

DESIGNING AND BUILDING 'ACTIVE' ROOFS

Many buildings these days are planning for walkable rooftops that can be occupied to some extent. The most common such project types are multifamily and mid- to large-size commercial projects that promote some type of rooftop terrace, skygarden, walkable green roof, or barbecue deck. Senior housing, schools, fire stations, and houses of worship are also looking on their rooftops as usable space. Even in cooler climates, the demand for rooftop access and outdoor living is stronger than ever.

A look at the market trends and design innovations as well as the basic technical considerations—codes, standards, regulations, engineering and construction practices, and new product technologies—shows how ticklish a problem these roof elements can be. It's as if a whole new project category has emerged, one that typically combines landscape architecture, spanning construction, and high-rise engineering.

"Usable outdoor space has come to be expected," says Faye Harwell, FASLA, Principal with Studio RHLA. "People looking for office spaces, and young people and empty-nesters comparing apartments and condominiums, all want some outdoor space." Until recently, rooftops tended to be utilitarian, forbidden spaces where owners stored maintenance equipment and locked off the premises. "Today, we're planning for rooftop stormwater management and places for healthy activity," says Harwell.

Education facilities are turning rooftops into outdoor classrooms, playgrounds, and even artificial fields for soccer and field hockey. "Playdecks are common in any urban



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Rooftop playdeck designed by MBB Architects atop St. Hilda's & St. Hugh's School, New York City.

LEARNING OBJECTIVES

After reading this article, you should be able to:

- + **DESCRIBE** new developments in walkable and occupied roofing assemblies and products.
- + **UNDERSTAND** the basic problems—and their solutions—related to structural and wind loading, anchoring, and code requirements for rooftop playdecks, vegetated roofs, and similar occupancies.
- + **LIST** the factors that impact the planning and feasibility analysis of occupied roof area designs.
- + **DISCUSS** ways to improve the design, installation, and long-term maintenance of roofs with traffic and loading.

environment where space is at a premium, and for many city schools it's their only outdoor play space," says Sara Grant, AIA, a Partner with Murphy Burnham & Buttrick (MBB) Architects, in New York City. "Rather than a simple playground on a raised field, schools are planning for varied uses, including zones for active play and other, quieter areas, such as gardens or niches where kids can relax during recess."

Many K-12 schools are using modular and pedestal deck systems with adjustable supports to create level surfaces in garden zones, says Grant, with rubberized flooring and surrounded at their perimeters by fencing or retractable netting in active play zones. The enclosures are designed to withstand wind and snow loads. Some are designed to be removed and stored in the off-season.

"These pedestal deck systems enable project teams to create flat surfaces for users while allowing required roof pitch to drain below, without incurring too high a construction cost," says Deniz Ferendeci, AIA, LEED AP BD+C, Director of Building Services with Boston architecture firm Dyer Brown. The first step, he says, is to work with your structural engineer to determine solutions to the project's wind uplift forces. Then comes detailing

for handrails and guardrails, which have specific force requirements and need supports that are well reinforced.

For new construction, AEC teams are gravitating to structural approaches that incorporate rooftop terraces, pools, and plantings. "Most of our work makes use of flat-plate concrete or composite slab-on-deck construction with a topping slab that slopes to the drain," says Susie Teal, Architect/Senior Associate at New York firm CookFox. "For green roofs and roof gardens, we advocate for an inverted roof membrane assembly (IRMA), which allows the widest flexibility in garden programming." IRMA, a common roof assembly, consists of a single-ply or built-up membrane installed over a structural concrete slab and topped with insulation.

SECRET DESIGN ELEMENT: BLUEBERRIES

The first step in designing occupied rooftops is to determine how building setbacks and rooftops can serve the occupants' needs and experience.

Collaborative programming is essential, says MBB's Grant. For the renovation of St. Hilda's & St. Hugh's School, in Manhattan, the architects and design team met with the school's physical education staff, teachers, students, and parents

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DESIGN FACTORS FOR CREATING OCCUPIED ROOFS

Rooftop occupancies must be designed and built according to a few general principles.

