Partners HealthCare Redefines Resilience and Restoration in Innovative Waterfront Hospital

Spaulding Rehabilitation Hospital Charlestown, Massachusetts

Benefits

- A hospital of the future that is designed for resilience and an ability to continue operations in the event of extreme weather events and sea level rise or surge, as a result of climate change.
- Remediation and redevelopment of a waterfront brownfield site reflects Spaulding's commitment to the "rehabilitation of people and place," to the City of Boston, the community of Charlestown and the goal of providing access to water for therapeutic purposes.
- Offered as a development site by the City of Boston, the hospital has become an exemplar of resilience strategy and planning.
- Design integrates essential program requirements, a therapeutic environment, climate resilience and beauty.

Challenge/Situation

According to the Center for American Progress, between fiscal year 2011 and 2013, the federal government spent $136 billion on disaster recovery but only $22 billion to increase preparedness—or $6 on recovery for every $1 spent on prevention. For every dollar spent on health care, 70 cents is spent on treatment and four cents is spent on prevention. In 2012, superstorm Sandy cost $65 billion in recovery effort and 159 people died, mostly from drowning. In the New York metropolitan area, 650,000 homes were damaged or destroyed and five hospitals were forced to shut down.

While Partners had incorporated environmentally responsible features into some of its other buildings (lowering energy consumption and reducing toxic construction materials), it was the proposed waterfront location of the Spaulding Rehabilitation Hospital that provided the impetus to address resiliency as a design strategy. Preliminary design for the Spaulding Rehabilitation Hospital began in 2006, recommencing in 2008 for completion in April 2013. While the resilient aspects of the design were informed by Hurricane Katrina (2005) and by the flooding of the Cumberland River in Nashville Tennessee (2010), it was only as the building neared completion in October 2012 that superstorm Sandy struck close to home, vindicating many of the innovative solutions incorporated in the design.

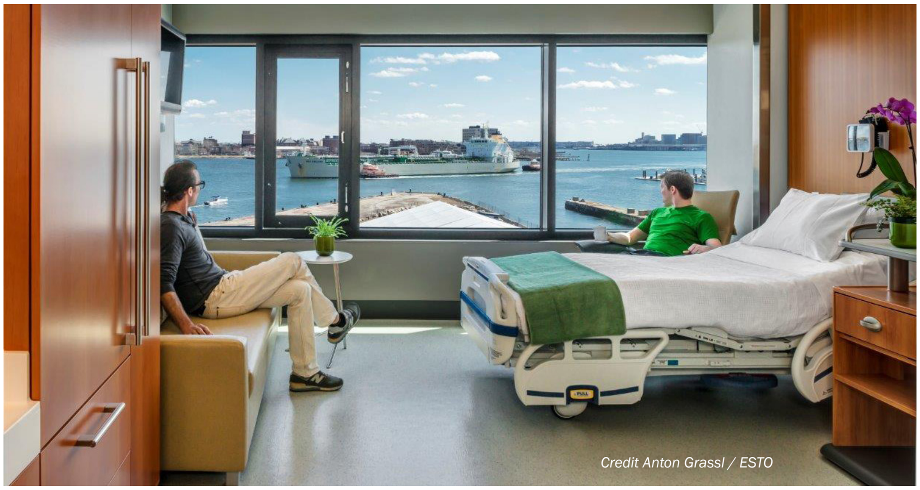
About Spaulding Rehabilitation Hospital

The 132-patient room, 378,000 square foot Spaulding Rehabilitation Hospital was built to replace an aging facility originally designed as a nursing home and that could no longer meet the demands of the community in its existing space. The site that was selected for the new hospital—the former Charlestown Navy Yard where WWII frigates were once docked and restored—was a brownfield parcel that went through a year-long $23 million remediation process.

Seventy-five percent of the ground floor is designated a "facility of public accommodation" comprising a cafeteria, conference rooms, a chapel, a gift shop and a pool available to the public at scheduled times. The new waterfront site allows the hospital to continue its water sport therapy program.

Climate Resilience

In ecology, resilience is the capacity of an ecosystem to respond to a perturbation or disturbance by resisting damage and recovering quickly.



Patient rooms have a clear view of the harbor and city. Components and finishes are selected from Perkins+Wills' "Transparency List" of safe materials. Windows are tripled glazed obviating the use of perimeter heating. Each room has an operable window, keyed for use only in emergencies. Common spaces (gym, pool, cafeteria etc) have windows operable at any time.

Sustainability and Resiliency in a Health Care Environment

The term "sustainability" has been in common use for many years and is the defining characteristic of environmentally responsible design incorporated into LEED certification. The definition most often cited is from *Our Common Future* (the Brundtland Report, 1987): "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

"Resiliency" is a term more recently introduced into the vocabulary of design, defining the capacity of a building and systems to withstand abrupt changes (shocks to the system) or more long-term changes in conditions. The ability to withstand impact, to adapt and to prevail in the face of acute or chronic change is the essence of resiliency.

Sustainability and resiliency are important in the field of health care for three reasons:

1. The health care sector is the second most intensive energy user in the commercial sector and is a major contributor to the production of greenhouse gases and climate change.

