WHITE PAPER

Retrofit Roofs Offer Design, Environmental, and Financial Benefits in New and Existing Construction **(Updated August 2016)**

The purpose of this white paper is to introduce the various applications for retrofitting roofs with new metal roofing and light-gauge steel framing systems. It covers the applications, benefits, technical aspects and opportunities for the use of metal roof systems in a repurposing or refurbishing process. All of these systems apply to existing roof construction, but some can be used effectively in new roof conventional building construction.

In this paper, retrofit refers to a complete, fully engineered metal system designed for installation over existing flat or sloped roofs made of various types of material. For architects, retrofit presents an opportunity to expand their business, particularly incorporating reroofing as part of a building repurposing project or more so in installation of new roofing where architects have previously not been involved.

Figure 1- Completed Retrofit Application

For building owners, retrofitting provides a number of benefits:

- Improved appearance for existing buildings
- Ease of installation in new construction
- Reduced environmental impact
- Improved energy efficiency

Existing Building Solutions

Since the late 1970's, retrofit has been a quick, cost effective solution for problematic roof geometry, maintenance issues and outdated appearance. In more recent years, thermal efficiency and energy savings are the hallmarks of a retrofit roof application. In addition, retrofitting has become an intricate part of building repurposing and renovation.

As building owners become more involved in energy and environmental issues, they are finding greater benefits from retrofitting roofs with metal. In addition to being aesthetically pleasing, metal is a sustainable material that is made from recycled material and is fully recyclable at the end of the building or the roof's service life. Metal also has reflective and emissive benefits, so it reduces cooling energy and the building's carbon footprint. Installing a retrofit system typically does not require removal of the existing roof or wall material so it also reduces landfill waste. It may also help a LEED project to become certified under the USGBC's LEED building rating program.

By solving roofing problems, a retrofit system helps reduce roof maintenance and offers a long service life. The key to this is the use of metal roofing. Metal roofing systems have a service life of nearly double its closest competitive roofing system, which currently is modified bitumen or built-up roofing (BUR) according to a previous market survey of building owners conducted by Ducker Worldwide, Troy, MI. The study showed the life of a metal roof at 41.6 years and only 23 years for both modified bitumen and BUR. Statistics from the same study put maintenance costs of metal roofing at 10 cents (USD) per square foot per year, compared to BUR and modified, both at 17 cents. Today, based on research conducted and funded by the MCA, low slope unpainted 55% AlZn coated metal roof systems have been found to have a service life of at least 60 years. This research was substantiated by third-party research that investigated existing 20 to 30-year old 55% aluminum zinc low-slope unpainted standing seam roofs from five different U.S. climate zones and subsequent laboratory testing of the roof material substrate, weatherproof sealants and fastening systems.

Roofing Applications

The most common retrofit applications are metal over existing flat roofs or metal over existing sloped roofs. Both of these improve a building's appearance and reduce maintenance, but each can offer solutions to different problems.

All retrofit systems are fully engineered using laboratory test data for wind uplift and structural design of light-gauge framing systems. From the design phase through completion of installation, several steps must be taken to ensure the structural integrity of the existing roof system.

Key areas that need to be considered in the design phase include:

- Inspect the existing roof thoroughly
- Analyze the existing roof structure to ensure it can hold the added weight of 3-to-5 pounds per square foot depending on the gauge of the new metal roof and the required support framing system to meet governing building codes.
- Determine the engineering needed on support framing to distribute newly imposed snow loading and weight of the retrofit framing and new roofing materials.
- Determine the engineering need for support framing anchorage systems to resist wind uplift.
- Specify temporary waterproofing at anchors
- Evaluate other opportunities to improve efficiency such as a more balanced ventilation system, more insulation to meet adopted energy code requirements, and renewable energy systems.

These steps are essential. In particular, the ability of the existing building to accept the new retrofit system must be analyzed by an independent structural engineer. This will define the proper construction of the system to meet all life-safety standards.

It also is imperative that the new retrofit system be properly anchored to the existing roof's structural system. Improper attachment can result in the new roof system being torn from the building due to severe wind uplift. It has been documented in wind uplift tests that proper attachment is the main factor in system integrity.

