High Performance Building Requirements for Sustainability

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Abstract:

Most green or sustainable building codes being developed today are limited in scope to site selection and development; water resource conservation; material resource conservation; energy conservation; and interior environmental quality criteria. High Performance Building Requirements for Sustainability, compiled by the Portland Cement Association, expand upon these basic requirements by adding functional resilience for increased durability and disaster resistance for buildings to be designated high performance, green, or sustainable.

Introduction. In the United States, the current trend in the development of building codes, referenced standards, guides, and certification programs for green or sustainable buildings focuses on adding site selection and development; water resource conservation; material resource conservation; energy conservation; and interior environmental quality criteria to any building and then labeling or certifying such building as green or sustainable. In many jurisdictions in the United States there is no building code or the building code may only be applicable to specific occupancy and use groups. In most jurisdictions where there is a building code the scope and intent of the code tend to be limited to the minimum requirements for occupant life safety. Adding the typical sustainability attributes to buildings regardless of their durability, design service life and ability to resist damage from disasters seems counterintuitive to sustainability.

High Performance Building Requirements for Sustainability, compiled by the Portland Cement Association expand upon these basic requirements by adding functional resilience for increased durability and disaster resistance for buildings to be designated high performance, green, or sustainable. The inclusion of provisions for functional resilience is intended to more appropriately address the combination of environmental, societal and economic considerations to enhance the sustainability of individual buildings, communities, and the planet.
Green Code Development. Many state and local jurisdictions, often due to political pressures, are developing “green building” or “sustainable building” codes. For these jurisdictions, this is a daunting task because, unlike many other building code requirements, there currently is no national model code for green or sustainable buildings other than requirements for low-rise residential buildings. In the absence of such a model, jurisdictions are developing their own requirements, referencing or adopting guides or sole-source certification programs, or modifying criteria in nationally developed standards. The primary resources that exist or are under development include:

1) US Green Building Council (USGBC) *Leadership in Energy and Environmental Design for New Construction (LEED-NC)*.
2) Green Building Initiative *Green Globes*.
3) Jointly developed and published National Association of Home Builders (NAHB) and International Code Council (ICC) *National Green Building Standard (ICC 700)*.
4) American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE) *Design of High-Performance Green Buildings Except Low-Rise Residential Buildings (ASHRAE 189.1)*.
5) Jointly American Institute of Architects (AIA), ASTM International (ASTM), and International Code Council (ICC) *International Green Construction Code (IgCC)* currently under development; and
6) Several standards developed and under development by ASTM International Committee E60 on Sustainability.

**LEED-NC.** *LEED-NC* is a fee-based certification program administered exclusively by the USGBC. *LEED-NC* focuses on five key areas: 1) sustainable sites; 2) water efficiency; 3) energy and atmosphere; 4) materials and resources; and 5) indoor environmental quality. *LEED-NC* is the first of its kind certification program for green buildings. It was not developed using an American National Standards Institute (ANSI) accredited standards development process and it is not written in mandatory language that can readily be adopted and enforced as a building code. Many of the criteria in *LEED-NC*, especially those related to site selection, are typically outside the purview of the building code department.

**Green Globes.** *Green Globes* is an environmental assessment methodology and like *LEED-NC*, it provides a score for the building based on a point system. This approach has seven categories: project management; site; energy; water; resources/materials; emissions, effluents, and other impacts; and indoor environment. Green Globes Design is promoted as both a guide to integrating green design principles and an assessment tool. The program is questionnaire-based. Based on responses to the questions, the user is
provided with percentage eco-ratings for the seven categories; highlights of the design; suggestions for further improvements to the design; and hyper-links to information on building systems and management. Green Globes was not developed using an ANSI accredited standards development process and is not written in enforceable mandatory code language.