Among the most critical:

1 PROJECT PLANNING. The first step in designing a usable roof is to evaluate the overall practicality of the intended uses. "Start with a feasibility study to get all the relevant information on the table early, and evaluate what's achievable in a realistic way with the owner group, rather than learning too late that the proposed uses will be cost-prohibitive," advises MBB Partner Sara Grant.

The feasibility study should address specific uses, adds John Cetra, FAIA, Co-founder

of CetraRuddy. "Roof access constraints need to be understood before proposing certain roof uses," he says. "For example, building mechanical systems are becoming more sophisticated, so more space is required for elevator machine rooms, air-conditioning equipment, and exhaust fans." These competing uses may reduce the available rooftop footprint.

In the pre-schematic phase consider working with engineers, roofing and waterproofing contractors, and landscape architects who have experience in designing and building active rooftop spaces. "There are so many

things to consider: code, safety weight loads, integration with the architecture, and sustainable practices," says RCLA Partner Robin Key. "These are very complicated projects, and many jurisdictions require project teams to submit drawings indicating irrigation systems, structural calculations, wind load issues, and more." Key says it's often difficult to complete the work without "a full complement of experts."

2 ENGINEERING, LOADING, AND WEATHER. Other structural considerations (beyond the building's basic structural design) that can constrain the kinds of uses and occupancies

allowed for existing and new roofs include wind loading and wind uplift forces, water and moisture management, and roof performance under variable weather conditions. All require attention from experts.

3 FINISHES AND ACOUSTICAL SEPARATIONS. Rooftop use also poses the threat of noise problems for the occupants below the walkable roofs. "It depends on what the use of the deck is, and how the space underneath is used," says MBB's Grant. "If we're designing a play area over classrooms, we're also planning for a substantial acoustical separation."

to evaluate uses for new roof playdecks. “We wanted to make sure there would be enough variety and changeability over time, Grant says. They looked for furnishings that could be moved easily, and they wanted convenient storage for equipment and exhibits created especially for the roof—an airplane fuselage, a miniature tugboat, and other playscapes, all held down by custom anchoring systems designed for frequent changeouts. For school roofs, Grant recommends not going overboard with programming and building. “Design your system to allow for change over time,” she advises.

The roof at St. Hilda’s & St. Hugh’s sits astride the pre-K-to-8th-grade gymnasium. It includes two grades of safety surfaces, containers with native shrubs and trees, a green wall, and a screened outdoor classroom. “The green wall is made with trays that are lifted up and installed vertically,” says Robin Key, RLA, ASLA, CLARB, a Partner with RKLA Studio Landscape Architecture. The trays contain ferns, which the students study in their science classes. “We also planted blueberries, which are also in their curriculum,” says Key. “They were delighted to be able to have a fruit crop.”

Hospitals and assisted living facilities are also using rooftops for patient access to the outdoors.

Among them: Virginia Hospital System, in Alexandria, and Walter Reed Army Medical Center, Bethesda, Md. Harwell says that, in each case, the rooftop spaces were designed to “enrich” the overall project.

Religious institutions and affordable housing operators are finding cost-effective ways to employ their roof areas for break areas, reception spaces, or container gardening, says RKLA’s Key, whose firm has created a rooftop terrace for a synagogue and roof gardens for a senior affordable housing facility. “For these clients, it’s important to consider the maintenance component for any roof finishes, furnishings, and plantings,” Key warns. For example, trees in containers need to have their canopies and roots trimmed every few years.



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The rooftop deck at St. Hilda’s and St. Hugh’s has an adjustable pedestal deck, rubberize flooring, protective fencing, and extensive plantings, including a living wall.

For Rodeph Shalom School, on the Upper West Side of Manhattan, Grant’s team is building a floating floor to support a playdeck located directly over academic spaces; the floating floor will help control noise transmission to the classrooms.

Grant advises that roof areas designed for games involving ball play should have a rubberized floor that is several inches thick. The flooring’s surface depth should be engineered for such variables as typical fall height.

4 MECHANICAL SYSTEMS. Certain rooftop MEP installations may require protective enclosures for safety purposes. You will also have to account for noise and unwanted heat

generation from cooling towers near occupied spaces. But sometimes rooftop occupancies can benefit from integration of the MEP systems. MBB’s Grant notes that the rooftop playdeck on one of the schools her firm designed has a snowmelt system built into the play surface. This improves safety, reduces the need for shoveling, protects the rubber surface, and extends its service life.

