EXPLORING the Sustainably Built Environment

The Roof As a Platform

THOMAS W. HUTCHINSON, RRC, FRCI, AIA
Hutchinson Design Group, Ltd.
232 East Main Street, Barrington, IL 60010
Phone: 847-756-4450 • E-mail: hutch@hutchinsondesigngroup.com

ABSTRACT

With the current administration's emphasis on solar and alternative energy sources, the design of wind rooftop solar energy and wind turbine production systems will grow exponentially. This growth will have tremendous effects on the roofing industry. This paper will begin to address the roof-system assembly components that a roof-system designer will need to consider so that the energy systems can be appropriately integrated into the roof system for this new use.

SPEAKER

Mr. Hutchinson is a graduate of the University of Illinois with master's degrees in both architecture and civil engineering. As a licensed architect in Wisconsin, Illinois, and Ohio, and a registered roof consultant, Mr. Hutchinson has received recognition globally for his expertise in roof-system design and building envelope issues. He has made numerous presentations globally on topics such as: keys to sustainable construction, environmentally sensitive and energy-conscious roofs, and preventing building envelope failures through sustainable construction. Mr. Hutchinson believes in the complete integration of all building components into roofing and building envelope system design. Mr. Hutchinson is currently a principal of Hutchinson Design Group, Ltd., and is a Fellow and past president of RCI, Inc. He is a member of the American Institute of Architects (AIA), Construction Specifications Institute (CSI), the National Roof Contractors Association (NRCA), the American Society of Testing and Material's (ASTM) Committee D-08 on Roofing, Waterproofing & Bituminous Materials, and RCI, Inc.

The Roof as Platform

Photo 1 – Roof designers in the past strived to keep all equipment and foot traffic off of the roof. This 22-year-old ballasted EPDM roof is in excellent condition, in part because of the lack of roof top activity.

INTRODUCTION

For decades, "Keep it off the roof" has been the mantra of knowledgeable roof-system designers. Keeping the roof free of mechanical equipment, superfluous items such as IT cables, satellite dishes, antennas, conduit, gas pipe, and unnecessary foot traffic has always been a first means of extending the roof's potential service life. This forethought and hypothesis in the design phase has actually proved to be correct as roof system service life rose (see *Photo 1*).

There were always roofs that not only required daily foot traffic, but by their very design, actually demanded it. Rooftop surfaces, such as those designed to play tennis or basketball upon, encompass rooftop pools, and/or those which required daily mechanical inspections were the exception (see *Photo 2*).

Photo 2 – The author designed this rooftop tennis court on the Lakeshore Athletic Club roof to serve a function besides just watertightness.

Another factor in the '80s and '90s was an emphasis on proactive maintenance, for which it was always a challenge to procure the owner's buy-in. Recent studies by this author on long-term service-providing roofs has revealed that a significant number of roof systems appear to actually have performed well because of the lack of any rooftop activity, including maintenance (see *Photo 3*).

CURRENT CHALLENGES TO THE ROOF-SYSTEM DESIGNER

In recent years, a great many outside influences have been affecting roof-system design: the USGBC's LEED® program; the EPA's EnergyStar® program; energy codes; and an overall acceptance of the environmental movement, regulation and code changes to reflect current trends and subsequent code adoptions by

Photo 3 – The 24-year-old fully adhered EPDM roof at right is still in excellent condition. As part of the roofing removal and replacement design 24 years ago, the author removed all abandoned rooftop equipment and placed mechanical equipment below in an effort to "keep equipment off the roof."

Photo 4 (inset) – The inclusion of rooftop equipment such as solar arrays is becoming more and more common. The designer of this roof did a fine job of raising the panels off the roof and spacing the support to allow for access. It is unknown if additional protection in the areas of foot traffic has been installed.

Photo 5 (below): The installation of wind turbines on roof areas will become commonplace in the near future. Designing the roof system to accommodate them as well as their maintenance is an important consideration for sustainable roof systems.

code and city bodies. These outside influencers create a maze of requirements for the designer, placing a great deal of liability on their shoulders without any liability/responsibility for these code influencers. As wrong as this may be, until revisions are adopted, the roof-system designer is obligated to work within this framework.