**ICC 700.** ICC 700 uses a points-based system consistent with the key elements in Version 2.2 of the *LEED-NC*. The points system is split into three categories. The first includes threshold levels for site design and development for sustainable sub-divisions. The second is for green building design and construction and the third set of thresholds are for additions and renovations. While these provisions are in mandatory language, enforcement as a “green” building code could be very difficult since there are few baseline requirements that must be applied to every building. For site development, depending on the level of sustainability desired or required by the jurisdiction, the compliance options range from as few a 79 points to more than 175 points out of a possible 326 points. For the green building component, it is even more complicated with a range of 222 to more than 697 points out of 1,000 plus possible points.

**ASHRAE 189.1.** ASHRAE has partnered with USGBC to develop a standard that addresses the key elements of the *LEED-NC*. The standard focuses on 1) site sustainability; 2) water use efficiency; 3) energy efficiency; 4) indoor environmental quality; 5) building’s impact on the atmosphere, materials, and resources; and 6) construction and plans for operation. The standard may be adopted by reference into the locally enforced building code to establish design and construction requirements for green and sustainable buildings. The standard is written in mandatory language and was developed using an ANSI accredited standards development process. The standard is not applicable to low-rise residential buildings (i.e. single family dwellings and multi-family dwellings three stories or less in height).

**IgCC.** Another national effort is the proposed green building code being developed to address design, construction, and operation of all buildings other than low-rise residential buildings. The *IgCC* contains mandatory requirements and optional compliance electives in seven key areas: 1) natural resource conservation and responsible land use; 2) material resource conservation and efficiency; 3) energy conservation, efficiency and earth atmosphere quality; 4) water resource conservation and efficiency; 5) indoor environmental quality and comfort; 6) building operations, maintenance and owner education; and 7) existing buildings. The proposed approach of optional compliance electives may be used in several ways. A jurisdiction desiring to have buildings more “green” than is achieved with the mandatory requirements may set target levels of additional compliance electives that must be met. The jurisdictions also have the option
of requiring specific compliance electives be satisfied in addition to the mandatory requirements based on the specific needs or environmental issues that are important to their community. The jurisdiction may also choose to combine these two optional strategies to implement a more rigorous green or sustainable building code. This model code is expected to be available for public comment in May of 2010 and after further revision, to be published as part of the 2012 set of ICC model codes.

ASTM Standards. ASTM Committee E60 on Sustainability is developing several standards that may ultimately be used in the previously mentioned standards and building codes for the design and construction of green or sustainable buildings. This work at ASTM addresses a large variety of topics. For buildings and construction the key existing documents or documents under development address 1) cleaning materials and methods; 2) environmental life cycle assessment for building materials and products; 3) data collection for sustainability assessment; 4) earthen building walls; 5) green roof systems; 6) general principles of sustainability; 7) water conservation; 8) marketing and product claims; 9) environmentally preferable products; 10) wastewater; 11) rain water; and 12) product category rules for building products. The proposed standards with very broad scopes are slow in their advancement through the development process. However, the more generic and narrow-scoped standards continue to be developed at a much faster pace.

State and local codes. Several of the documents written in mandatory language are still in draft form or have only recently been published. In the absence of these documents, local jurisdictions began developing their own building code requirements for green or sustainable buildings. In some instances, jurisdictions have opted to set levels of compliance with the LEED-NC as their green building code requirements. Unfortunately the LEED-NC is not written in mandatory language that can be easily regulated and enforced. The LEED-NC program is an excellent approach for achieving green buildings through contractual arrangements between project owners, contractors, and designers or to serve as a basis to determine tax credits, however the lack of enforceable mandatory language makes LEED-NC less than ideal for a regulatory building code.

