Best 4

Competing Performance Criteria in Renovation and Repurposing of Existing Building Exterior Enclosure Systems

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THE CONCERN

A building owner has decided they need to repurpose their original masonry bearing wall train station constructed in 1899, to a state of the art medical research facility including high humidity wet laboratories. Due to the new chairman's commitment to the environment and the need for very close control of the interior temperatures for laboratory work there is also a commitment to at least meet, and hopefully exceed, the current code mandated thermal insulation. The building will also be used for high-end government contracting which mandates "blast resistant' windows. To round out the picture:

- This building is located in Duluth Minnesota.
- The existing structure is on the national historic register
- The space needs are very tight and do not allow a building within a building approach.

While the description of this building is a fabrication, it is only barely so. It is actually a conglomeration of similar conditions I have encountered on real buildings with very similar desires by owners and their architectural designers.

These kinds of conditions often lead to conflicts between aesthetic desires and required performance criteria, as well as the sometimes nearly impossible task of meeting basic code and regulatory mandates. All too often, the project team (designer, owner, and constructor) does not identify the conflicting requirements early enough, and then are at a loss for resolution of these conflicts at a late date in the project process. The necessary steps required to sort through the maze of options, desires, preferences, and conflicts are to clearly identify them, understand them, and to then find an appropriate and logical path for decision making. In many cases this will include making choices and compromises between the competing demands.

The information presented in this paper is intended to help the project teams who find themselves in similar situations discover a path to reach reasonable conclusions, and assist them in determining if the building is appropriate for the intended use.

INTRODUCTION

In the current building construction market there is, and almost certainly in the future there will be, a demand to repurpose existing buildings for new uses and/or to improve their performance for existing uses. While this process can be both economically and environmentally sound, it often offers challenges in meeting conflicts between desired performance criteria for the building exterior enclosure systems and the building structure and/or the basic fabric of the building.

This desire and practice is not new, and has in fact has been present in various forms for a very long time. The Musee d'Orsay, Paris France (Figure 1), The Ann Franck House, Amsterdam, Holland (Figure 2), and the Tower of London, London England (Figure 3) represent some high profile examples of this approach.

Figure 1: Musse d'Orsay, *Looking over the Musse d'Orsay,* Derek Key; CC-BY-2.0.

Figure 2: Anne Frank House, *Anne Frank House Amsterdam the Netherlands*, Massimo Catarinella; CC-BY-SA-3.0.

Figure 3: Tower of London, *Tower of London*, Carlos Delgado; CC-BY-SA.

Do these represent good repurposed uses of existing Buildings? Perhaps, it appears that each had logical reasons and productive service life after their original uses. However, most of us see more ordinary examples of buildings that have been repurposed for new occupancies and uses nearly every day without considering it. The one room school house that is now a winery, antique shop, or home (Figures 4 and 5, Photo of Winery, Brooklyn, MI.). The gas station that is now a floral shop, the public school that is now a church.

Figure 4: *Cherry Creek Winery, SmithGroupJJR*

Figure 5: Detail, *Cherry Creek Winery, SmithGroupJJR*

How about the gas storage buildings in Austria turned into apartments (Figure 6: Exterior of Gasometer, Vienna, Austria, and Figure 7: Interior of Gasometer, Vienna, Austria).

Figure 6: *Gasometers in Vienna, Austria,* Andreas Poeschek; CC-BY-SA-2.0-at.

Figure 7: *Gasometer C inside,* Andreas Poeschek; CC-BY-SA-2.0-at

Or, the grain elevators in Akron that are now a hotel (Figure 8: Exterior Quaker Square Inn, Akron, OH, and Figure 9: Exterior Quaker Square Inn, Akron, OH.), or the industrial facility turned into apartments. (Figure 10: River Place Apartments, Detroit, Mi.).

Figure 8: *Quaker Square SW,* Dcamp 314-Own work. Licensed under Public Domain via Wikimedia Commons.

Figure 9: *Interior,* Steve Loya, www.goflyingturtl.blog.spot.com

Figure 11: *"Parke Davis Plant* Building, Detroit, MI", Andrew Jameson – Own work. Licensed under Creative Commons Attribution-Share Alike 3.0 via Wikimedia Commons.

The list goes on and on and this, by the way, is not a new trend. We find that throughout history this has been common practice. Why? Because it is efficient and preserves both resources and labor! What is new is the sophistication that we now expect from our buildings with regard to performance, especially in their exterior enclosure systems.

In this paper I deal with some examples from my practice over many years. The intent here is to address the considerations associated with repurposing, show examples of repurposing, and provide some "real world" examples of the consequences that may attend such an effort,

As a matter of definition for this paper:

REPURPOSING: The implementation of new uses or new performance levels in a building and the attendant change(s) required to raise one or more performance attributes of the building exterior enclosure systems to suit the new use, or uses, or performance requirements.

In today's approach to design, construction, and occupancy of buildings there is an increased expectation that buildings will perform in a specific manner, and at specific levels, with regard to particular performance attributes. However, this approach is often fraught with conflicts that either cannot be easily resolved, or may even result in conditions wherein the desired performance level of one attribute of the exterior enclosure may induce a failure in another component of the building. Examples of this concern are presented later in this paper.