With the advent of code adoption, the recent federal governmental endorsement of alternative energy sources has inadvertently increased pressure on the roof's ability to perform. Now the roof system must not only provide watertight and thermal protection, but also be a work surface for other building components and, subsequently, a work platform to support the ancillary rooftop production of energy. In less than a decade, the concern of "keep it off the roof" has evolved to "how can the roof surface be used most effectively for other nonroof-related activities?" The roof surface has become too valuable a space to be left underutilized.

Roofs are now being asked to be the base support for other functions that need to be designed and integrated into the roof system so as to act almost independently of the roof. Examples of such roof-system requirements are:

- Support solar arrays, their installation, and related cabling (see *Photo 4*).
- Be a solar energy-producing surface.
- Support wind turbine energy-producing equipment, its installation, and related cabling (see *Photo 5*).
- Provide waterproofing and support to garden roof systems.
- Provide support for and access to large mechanical units and related ductwork and piping (see *Photo 6*).
- Provide access to and support rooftop decks and the activities they encourage (see *Photo 7*).
- Provide base for mobile antennae (see *Photo 8*).
- Provide a base for signage.

Photo 6 – The roof of today: Note the solar array, cellular antennae and large HVAC equipment. The roof has become too valuable, as a piece of real estate, to ignore.

Photo 7 – Roofs performing as platforms for ancillary activities need to be designed to accommodate both the construction and the use of the roofs after installation.

ACHIEVING SUCCESSFUL ROOF SYSTEMS AS PLATFORMS

As with all successful construction projects, the necessary first step is planning and understanding the required needs of the ancillary equipment to be placed upon the roof. Knowing the construction process and how the building and roof will be constructed is a benefit as well. The designer must think about constructability and design within those parameters.

Most roof consultants would be in - volved in these decisions in roofing removal and replacement projects, while the purvey of new construction tends to belong to the architect, engineer, and registered licensed professionals. While the process involved for each is similar for the purposes of this paper, decisions and implications for new construction situations will be assumed, as they are greater and broader in scope.

The success of the "roof as a platform" is achieved through the successful accomplishment of numerous tasks across a broad spectrum of phases. These phases can be categorized as follows:

- Planning and design,
- Construction documents (construction drawings and specifications) and the coordination with other impinging

Photos 8A and 8B – Roofs have become prime candidates for the installation of cellular towers. As such, roofs need to be designed to accommodate for the installation and maintenance of the tower and the associated piping, cables, etc.

disciplines,

- Roof construction, and
- Roof protection after installation and during rooftop equipment installation.

PLANNING AND DESIGN

There are numerous technical articles, manuals, and books that deal with roof-system design and details that are beyond the scope of this paper. This paper will deal only with those roof-system parameters that are directly affected by "roofs-as-platforms" design.

As soon as it is known that the roof will be asked to perform functions above and beyond those normally associated with roofs, the designer should immediately start a matrix of those functions, their design, construction, and maintenance requirements (see *Figure 1*). For each item, the effect on the roof and needed design considerations can then be determined. This preplanning will help organize the designer and the design and coordination issues he or she will face.

Design Considerations

1) **Roof Deck:** The use of the roof as a platform for other services will most often involve rooftop equipment. The type of equipment, its need for securement, dead load, and potential live load weight will need to be determined and coordinated with the equipment-related design engineer or structural engineer. The roof deck and structure will need to be designed to

IMPACTING ROOFTOP ANCILLARY SYSTEMS

Rooftop System	Component Impacting Roof System	Roof System Design Impacts	Required Action	Result
Rack-supported solar array systems	Supports will penetrate roofs	1. Willl need to be structurally supported	1. Review with structural engineer	1. Detail coordination
		2. Penetrations will need to be appropriately flashed	2. Detail redundant flashing to resist potential damage	2. Detail coordination
		3. Solar panels need to be above roof for access. Define height in solar array; specification coordination.	3. Coordinate desing height with electrical engineer. Coordinate in specification	3. Equipment and installation coordination
		4. Solar panels will create snow drifting and reduce melting due to solar radiation	3. Review with structural engineer possible requirement to increase deck gauge; include in metal deck specification.	4. Life safety

Figure 1

accommodate the system's weights and potential support. Characteristics such as potential resultant snow loads, drifting, and reduced snowmelt due to shading will need to be accommodated.

2) **Wind:** Rooftop equipment that extends above the roof surface often results in sail-like manifestations that will need to be accommodated by both the structural engineer and the roof-system designer. Potential wind uplift to the roof surface by vortexes created by the rooftop equipment also need to be considered.