Trends in Sustainability Requirements. From the materials standpoint, the current versions of ASHRAE 189.1, ICC-700, and the draft of the IgCC are very generic focusing on features such as 1) reuse of materials and recycled content; 2) regionally extracted, harvested, processed and manufactured materials; 3) construction waste; and 4) renewable materials. Each of these documents emphasizes the overall energy performance expectations for the buildings. This is appropriate because, currently the most significant positive environmental impact that can be made through the design and construction of buildings is by reducing the heating, cooling, and lighting loads provided
by energy generated using fossil fuels. This emphasis in codes and standards is expected
to change over the years. The U.S. Department of Energy is encouraging programs that
will require new buildings to be net zero energy buildings by 2050. A net zero energy
building is one whose net energy consumption from utility grids for heating, cooling or
lighting buildings is neutral (i.e. zero). For such buildings, the energy used for the
operation of the building must be generated on site, or by some definitions be provided
by green power. Green power is considered to be energy produced via renewable power
generation systems including photovoltaics, wind power, tidal power, or geo-thermal
power. Excess energy generated on-site is passed on to the energy grid for credit and
allows the building to draw from the energy grid when on-site generation may not be
possible. As the use of fossil fuels to operate or generate power for buildings is reduced
the percentage of fossil fuels that must be used to produce, transport, deconstruct, and
remove building materials will been seen as a more significant component with regard to
the environmental impact.

Both, ASHRAE 189.1 and IgCC, have targets for achieving increased energy
efficiency for the operation of buildings. The use of thermal mass is considered in both
proposed documents, however prescriptive methods for implementing the benefits of
thermal mass in the exterior walls of buildings is only in ASHRAE 189.1. In the IgCC
process the Brick Institute of America, International Masonry Institute, National Concrete
Masonry Association, and Portland Cement Association have continually made efforts to
incorporate thermal mass provisions into the requirements. Such provisions are important
not only to assure effective and efficient methods for combining the energy conservation
features provided by thermal resistance and thermal diffusivity, the latter being the ability
of massive building materials to reduce and delay heating and cooling loads; but also to
help direct designers and owners to options that include thermal mass for passive solar
and natural ventilation strategies to further reduce heating and cooling loads.

The IgCC and several of the ASTM standards have proposed language that
focuses on just the environmental impacts of the materials themselves without
consideration of the performance of the materials or products in their intended
applications. Key areas being identified for comparison of building products and
materials are: green house gas and global warming potential; energy efficiency and
renewable energy; water efficiency and quality; material optimization; acidification;
smog; ozone depletion; and eutrophication. For many applications this could misdirect
designers and owners away from materials otherwise suitable for green or sustainable
buildings. This confusion and misdirection could be as simple as ignoring the high
embodied energy used to produce fibrous glass insulation relative to some other building
materials versus the amount of energy conserved over the life of a building because the
required insulation levels are set high.
Further a materials approach may mislead and misdirect designers, specifiers, and owners when complete systems for an intended application are not addressed. For example, specifications may require light gauge steel framing to consist of at least 14% zinc as a galvanic coating for corrosion resistance whereas reinforcing steel used in masonry is inherently protected by the masonry itself but not given credit in green building requirements. Another is specifying high R-values for insulation in order to be green without adequate consideration of the placement and use of concrete or masonry with their inherent thermal mass benefits. Furthermore, structural steel members may require sprayed on fire protection to achieve the same performance levels obtained with non-combustible concrete or masonry construction. Additionally, acoustical treatments and finishes may be required for many building systems in lieu of considering concrete or masonry’s inherent ability to reduce sound transmission. Even the use of some finishes may be eliminated by allowing masonry to be left exposed. Key sustainability features of concrete and masonry construction are that these systems and combinations of these systems can provide many of the intended functions of the building elements for the specific requirements of the building’s occupancy and use.

**Functional Resilience.** Significant components for truly sustainable buildings appear to be overlooked on almost all nationally developed sustainability guides, certification programs, standards and codes being promoted. The crucial lacking components are those related to enhanced durability, increased disaster resistance, and improved property protection. How sustainable are buildings if they require frequent routine maintenance and repairs or must be replaced, reconstructed or renovated after disasters? For example, the U.S. Army Corps of Engineers reported that after Hurricane Katrina, 44 million cubic yards of construction materials and building contents were disposed of in landfills. In addition, to this day, five years later, communities are struggling to attract businesses and provide housing, schools, and services in areas affected by the disaster. Many business and home owners are still paying for repairs.