Solutions

The two common types of retrofit installations on existing structures are for new functional low slope (Figure 2) and architectural steep slope (Figure 3) roof applications. During installation of either of these retrofit systems, the building interior is not exposed to outside elements or contamination from construction.

Low slope installations are usually utilitarian and economically driven. A variety of framing methods can be used to turn a flat roof into a new roof sloped with a pitch from 1:4 to a maximum of 2:12. Typically a low slope application does not add curb appeal, but is designed to improve the discharge of rainwater.

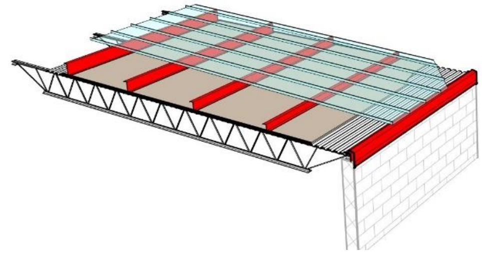

Figure 2 - Low Slope Retrofit

Retrofit systems can solve other problems that may result from existing roof geometry such as poor drainage, snow drifting, or addition of a new building adjacent to the existing structure.

Steep slope installations are commonly a slope greater than 2:12. They are more architecturally driven and turn a flat or minimal slope roof into a design statement through a more aesthetic appearance. Environmental features can also be incorporated in steep slope installations, such as snow guards, cool roof coatings, and renewable energy systems.

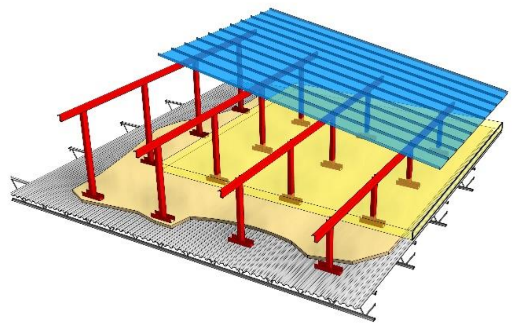

Figure 3 - Steep Slope Retrofit

When steep sloped metal roofs are installed over conventional membrane roofs, tear-off of the existing roof is normally not required and removal of existing roof insulation may not be necessary unless required by local codes.

The International Building Code requires some existing membrane materials to be removed, but it allows an exception for reroofing buildings that have existing metal roofs. An existing metal roof does not typically have to be removed.

In all cases, a properly designed retrofit system improves thermal resistance and offers a balanced ventilation system. If needed, additional insulation can be installed during the retrofit process.

In new construction, retrofit framing can be used as a cost effective alternative to other light-gauge or structural framing methods. Framing for this type of retrofit system is essentially fabricated in the field and erected directly onto a concrete deck or other "attic" floor support system.

Rooftop Equipment

A key consideration in designing a retrofit system for flat roofs is location of the rooftop equipment. Typically, this involves air-handling and non-air handling equipment for heating and air-conditioning systems (Figure 4), as well as skylights, sanitary vents, exhaust fans, and fresh air intakes. How this equipment fits into the retrofit is up to the designer, but the location of existing equipment usually dictates what can be done.

Figure 4 – HVAC Extension to new roof

The first option may be to install a roof over the existing equipment. This will be determined by first evaluating all aspects, including required exhaust needs.

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Another option is to relocate the air-handling units to the new roof plane (Figure 5). If this is the desired application, a structural support system must be engineered to accommodate the weight of the existing equipment. In addition, new air-handling ductwork will have to be installed from the relocated unit to the existing roof penetration. It is recommended to only use curbs approved by the new metal roof manufacturer.

Figure 5 – Air Handler raised to new roof

A third option is to relocate all the larger equipment to a common area in a mechanical well (Figure 6). In this case the overall design must accommodate the well in the roof geometry and new ductwork will need to be routed to existing roof penetrations.

Non-air handling equipment can be relocated to a platform above the new roof.