HIGH PERFORMANCE BUILDINGS

As recently as 35 to 40 years ago buildings were normally built in a certain fashion, with certain expectations of performance based not upon analytical procedures as we can do today, but based rather upon the expectation that it would perform similar to another building built in a similar fashion, with similar systems and components. This is not to say that all buildings were designed and constructed by this process, but certainly it was the norm, not the exception. While testing of in-place systems was performed on some buildings, the concept that higher R meant better insulation was about as far as we went in measuring or anticipating performance of the exterior enclosures of buildings in most cases. Even this was directed more to sizing and designing mechanical systems and equipment more than energy efficiencies. A perfect example would be the glass box buildings which were heating on one side of the building and cooling on the other – at the same time!

One of the approaches often applied to repurposing is improvement in performance of certain aspects of the building. A term that is frequently applied to the intended results of this approach is "high performance."

What constitutes "high performance"? During the last 15 years or so this term has been closely linked to energy and compliance with green/sustainable building rating systems. Given that these rating systems typically have a tiered path for compliance a "High Performance Building" could be anything from a marginal improvement above codes and regulatory minimums up to a building with zero net energy usage. In my opinion, the term "high performance" is very vague as normally used today, and effectively means whatever the individual using the term thinks it should! That is to say that there are no widely accepted and used consensus or regulatory standards for the use of this term, at least not measurable performance standards. Normally when one hears this term it is couched in terms of energy usage. Even though there have been attempts to define this term with regard to energy, the definition (by performance terms) is fuzzy, at best, and does not really reflect the true spirit of the term. While there are some attempts being made to define the meaning of high performance by certain organizations, such as NIBS, there are currently no widely accepted standards being used consistently.

At this time, the term "high performance" is also too tightly tied into the notion that first cost is the most important concern. First cost may be the most important concern to the owner in some cases, however in these cases it may then be a simple conclusion that these buildings cannot truly be considered to be high performance. The one thing that does seem to be consistent in the discussions I have heard about high performance is that the term is currently used with regard to the energy usage of buildings. Based upon my experience it seems simple enough to conclude that first cost and high performance will continue to be at odds until we start paying for the real cost of energy.

In effect, the term "high performance" is essentially defined on a building-by-building and owner-by-owner case in current practice. The definition of high performance is of course dependent upon the performance issue being considered. For example, if I desire a building which has high resistance to blast loads the performance expectation will be determined by the owner's perception of the level of protection desired, in conjunction with the location and threat levels to the building. Even within this example there are at least two considerations: resistance to glass shard displacement (glass shard retention level), and progressive collapse of the frame. Note that these properties are also addressing (at least on the surface) two components of the building – the enclosure and the structure. It is not improbable that a building with too much resistance to glass shard displacement in the exterior enclosure could result in excessive loads being placed upon the building frame or bearing walls, thus leading to another type of failure, one that perhaps presents even more risk than the original concern. In the end we need a definition of high performance, and a setting of levels, which is widely accepted, and which is based in a logical consideration of the issues across the whole spectrum of building types, uses, and service life expectations. This should also include all of the performance attributes associated with building exterior enclosure systems. Ideally, the definition and levels would be developed through the consensus process. Hopefully, such a definition will also be based in the consensus process. In point of fact Public Law 109-058, The Energy Policy Act of 2005 calls for this, at least relative to energy (Figure 11: Section 914: Building Standards).

Energy Policy Act of 2005 (Public Law 109-058)

Section 914. Building Standards.

1. Definition of High Performance Building – In this section, the term "high performance building" means a building that integrates and optimizes all major high-performance building attributes, including energy efficiency, durability, life-cycle performance, and occupant productivity.
2. Assessment – Not later than 120 days after the date of enactment of this Act, the Secretary shall enter into an agreement with the National institute of Building Sciences to -
    1. conduct an assessment (in cooperation with industry, standards development organizations, and other entities, as appropriate) of whether the current voluntary consensus standards and rating systems for high performance buildings are consistent with the current technological state of the art, including relevant results from the research, development and demonstration activities of the Department;
    2. determine if additional research is required, based on the findings of the assessment; and
    3. recommend steps for the Secretary to accelerate the development of voluntary consensus-based standards for high performance buildings that are based on the findings of the assessment.
3. Grant and Technical Assistance Program – Consistent with subsection (b) and section 12 (d) of the National Technology Transfer and Advancement Act of 1995 (15 U.S.C. 272 note), the Secretary shall establish a grant and technical assistance program to support the development of voluntary consensus-based standards for high performance buildings.

Figure 11: Portion of Energy Policy Act of 2005 (Public Law 109-058).

However, to my knowledge the implementation of the portion of the act calling for *"voluntary consensus standards and rating systems for high performance buildings...consistent with the current technological state of the art"* has not yet occurred. Special note should be made of the fact that Section 914 does not include any language relevant to cost, other than life cycle performance, and in that reference the pay-back time is not mentioned.

Due at least in-part to our practices of design and construction of the past, it is mandatory that before we start expecting to implement higher performance levels in an existing building, we must first understand what abilities the enclosure systems actually possesses relative to the various performance attributes. You can cause serious problems if you proceed into construction without fully considering these inherent attributes of the existing building during the design process.

It is imperative that before you start revising the exterior enclosure systems of your existing building to provide high performing systems, or change the use or occupancy of a building, that you first evaluate the existing systems and understand the potential impact of your intended “improvements” or repurposing.

