PENNSYLVANIA STATE UNIVERSITY

Aluminum Tiling

Alcoa Project Final Design Report

Nathasha Ramirez, Ryan Shapiro, Ryan Schaeffer, Stephen Ernharth

EDSGN 100 Sec. 17
12/12/2013

We have been instructed to create a process or product that will use aluminum's intrinsic properties to increase the sustainability of the campus. Our goal is to make classrooms more energy efficient using aluminum products. To accomplish this we've created the design specifications for aluminum tiles that will reflect more light around the room to lower lighting costs.

Table of Contents

1. Introduction to Task 2-3
   - 1.1 Project Objective 2
   - 1.2 Alcoa Background 2
   - 1.3 Aluminum's Useful Properties 3
2. Problem and Research 3-4
   - 2.1 Recognition of the Problem 3
   - 2.2 Customer Needs 3
   - 2.3 Solution Approach 3-4
3. Specifications 4
   - 3.1 Final List of Specifications 4
4. Design Ideas 4-5
5. Evaluation 5-7
   - 5.1 Pairwise Comparison Weighing Matrix 5-6
   - 5.2 Design Ideas Screening Matrix 6
   - 5.3 Weighted Matrix 7
   - 5.4 Design Solution 7
6. Analysis 7-8
   - 6.1 Tile Structure and Details 7
   - 6.2 Cost Analysis 8
7. Conclusion 8-9

Introduction to Task

Project Objective

The assignment was to identify and take advantage of opportunities around the campus in which aluminum could be used to increase sustainability. To be sustainable, the product must maintain social, environmental, economic proficiency. The ways in which we can do this are by increasing energy efficiency, durability, and affordability. We can also create a recyclable and reusable product with many markets and buyers. By doing this, the success and profits made from our product will grow and thrive by meeting the needs of society.

Alcoa Background

Alcoa is by far the leading producer of aluminum and fabricated aluminum, as well as the largest miner of bauxite and refiner of alumina. Aside from producing aluminum, they also engineer aluminum based products. Their technologies are bought by many different firms and used in products, such as colored aluminum (for devices). They, in fact, developed the first aluminum tea kettle, and from the early 1900s, their aluminum has been used to lighten automobiles. More importantly, aluminum from Alcoa is used largely in aerospace, due to its relatively low density (while still being a strong material). From aluminum foil and cans to truck wheels, Alcoa's innovations continue to lower energy costs and improve efficiency. A large fraction of the aluminum they process is recycled, which makes aluminum that much more of an important metal for building and other purposes. What also distinguishes them (and makes them the biggest aluminum producer) is that their aluminum production facilities operate at very low costs relative to others'.

Aluminum's Useful Properties

Aluminum is the second most used metal after steel. Aside from its myriad of uses, from kitchen ware to automobiles, a highly polished piece of aluminum can reflect up to 97% of the light that's shone upon it. Lightning sheets, a term used to denote highly reflective aluminum, are used for jobs more centric on lighting. Not only is it reflective but also lightweight. Due to its low density you can transport more at once. Aluminum is also relatively inexpensive to recycle. In fact, about 70 percent of the aluminum in use today was in cycle in 1888.

Defining the Problem

Recognition of the Problem

We aim to make rooms more energy efficient by reducing lighting costs using aluminum products.

Customer Needs

According to the feedback from Alcoa; we arrived at various conclusions regarding the characteristics they wanted from our product. Alcoa has made it clear that they are looking for a product or process that relies on the use of aluminum to increase sustainability, while being cost effective, practical, and easily marketable.

Solution Approach

We have decided to create an aluminum product that will reduce the amount of energy needed to brighten a room. With aluminum's reflective properties it should be able to efficiently utilize

the light being used, resulting in a decrease of energy required to make rooms sufficiently illuminated.

Specifications

Final List of Specifications

When we formulated our ideas and specifications for the tiling, our group agreed that the best way to measure most sustainable specifications is by comparing the cost, efficiency, marketability, etc. to ceramic tiling and other top alternative flooring choices for but not limited to school classrooms, lobbies, and hallways.

- Uses Aluminum
- Durable (Than ceramic/other alternatives)
- Marketable (Many markets, i.e. schools, buildings, shops, malls)
- Functions as intended
- Applicable (Easy installation, multiple uses)
- Energy efficient (Than ceramic/other alternatives)
- Cost effective (Than ceramic/other alternatives)
- Recyclable (Hopefully more than competitor products)

Design Ideas

We decided that the application of aluminum in the form of tiles, wall paneling, or window blinds will achieve our goal. Each of these would be used in a room or building setting where light can easily be reflected.

By using aluminum as window blinds, we wanted to use aluminums reflective properties to brighten a room when there was limited or no natural light available from outside. These blinds would work primarily at night time by spreading inside lighting and eliminating the need

for sunlight. With the idea in mind, our group identified its limited usage and saw it lacked the ability to create a major change in energy efficiency due to the restrictions of application.

Our next idea was to use a tile or wall panel on the outsides of a room to reflect light and ultimately increase the lighting in a room without using additional electricity. Our design would be a construction of skinny aluminum sheets from the floor to the ceiling and would extend to the desired length of the wall. Many colors, tints, and textures could be implemented in the design to make the panel eye appealing and stylish while maintaining its purpose and effectiveness. Our group concluded that much of the typical wall space in a room is needed for writing boards, educational pieces, or other posters and pictures that an instructor would enjoy having in their room.

Our group's final idea was to use aluminum as a flooring tile to brighten any room or space by reflecting the light present. Like the walling, the floor tiles could be colored, tinted, or textured to add a stylish side to the design making it more marketable and usable in many instances. Depending on the lighting present, darker tints could be made to alter the reflectiveness wanted where it is needed.

