Integrating Resilience into the B3 Guidelines

A report prepared for the
Minnesota Legislature
By
The University of Minnesota
Center for Sustainable Building Research
And
Minnesota Climate Adaptation Partnership
And
HGA Architects and Engineers
And
Willdan

Cover Image: Jerry Holt/Star Tribune via Getty Images - Downtown Saint Paul on June 14, 2023

Funding:
Per the requirements outlined in Minnesota Statute 3.197, the cost to prepare this report was $35,595

Contributors:

Center for Sustainable Building Research (CSBR)

The Center for Sustainable Building Research is a research center in the College of Design at the University of Minnesota. Building on past success and looking into the future, the work of the Center is focused in six areas, each directly linked to each other and to the built environment: energy and climate change; the water cycle; sustainable materials for a healthy built environment; measuring regenerative design; equitable designs to provide sustainability for all; and creating regenerative and resilient communities. It is impossible to solve any of these problems in isolation from each other, thus transforming building industries and the built environment will strike at root causes.

University of Minnesota Climate Adaptation Partnership (MCAP)

The University of Minnesota Climate Adaptation Partnership (MCAP) offers critical resources and training to help communities respond to changing weather and climate conditions and prepare for the years to come. Affiliated with both University of Minnesota Extension and the College of Food, Agricultural and Natural Resource Sciences, MCAP performs foundational climate research while also offering hands-on support to individuals and organizations across a range of backgrounds and industries in Minnesota, the Midwest region and beyond.

HGA Architects and Engineers

A national interdisciplinary design firm rooted in architecture and engineering. We believe that the best design results from deep insight into the people and passions that animate each unique environment. HGA employs an integrated, research-based approach to design. Research is foundational to our work and philosophy. The scope of our research work is broad—from the innovations that will drive our clients' future business to the technological and social changes that will enable unique and inspiring design solutions. We also aim to learn from individual projects through leveraging technology, data collection, and ethnography—to inform the next project, and translate into the next great idea.

Willdan

For 60 years, Willdan has delivered industry-leading engineering and energy solutions that have transformed government and commerce – having implemented over 100 utility programs and served 230,000 small business, healthcare, hospitality, and education customers nationwide.

Introduction

Possible Future Climate Impacts to Built Environment

Future weather scenarios have the potential to significantly impact the built environment in Minnesota. Increased flooding from more frequent and intense rainfall events overwhelm stormwater systems and damage infrastructure. Rising temperatures heighten energy demand for cooling, straining power grids and increasing utility costs. Cooling systems in existing buildings are also likely to be strained,causing unsafe indoor temperatures for some[1]. Milder winters affect the longevity and performance of building materials designed for colder conditions, resulting in premature deterioration[2]. High density of impervious surfaces (e.g., paved roads, parking lots, roofs, sports fields with highly compacted soil) in urban areas may cause more intense heat island effects, exacerbating heat-related health issues. Furthermore, more severe weather events and temperature fluctuations lead to higher maintenance and repair costs for buildings and infrastructure. Changing precipitation patterns also impact water supply and quality, necessitating upgrades to water management infrastructure, such as stormwater drainage and storage, sewer systems, and treatment plants. Existing buildings may require retrofitting for protection against extreme weather, including stronger roofs and enhanced drainage. Transportation networks face disruption from flooding and winter storms, impacting accessibility and safety. Additionally, shifts in local ecosystems can affect green infrastructure, such as urban trees and parks, which play a crucial role in providing shade and managing stormwater. Warmer temperatures contribute to increased invasive pest activity (e.g., termites[3]), weakening building integrity and demanding maintenance. Lastly, climate-related factors pose public health risks, prompting the need for changes in building designs to improve air quality and ensure access to healthcare facilities[4].

The B3 Guidelines have led to significant reductions in energy and water use while providing high quality spaces, often with an expected building life of 50-100 years. While the B3 program mandates 10 years worth of monitoring and reporting for energy use, little is required to ensure the longer term success of projects following the B3 guidelines. This creates an opportunity to integrate resilience and long term strategies into the B3 guidelines that complement the short term efficiency goals of the program. Because the B3 guidelines have always taken a holistic approach to sustainability, many measures already required by the Guidelines provide some resilience benefit, meaning the existing guidelines can be adjusted and enhanced for resilience. For each guideline section, resilience opportunities are outlined and proposed guideline items are summarized.

---

[1] Attia, Shady, Ronnen Levinson, Eileen Ndongo, Peter Holzer, Ongun Berk Kazanci, Shabnam Homaei, Chen Zhang, et al. 2021. Resilient Cooling of Buildings to Protect against Heat Waves and Power Outages: Key Concepts and Definition. *Energy and Buildings* 239: 110869. https://doi.org/10.1016/j.enbuild.2021.110869.