2. Patients treated in hospitals are in a weakened condition and employees who work in hospitals over the long term are often in a stressed state, both factors making it critically important that the internal environment should be healthy and toxin-free.

3. In times of emergency, increasingly in situations exacerbated by climate change such as heat waves, extreme precipitation, hurricanes, floods and

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sea level rise, it is critically important that hospitals and health care centers remain functioning and viable.

The sustainable features of a building primarily address the first two issues, to mitigate the effects of buildings and operations on the environment and its inhabitants. The resilient features of a building are designed to address the third issue, to continue functioning in the face of challenging conditions. Sustainable and resilient design features are complementary and symbiotic as is the relationship between physical design and operations.

Achieving LEED Gold certification, Spaulding Hospital incorporates numerous sustainable features and systems for conserving energy, reducing carbon emissions and conserving natural resources. Renewable, non-toxic materials are used wherever possible and systems installed for the recycling and reuse of materials in the supply chain. The overall goal in building sustainably is to ensure the long-term viability of the environment and the vitality and health of the population. The challenge for the design team was to develop realistic and implementable goals for ensuring that a sustainable hospital would also be resilient in the face of anticipated climate change.

Resilient Design Goals

The decision was to invest in the city on a waterfront site close to the former hospital. While developing a hospital on a suburban greenfield site may have been less expensive and technically less problematic, the Trustees endorsed the view that the hospital has a commitment to its patient and employee constituency in the city in a location readily accessible by public transportation. The cost of remediating the industrial brownfield site (vacated by the Navy some years before) was offset by a lower purchase price. Having made a commitment to the sustainability of its patient base and the city, the Spaulding team adopted resilient design as an integral part of the objectives for the building on this potentially vulnerable site.

The goals developed for a resilient design were:

1. To protect patients and employees from the effects of extreme weather and long-term climate change.
2. To maintain basic building systems and services for a period of at least four days from the onset of an emergency.
3. To integrate into the building systems a measure of redundancy whereby in the event of system failure an alternative or backup would provide a substitute.
4. To maintain this degree of resiliency over the lifetime of the building (approximately 80 years).

Integrated Design Strategy

The underlying strategy for a successful design outcome was to ensure full participation of all team members from start to finish in developing goals and objectives. Throughout design and construction stages project meetings were attended by owner and user representatives, the design disciplines and the construction management team, with critical input from specialist consultants. As design progressed and into the construction stage, when decisions had to be made regarding cost containment, design changes or implementation strategies, those decisions were made by stakeholders who had developed and subscribed to the initial goals and objectives, maintaining the core values that had been articulated at the outset.

Another strategy employed in the design phase was to utilize specialty sub-consultants outside the core team, to lead strategy or design charrettes to explore new technologies and to test and verify the feasibility of adopting some of these.

Addressing resiliency goals, investigations included:

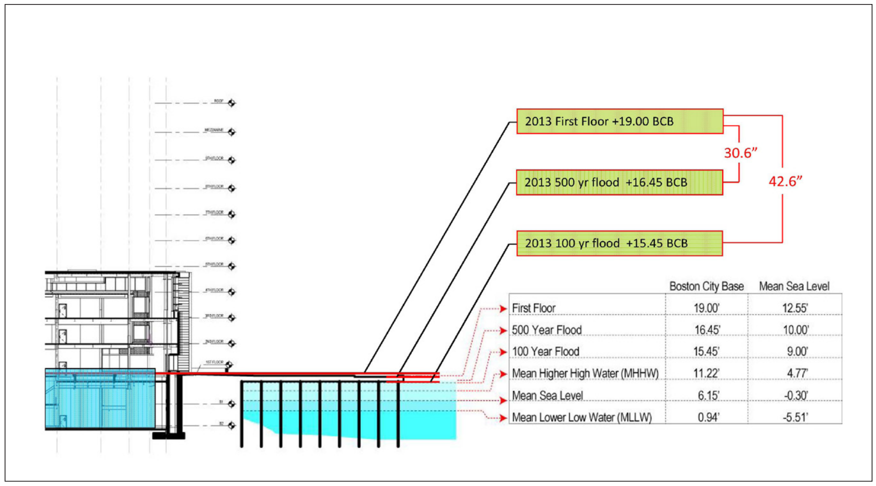
1. A review of current scientific literature on the probable effects of climate change including sea level rise in the Boston Harbor, predicted frequency and intensity of rainfall over the short- and medium-term, and the predicted duration and intensity of heat waves.
2. A review of recent experiences of health care facilities in the face of extreme weather conditions, including the Memorial Hospital in New Orleans during and after Hurricane Katrina; and hospitals in Nashville, Tennessee flooded by the Cumberland River in 2010. Contractors' experience in post-disaster restoration proved to be highly informative.
3. A review of infrastructure dependencies, principally for utilities and transportation.

Design Responses

The resilient design responses to these challenges include:

1. Establishing a datum to elevate the ground floor as high as possible within the limitations of connecting with surrounding streets and height restrictions on the building. This placed the ground floor datum at 42" above the current 100-year (One percent probability) flood line, 30" above the 500-year (0.2 percent probability) flood line. Taking into account the IPCC projected range of sea level rise of 30" to 60" by 2100, this elevated the building high enough to be out of significant danger of flooding for most of its projected life.

