

## Analysis 2: Greenroof Design

### Introduction

Greenroofs can be a great alternative to conventional roofs that can be environmentally friendly and serve many other purposes including cost and energy savings. They can greatly help stormwater control, reduce heat island effects, create energy savings, cause a decrease in pollution and help with noise reduction.

In addition to environmental and economic effects, implementing a greenroof can greatly assist in receiving credits for a LEED Certified Building. The proposed greenroof will help with the following credits that were sought after for LEED Certification earlier in the report:

- SS Credit 5.1: Site Development: Protect or Restore Habitat (1)
- SS Credit 5.2: Site Development: Maximize Open Space (1)
- SS Credit 7.2: Heat Island Effect: Roof (1)
- WE Credit 1.1: Water Efficient Landscaping: Reduce by 50% (1)
- WE Credit 3.1: Water Use Reduction: 20% Reduction (1)
- EA Credit 1: Optimize Energy Performance (2-10)

Note: The number in parentheses after the credit name is the amount of credits that can be obtained.

When discussing greenroofs, there are two types to consider: extensive and intensive.

### Extensive

Extensive is the simplest type of greenroof. The growing media ranges between 2 ½ inches and 6 inches. Due to a simpler design, this type of roof requires lesser and lighter layers, is less expensive and requires less maintenance than an intensive greenroof. Extensive greenroofs can be installed with slopes up to 30°. Costs can range between \$14 and \$25 per square foot.

### Intensive

Intensive greenroofs are more complex than extensive. They generally have a growing media beginning at 8 inches and can be as large as 15 feet. With this increase in the amount dead loads applied to the roof, the structural capacity needs to be greater and as well as the mechanical capacity due to the increased stormwater drainage.

Expenses for an intensive greenroof will range from \$25-\$40 per square foot or more depending on the complexity.

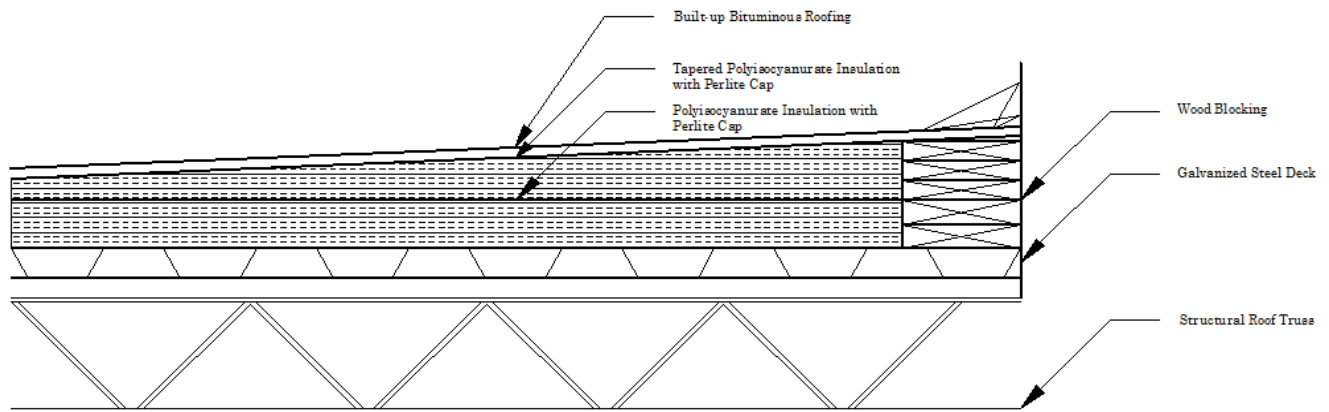
### Components of a Greenroof

Greenroofs have the following necessary layers: waterproof membrane, insulation, drainage, filter fabric, growth media, plant material and water storage and irrigation.

Just as with a conventional roof, waterproofing is necessary and built-up bituminous roofing could be used. Insulation is not required, but with the proposal of reusing the existing Pasadena Elementary School, it may be recommended due to heat transfer from the water in the greenroof system into the building.