[2] Al-Shatnawi, Zahra, Caroline Hachem-Vermette, Michael Lacasse, and Bahador Ziaeemehr. 2024. Advances in Cold-Climate-Responsive Building Envelope Design: A Comprehensive Review." *Buildings* 14, 11: 3486. https://doi.org/10.3390/buildings14113486.

[3] Zanne, Amy E., Habacuc Flores-Moreno, Jeff R. Powell, William K. Cornwell, James W. Dalling, Amy T. Austin, Aimée T. Classen, et al. 2022. Termite Sensitivity to Temperature Affects Global Wood Decay Rates. *Science* 377, 6613: 1440–44. https://doi.org/10.1126/science.abo38

[4] Cissé et al. 2022. Health, Wellbeing, and the Changing Structure of Communities. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 1041–1170. doi:10.1017/9781009325844.009.

Resilience Opportunities and Recommended Changes

Performance Management

The Performance Management guidelines are designed to assist project teams in gathering necessary information and coordinating the design, construction, and operations processes in order to ensure that each project successfully meets key performance criteria, including those of the B3 Guidelines. These guidelines are a rich area for risk assessment, resilience planning, and ensuring operational resilience after building handoff.

- P1 - Design and Construction Process
    - Add resilience requirements to Owner's Project Requirements (OPR), Commissioning Plan, Basis of Design (BOD) templates
        - Integration of requirements as early as possible
    - Perform a Hazard/ Vulnerability /Risk assessment including future climate and relevant state, county, and municipality assessments using the to-be-developed B3 Resilience Worksheet 2.0. Establish resilience response mode.
        - Tool for designer communicate to owner

- P2 - Operations Process
    - Develop Resilient Operations Guide for owner-operator that explains the functionality and maintenance requirements of any active or passive resilience features
        - Responsibility of follow up
            - Tracking tool input
            - Benchmarking
        - Metrics and indicators - how to document cost avoided and other benefits beyond energy conservation
            - Department level metrics - Climate Adaptation Framework
                - Final Report - Resilience Metrics developed for the Resilient Communities goal chapter of the CAF

Site and Water

The Site and Water guidelines are intended to support the design and maintenance of project sites, to promote ecological integrity, and to support healthy, biodiverse plant, animal, and human communities by restoring soil, habitat, and water quality. The current site and water guidelines serve as a robust foundation for sustainable site and water management. However, to remain effective in the face of climate uncertainty, future iterations of the B3 Guidelines must integrate improved strategies for drought resilience, ecological adaptation, and localized environmental risk mitigation.

- S.0 - Site and Water Strategies
    - Use the user-input strategies and site data to generate a risk profile for flooding and for drought and streamline this input for MIDS.
        - Combine with resilience assessment tool inputs / outputs

- S.1 - Site and Water Connections
    - Incorporate green and green/blue/grey infrastructure requirements where appropriate
    - Require development of a flood risk and hazard mitigation plan for each project with a high risk profile as identified in S.0
    - Require a drought and heatwave mitigation plan for projects identified as high risk in S.0
    - Evaluate plant and animal connection networks way earlier in the planning/design process
- S.2 - Site Water Quality and Efficiency
    - Enhanced requirements for sites with high risk of flooding + high ability to infiltrate
    - Increase stringency of building/development in flood zones - currently defined based on 100 year event elevation but this should be increased to account for future precipitation/flood projections
    - Enhanced requirements and incentives for on-site storage and reuse, and retention of open water habitat/fire safety features
    - Enhanced measures and incentives for xeriscaping and drought tolerant plantings
    - Additional reduction in building water use (more than 50% from baseline - 1992 or 3 building) for buildings/sites with high risk of drought
        - Change baseline or change percentage reduction
    - Disallow potable water for any irrigation (currently allowed within first 5 years establishment period and during drought conditions)
        - Establishment period based on plant type (tree/shrub/ground cover) - SITES example
    - Create a crosswalk between MPCA's MIDS, Hydrocad, and P8 to allow teams to model and estimate stormwater performance (Volume and Quality) using their choice of tool
- S.3 - Soil
    - Add enhanced erosion control plan requirements for sites with high risk of flooding
    - Disallow any green field development. Integrate this requirement early in the planning/design process
    - Increase wetland buffer distance and ensure appropriate vegetation is planted/maintained
        - Prescriptive requirements
    - Enhanced measures for soil health and connectivity of ecosystems
- S.4 - Vegetation
    - Additional restrictions within MN State Pre Design Process to avoid critical habitat and sites along connective habitat/vegetative corridors
    - Provisions and incentives to increase tree canopy, vegetated area, and enhance connections with surrounding vegetation*
        - Use DNR Class Fact Sheets
    - Preference site albedo reduction with tree canopy and pervious vegetative cover to impervious and pervious built areas*

- S.5 - Animal Habitat Support
    - Provide additional detail and connections to GIS tools that help design teams determine applicable strategies for their site.*

*These items are included in the Guidelines v3.2 Revision 03 that is currently in progress.