Electrical and plumbing equipment, exhaust fans and fresh air intakes can also be extended through the new roof, with a curb for the fans and air intakes. The design should also include access for maintenance and potential replacement of these items.

Figure 6 – New HVAC Well

Sloped Roofs

Designing retrofit systems for sloped roofs requires attention to many of the same details in the design stage as for flat roofs. These include analyzing the existing roof support system and using the opportunity to improve ventilation systems and insulation levels and potentially adding renewable energy systems to the design. In sloped roofs it also is important to determine the necessary wind uplift performance so that the system meets applicable building code requirements.

Both metal and conventional sloped roofs can be retrofitted with metal roof systems.

Existing metal roofs are either ribbed panels or standing-seam panels. In a metal-over-metal retrofit (Figure 7), new sub-framing is installed over existing purlins and joists; some systems are also notched to nest with the existing metal roof profile which will also strengthen the roof's corner and edge wind zone areas and allow for an upgrade to currently adopted building code wind speeds.

Figure 7 – Metal-over-Metal Retrofit

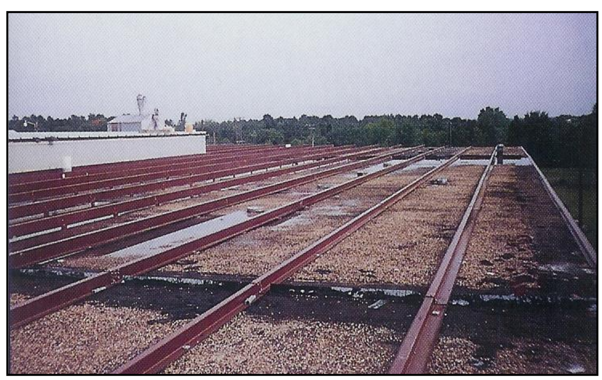

Figure 8 – Low-slope Retrofit over BUR

Conventional roofs are typically one of four types: composition shingles, built-up roofing (BUR), single-ply, or modified-bitumen. When a metal roof is retrofitted over conventional roofing materials, a new support framing system is anchored to the existing structure (Figure 8). This new framing system must be engineered to maintain the structural integrity of the existing roof's support framing, where the newly imposed loads are distributed properly. It is important to note that flat roofs are generally designed to uniformly distribute loads and if the existing roof is ballasted with gravel or rock this material can typically be removed to lighten the existing roof loads. Retrofit framing systems will impose a series of concentrated loads into the existing roof framing. Because of this, a structural engineer should conduct a design analysis to confirm the existing roof will not be overloaded.

Energy Efficiency

The retrofit process offers some excellent ways to improve a building's energy efficiency and help reduce its carbon footprint. By adding a few low cost elements to the retrofit system, the designer can help the building owner realize significant savings.

These elements can include extra insulation for improved thermal resistance and/or a radiant barrier installation and more ventilating space. Another consideration in designing the retrofit system is to use solar technologies to add thermal heat-recovery or power systems.

Figure 9 – New Fiberglass Insulation on old roof

Older flat and sloped roofs typically are not energy efficient because of poor insulating qualities and air infiltration. On average, they have thermal resistance (R) values between R-6 and R-10, which is generally far below most locally adopted energy codes. Today, most building codes have minimum R-values based on ASHRAE 90.1 and the Federal Model Energy Code. ASHRAE 90.1 recommends R-26 for metal buildings and R-38 for conventional buildings. Adding roof insulation in a retrofit application can improve the building's thermal efficiency and may also represent a tax benefit to the building owner. Whether a retrofit is over existing flat or sloped roofs, a properly designed and balanced ventilation system must be included in the assembly. Doing so eliminates any potential condensation issues and allows the building to meet airflow rates required by code.

Clearly a major energy benefit in a retrofit system is the increased natural ventilation, especially in steep-slope metal-over-metal applications, provided by convection that is inherent in a retrofit application. This is referred to as above sheathing ventilation (ASV)[1].