2. Elevating the access ramp to the below grade parking to a peak datum equal to the ground floor grade of the building so that the parking should not flood prematurely.



3. Locating all critical mechanical and electrical equipment on the roof, taking into account the additional cost of routing and fireproofing the high-voltage electrical supply line up the 9-story building.
4. Installing a gas-fired combined heat and power plant on the roof to provide supplemental power in normal operation and sustained emergency power when the grid fails.
5. Waterproofing fuel and fire pumps located at grade or in the basement.
6. Elevating all vents at or above the ground floor flood datum.
7. Relocating all patient-critical functions above ground floor level—with the exception of food services.
8. Providing secure on-site storage for at least four days of linens, food, supplies and other materials essential to health care delivery.
9. Incorporating operable windows into all public and common spaces, and into patient rooms, with the latter keyed for use only in an emergency.
10. Incorporating excavated granite blocks and live oak beams into the landscape design as reef-like barriers to mitigate storm surge intensity.

Lessons Learned: Challenges and Achievements

Many of these lessons learned and the challenges overcome and remaining surfaced during the course of integrated design team discussions:

1. Integrated teamwork in design and construction is essential to a successful framing of questions, to an outline of potential consequences, to identifying the range of solutions, and to integration of resilience measures into the broader task of creating a functional, high-performance, environmentally sound and aesthetically pleasing building.
2. Framing the right questions are the first priority: what is the design life of the facility; what personnel and systems are critical to its functioning; what are the specific vulnerabilities; what are the potential consequences of failure in

terms of life safety, business continuity or consequential loss?

3. There are no absolutes: no measure by itself will reduce risk to zero. A combination of strategies is essential to resilience thinking, incorporating the principle of redundancy, back-up alternatives in the event of failure. Elevating the ground floor level alone may not fully negate the potential risk of flooding; so a companion or redundant strategy is to ensure that if flooding does occur, it will not have devastating consequences.
4. Changes to "business as usual" often meet with passive inertia or active resistance. A clear and logical goal statement is the starting point for requesting an agency or a utility company to do something different from the norm. In the northeast (but not in the gulf coast region), elevating utilities above ground floor level is not common practice so the argument has to be made and alliances formed to make change happen.
5. Risk evaluation is critical to developing priorities for a resiliency strategy. Categorizing the types of event, the probability of occurrence and the potential consequences of such an event are all fundamental to prioritizing where to focus resiliency design and the allocation of capital and operational funding.
6. Understanding dependencies: individual buildings can be designed or retrofitted to be reasonably resilient but are almost inevitably dependent on contextual infrastructure for power, gas, water and sewer, transportation links and other support systems. It is important to engage local agencies and utility companies in the overall utility strategies.
7. Physical resiliency should be complemented by operational resiliency. The ability of staff and service providers to access the facility during and following extreme weather events is essential to ensure continued operations.

Redundancy in communications systems is achievable through the use of landlines, mobile phones, walkie talkies and radio. Preemptive planning and contractual arrangements with vendors go a long way to ensuring continuity of service at times when supply chain systems or facilities are disrupted.

8. Resiliency principles, incorporated into the design process along with principles of sustainability, contribute to the enhancement of safe, functional, efficient and aesthetically pleasing health care facilities. Even in existing buildings, resilient retrofits can be undertaken with other programmatic mandates so that these features are seamlessly integrated into a holistic design.

9. Lessons learned during the research, design and construction stages in developing Spaulding Hospital were shared with the City of Boston and other public agencies as a public good and as an opportunity for feedback on diverse applications going beyond this particular site and program. The City of Boston has recently incorporated a resiliency questionnaire into the zoning code[1], encompassing some of the thinking initiated in the Spaulding project. This appropriation of a single project experience has the advantage of normalizing many of the design features, reducing obstacles to change and realizing economies of scale.

Further work

The work on incorporating resilient features into the Spaulding hospital has generated further planning studies throughout the Partners system to reduce risk to patients, employees, facilities and intellectual property accruing to this important academic medical center and associated hospitals. In addition to patient and employee safety and well-being, incorporating resilient design features into hospital and laboratory buildings has significant economic importance, particularly for Partners HealthCare whose annual research funding amounts to $1.5 billion. Boston hospitals account for approximately 5,000 acute care beds. New York's experience of super storm Sandy in 2012, during which patient lives were lost, evacuation strategies were strained to the limit and years of valuable research materials and evidence were lost delivers a clear message to the Boston area medical and research community that human lives and economic well-being are at stake in the event of extreme weather events and sea level rise.

Beyond incorporating resiliency into new buildings, further work is called for on three levels:

- Reviewing the vulnerabilities of all buildings on the hospital campus, new and older, evaluating risk as a function of the probability of an event occurring and the potential consequences.
- Reviewing the dependency of hospital buildings and campuses on infrastructure for utilities and transportation.
- Reviewing operations and emergency preparedness protocols through the lens of climate change and extreme weather events.