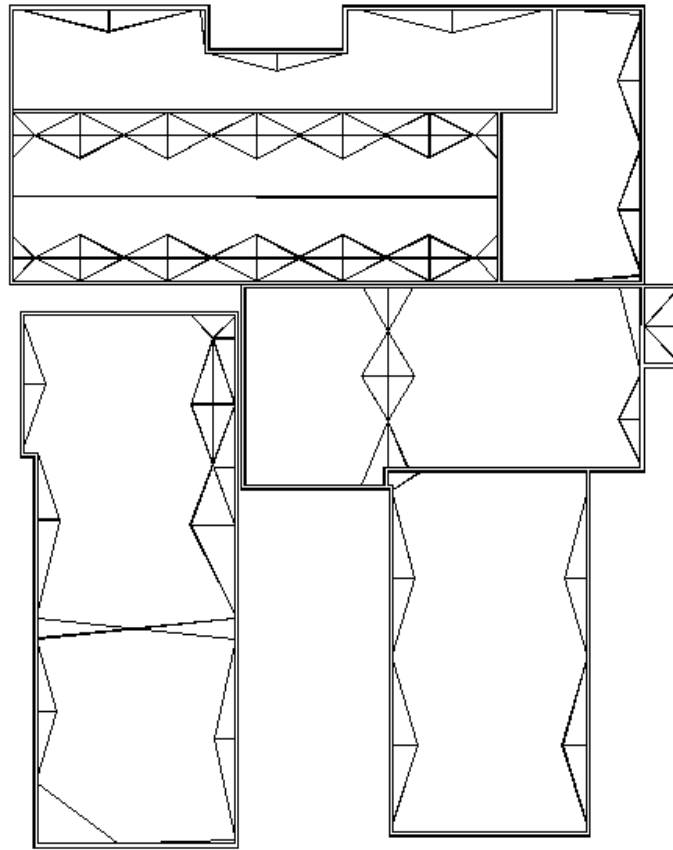
### Original Roof Design

The original design of the school was a basic roofing system that mirrored today's standards. A 1-1/2", 20 gauge acoustic steel decking with tapered insulation that sits on top of steel roof trusses. There is cap flashing and thru-wall flashing below a bituminous membrane that serves as moisture protection. A section of the original design is shown below.



Existing Roof Section

Below is the original design for the roof plan for Pasadena Elementary School. Note that all slopes for tapered insulation shown on the plan are 25"/12".



**Existing Roof Plan**

### **Proposed System**

A unique alternative to what most people think of greenroofs are Green Roof Blocks. They consist of 24" x 24" heavy gauge aluminum containers and are portable units that can be rearranged. They contain durable and drought resistant sedums that stand in 4" of growing medium. The lifetimes of the sedums are 100 years in length. The sedums sit on a 3/8" thick walk pad material that protects the roof from any moisture that the sedums might cause and in addition helps with roof drainage.

The types of plants are recommended based on the regional area the building is located in. Pre-planted sedums are chosen with some flexibility by the manufacturer.

Notice in Appendix D the types of plants that are recommended for the Pasadena, MD area.

This alternative is lightweight and is less expensive than other green roof options. Also for installation all you have to do is set the mobile units on top of the roof. Installation is performed by the same manufacturer and about 500 modules per day can be installed with the help of 8 workers.

The green blocks help with 15% energy savings and over a 2 year period can capture 80% stormwater. This captured stormwater can be reused in the building which reduces potable water use and can assist in obtaining LEED credits.

The units are manufactured by Green Roof Products which is a subsidiary of Saint Louis Metalworks Company located in Florissant, Missouri. Only a 3-week period is required for orders so it does not affect the schedule due to having a long-lead time.



