-scale project. Twelve years later, the applicability of renewable energy technologies is endless and has burgeoned into many areas of the built environment including commercial, residential, industrial, agricultural, transport, and can even be found on the international space station. As such, the integration of sustainable design in future construction projects is no longer a novelty.

Water usage: Climate change causes an increase in extreme temperature which can cause scarcity of essential resources such as water. An increase in extreme heat events over prolonged periods of time can lead to reduced rainfall and eventually drought which can impact both the construction phase and post-construction operation and management of the asset. Adequate water supply is an essential element of the construction process and where supply is limited, the feasibility of construction projects will be impacted as water restrictions are imposed and water prices increase. Simulating plumbing fixtures and mapping their positioning is a functionality frequently utilised by BIM to ensure adequate positioning of pipes and early identification of design conflicts. This functionality has the capability to be expanded to include simulation of water conservation measures. BIM can function in combination with smart appliances and sensors to simulate water usage used within the lifecycle of an asset by adjusting the specifications for the desired consumption and varying between water systems. With the ability to digitally visualise water supply and drainage, water usage projections can improve the efficiency of water consumption in infrastructure, reducing wastage and saving costs for the end-user. By simulating the project in the design phase, BIM is capable of calculating data such as the water flow within pipes and hydraulic pressure, information which can be used to determine the optimal equipment size to adhere to suggested parameters.

Materials: In 2005, Australia's construction sector was reported as being the largest consumer of materials while also recording a considerably lower recycling rate compared to other OECD countries. As such, materials used in construction is one of the largest contributors to embodied gas emissions and is a ripe area to address in Australia's aim in reaching a net zero emissions target. There is an environmental cost to all materials and while the construction industry tends to opt for convenience and reliability, there is client-side demand for improved cost-effectiveness in the operation of an infrastructure's lifecycle post-construction. Materials that are adaptable, reusable, and can be demolished and recycled not only help in minimising environmental impacts but also extends the lifetime of a building's infrastructure thereby, saving on material in the future. Modelling sustainable materials in the design phase of a project can lead to the streamlining of materials so that it can be manufactured off-site while also reducing material overrun. Other methods of reducing material waste is to opt for alternative less energy intensive materials, for example, wood instead of brick. BIM can model and test the use of alternative materials to assess the capability of its intended function and its performance over time.

COST SAVINGS

Data on the cost savings due to the use of BIM technology in construction projects is scarce and the integration of sustainable design in the construction sector in Australia is yet to indicate "tangible positive results." This is largely a result of a lack of political will in instituting regulatory requirements as well as weak sustainability awareness and consumer power to change the status quo. According to *Yang and Yang* (2015), "Voluntary uptake of sustainable housing is still in its infancy in Australia, mostly driven by motives of experimentation, showcasing and marketing."

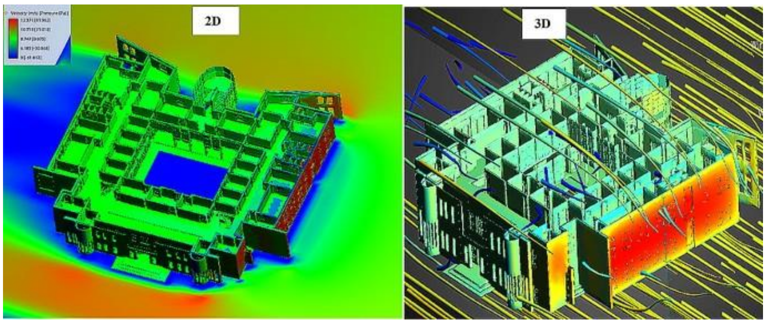


Source: SpringerLink

However, A 2016 report by the Australian Sustainable Built Environment Council (ASBEC) estimates a savings of approximately AU$20 billion if the goal of zero carbon emissions is achieved by residential and commercial buildings by 2050. Sustainable buildings are reported to operate 28% more efficiently than conventional buildings and there are undeniable savings, both direct and indirect, that can be attributed to the integration of sustainable design in construction projects, both during the construction process and in post-construction. The financial benefits and cost savings incurred as a result of sustainable construction are far-reaching and include lower material use, reduced energy consumption, water cost savings, lower cost of facility maintenance and repair, as well as indirect benefits to society such as reduced pollution and environmental protection.

CONCLUSION

Climate change is a looming threat and just like the tale of a frog in a heating pot, we sit complacent in our apathy until the gradual increase takes us to a point of no return. Australia has committed to addressing climate change by setting a target of zero net emissions by 2050. To reach this target, Australia must tackle one of the largest contributors of greenhouse gas emissions in the country – the construction sector. The construction and maintenance of buildings alone account for almost 25% of Australia's greenhouse gas emissions and is projected to increase with the growing population.



Source: SpringerLink

While the catastrophic impacts of climate change are a looming threat, early indications are felt today and in order for our built environment to withstand the impending threats, we must prepare for these changes by designing for these new extremes. BIM technology has been widely implemented in the construction industry for decades and has recently been embraced in the area of sustainable design. Uptake has been slow however, the functionality to incorporate sustainable design principles exists within BIM and its potential to bring about cost savings through the reduction in greenhouse gas emissions both in the construction process and post-construction phase, is undeniable. BIM's capability to design infrastructure adapted to the climatic conditions of its location holds vast potential for building durable and sustainable assets that operate more efficiently and bring about cost savings.

BIM's role in addressing greenhouse gas emissions is not just a conceivable tool but one of essentiality. Designing for the future requires preparedness in the design phase of a construction project and BIM's capability to simulate both the physical and functional features of sustainable design is key to reducing greenhouse gas emissions across the lifecycle of the asset.