5 MOVABLE OBJECTS AND FURNISHINGS. The design of active roof areas must consider the potential effects of rain and wind on objects and furnishings. “In specifying outdoor furniture, the project team can’t assume tenants will store everything

properly when they’re done using them, so rooftops need furniture that won’t blow away in high winds,” warns Dyer Brown’s Director Deniz Ferendeci. “You don’t want to see your Crate & Barrel couch flying around downtown.”

6 PLANTED ROOFS AND ROOF GARDENS. Experts recommend specifying plant life that is self-sustaining for rooftop projects. CookFox Senior Associate Susie Teal says plant vendors offer lightweight systems with soils and plant types that take the heat load off the building but don’t need bulky irrigation systems and constant watering. “Solar orientation, wind profile and mitigation, irrigation, and maintenance are crucial,” says Teal. “We work

closely with landscape designers to select plants suitable for the microclimate created by the roof, for both winter and summer extremes.”

7 CODES AND STANDARDS. Most jurisdictions have limits on roof uses and occupancies. In certain localities, a deck for 50 or more persons may require an assembly permit and two means of egress, says Ferendeci. In others, codes call for a second stairway when creating a space for more than a certain number of residents—in New York, the threshold is 74. A roof area available to all occupants must be designed for its maximum occupant load, which cannot exceed code allowances based on the building type.

INSTALLING ACTIVE ROOFS IN MIXED-USE AND COMMERCIAL APPLICATIONS

More than ever before, commercial office and mixed-use buildings are incorporating walkable roofs, accessible terraces, and rooftop installations as tenant amenities to attract office tenants and enhance the occupant experience. To capture outdoor spaces that can be economically converted and still meet building code requirements, developers are incorporating perimeter protections, pedestal decking or pavers (as needed to protect the horizontal substructure), and suitable furnishings and décor.

In New York's Meatpacking District, an 18-story office building called 412W15 is nearing completion. The developers, real estate investment manage-

accessible except for maintenance," says CookFox's Teal. Converted rooftops need to be shored up to accommodate planned additional loads. To reduce the added weight, designers can specify minimal new structures and roof installations. Some urban gardeners are experimenting with very lightweight engineered soils for rooftop plantings. One specialty contractor, Brooklyn Grange, uses a blend of mushroom compost and porous stones that drains well and can support rooftop plant life in garden beds of about 8-12 inches in depth.

It's one thing to make such garden areas accessible. They must also be done in a manner that encourages regular use by building occupants, says Teal. "This requires working closely with building owners to address access, security, and maintenance, as well as adherence to safety and occupancy regulations," she cautions.

As for active rooftops in new construction, work is under way on a nine-acre site in Staten Island, N.Y., for Corporate Commons Three, an eight-story, 330,000-sf office block from developer Nicotra Group. It will have a 40,000-sf rooftop farm that will provide fresh food to a nonprofit restaurant in the building, says CetraRuddy's Thomson, whose firm is leading the architectural design.

To compete with these sexy greenfield projects, owners of existing commercial buildings are upgrading their rooftop spaces and attempting to capture setbacks to provide additional occupied zones. "Most commercial office buildings in downtown areas don't even have setbacks that can be repurposed as decks," says Dyer Brown's Ferendeci. For the revamp of 116 Huntington in Boston's Back Bay, his firm transformed the original unsightly setbacks into attractive spaces for tenant use. In an area filled with many new office properties, the strategic renovations by owner Columbia Property Trust helped turn 116 Huntington into a premier location commanding top rents.