3) **Service Supports:** The rooftop equipment will require supports. Optimally, it is recommended that the equipment be elevated above the roof surface on a raised platform curb so as to isolate it from the water plane of the roof. The platform should be designed to be structurally sound and fulfill the requirements of the roof deck and wind concerns noted above. If a platform curb is not possible, an appropriate support base is required. It should integrate into the structure and be able to be appropriately flashed into the roof system. It should also provide proper clearance to the roof membrane for the purpose of maintenance or repairs. This author believes in redundancies, a theme that will be repeated numerous times. As such, the base of the support should be waterproofed at the roof deck level, perhaps into a vapor retarder. Vibration and harmonic movement will work on the rooftop flashing and a secondary barrier will provide added protection.

4) **Vapor Barrier/Air Barrier/ Temporary Roof:** The use of a vapor retarder or temporary roof as a design element (as opposed to being required by building environments) is highly recommended when the roof surface will be a platform. Much of the construction of the ancillary rooftop equipment has roof-surface damage potential from installation crews unfamiliar with roof covers and packaging that can easily damage roof membranes and flashings. As such, if a vapor retarder or temporary roof can be installed and a large portion of the rooftop equipment installed working over the vapor retarder or temporary roof with the finished roof installed afterward, the inherent quality of the roof can be improved. The vapor retarder or temporary roof also provides temporary interior protection from moisture intrusion and for the installation of interior HVAC and piping in dry conditions.

5) **Insulation and Protection of Same:** The importance of thermal insulation has never been greater. Higher thermal values and greater insulation thicknesses are becoming the norm. The thermal insulation in roofs of the future will represent a substantial initial investment as well as an investment for potential future savings. As a valued component of the roof system, depended upon for energy savings and roof-cover substrate, it is now being called upon to support a roof acting as a service corridor. As such, it should be protected from potential damage. Consequently, the insulation should be protected by a coverboard of substantial density and point-load resistance. Most roof-system manufacturers produce walkways that protect the roof membrane but do not have the thickness to prevent damage to the roof insulation.

6) **Foot Traffic:** The roof system that is requested to perform as a platform will need to be designed for heavy foot traffic and for access to both roof and rooftop equipment (see *Photos 4* and *10*). The key for roof-system designers is to understand construction sequencing. More often than not, the roof surface, if need be, is designed to prevent and resist physical abuse after the roof is installed. With "platform roofs," the need is immediate to prevent damage by those other trades installing energy equipment such as solar arrays, wind turbines, hot-water tanks, and the like. The roof surface will be impacted not only by foot traffic but by material packaging, tools, sharp materials as well as workman set-up and construction. As recommended above, the most quality-oriented design parameter would be to install a vapor retarder or temporary roof and allow this work to take place, and then to have the new roof installed free and clear of this other work. If this is not possible, the use

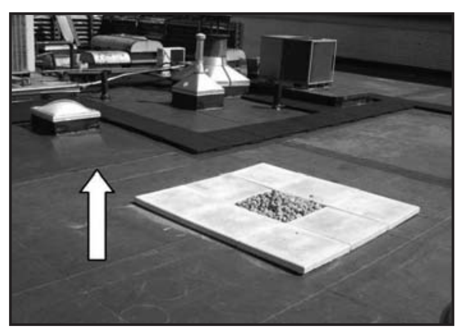

Photo 9 – A sacrificial protective layer of 90-mil EPDM membrane was installed in and around all the mechanical equipment on this roof area as added protection in addition to the 2-in rubber walkways.

of the most robust and puncture-resistant membrane is recommended: 80 and 90 mil for single plies. Additionally, in known areas of construction and anticipated maintenance foot traffic, a second sacrificial protective layer of membrane should be installed (see *Photo 9*).

Photo 10 – This solar panel installation allows little room for maintenance of the roof surface below – a requirement of the roof warranty.

The designer needs to indicate in the specifications who will provide the protection. On a recent project, this author provided for a roof-protection allowance so that a roofing contractor could come in and protect the roof during major masonry demolition rather than asking the masonry contractor to do so. This scenario worked well. On new construction it is recommended that the installing roof contractor be required to provide this protection and that the specified scope of protection be defined in the specification and on the drawings.