The Portland Cement Association (PCA), recognizing the need for increased safety, security, and property protection for sustainable buildings and communities, has routinely encouraged that appropriate requirements be incorporated into the national reference standards, model building codes, certification programs, and guidelines. Unfortunately, balance requirements necessary to satisfy the American National Standards Institute (ANSI) accredited consensus processes employed by the standards development organizations typically limit the concrete and masonry industries to a single voice on the committees of many of these programs. With entities such as the American Institute of Architects (AIA), National Association of Home Builders (NAHB), Building Owners and Managers Association (BOMA), and several material interest groups such as...
steel and wood opposing the recommendations of the concrete and masonry industries, committee votes in support the concepts being put forward by the concrete and masonry industry are rarely successful. BOMA is on record in a variety of forums advising they would support safer, more secure, and more sustainable building construction as long as it did not cost one penny more to build. Individuals representing AIA have testified that codes must be the absolute minimum for life safety and all other design and construction decisions should be contractual between the owners, designers, and contractors. NAHB routinely opposes code changes that increase the cost of new construction. The reality is that the initial costs will tend to be higher to incorporate functional resilience or any other aspects of sustainability in most sustainable buildings. The significant savings are in the routine operation, use, and even reuse of these quality, durable buildings. The potentially higher initial cost of construction is a price that must be paid to improve buildings and protect the environment.

In response to this resistance in the development of national standards and model codes, PCA has compiled building code requirements that provide the common sustainability requirements combined with functional resilience provisions to achieve substantially more sustainable construction. These requirements have been formatted as amendments to be appended to the ICC International Building Code (IBC) by adoption agencies such as state and local governments. Opposition to the PCA recommendations suggest that simply adding energy conservation features, air quality measures, material resources and site selection provisions and water conserving fixtures to buildings built to the minimum life safety code requirements is all that is necessary for sustainable structures. In fact, most of the sustainability programs being developed today do not even require that buildings must be built to the minimum life safety requirements of the building code much less consider property losses. But these property losses are significant.

Direct property losses for common building damage from natural and man-made events, including thunder storms and other wind storms, tornadoes, hail storms, wildland fires, structure fires, flooding and tropical storms are shown in Graphs 1 and 2. As shown in Graph 2, in 2008, the direct property losses due to natural disasters were approximately

![Graph 1. Annual Loss for Disasters in the United States, excluding Tropical Storms, Hurricanes, and Earthquakes, in Millions of Dollars]
$38,000,000,000. The average annual direct property losses due to disasters is equal to about 5% of the total value of new construction put in place each year. Damaged property must be repaired or replaced. In many instances the damaged materials are no longer suitable for reuse or reconstruction and must go to landfills or be incinerated.

The direct property losses do not consider the community resources required for emergency response, the loss of tax revenues to jurisdictions by homeowners who relocate or businesses that relocate or simply go out of business. Most economist estimate that for every one job lost due to a disaster there is a resultant loss of approximately 2.5 other jobs. The direct property losses also do not reflect the reduction in resources expended for disaster relief. Combining typical sustainability features with an appropriate level of increased disaster resistance and enhanced durability are necessary to minimize the overall negative impact of these disasters to the community. New building construction with sustainability that includes functional resilience provides increased safety and security and protects property. Enhanced property protection reduces loses to individuals and communities and reduces the amount of building materials and contents that must be disposed of when disasters occur. These requirements can also serve as a solid basis for achieving certification of green buildings.

**HPBRS.** The High Performance Building Requirements for Sustainability (HPBRS) are a comprehensive set of mandatory and enforceable criteria compiled as amendments and appendices to the ICC *International Building Code (IBC)*. The requirements are
consistent with the intent of ASHRAE 189.1 and LEED-NC, but are limited to the criteria that are typically within the purview of the building code department. The HPBRS are applicable to all buildings addressed in the IBC, except Group U, utility occupancies, which are rarely conditioned and rarely have occupants. The major features of the HPBRS are:

**Design Service Life Plan.** HPBRS require that project submittal documents include a design service life plan and that the plan not be less than 60 years for all buildings except some buildings in the storage and factory occupancy and use groups.