SUSTAINABILITY

Sustainability and good stewardship of resources is probably one of the key reasons to consider repurposing of any building. In 2011 the Preservation Green lab, in cooperation with the National Trust for Historic Preservation, published the report, The Greenest Building: Quantifying the Environmental Value of Building Reuse. In this report they conclude that, *“the reuse and retrofit of equivalent size and functionality can, in most cases, meaningfully reduce the negative environmental impacts associated with new building development.”* Their analysis indicates that it would take anywhere from *“10 to 80 years for a new building that is 30% more efficient than an average performing existing building to overcome, through efficient operations, the negative climate change impacts related to construction.”*

One of the key components to evaluating sustainability of buildings is consideration of their durability, or the measure of how long they are able to serve as functional buildings. While I am not aware of any formalized and truly reliable method to measure such performance, it should be clear that the longer we continue to utilize the embodied energy and materials in existing buildings the more sustainable they are likely to be, simply by virtue of not having to invest additional raw materials and energy to replace them.

Unfortunately, the performance expectations we have come to think of as normal today, and current criteria for new uses of an existing building, may be completely beyond the ability of buildings even 30 to 40 years old to accommodate without significant intervention and change. While these higher performance expectations are fine and represent good long-term thinking for new buildings where we have complete control over the outcome, they may not be reasonably attainable when repurposing existing buildings. The term “unrealistic” could have many different meanings. **However in this case I define this as the point where:**

“Changes which necessitate intervention to existing exterior enclosure or supporting systems to a degree which either endangers fundamental aspects of the systems which are either unacceptable from a point of view of historic preservation, or to a degree which requires expenditure of materials and effort beyond that of a new facility.”

With this said, the issue is actually quite simple; before marching off to save a building by repurposing it and raising every performance attribute of the enclosure to current standards (or beyond), maybe we should stop and consider what we expect to accomplish.

WHAT SHOULD WE DO?

For starters, we need to consider what we actually mean when we talk about the concept of changing performance levels of various systems for the exterior enclosures of an existing building. This discussion should probably begin with consideration of how we evaluate building enclosure systems performance.

In approximately 1984 Yorkdale identified a long list of performance characteristics in efforts to start ASTM subcommittee E06.55 on the Performance of Exterior Wall Systems. Inherent in this well-known article, as well as in present practice today, is the concept that performance levels can and should be quantified for service needs, and in most case can and should be measured to validate performance. The following list includes some of the performance attributes he suggested should be considered.

- Blast resistance
- Forced entry
- Ballistic resistance
- Water intrusion resistance
- Wind resistance
- Fire resistance
- Thermal protection
- Ultraviolet exposure resistance
- Heat aging-resistance
- Snow accumulation and drifting
- Thermally induced movement
- Hail resistance
- Acoustic resistance
- Moisture migration
- Seismic resistance

This list represents those we most often deal with, but there are certainly others to be considered.

Yorkdale did not invent the concept of measuring and quantifying performance levels for exterior building enclosure components and systems. Our industry has been doing this by different methods and at different levels for a long time. He did however help to bring the subject into the consensus process of ASTM through creation of subcommittee E06.55 on Performance of Building Enclosures.

For my part, this was the first time I was exposed to a cohesive presentation of the concept being expressed, that exterior building walls (the enclosure) should be considered in this manner. Inherent in this approach is the concept that each performance attribute is predictable and quantifiable, and the components of the enclosure can and should be designed and constructed to the needed or desired level. In my opinion the logical extension of this concept is that: the actual in-place performance of each enclosure system could impact the other systems, and the success of the total exterior enclosure is dependent upon all of the pieces and systems. This is a fundamental part of the successful approach to repurposing existing buildings; consider the interrelationship of each component or system of the exterior enclosure and the potential for negative impact on one system or component when increasing performance levels of one or more of the others.

HOW SHOULD WE DO IT?

It is generally accepted that the performance criteria for the exterior enclosure of any building should be determined by a comprehensive analysis that considers the intended occupancy, the anticipated exposure conditions, and the desired performance level of each enclosure system or component. In other words, how must the enclosure systems or components perform to provide the desired functions, and to what levels? In addition to these performance considerations we must also determine what levels are desired for performance of the envelope systems with regard to long term usage and sustainability. In the case of existing buildings we must first determine the nature and attributes of the existing construction in order to develop an accurate understanding of what may be possible to accomplish, and what steps will be necessary to meet certain levels of performance. The step that is often missed when attempting to repurpose existing buildings is comparing the abilities and attributes of the particular enclosure system we wish to improve, against other systems and components associated with this system. In order to accomplish this step we must accomplish three steps:

- First, obtain a clear understanding of the abilities and characteristics of each system or component of the exterior enclosure system.
- Second, develop an understanding of the interrelationship of each of these systems and components, specifically the way in which they impact or effect each other.
- Third, implement a method to compare these relationships and impacts.

Only after we have accomplished all of these steps can we make a reasoned assessment of the full impact, both positive and negative, we may be creating by changing performance levels of the various enclosure systems. In my opinion, this is the only reliable way to develop a clear understanding of the potential impact which new and higher levels of performance of any single enclosure component or system may have upon the other enclosure components and systems and their supporting structures.

Finally, (ultimately), we must determine what will all of this cost, and determine if the resources and time are available to accomplish these goals? I bring this up here for a very simple reason, owners, architects, and engineers sometimes get carried away with the good things they might accomplish and do not properly evaluate these component of the equation, time and money, in sufficient detail and at the correct time. It is very frustrating to have figured out all of the details, means, and methods to meet the physical and aesthetic goals, only to determine that they cannot be funded. It is much more cost and schedule effective to make the cost and schedule decisions early in the process. The issue of time and funding will not likely just go away. Sounds simple enough, but what does this all mean to the project team?