Depending on existing conditions, older buildings may require little additional work to prepare the usable outdoor zones. "For many of these applications, the architects may only need to detail decorative elements," says Ámbar Margarida, CID, IIDA, Assoc. AIA, LEED Green Associate, a Principal with Spacesmith LLP. For her firm's design of Bacardi-Martini's offices at 475 Fifth Avenue in Manhattan,



Rockpoint Group's office building at 412W15, designed by CetraRuddy, has multiple terraces on setbacks as tenant amenities.



ment firm Rockpoint Group and hospitality-oriented partner Highgate, have activated terrace spaces on the second, seventh, tenth, and eighteenth floors in order to make all roof setbacks accessible to the office tenants. "These outdoor spaces are seen as amenities," says Charles Thomson, Project Manager with the building's architect, CetraRuddy, which is also completing roof decks in the renovation of 413W14, a separate, early-1900s structure connected to 412W15. The roofs of the buildings vary in structural type: one is heavy timber, the other, concrete reinforced. Neither building was designed to handle the required structural loads for having people on the roof, says Thomson. A lot of structural reinforcing has gone in to making the office building attractive and competitive.

This is typical for office buildings. "Many older rooftops and terraces were not meant to be

the project team added screens, bar ledges, and furniture on the terrace, as well as planters and plantings. “The pavers, drainage systems, and other structures were already in place as part of the existing building or were installed by the landlord,” says Margarida.

That’s not always the case, she says. Sometimes it’s necessary to deal with the height differences between the building interior and the balcony or terrace. In other cases, the team may have to find ways to ensure that the outdoor horizontal surfaces do not undermine the building’s U-values and thermal performance. Getting drainage and proper waterproofing and flashing right is also critical.

Then again, sometimes adding a roof deck or green roof can help solve a maintenance problem, says Dyer Brown’s Ferendeci. For the firm’s work on 125 High Street, a Class A office building owned by Tishman Speyer in Boston’s Financial District, the team designed a new green roof to correct costly maintenance problems and provide a more visually appealing presentation. “This relatively maintenance-free system reduces stormwater runoff and protects the roof from ultraviolet light and overall wear and tear,” Ferendeci says.

OCCUPIED ROOFS IN MIXED-USE AND MULTIFAMILY PROJECTS

Ten or 15 years ago, you’d have to search hard to find a green roof or occupied roof in an apartment or condominium project, says Michael Johnson, AIA, Design Principal, Carrier Johnson + Culture. Around that time, his firm started using the terms “skylife” and “vertical cities” to describe their concepts for activating upper floors in commercial and residential areas, which they used to re-energize parts of San Diego and other West Coast cities.

Three recent multifamily and mixed-use projects are or will be populating their rooftops with usable space. They are Holland Partner Group’s The Brand, Glendale, Calif., and two projects under construction in San Diego: Lennar Multifamily’s balconied 520 West Ash and Cisterra’s ambitious 7th and Market, with extensive terracing. All have rooftop pools, fire pits, gardens, or decks, even though they differ remarkably in design expression.

“Today, multifamily developers compete directly on the quality of the amenities, and they clearly see that they boost their rents, enhance



DARRIN HUNTER / COURTESY DYER BROWN

the living experience, and add to the building and the urban environment,” says Carrier Johnson’s Johnson.

Even in markets with cold winters and frequent rain, rooftop access is a marketable add-on. “Much as all floor area in urban markets must be maximized, the roofs of residential buildings are being maximized, even with significant costs,” says CetraRuddy’s Thomson.

“Owners are willing to pay for these spaces because potential tenants are giving preference to buildings with rooftop amenities.” As proof, he cites the record-setting sale prices for units in MetroLoft’s adaptive reuse of the historic 443 Greenwich and 13-story 572 Eleventh Avenue, both in Manhattan. Each has extensive rooftop amenities, including private roof terraces for penthouse units as well as shared terraces with plantings and outdoor dining and grilling areas.

Occupied rooftops in residential buildings can also lead to headaches, from maintenance and repair needs to environmental hazards, says CookFox’s Teal. “In an era of increasing storm intensity related to climate change, on-site stormwater management is increasingly critical, requiring attention to detail at roof drains, and ensuring regular maintenance of drainage systems,” she says. On the plus side, she notes that some cities permit stormwater detention tanks to be downsized if the building includes a green roof.

AEC teams working in dense urban environments also have to account for snow loads and mitigating glare caused by solar reflection from adjacent buildings, says Teal. +



For 125 High Street, Boston, owner Tishman Speyer and architect Dyer Brown retrofitted a green roof on the office building to ease maintenance, control stormwater runoff, and reduce wear and tear on the roof.