Photo Taken from <http://www.greenroofproducts.com/>

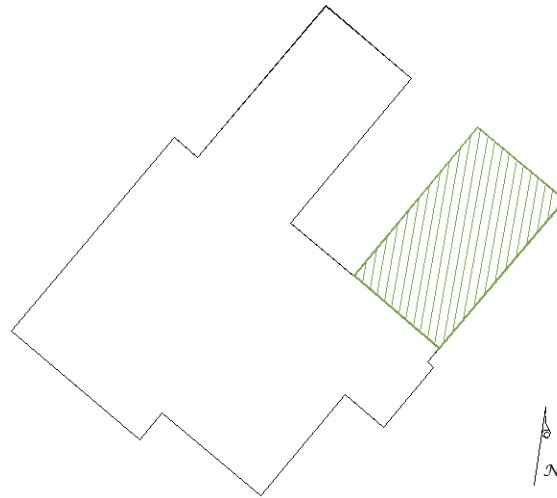
### Green Roof Blocks

They are estimated at \$12.50 per square foot. Since the area of the roof is 49,280 square feet the following is the estimate for these green roof blocks if used on the entire roof:

<b>Price per square foot =</b>	<b>\$12.50</b>
<b>Roof square footage =</b>	<b><u>x 49,280</u></b>
<b>Total Estimated Price =</b>	<b>\$616,000</b>

The cost of \$616,000 is a great amount to add to construction costs and therefore, it would be difficult to convince most owners to purchase the system. Below is a calculation of the cost that would entail placing the green roof blocks on the northwest wing of the building only.

Price per square foot =	\$12.50
Roof square footage =	<u>x 8,890</u>
Total Estimated Price =	\$111,125



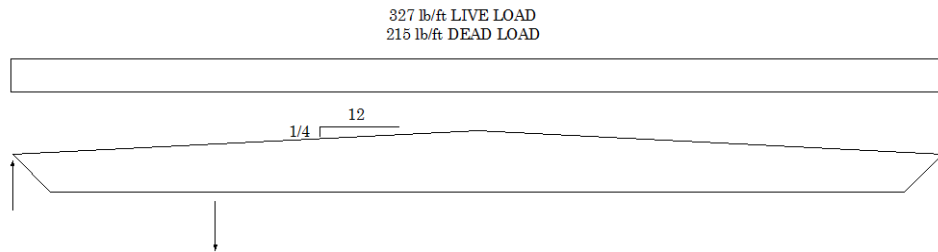
#### **Footprint of Building with Shading of Location of Area Green Blocks to be Added**

An amount of \$111,125 is much less than that of \$616,000 and would be easier to convince the owner of its value and that it is worth purchasing. Compared to a total project cost of \$14,042,006, the amount to add green roof blocks is not that much and would be a great impact on the energy efficiency of the building.

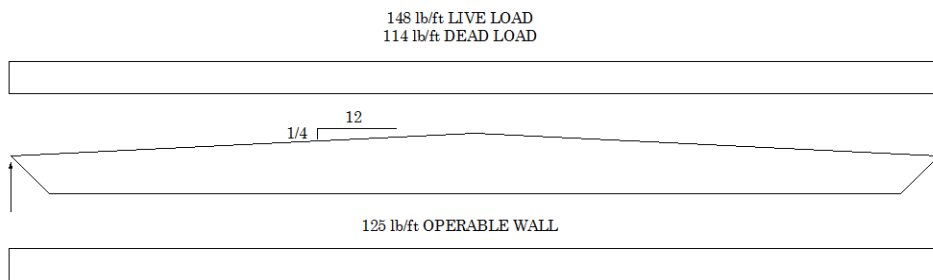
Installation of the roof blocks is performed at a rate of 500 modules per day with the help of 8 workers provided by the manufacturer at no additional cost. To install the roof blocks on the area of 8,890 square feet it would take 18 work days or just under 4 weeks to complete.