Often in the case of repurposing buildings for new uses there are additional and more subtle, or less obvious, factors which must be considered. These might include issues such as the types and conditions of materials intended to remain in-place, and the susceptibility of these existing systems to damage from different environmental conditions. In performing some research before starting this paper I discovered a short article in a real estate magazine devoted to repurposing buildings for new uses. In this article I found the following:

"……..someone who bought a beautiful, historic millhouse and turned its picturesque environs into the cutest little restaurant. To make his patrons comfortable, the restaurateur installed air conditioning for the first time in the building's history. And comfortable they were, until they found wriggling things in their soup. Turns out the change in humidity and temperature brought on by the A/C caused worms to migrate out of the building's ancient beams and into the food."
("Repurposing the Right Way", by Meg White; Realtor Magazine, November 2012.)

While this may be an extreme example, it is indicative of the concept that we need to know what we are dealing with and what the potential consequences of change in the environment or exposure conditions may bring. In this case an unexpected but apparently necessary step was missed. Sometimes we literally have to go beyond the surface of what we see to get the whole picture.

Further complicating the matter may be the desires (or in some cases regulatory requirements) to maintain certain historical features of the building. This sort of circumstance can, and does often, lead to conflicts between aesthetic desires and required or desired, performance criteria, as well as the sometimes seemingly impossible task of meeting code and regulatory mandates.

THE PROCESS

Going back to the first paragraph in this paper where I indicated the problem I am addressing; I identified a hypothetical building as follows:

- The existing building is a train station from 1899 with masonry bearing walls.
- It is to accommodate a new occupancy for a state-of-the-art medical research facility.
- This occupancy will include high-humidity wet laboratories.
- It is desired to meet or exceed the code mandated thermal insulation levels.
- Occupancy requires “blast resistant” windows.
- Building is located in Duluth Minnesota.
- The existing structure is on the National Historic Register
- The space needs are very tight and do not allow a building within a building approach.

The first step to sorting through the maze of options, desires, preferences, and conflicts that may be present in any repurposing project is to clearly understand them, and to then find an appropriate path for decision making. In many cases this will include making choices and compromises between competing demands.

One way to get a handle on the number and types of the various performance criteria desired for the exterior envelope systems of any specific building is to put them into a chart form. This may seem fairly simple and not necessary to state. This is often not done this way, and in fact, listing and comparing performance requirements is rarely performed. This comparison process can assist the designers and the owner in getting a grasp on the potential complexity of the situation. Figure 12 (Example of a method to accumulate and document exterior enclosure systems desired performance levels) indicates an example of a form from a recent new building project in which I was involved.

Performance Criteria		Skylight Type 1	Curtain Wall Type 1	Ridge Skylight	Curtain Wall Type 2 (Vision)	Curtain Wall Type 2 (Spandrel/Shadow Box)	Curtain Wall Type 3 (Vision)	Curtain Wall Type 3 (Spandrel/Shadow Box)	Composite Metal Panel Rainscreen	Metal Plate Rainscreen	Louvers/ Foamed Metal Panels	Glass Rails	Membrane Roofs	Grade Level Plaza Waterproofing and Planters	Floors Slab on Grade	Grade Floor over parking	Floors (Over Soffit)	Below Grade walls
Wind			1	1	1	1	1	1	1	1	1	1	1		N.A.	N.A.	N.A.	N.A.
Seismic		2	2	2	2	2	2	2	2	2	2	2	2		N.A.	N.A.	N.A.	N.A.
Blast/G.S.		N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.		N.A.	N.A.	N.A.	N.A.
Water		15 psf	12psf	15psf	15 psf	15psf	12 psf	12psf	12 psf	12 psf	12 psf	N.A.	W.T.	W.T.	N.A.	N.A.	N.A.	W.T.
Air	PSF	8 psi	8 psi	8 psi	8 psi	8 psi	8 psi	8 psi	6.24 psi	6.24 psi	6.24 psi	N.A.	8		N.A.	N.A.	N.A.	N.A.
	CFM	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.06	0.06	0.02	N.A.	TBD		N.A.	N.A.	N.A.	N.A.
Snow		1	1	1	1	1	1	1	1	1	1	N.A.	1		N.A.	N.A.	N.A.	N.A.
Deflection		9, 10, 11	9, 10, 11	9, 10, 11	9, 10, 11	9, 10, 11	9, 10, 11	9, 10, 11	TBD	TBD	TBD	11	N.A.		N.A.	N.A.	N.A.	N.A.
Thermal	Note		19		16,17	14	16, 17	14				N.A.	-		N.A.	N.A.	N.A.	N.A.
	Proposed	U-0.5	1<	U-0.5	U - .38 R-2.63		U - .38 R-2.63		R-16	R-16	R-16	N.A.	R-25		R-10 Unheated R-15 Heated	R-20	R-30	R-7.5 ci
	Code Min.	U -0.5	U - 0.38 R-2.63	U -0.5	U - .38 R-2.63	N.A.	U - .38 R-2.63	N.A.	R-15.63	R-15.63	R-15.63	N.A.	R-25		R-10 Unheated R-15 Heated	R-10	R-30	R-7.5 ci
	Performance																	
Condensation		8	8	8	8	8	8	8	8	8	8	N.A.	8		N.A.	14	14	N.A.
W.B. Impact		N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.		N.A.	N.A.	N.A.	N.A.
Periodic Maintenance		3, 4	5, 16	3, 4	5, 12	5, 12	5, 12	5, 12	5	5	5	N.A.	3		N.A.	N.A.	N.A.	N.A.
Thermal Movement		6	6	6	6	6	6	6	6	6	6	N.A.	N.A.		N.A.	N.A.	N.A.	N.A.
SHGC		0.4 (Code)	0.4 (Code)	0.4 (Code)	0.40(Code)	N.A.	0.40 (Code)	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.		N.A.	N.A.	N.A.	N.A.
Reflectance		TBD/15	TBD/15	TBD/15	TBD/15	TBD/15	TBD/15	TBD/15	13	13	13	N.A.	TBD		N.A.	N.A.	N.A.	N.A.