FOR PLANTED ROOFS, MEMBRANES MATTER

Green roofs are common solutions for occupied roofs, but they create more potential for moisture incursion over single-ply layers such as TPO or multiple-ply roof systems like built-up roofing.

For planted roof projects, designers much pay careful attention to structural loading, stability, wind effects, and life safety factors. They may assume that the planting systems can serve as ballast, like gravel or heavy pavers. But there are risks, which insurers are quick to point out.

"FM Global considers both stone ballast and living green roofs to be prone to an increased risk of damage from wind uplift and windborne debris," according to the Wiley design guide, *Green Roof Systems*. Designers may rely on ballast materials to help prevent membrane uplift under high winds, but when ballast itself becomes windborne, the uplifting effect could lead to membrane tear-off and even catastrophic roof failure.

Project teams should familiarize themselves with recommendations and standards recently for garden roofs with regard to fire and wind resistance, such as in FM Global's own Loss Protection Data Sheet (LPDS) 1-35 *Green Roof Systems*, and two standards from the single-ply roofing industry: ANSI/SPRI VF-1 *External Fire Design of Green Roof Systems*, and ANSI/SPRI RP-14 *Wind Design for Green Roof Systems*.

The structural capacity of the deck must be matched with the type of garden roof being considered. A key detail is maintaining the waterproofing membrane vertical flashing at an approved height above the overburden, which is the planting or paving (or both) installed over the membrane or waterproofing layers.

Membranes have to resist the biological impacts and root penetration of the green roof. Purpose-made barriers can be specified for these purposes, but all materials should have good resistance to chemicals and have low vapor-transmission and water-absorption levels. They should also be approved for use underground and under ponded water.

STRUCTURAL PROTECTION FOR ROOFTOP USES

■ Two primary considerations for occupied roof areas are structural loading and the effects of wind, including wind loads and uplift forces.

When it comes to roof structural loading, "The building must have the capacity for the live loads and dead loads anticipated for the new roof decks," says Deniz Ferendeci, AIA, LEED AP BD+C, Director of Building Services, Dyer Brown, Boston. "Project teams must also work with their structural engineering consultants to assess wind uplift forces, which are increased for every additional floor and for added height."

In new construction, if the roof area is open to all residents (not just residents of a private terrace), occupant load becomes the overriding design issue, says CetraRuddy's John Cetra, FAIA. For existing buildings, especially older structures, renovations can be extensive and costly. "Many roofs of existing buildings aren't designed for a live load capacity that would comply with code," says Cetra. "They have to be reinforced with significant additional structure above the roof." In some renovation projects, particularly for historic buildings, it may be better to build a new roof than to try reinforce an existing roof to make it accessible for use.

Wind loading and wind uplift for rooftop installations and planted roofs can also be tough sledding. "Any new decks, containers, and other useful decorative elements must incorporate proper anchoring," says Robin Key, RLA, ASLA, CLARB, Partner, RKLA Studio Landscape Architecture. Arbors and trellises are especially difficult in terms of wind anchoring.

Most AEC teams prefer to anchor their roof installations to the building structure, but a combination of adhered and anchored connections can be used, as well as ballasted systems, which are held in place by their own weight. For example, heavy pedestal pavers or pavers with metal plates may be secured on top of lightweight pedestals. In locations with very strong winds, however, the building code may require that the systems be more tightly secured: both the pavers to the pedestal heads, and the pedestals to the roof substrate, using screws, adhesives, or combination of the two.

Wind loads for roof areas and forces acting on roof installations can be calculated using the design standard ASCE 7-05 *Minimum Design Loads for Buildings and Other Structures*. It includes a wind section with design pressures given for components and cladding, which can also apply to smaller area systems such as decks, pallets, and planters. Uplift calculations on horizontal elements are just as important as lateral forces acting on rooftop privacy walls and screens.

"To account for the vagaries of weather, rooftop gardens and green roofs should feature secured planters and structures that are mechanically anchored or secured with sufficient soil weight," adds CookFox's Susie Teal. "The sedum acts as a ground cover to secure loose soil," helping stop erosion of the rooftop greenery, she adds.

+ EDITOR'S NOTE

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