7) **Material and Equipment Storage:** Roofs that will perform as platforms are doing so for a reason and typically will involve the placement of packaging, equipment, and assembly construction (see *Photo 11*). These activities can often physically damage not only the roof membrane but roof insulation and flashings. If ropes for fall protection are required, they should not be allowed in any way to wrap roof curbs, vents, etc. Base flashing corners should be doubled if it is anticipated that ropes and extension cords will abrade them.

The designer should specify exact protection measures for material storage, debris storage, work areas, and assembly. This author has found that generic requirements such as "roofing contractor shall protect new roof installation until accepted by the owner" are insufficient and too broad. Is the roofing contractor to protect the newly installed roof from every other trade on the roof? This never happens and is never enforced. Specific protection measures should be specified; ones on which a contractor can actually place a definite number.

Photo 11 – Roofs acting as platforms should be designed not only to withstand the impact of constructoin crews unfamiliar with roofs, but also the equipment packaging, debris, and assembly areas.

8) **Specify Rooftop Maintenance:** Following the completion of the roof and installation of the rooftop equipment, the equipment will undoubtedly require maintenance. This maintenance, as well as the first couple years of climatic cycling, can affect the roof systems: seams may pop, flashings pull, punctures and cuts may reveal themselves, and debris may accumulate at roof drainage systems. On a roof with so much activity occurring after the initial

construction, proactive and specified roof maintenance is recommended for the first two years. This can be specified and included in the project documents. On large projects, it is not uncommon to have the roof completed and the actual building completion months and even years later. By requiring the roofing contractor to return, minor items can be attended to before they manifest into larger concerns that are not covered under any warranty. Designers and owners should consider this a quality insurance item.

9) Codes: Roof-system assemblies are tested without rooftop equipment. Consequently, the addition of such equipment on the roof surface may impact code compliance. The design professional must:

   a. Verify and coordinate with the electrical engineer that all required rooftop electrical components are code-compliant.

   b. Verify compliance with all applicable codes.

   c. Consult with the roof membrane manufacturer to verify that potential rooftop products will not adversely impact the fire classification of the roof system.

   d. Verify the rooftop equipment will not produce wind vortexes that will result in roof-system wind damage.

CONSTRUCTION CONCERNS

Even the most attentive roof-system designer – one who endeavors to provide a fine set of all-encompassing details – cannot anticipate all construction sequencing and field modifications and nuances. As a result, the roof system acting as a platform for other concerns will benefit greatly by onsite observation by qualified roof consultants and architects who have been involved in the project. These individuals need to be able to not only confirm installation in accordance with the contract documents, but also be able to make field decisions and provide design and details for alterations as they arise. Field sketches for conditions that have changed need to be expeditiously produced and provided to the appropriate parties.

This individual will also need to take a leadership role in preconstruction and coordination meetings, raising questions regarding sequencing, protection, and all other concerns that have potential to damage or affect the roof system. Leaving this quality quotient to the general contractor, builder, or roofing contractor is often a lost cause.

The receipt, review, and coordination of shop drawings related to the specific rooftop equipment is an imperative exercise. It is an additional coordination activity prior to construction – a chance to improve the roof's quality. A key activity is the sharing of information; for example, solar array rack-support-system shop drawings should be provided to the architect, who in turn should forward them to the roofing contractor to verify detailing. Conversely, any questions and concerns raised by the roofing contractor should be shared with the solar-array installing contractor, and the process of revising and resubmitting shop drawings and review sharing should be commenced again.

COMMISSIONING

The close-out of projects has often been said to take 90% of the time with only 5% of the fee left. Closing out even a simple project is an arduous task. The main part of the project is complete, new projects are on the horizon, and producing paperwork is not as much fun as the construction. Nonetheless, the formal close-out of a project and the related paperwork is an important component of a successful project. Warranty and close-out documents, in addition to providing promises of corrective action, also provide protection for the owner, contractor, architect, and manufacturer as they define an installation and scope of warranty coverage required by the contract documents.

Warranty inspection by the roof-system manufacturer needs to be considered and coordinated. If equipment will cover (hide) pertinent details, inspections prior to the materials' installation may be required.

The roof-system designer, when performing "punchlist" inspections, should look at the entire roof platform as a holistic concern and indicate all items that affect the roof system's performance. Items that need to be completed by electricians, plumbers, and mechanical trades, when coordinated with the roof "punch list," tend to indicate the importance of one to the other. Obviously, verification of completion is required.