Note	Criteria
1	Per consultant preliminary analysis included in schematic design package
2	Comply with requirements for seismic category B per building code and schematic design package
3	Worker and tools point loads
4	Rolling Scaffold and workers tools and glass unit
5	250 lb. point load
6	180°F change in temperature
7	Include air barriers in assembly
8	No condensation on or within assembly at ambient outdoors down to 10°F. Interior 30% RH at 74°F Winter
9	Normal to wall plane - L/175 to 13'-6" high, L/240 past 13'-6" height, 3/4" max.
10	Parallel to wall plane - L/360 with 1/8" max - limit to 75% glass pocket return
11	No metal to glass contact under load
12	Load per 2012 Building code
13	Color dependent / to be determined
14	R-12 insulation behind metal back pans
15	Determined by glass selection
16	Includes vision and spandrel portions of typical units.
17	Values for overall frame and glazing.
18	Prescriptive values
19	Use of single pane glass requires make up in another area.
N.A.	Not Applicable
W.T.	Water Tight (No leakage)
TBD	To Be Determined
ci	Continuous insulation

Example of a method to accumulate and document exterior enclosure systems desired performance levels.

Figure 12

While this was a very large building, it was also relatively simple in terms of the number of systems. I found this tool to be very helpful in getting our project team focused on the issues. I have not yet had the opportunity to take this similar approach on a renovation or repurposing project. An example of how one could incorporate our theoretical project into this approach as a test case is illustrated in Figure 13 (Comparison of existing and desired exterior enclosure system performance level).

Thermal		New			
	Code Min.	Existing	U -0.5	U - .38 R-2.63	U - .38 R-2.63
		New	?	?	?
	Performance	Existing			

Fill in variables

Performance Criteria			Operable Windows	Masonry Type 1	Masonry Type 2	Masonry Type 3	Composite Metal Panel Rainscreen	Louvers/ Foamed Metal Panels	Glass Rails	Membrane Roofs	Grade Level Plaza Waterproofing and Planters	Floors Slab on Grade	Floors (Over Soffit)	Below Grade walls
Wind		Existing		1	1	1	1	1	1	1		N.A.	N.A.	N.A.
		New												
Seismic		Existing	2	2	2	2	2	2	2	2		N.A.	N.A.	N.A.
		New												
Blast/G.S.		Existing	?	?	?	?	?	?	?	?	?	?	?	?
		New												
Water		Existing	15 psf	15 psf	12 psf	12psf	12 psf	12 psf	N.A.	W.T.	W.T.	N.A.	N.A.	W.T.
		New												
Air	PSF	Existing	8 psi	8 psi	8 psi	8 psi	6.24 psi	6.24 psi	N.A.	8		N.A.	N.A.	N.A.
		New												
	CFM	Existing	0.02	0.02	0.02	0.02	0.06	0.02	N.A.	TBD		N.A.	N.A.	N.A.
		New												
Snow		Existing	1	1	1	1	1	1	N.A.	1		N.A.	N.A.	N.A.
		New												
Deflection		Existing	9, 10, 11	9, 10, 11	9, 10, 11	9, 10, 11	TBD	TBD	11	N.A.		N.A.	N.A.	N.A.
		New												
Thermal	Note	Existing		16,17	16, 17	14			N.A.	-		N.A.	N.A.	N.A.
		New												
	Proposed	Existing	U-0.5	U - .38 R-2.63	U - .38 R-2.63		R-16	R-16	N.A.	R-25		R-10 Unheated R-15 Heated	R-30	R-7.5 ci
		New												
	Code Min.	Existing	U -0.5	U - .38 R-2.63	U - .38 R-2.63	N.A.	R-15.63	R-15.63	N.A.	R-25		R-10 Unheated R-15 Heated	R-30	R-7.5 ci
		New												
	Performance	Existing												
		New												
Condensation		Existing	8	8	8	8	8	8	N.A.	8		N.A.	14	N.A.
		New												
W.B. Impact		Existing	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.		N.A.	N.A.	N.A.
		New												
Periodic Maintenance		Existing	3, 4	5, 12	5, 12	5, 12	5	5	N.A.	3		N.A.	N.A.	N.A.
		New												
Thermal Movement		Existing	6	6	6	6	6	6	N.A.	N.A.		N.A.	N.A.	N.A.
		New												
SHGC		Existing	0.4 (Code)	0.40(Code)	0.40 (Code)	N.A.	N.A.	N.A.	N.A.	N.A.		N.A.	N.A.	N.A.
		New												
Reflectance		Existing	TBD/15	TBD/15	TBD/15	TBD/15	13	13	N.A.	TBD		N.A.	N.A.	N.A.
		New												

Note	Criteria	Note	Criteria
1	Per consultant preliminary analysis included in schematic design package	13	Color dependent / to be determined
2	Comply with requirements for seismic category B per building code and schematic design package	14	R-12 insulation behind metal back pans
3	Worker and tools point loads	15	Determined by glass selection
4	Rolling Scaffold and workers tools and glass unit	16	Includes vision and spandrel portions of typical units.
5	250 lb. point load	17	Values for overall frame and glazing.
6	180°F change in temperature	18	Prescriptive values
7	Include air barriers in assembly	19	Use of single pane glass requires make up in another area.
8	No condensation on or within assembly at ambient outdoors down to 10°F. Interior 30% RH at 74°F Winter	N.A.	Not Applicable
9	Normal to wall plane - L/175 to 13'-6" high, L/240 past 13'-6" height, 3/4" max.	W.T.	Water Tight (No leakage)
10	Parallel to wall plane - L/360 with 1/8" max - limit to 75% glass pocket return	TBD	To Be Determined
11	No metal to glass contact under load	ci	Continuous insulation
12	Load per 2012 Building code		

Comparison of existing and desired exterior enclosure systems performance level.