## Structural System Analysis

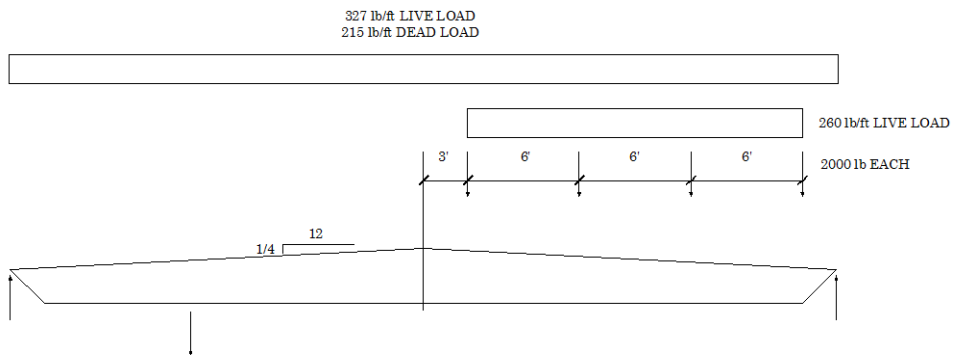
The original design loads (lb/ft) for the four structural trusses used in the building for support of the roof are below:



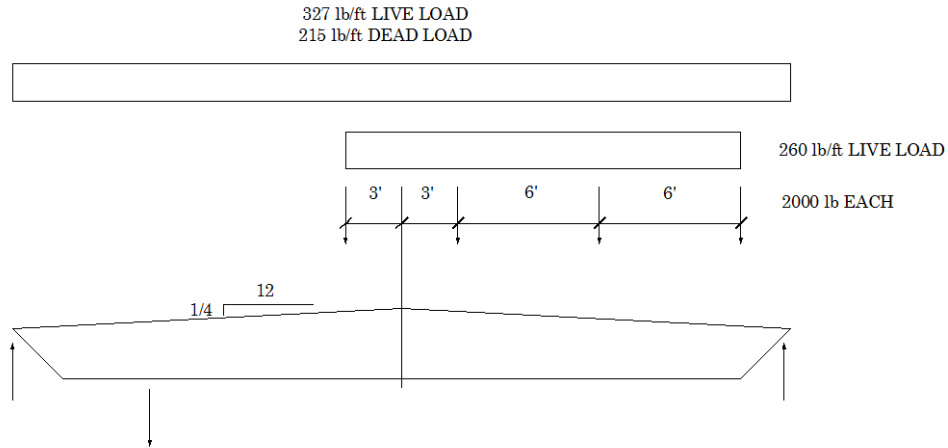
**36LHSP1**



**36LHSP2**



**36LHSP3**



### 36LHSP4

Note: For trusses 36LHSP1, 3 and 4 1000 lb live load at any location bottom chord shall be designed to transfer load to the adjacent panel points.

Below is the calculated dead load weight the roof trusses should be able to support based on weights from ASCE7-02 Table C3-1 Minimum Design Dead Loads. Notice the green roof blocks add a dead weight of 85 pounds per linear foot the trusses have to support.

	Weight (psf)	Weight (plf)
1 1/2" Galvanized Roof Deck (18 gauge)	3	15
Concrete	24	120
3' Polyisocyanurate Insulation with 1/2" Perlite Cap	2	12
Tapered Polyisocyanurate Insulation with 1/2" Perlite Cap (1/4"/ft min. slope)	7	34
Bituminous Membrane, gravel covered	6	28
Green Roof Blocks	17	85
<b>Total</b>	<b>59</b>	<b>293</b>

**Designed Dead Load = 208 plf**

**Truss Dead Load Tolerance= 215 plf**

There are four types of trusses used in the building as noted above. When first beginning to look into the green roof blocks a weight of such magnitude was not anticipated. The trusses original to the building's design are not capable of holding such a weight and therefore would need to be redesigned by the structural engineer.

## Conclusions

A greenroof can be a great addition to a building causing an increase in energy efficiency at a minimal additional charge to the owner. Greenroof blocks are a slightly different alternative than what people typically think of when they think of greenroofs. However, they tend to be cheaper in price compared to other greenroofing options and provide minimal impact to the structural system of the building.

These blocks add 85 pounds per linear foot that the roof trusses must support. When originally looking at the system it was not realized that although lightweight, the greenroof system would weigh as much as it does. It was determined that the roof trusses could not support the extra weight of the green roof blocks and new trusses would have to be chosen by the structural engineer that could support the extra weight.