The owner should be brought into the commission loop by being informed of the need for proactive and continuous rooftop maintenance, as is required by the roof warranty, common sense, and by the fact that the roof has been designed to perform many functions. The completed roof system now needs to be managed. All roof activities should be recorded. Why? What work has been performed? Who performed it? Was any damage done to the roof by the work performed?

Yes, the roof should be inspected as a quality assurance measure before and after any rooftop activity or ancillary work. The author has found that when work crews requiring rooftop access are informed that the roof was inspected prior to their arrival and that it will be inspected after their departure, they realize the importance placed upon the roof and are likely to take greater care. Locking the roof-access point and monitoring access as opposed to unrestricted access works wonders.

RECOMMENDATIONS

To achieve sustainable (30-year) roof systems that serve as a platform for some type of alternative and ancillary function in a watertight manner, the following is recommended.

1. Design the roof and all functions in a holistic manner, integrating all items into each other.
2. Plan and organize the requirements of each element impinging on the roof system. Define each and its potential effect on the roof system.
3. Design considerations should take into account:
   a. A roof deck of appropriate strength.
   b. A roof deck and structure that will resist not only the imposed loads by the roof system, but also those created by all rooftop equipment.
   c. Service Supports: Gain a complete understanding of how the rooftop equipment needs to be supported and how it should be integrated into the roof system. Remember that most of the equipment being placed upon the roof has not been designed with the roof in mind.
   d. Consider the use of a vapor retarder and/or temporary roof so that rooftop construction can be completed and damage to the new final roof membrane is not incurred.
   e. Protect the thermal insulation from the deleterious effects of repeated foot traffic, material, and equipment storage.
   f. Design the roof surface to be protected from foot traffic, material storage (i.e. pallets), debris, and construction material assembly. Consider the use of 2-in-thick rubber walkway pads, concrete pavers, and additional layers of membrane.
   g. Design and specify specific rooftop protective measures.
   h. Design and specify rooftop maintenance for the first two years after installation.
4. Be involved onsite in the construction observation, and provide solutions to field conditions as they arrive. Look to see that other trades are informed of their impact on the roof.
5. Commission the roof as a holistic concern at the completion of construction.

CONCLUSIONS

Roof systems today are required to perform many more functions than their predecessors, and by default, need to be designed in a way that reflects these new needs. Failure of building owners, builders, architects, roof consultants, manufacturers, and contractors to understand that the fundamental purpose of the roof is now being subverted for a greater good will result in long-term concerns and litigious activity.

Taking a holistic approach to the roof-system design, its construction, and its management will result in watertight performance while supporting many other rooftop activities. The days of the "out-of-sight and out-of-mind" approach to roof systems is over. The roof as a valuable contributor to a building's environmental, aesthetic, and energy performance has now become the norm.

FOOTNOTE

1. Thomas W. Hutchinson, "Designing Replacement Roof Systems to Achieve Long-Term Service Life: A Sustainable Solution," *11th International Conference on Durability of Building Materials and Components (DBMC)*, Istanbul, 2008.

REFERENCES

Natasha Biasell, "Innovative Roofing Inspires Solar Energy Collaboration," *Interface*, July 2009: 22-24.

Philip D. Dregger, "Retrofit Rooftop Solar Voltaics – How to Save Money on Energy ... and Avoid Spending It on Repairs," October 7, 2008 PowerPoint™ presentation.

Michael Gumm, "Integrating Photovoltaics onto Building Envelope Surfaces," *Interface*, December 2008: 11-23.

Thomas W. Hutchinson, "Designing Replacement Roof Systems to Achieve Long Term Service Life: A Sustainable Solution," *11th International Conference on Durability of Building Materials and Components (DBMC)*. Istanbul, 2008.

Ashley St. John, "Thomas Co. Installs a Roof System on the Atlantic City Convention Center," *Professional Roofing*, August 2009.

Ed Kane, division manager of technology for Firestone Building Products, interviewed by Thomas W. Hutchinson, October 2009.

Joe Malepezzi, code enforcement for Carlisle Syntec, interviewed by Thomas W. Hutchinson, October 2009.

Allen Sopko, warranty service for Firestone Building Products, interviewed by Thomas W. Hutchinson, October 2009.