Figure 13

For this purpose I indicated the performance criteria in two categories:

- The existing performance, or what the systems currently provide.
- The desired or proposed performances.

This approach facilitates a quick comparison of the current performance of the existing system against the desired performance level.

As an example: we can see that the existing thermal performance for the exterior walls of our example building is very low relative to current standards. This is an old building with solid masonry walls, and likely tile, stone, or plaster interior finishes, and no thermal insulation. Assume for purposes of example that the desired thermal insulation was expressed as, *"to meet the current energy code"*. The 2012 International Energy Code requires a U value of 0.061 for a commercial building with solid masonry walls in Duluth, Minnesota, Zone 7. The anticipated R value this wall assembly would be R=16.4. This criteria raises one immediate concern:

- Where can we add the insulation? At this point there has been no confirmation of what the interior finishes are in this existing building, just an assumption. It is reasonable to assume that there is no insulation based upon the date of construction, and that there are at least some areas of the building (probably most), which have some form of plaster interior finish, or perhaps tile or decorative stone or masonry.

While these may be reasonable assumptions it makes much more sense to determine what we actually have to work with. There are a variety of steps involved in this process, and each building may require a different level of investigation. Adequate information regarding the existing conditions of the building and validation of the criteria is critical to proper decision making.

In this case we need to determine the following for the existing conditions:

- Is there any thermal insulation in the building at this time? If so, types, amounts, and locations?
- Are there interior finishes on the building which cannot be removed or covered over to add insulation? If so, to what extent and where?
- Is additional insulation desired for all enclosure components? Might the benefits of insulating one system more than others be beneficial?
    - What is the roof to exterior wall geometric relationship?
    - If this is a large flat plate type of building there may be more opportunity to gain thermal performance in the roof than in the walls.
- Is the original criteria to add insulation based in comfort, function of interior spaces, decreasing operating costs, or a desire to save energy?
- How might adding thermal insulation to the exterior walls impact the existing masonry?
    - The addition of thermal insulation to the exterior walls will decrease the wall (masonry) temperatures.
    - What are the water absorption characteristics of the existing masonry walls? Do we know how absorptive they are?
    - To what extent, and at what rate do the masonry walls dry after absorption of water?
    - Is the absorption characteristic of the wall inherent in its design, or can the behavior be changed by corrective work to the walls?
    - What is the risk of freeze-thaw damage to the existing masonry due to the absorption of water and freezing temperatures? Note: Lower masonry temperatures occur when the masonry is cut off from the heat source by insulation.

Until we answer these questions to a reasonable degree of certainty, we cannot address in an informed manner the question of whether we need additional thermal insulation, and if so where can it be applied. Each of these questions has an answer, and the answer to each impacts the overall solution. While certain of these questions may require field investigation, including intrusive probes and testing, others may be very simply answered. Take the component question regarding water absorption of the masonry for example. This is a property which can be answered to some degree at least by testing. On the other hand, if the train station is of a certain design the need for testing may be obviated by the presence of large overhangs which protect the walls form direct exposure to rain water. The needs for intrusive probes and testing will become apparent to those with the proper knowledge and experience to perform this type of service. If that type of knowledge is not available on your project team, it would be wise to get the right people (experts in the area of building enclosure materials and systems) on-board before proceeding.

So, do we need to add insulation to the walls, and if so where? At this point we cannot answer that question because of a lack of information. The only way past this is to obtain the needed information.

At this point perhaps it is time to back up and evaluate the original project criteria or conditions:

- It is desired to meet or exceed the code mandated thermal insulation levels.
- “The space needs are very limited and do not allow a building within a building approach.”

Has anyone considered that the space needs may be resolved by adding area to the building? Has the program been validated to prove this point? Is it possible that the mass nature of the building will alleviate some of the need to add thermal insulation? Has anyone determined that we actually need thermal insulation in order to function properly? Perhaps the building repurposed occupancy generates excess internal heat due to operations and the building would function better and more efficiently without added insulation. May the planning of the interior spaces be such that areas with a need to preserve existing interior finishes become areas that do not need to have insulation added?

The point is that in every design there are many questions to be asked and answered before we make firm decisions and come to conclusions about what steps must be taken in order to determine the best course of action. In the case of repurposing buildings it is even more important and is in fact often a more difficult task, requiring significantly more effort, than designing new buildings. Without having the right information and asking the right questions we cannot come to the right conclusions. It is important that we develop the practice of constantly searching for alternative approaches that may not be apparent without creative thinking.

In repurposing buildings it may be necessary to regularly revisit the criteria originally established to make sure that it is still valid, and accomplishable. It will likely be productive to regularly revisit and revalidate the original project criteria as solutions are developed.

In this particular project there would likely be a time when we had to advise the Owner that in some cases it was not possible to meet the desired performance improvements of the new occupancy and performance desires while still retaining the essential character and historic importance of the building. In other words it is time to determine if we have the right building for the desired performance, or whether the desired or code required performance properties can be revised. While we have only addressed the thermal performance of the exterior walls for this theoretical building at this point, there will be other challenges as the design process proceeds.