Energy and Atmosphere

The Energy and Atmosphere guidelines promote the design and operation of energy-efficient buildings to reduce expenditures on imported fuel, reduce the impacts associated with greenhouse gas emissions, minimize negative impacts of refrigerant selection, and ensure readiness for next-generation energy infrastructure. The future performance of a project meeting today's B3 guidelines was studied extensively and confirmed the hypothesis that measures taken for energy efficiency today, including highly insulated walls and roofs, limited glazing areas, and passive considerations, all maintain efficiency while performing in future climate, and can enhance passive thermal resilience during extreme events.

- E.1 - Energy Efficiency
    - Run energy model in future climate scenario(s) to assess potential for unmet heating or cooling hours based on current system design
        - Stress test based on extremes
- E.2 - Renewable Energy
    - Install renewable energy generation system paired with battery storage. This system should be sized to meet minimum emergency electrical loads including but not limited to thermal control, ventilation lighting, refrigeration for medical purposes, and vertical transport.
        - Building specific requirements - medical e.g.
- E.3 - Efficient Equipment and Appliances
    - Assume that future cooling loads will be larger, and system size may need to increase at end of life replacement. Size mechanical room, conveyances, and electrical panels accordingly.
    - If using a ground source heat pump, designate site area to be reserved for additional well fields if they become necessary to meet demand or due to drops in efficiency from ambient condition changes.

Indoor Environmental Quality

The Indoor Environmental Quality (IEQ) guidelines are intended to provide high quality indoor environmental conditions to promote occupant health, well-being, and productivity. Protecting health and well-being will become more challenging in the future climate, and the IEQ guidelines are integral to ensuring the safety of occupants in extreme conditions.

- I.3 - Ventilation
    - For wildfire prone areas, follow best practices outlined in ASHRAE 44 - Protecting Building Occupants from Smoke During Wildfire and Prescribed Burn Events[5]
        - Includes guidance for: monitoring, controls, envelope tightening, filters and fan sizing, portable air cleaners, hybrid / naturally ventilated buildings, commissioning, communication to operations team, and operations
    - For projects with high density occupancy and or primarily vulnerable populations, meet the minimum requirements of ASHRAE Standard 241 - Control of Infections Aerosols[6]
        - Includes requirements for minimum clean airflow rate, air distribution and natural ventilation, air cleaning, assessment, planning, and implementation, and operations
- I.4 - Thermal Comfort
    - Design the building or an appropriately sized portion of the building to maintain thermally safe temperatures during an extended power outage, during both the hottest and coldest projected periods in a future climate scenario. This will require energy modeling and consideration of passive solutions.
    - Maximize the potential of passive cooling by providing operable windows in appropriate spaces, and meet the size and location requirements of ASHRAE 62.2 section 6.5[7].
        - In habitable spaces - ventilation opening at least 4% of room floor area, 5ft2 minimum
        - Air inlets must be at least 10’ from known sources of contamination and placed so entering air is not obstructed by seasonally variable objects like snow or vegetation.
    - Specify east, south, and west facing windows with high heat resistance (low SHGC) or with phase-change technology that can block heat from entering the building.

Materials and Waste

The Materials and Waste guidelines are intended to reduce the embodied environmental impact and toxicity of building materials. The goal of reducing embodied impacts lends itself to increasing the resilience and durability of building materials, and protecting against increasing extreme weather and changing habitat ranges of pests.

- M.3 - Waste Reduction and Management
    - Where applicable, increase the durability of building envelopes by meeting the requirements of:
        - Fortified Standards - a construction standard designed for high wind and or hail hazards

[5] Aligns with proposed LEED v5 Guideline EQ:Resilient Spaces
[6] Aligns with proposed LEED v5 Guideline EQ:Resilient Spaces
[7] Aligns with proposed LEED v5 Guideline EQ:Resilient Spaces

            - Should be an owner requirement, doesn't overlap with B3 guidelines and we don't need to reinvent the wheel.
        - ASTM E2395-Standard Specification for Voluntary Security Performance of Window and Door Assemblies with Glazing Impact
    - Where applicable, including currently identified risk areas and assumed future risk areas, follow design guidance for termite resistant foundations and walls provided by the Building America Solution Center[8]

Guideline Next Steps:

- Collect initial feedback based on proposal above
- Develop specific guideline language and supporting sections
    - Submission requirements
    - Meeting the guidelines
    - Resources
    - Any necessary templates / tools / calculators
- Focus group review and feedback of new guideline language
- Updates to guidelines based on feedback
- Final editing by copy editor
- Prepare web materials to launch new version
- Launch

Future Research:

Integration of requirements with MN state pre design process (Esp for site selection)
Further refinement to 4.0
Integrated planning tool (LCCMR proposal)
Integration with other existing and upcoming tools

[8] https://basc.pnnl.gov/resource-guides/termite-resistant-foundations-and-walls