**Fire Protection.** Enhanced fire protection is provided by 1) mandating automatic fire sprinkler systems for all buildings except low hazard storage and factory facilities; 2) eliminating sprinkler trade-offs that increase fire areas of buildings placing more property and more of the structure itself at risk for damage during a fire; 3) increasing the fire protection and rating of exterior building elements to minimize the potential for conflagrations within a community; and 4) maintaining a high degree of fire resistance ratings for building elements by not permitting Type IIB, Type IIIB, and Type VB construction. In the IBC the fire resistance ratings of these types of construction is reduced or eliminated simply because a building might be a story shorter or have a smaller floor area. The use of National Fire Protection Association Standard for Installation of sprinklers in Residential Occupancies Up to and Including Four Stories in Height (NFPA 13R), which does not require sprinklers in concealed combustible spaces, is prohibited.

**Disaster Resistance.** Throughout the HPBRS there are provisions that improve the ability for the building to be more resistant to natural disasters. Such provisions will generally result in buildings that will be more durable and
have lower maintenance and operating costs. Such buildings will also be more easily occupied after a disaster, assisting in the community’s ability to recover after a disaster. Storm shelters are required in hurricane and tornado prone areas. Compliance with the ICC International Wildland Urban Interface Code (IWUIC) is mandated where there is a presence of quick-burning forage, limited fire department access, prevalent weather conditions or other mitigating factors. Structures must be designed to withstand higher wind loads. Roofs and exterior walls must be more impact resistant to minimize the damage and replacement of materials due to hail damage. Buildings must be designed and constructed to the minimum requirements of the American Society of Civil Engineers/Structural Engineering Institute Flood Resistant Design and Construction (ASCE/SEI 24) except jurisdictions are not permitted to consider flood protective works such as levees in determining the flood elevations. In addition, flood elevations are required to be determined as the higher of the design flood elevation, base flood elevation plus three feet, or the 500-year flood.

**Interior Finishes.** Flame spread limits for interior finishes are more stringent and there are volatile organic compounds (VOC) limits for materials and trim, adhesives and sealants, and paints and coatings. Limits are also placed on the use of resins for composite wood, wood structural panels, and agri-fiber products.

**Interior Environment.** For improved occupant health, safety, comfort and productivity there are requirements for ventilation and particulate matter removal; carbon dioxide detectors and alarms, recreational smoking areas design and construction if permitted, temperature and lighting controls, sound transmission reduction, and building entrance mats for removing and capturing debris. The sounds transmission criteria address sound from adjacent spaces, exterior noise, and structure-borne sound.

**Energy Efficiency.** Energy efficiency is primarily mandatory reductions in energy use for conditioning interior spaces, by setting the maximum design building energy performance such that energy costs are at least twenty percent less than the Energy performance for a building designed to meet the criteria of either ICC International Energy Conservation Code (IECC) or the ASHRAE Energy Standard for Buildings.
Except Low-Rise Residential (ASHRAE 90.1). There are also criteria for daylighting; lighting loads and controls; fenestration area limits; peak load reduction; and use of U.S. Environmental Protection Agency Energy Star compliant appliances and equipment.

Roofs and Exterior Walls. In addition to provision for increased resistance to damage from wind storms and hail storms; there are requirements for exposure to external fire; and minimum solar reflectance indices to limit heat gain. For walls there are air barrier requirements and requirements for exposure to water from landscape irrigation systems. For roofs, there are criteria for rain water management.

Plumbing. Requirements related to plumbing include the mandatory use of low flow plumbing fixtures and water metering.

Material Resources. Not only are there requirements providing areas for the collection and storage of recyclables, but also provisions on how to design and construction such areas to achieve appropriate levels of property protection and life safety. Construction waste limits are provided and design and construction methods that result in material reduction, material reuse and favor recycled content are addressed. The use of regional materials and provisions for pollution prevention related to the harvesting, extraction, processing and manufacture of materials are included.