I believe that the approach described for the example above is helpful in demonstrating the conflicting demands that sometimes overly zealous team members and supporters of potential projects for repurposing and/or retrofit place upon the project.

There are several additional examples of performances and systems which would need to be considered in the sample building, or likely in most repurposing of any existing building. In this case these include:

- Condensation performance
- Blast resistance/glass shard resistance
- Water absorption of mass masonry/potential freezing
- Regulatory restrictions to changes of historic buildings

Some general guidelines to remember in early considerations for the possibility of repurposing any building include:

- The further specific desired performance levels are from the existing systems capabilities, the more challenges there will be.
- The more criteria imposed, the greater the chance of significant conflicts and problems to be resolved.
- Historic preservation imposed limitations can offer significant roadblocks to changes in certain performance attributes.
- Many existing buildings are not well suited for full compliance with modern performance standards.
- Repurposing existing buildings to attain modern performance and significant changes in interior climate and use (occupancy) may well lead to degradation of the existing structure if not performed properly.
- There is significantly more effort required by both the owner and the design/construct team to repurpose buildings. The more divergent the intended use from the original, the larger the discrepancy in effort.
- Significantly more effort should be expended in the quality assurance/quality control efforts during both the design and construction process. Often the success of the project is highly dependent upon the details.

MAKING THE CHOICES

This is probably the most difficult aspect of repurposing projects – making choices. One of the problems is that the goals of projects are often established based upon incomplete information, non-scientific judgments regarding existing conditions, and wishful thinking. The reasons behind this condition are not the subject of this paper. They are important however to the process overall. The best advice to the design professionals and constructors is to provide the decision makers (the owners) with the following advice whenever they are contacted regarding a repurposing project:

- Do not make decisions without sufficient supporting information.
- Do not assume anything about existing buildings.
- There will be surprises as the project develops and more information regarding the existing structure becomes available.
- There will be surprises regarding the interaction of the existing building and proposed systems, or systems improvements.
- Always be ready to re-evaluate your goals. Things will change based on the 2nd, 3rd, and 4th points above.
- Keep substantial contingencies of both time and money in the project. Again see the points above.
- Be prepared to enter into agreements that provide appropriate levels of quality control and quality assurance. This is true for both the design and construction process.

THE CONSTUCTION PROCESS
The construction process for the exterior envelope in repurposing of buildings is a bit different than that for new buildings. Two issues make the construction process for the two building types significantly different. These are: the presence of unknown or “field” conditions, and the increased need for mock ups and quality control/quality assurance during the construction process.

- **UNKNOWN OR “FIELD” CONDITIONS**
  Unknown or “field” conditions are generally problematic when repurposing buildings, especially when the performance levels of the modified existing or replacement systems are asked to perform at higher levels, or under different service conditions, than the original. The goal is to eliminate, or at least greatly reduce, problems which may arise during the construction process by making sure that an adequate and comprehensive evaluation of the existing conditions that are to remain in service, or are to be improved for future service under the repurposing, has been performed. **This process must be designed to evaluate specific aspects of the particular system(s) and must recognize to what level the evaluation must be performed to attain the correct and adequate information.** Without access to accurate information it is not possible to make good decisions.

- **MOCK UPS AND QUALITY CONTROL/QUALITY ASSURANCE**
  As indicated earlier, the success of construction for repurposing buildings is often highly dependent upon the details. These buildings often require special construction techniques in order to make the proper transitions to existing conditions to remain, and in revising existing systems to perform at higher levels than their original construction. **One of the surest ways to run into problems with repurposing of existing buildings is to pay insufficient attention to the design and construction of details which tie new systems into existing systems, or are part of the improvement process for existing systems.** In construction of new buildings we have an opportunity to control the outcome of the various systems upon which the enclosure systems rely, and to which they will connect. In repurposing we must deal with what we have, and this

often requires special detailing and interfaces which are more complex, but still must be more flexible, than those for new buildings.

SOME EXAMPLES

As previously stated, it is imperative that before you start revising the exterior enclosure systems of your existing building into high performance systems, you first evaluate the existing systems and understand the potential impact of your intended “improvements”. Some examples follow:

- Quite often it is desired to dramatically increase the thermal insulation of an existing building when reroofing. Well that is good, right? We will improve the thermal performance of the roof system and save energy! The answer is a resounding **maybe!** Let’s start with a very simple question – did anyone determine what the live-load capacity of the existing roof structural system was before deciding to increase the insulation value? If not, how do we know the structure will withstand the additional snow load that is almost guaranteed to accompany the increased thermal insulation value of the new roof assembly in snow country? By the way, even reasonably temperate climates such as enjoyed by Washington D.C. can see very large snowfalls. I would estimate that in 20 or so significant reroofing projects over the years I have yet to hear a consultant, owner, contractor, or architect respond correctly to this question. I am generally met with a blank stare when the following simple question is asked: will the existing roof structural system support the increased snow load inherent in increasing the roof insulation value? This is then followed quickly by the realization of the potential implications of this question, and the often embarrassed answer that no, this has not yet been considered. In the worst case scenario the roof structure can be damaged if the new snow load exceeds the structural capacity, or the desired, or in some cases needed, thermal insulation performance criteria cannot be met. I have seen this happen. In a case such as this, expected and perhaps energy savings which cannot be attained may result in the project becoming a financial failure.