In a direct-to-deck installation, heat is conducted through the roof. With the ASV provided by a retrofit system, heat is dissipated out of the roof system in hot weather and the air space acts as an insulating layer in cold weather. Research conducted by DOE's Oak Ridge National Laboratory (ORNL) has confirmed that ASV provides up to a 30 percent reduction in heat gain through the roof and that this can be increased to 45 percent when a "cool" surface, is created with pre-painted systems using IR reflective pigments. The building owner may also be eligible for Federal tax benefits through the use of ASV.

The same ASV rooftop solar systems can also capture the hot air between the old and new roofs and use it to heat or provide energy for the building. Solar systems can be focused on heat recovery, water heating or power production. Feasibility for use on any building is subject to solar insolation values, which need to be determined in the design stage.

Including solar systems in the retrofit design may also qualify the building owner for additional savings through accelerated depreciation and Federal solar-energy tax credits.

Metal roofing creates an excellent platform for rooftop Photovoltaic (PV) technology installations (Figure 10). PV uses the sun to generate electricity. Today's PV systems include mono and poly crystalline Si, as well as: thin film; amorphous silicon (a-Si); cadmium telluride (CdTe); copper indium selenide (CIS); copper indium/gallium diselenide (CIGS); light-absorbing dyes; and dye-sensitized solar cells [DSSC].

The solar heat recovery system (Figure 11) collects radiant-heated air and redistributes it to the building's existing HVAC system. Solar water heating uses a looped tubing system that carries water glycol fluid heated by the sun's radiant heat. The glycol prevents the water from freezing in cold weather. This technology can be used to heat the building or to provide hot water for processes. The tubing is installed between the existing and new roofs and can be routed to the building walls and/or floors to bring radiant heat into the building. To heat water, swimming pools and/or process equipment, the tubing can be routed to heat exchangers located in tanks or other types of vessels.

Figure 10 – Laminated Photovoltaic Solar

Several important factors come into play when installing PV systems on metal roofs and on conventional roofing systems. A metal roof may accommodate necessary PV attachment hardware without roof penetration. Any rack-mounted PV system attached to a conventional roof requires waterproofing at the solar array attachments points. Because the realistic service life of a conventional roof membrane is less than that of a PV system, the PV system will need to be dismantled and reinstalled when the old roof needs to be replaced. So any cost calculation for re-installing a PV system over a newly installed conventional roof, must include this long-term roof-replacement costs. The service life of a metal roof is much longer than that of the PV system and mounting a solar system on a sloped metal roof can provide savings of 24 percent to 43 percent[2] compared to a conventional roof system. Of course, this considers re-installing the PV system after a conventional roof replacement.

Figure 11 – Solar Heat Recovery System

As mentioned above, using a standing seam metal roof with a PV system allows for Federal solar-energy tax credits, which have been extended through 2021. These include a rebate of 30 percent of the entire system cost; accelerated depreciation schedule (IRS sec 179b); and a 50 percent first-year bonus depreciation with the balance depreciated over the following 5 years. Additional state and local tax and utility incentives for solar systems and metal roofing can be determined by visiting www.dsireusa.org. Check with your tax professional.

In addition to the immediate Federal or state rebates and incentives, the building owner will realize savings from reduced energy use throughout the life of the PV system.

SUMMARY

Retrofit metal roof systems have been utilized for decades to resolve issues related to the use of petroleum-based low slope roof membranes such as high levels of maintenance and continual roof replacements over the service life of a building.

Thousands of buildings have already been retrofitted including schools, federal/military installations, state and municipal facilities, and commercial structures. Each of these buildings has been reaping the benefits and cost savings of this efficient reroofing concept. The use of energy efficient and sustainable retrofit metal roof assemblies can help ensure that dollars intended for education are spent on educating children rather than operating or maintenance costs.

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[1] Miller, W., Wilson, J., Karagiozis, A.,"*The impact of Above Sheathing Ventilation on the Thermal and Moisture Performance of Steep Slope Residential Roofs and A*ttics", ORNL

[2] Percentage of savings is referenced from the Metal Roof Advisory Group's presentation and studies. Rob Haddock, President. When not considering a conventional roof replacement on an existing building roof, the service life cost analysis will illustrate an actual savings between 10 and 20 percent for new construction.

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