Parking Areas and Drives. The size and number of parking spaces and configuration of traffic aisles are addressed. Minimum requirements for pavement thicknesses are provided to assure a minimum level of serviceability and durability. Heat island effects are minimized through the use of minimum solar reflectance indices for solid pavements, shading, or use of pervious pavements. There are requirements to retain the first flush of rain water on site or treat the water prior to it leaving the site to avoid contamination of the water shed by oil, tire debris, transmission fluid, or other deleterious materials on the pavement surfaces. Minimum lighting levels, rather than lighting loads are specified to maintain minimum levels of safety and security without excessive amounts of lighting.

Site Selection. The type of site that may be developed is addressed with regard to land use. Development on in areas such as prime farmland, flood plains, endangered or threatened species habitats, wetlands, and parks and preserves is restricted.
**Adoption.** Continued resistance from some competitive industry groups and interests groups dedicated to promoting the lowest possible initial cost for buildings regardless of the long term impacts to owners and future owners, our communities and planet can be anticipated. In many cases, the current minimum life safety requirements in the building codes are seen as too expensive to provide adequate reductions in the initial cost of buildings. Waivers from adopted building code requirements to build less than minimum code are being requested and approved more frequently. This trend is contrary to sustainable and resilient buildings.

While resistance from some can be expected, the concrete and masonry industries anticipate that many other interest groups not normally active in codes and standards development will rise to the occasion to encourage the adoption of high performance building requirements for appropriate occupancies and uses in their jurisdictions. The types of organizations that might see the long term benefits to adopting provisions such as the HPBRS include: American Red Cross Chapters, fire services (i.e. state and local fire marshals, fire fighters and fire chiefs), insurance industry interests (i.e. insurers and state insurance commissioners), state and Federal energy departments and emergency management agencies, USGBC chapters, and forward thinking community leaders. All these parties have an interest in increasing the safety, security, property protection, and disaster resistance for the people and employers in their communities for the long term benefits of sustainability – social, economic and environmental.

**Flexibility.** The HPBRS are designed to assign a high performance designation “- HP” to buildings designed and constructed to satisfy the requirements of the HPBRS. This does not mean that every building in every jurisdiction shall be required to be designed in and constructed in accordance with the HPBRS. The designation will indicate to various groups such as building departments, community planners, emergency management and emergency responders, energy departments, environmental interests, and civic leaders that these buildings are intended to be more durable, disaster resent and sustainable. Government entities may choose to require compliance with the HPBRS for all government owned or funded buildings. Some jurisdictions may require compliance for some occupancy or simply as a optional program for owners to provide buildings recognized and being safer, more durable and more environmentally sensitive. In some more forward thinking communities, the HPBRS may well be adopted for all buildings. The adoption of the HPBRS will depend upon the potential for disasters and resources available for recovery; the speed at which disaster prone communities need to recovery form disasters to assure a more consistent revenue stream and a complete and functional community; local politics related to economics societal and environmental issues; the amount of support from interests that recognize the benefits of expanding the typical
sustainability features with functional resilience; and the amount of resistance from parties interested in assuring that building codes continue to be focused on the absolute minimum requirements for life safety regardless of the negative societal and environmental implications of continuing to build disposable buildings and communities.

**Conclusion.** *HPBRS* is the first comprehensive compilation of building design and construction requirements written in mandatory language as amends and appendices to the most widely accepted model building code in the United States. The combination of functional resilience with energy and water conservation criteria; material resource and site development criteria; and indoor air quality is unique. The requirements extend beyond the impact of individual buildings by appropriately considering the impact of buildings in the community and on the planet. Acceptance of these concepts will result in better buildings, better communities and a better natural environment. State and local adoption as well as integration of these concepts into nationally developed building codes, standards, guides, and certifications programs is welcomed.