- Bearing masonry, or mass masonry, buildings were originally designed with little room for significant change to the basic geometry of the exterior walls. If you had windows in the building those windows were considered in the original design and for the most part the walls functioned with the windows in place. Sometimes a window might be added, and if properly done, the window may also be added without any significant impact to the building. What if, however, it was decided to add several windows in a mass masonry wall to accommodate repurposing the building to a new use? Does that work? The answer is that it may work and it may not. Generally when you remove significant portions of material from a mass masonry wall you will find that additional intervention is needed to restore/retain the continuity of the wall. This could come in various forms, but in effect the wall will require some form of intervention to retain its integrity and continue to function without deterioration and damage. In a case such as this, there is the risk that the weakness in the design will not be discovered during design or construction, and may result in structural failure of the wall. At best this problem will be discovered deep into the design or construction process and lead to added costs and schedule problems.

- Significantly better thermal performance is often available in glass assemblies available today than in those of the past. This assumption is particularly true with the advent of low– e coatings and thermally improved framing with true thermal breaks incorporated. Some framing only provides thermal improvement, which function at a lower level than thermal breaks. However, in some cases the improvements in glass thermal performance are not necessarily guaranteed by the use of more modern glazing products. For example, in one building the owner desired to correct leakage conditions of the framing, make significant changes to the appearance of the building, and make the walls more thermally efficient. It was also mandated that in no case could the heating load be increased by the new design, due to limits of the facility cooling system. The architect decided that the building appearance could be updated and significantly improved by doing away with the existing reflective glass, and using a more transparent material. This could be accomplished with new highly efficient glass coatings and insulating units. The wall was indeed much more efficient than the original construction in the winter, looked better, but just met the criteria to not increase the cooling load. Turned out the architect did not compare the Solar Heat Gain Coefficient of the original highly reflective glass units against the new low-e coated transparent glass insulating assemblies? While ultimately it was discovered that the owner criteria for the project had been met, there were anxious moments on the part of the architect while he waited for a fairly sophisticated (and expensive) analysis to be performed. While it did work, it could have gone either way. In this case, a more comprehensive analysis up front, would have saved the architect from the worry and expense near the end of the project.

- Glass shard retention requirements (blast resistance) have become fairly common with certain types of buildings. Most specifically we see this in military installations, government buildings, financial institutions, and in certain high security facilities. In effect, if the building is likely to be a target for terrorism, or is near such a building, the need for blast protection may be one of the required performance criteria. The design construct industry has become quite adept at designing and installing window or curtain walls systems that are fully capable of limiting the threat to life by developing systems that can indeed limit, to a very high degree, the amount of glass and glazing systems components released into the building interior in a blast event. However, when we do this, the load must be transmitted in some form into the surrounding wall and/or structural systems of the building. While this is accomplishable, it often presents one of the following difficulties:
    - The strength of the wall or structural system is not known and cannot be determined or accurately estimated without great difficulty.
    - The implementation of other secondary means to transfer the loads is not visually acceptable, is cost prohibitive, or cannot be imposed upon a historic building.

  In either case this can result in the inability to provide the appropriate level of blast resistance, or the imposition of visual or budget impacts that cannot be reconciled within the original project parameters.

Each of these four examples are based in facts of specific buildings I have worked on where the buildings were being repurposed or being modified to perform at much higher levels than originally intended. Unfortunately, in each case it was also true that the commitment to achieve the repurposing was made and could not be reversed. While each problem was resolved in one fashion or another with attendant cost overruns, schedule delays, and other complications, a clear and comprehensive understanding and evaluation of the goals of repurposing when matched against the abilities of the existing enclosure systems in a timely fashion would have been of great benefit.

These are not isolated examples. Similar examples can be found through most architects, engineers, and contractors who work in this field. Unfortunately, there is often a commitment to accomplish a specific task of repurposing before those with the knowledge to undertake the task are brought into the process. There is also a general lack of knowledge of the process that needs to be followed to successfully accomplish repurposing. Not every repurposing of buildings requires a high degree of technical competence or a specialized knowledge to perform them successfully. However, when that specialized knowledge base or high degree of technical competence is required, the entire project team must be ready to go down that road with an open mind and be prepared to take the appropriate steps, and sometimes make tough decisions.

SUMMARY

The information in this paper is intended to help owners, designers, and contractors who find themselves contemplating alternative uses or increased performance levels for existing buildings to develop a logical and analytic approach to the problem by understanding and identifying specific performance requirements and the potential limitations and conflicts which may be inherent between the desired performance requirements of the enclosure systems and the existing building. The likelihood of success will be much greater if the project team can come to a clear understanding of the goals (performance requirements of the various aspects of the exterior enclosure), determine what it will take to accomplish the goals, identify any conflicts between the desired levels of performance, determine ways to resolve those conflicts, and finally if there is no desirable resolution, make the hard decisions to determine which, if any, of the performance goals can be reconsidered or revised. In order to be successful you must first reach reasonable conclusions based upon sound analysis and information. If your analysis indicates the conflicts are too substantial, the potential for success is too low, or the risks are too high, it may be best to re-evaluate your original intentions.

Not every existing building can be reasonably made to conform to the needs of all new occupancies. If your building cannot be made to meet the desired performance levels, it may be best to find a different building for the desired use, or a different use for the specific building. This is particularly true when considering older or historic buildings. In these cases excessive performance levels of some enclosure systems properties may initiate deterioration of the building and thus remove that property from an already dwindling stock of buildings representative of our past.

Repurposing of buildings is an exciting and logical process. The key to success is to properly understand and perform the process in a logical and ordered manor, and to get the right building for the right occupancy.

Key Words: Existing exterior enclosure, repurpose, historical, performance criteria, sustainability.