Evaluation

Design Ideas Screening Matrix

	Concept Variants			
Selection Criteria	Tiles	Wall Panels	Blinds	Ref.
Uses Aluminum	+	+	+	0
Durable	+	+	0	0
Marketable	+	+	+	0

Functions as intended	+	+	+	0
Applicable	+	0	-	0
Energy Efficient	+	+	-	0
Cost Effective	0	0	0	0
Recyclable	+	+	+	0
PLUSES	7	6	4	
SAMES	1	2	2	
MINUSES	0	0	2	
NET	+7	+6	+2	
RANK	1	2	3	
CONTINUE?	YES	NO	NO	

Pairwise Comparison Weighing Matrix

	A	B	C	D	E	F	G	H	Row Totals	Row Total/Total
A	1	2	1	1	1	1	2	1	10	0.14
B	1/2	1	1	1	1	2	1/2	1/2	7.5	0.10
C	1	1	1	1/2	1/2	1/3	1/2	1	5.83	0.08
D	1	1	2	1	1	2	1	1	10	0.14
E	1	1	2	1	1	3	1	1	11	0.15
F	1	1/2	3	1/2	1/3	1	1	1	8.33	0.12
G	1/2	2	2	1	1	1	1	1/2	9	0.13
H	1	2	1	1	1	1	2	1	10	0.14
								Total:	**71.66**	

A=Incorporate Aluminum product(s)
B=Improve Durability
C=Marketable
D=Applicable
E=Energy Efficient
F=Cost Effective (More than ceramic in the long term)
G=Recyclable
H=Functions as Intended

Weighted Matrix

		Tiling		Wall Panels		Blinds	
Specs	Weight Factor	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Contains Aluminum	0.14	5	0.7	5	0.7	5	0.7
Improve Durability	0.10	4	0.4	3	0.3	2	0.2
Marketable	0.08	4	0.32	3	0.24	3	0.24
Applicable	0.14	4	0.56	3	0.42	3	0.42
Energy Efficient	0.15	4	0.6	4	0.6	3	0.45
Cost Effective	0.12	5	0.6	4	0.48	3	0.36
Recyclable	0.13	5	0.65	4	0.52	4	0.52
Functions as Intended	0.14	5	0.7	5	0.7	5	0.7
Total			4.53		3.96		3.59

Design Solution

The matrix helped us realize that blinds were not an option suitable for our customers' needs. They don't have enough application to be worth the increased costs as opposed to blinds made of other materials. Wall panels were a close contender but contained a major limitation because most walls are filled with other necessary items that would cover the aluminum. The aluminum flooring became our best option because of the effectiveness and usability of the design. The impact that the tiles can have on a dim room is the most dramatic design and also is the most practical for the stakeholders.

Analysis

Tile Structure and Details

The tiles are one square foot with a half-inch thickness. They are composed entirely of aluminum.

Cost Analysis

Tile Cost	$4.10 per sq. ft.	$4.45 per sq. ft.	$10.30 per sq. ft.
Amount of Tiling	x2240 sq ft.	x2240 sq ft.	x2240
Total cost of Tiles	$ 9,184.00	$ 9,968.00	$ 23,072.00
Labor Cost	$58.33 per hour.	$53.40 per hour.	$56.70 per hour.
Hours of labor	x180 for each room	x15 for each room	x110 for each room
Additional % fee	x1.2	x1.2	x1.2
Total Labor Cost	$ 12,600.00	$ 960.20	$ 7,484.40
Supplies and Materials	$.93 per sq. ft.	$.28 per sq. ft.	$1.83 per sq. ft.
Amount of Supplies	x2240 sq. ft.	x2240 sq. ft.	x2240
Total Cost of Materials	$ 2,090.00	$ 620.26	$ 4,100.00
Total Cost for Project	$ 23,874.00	$ 11,549.46	$ 34,656.40
Reflectivity of surface	40%	18%	90%
Price of electricity saved per year (Compared to the current flooring)	$112.54	$0	$368.30
Total savings over 50 years	$ 5,627.00	$ -	$ 18,415.00
Average number of installments (after 50 years)	x3.33 (14-16 yrs.)	x2.5 (20 years)	x1 (50 years)
Total Cost of Flooring Installments	$ 79,579.92	$ 28,873.65	$ 34,656.40
Energy Savings	$ 5,627.00	$ -	$ 18,415.00
Net Cost for Flooring Installments after 50 years (Per Room)	**$ 73,952.92**	**$ 28,873.65**	**$ 16,241.40**

Conclusion

After extensive thought we realized that we could try to reduce the energy costs of the school using aluminum. We decided to use aluminum's reflective properties to decrease the amount of lighting needed per classroom. From the customer's needs we were able to formulate a list of specifications our product should have to satisfy the problem as well as the client. After brainstorming and evaluating our possible products, we came up with aluminum tiles. To ensure that the design we have created is going to be effective, all the specifications we created must be

fulfilled. On average aluminum tiles last about 30 more years before needing to be replaced than other alternatives, such as ceramic and linoleum tiling. Installation of the tile would not be any more difficult than other tiles, the process would remain the same. Ceramic tiles reflect 18% of light in comparison to the 90% that aluminum reflects. This means that less lights need to be in use therefore not only do you spend less on electricity but also reduce byproducts of the production of electricity. After being recycled, aluminum tiles can be used for other projects while ceramic tiles can only be reused as tiles if they are not too timeworn. Via the cost analysis, aluminum tiling over a 50 year period turns out to be the cheapest flooring option. The quotes for aluminum flooring and installation costs were all from Alumafloor, a company that produces and installs aluminum floor tiles. All of these characteristics make the product very marketable. Our design satisfies all of our specs, therefor e it satisfies all of our customer needs, and so our design should be successful.