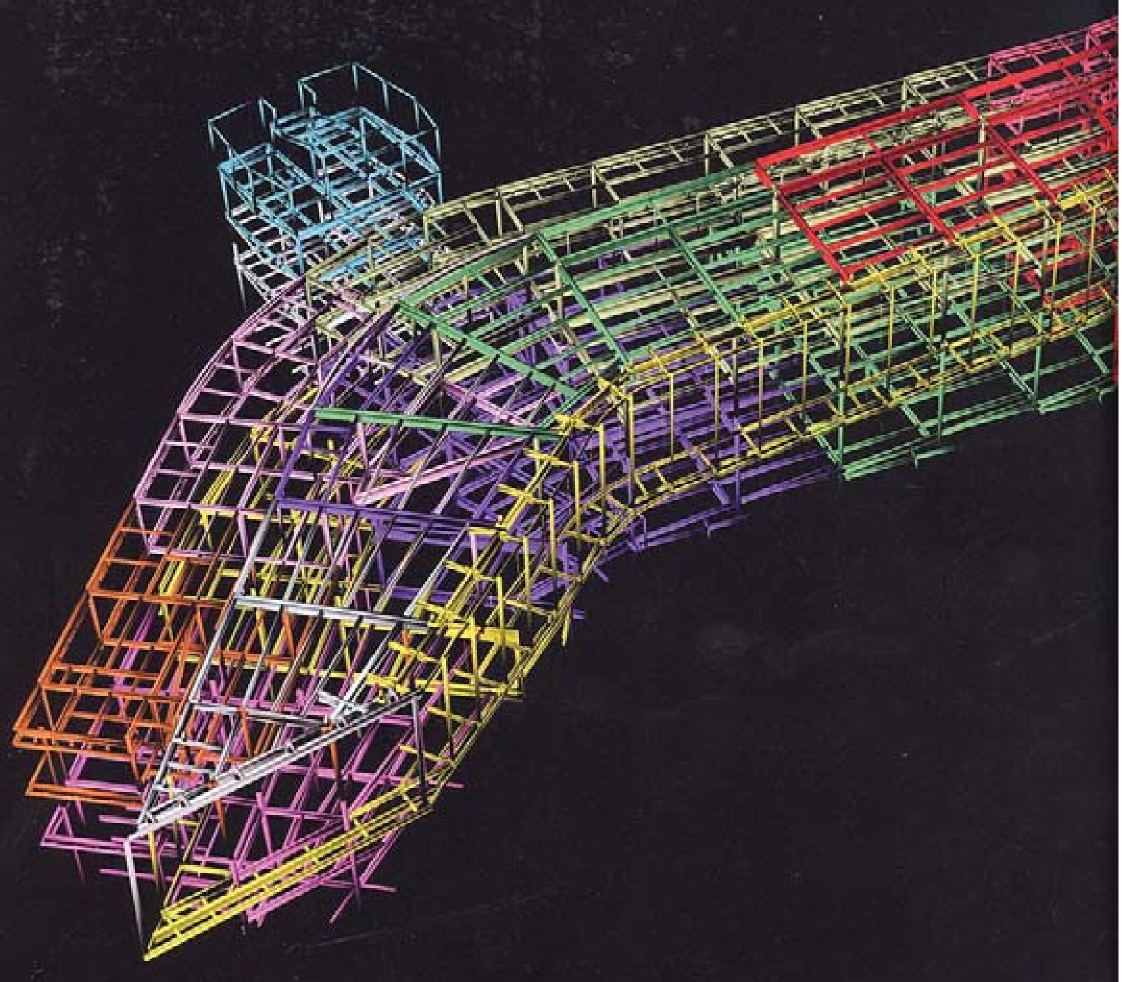
An Enthusiastic Sceptic



Nat Oppenheimer, principal of structural engineers Robert Silman Associates, is a dissenting voice among the advocates of building information modelling (BIM) – an enthusiastic sceptic. Could the quest for integration be leading towards oversimplification rather than customisation and differentiation? Even towards the sort of standardisation adopted with LEED ratings in the quest for sustainability?

Robert Silman Associates, Lewis Katz Building, Dickinson School of Law, Pennsylvania State University, University Park, Pennsylvania, 2006
For the Lewis Katz Building, the general contractor developed an information model of the entire steel frame based on 2-D CAD documents provided by Robert Silman Associates. The steel fabricator was able to generate a complete set of shop drawings in a short period of time based on the successful construction of the virtual building.

The sceptic, if he or she does his or her job correctly, is critical to the productive evolution of any movement, and as we embark on the Building Information Modelling (BIM) revolution, it is worth asking a few questions.

We embrace the promise of BIM – born from the notion of collaboration between disciplines and the integration of design – and recognise it as a paradigm shift in an industry that has spent too much of the past century trying to separate consultants on the same design team, to clarify liability and to shed responsibility. Any move towards accepting more responsibility is generally a good direction, and we are therefore enthusiastic about the potential of BIM and the cultural shift it appears to be initiating.

Nevertheless, we are concerned that the demands of the market will dampen the original promise and leave us, 20 years hence, with nothing more than an advanced pen-and-pencil set rather than a truly different way of designing and building iconic architecture.

Any discussion about BIM must recognise the broad field of architecture, engineering and construction, and note that any movement that tries to capture the imagination of the entire industry will never be able to be everything to everyone. This view is built on experience within the small corner of the industry that focuses primarily on unique, one-off designs that often aim to break convention rather than embrace it. Over the last 20 years, the structural engineers at Robert Silman Associates have continually sought out such projects, which have required them to overcome the challenges they present from many different angles. Software and industry shifts towards any sort of 'regularisation' or common denominator design thus hold little interest for the firm.

While BIM is alive and well in this field – and thriving in many academic circles and smaller firms – the current marketing trend for the industry does not seem to embrace many of the directions these smaller firms explore (custom fabrication, odd geometric shapes, custom mechanical systems and so on). This is unfortunate, as some of the most interesting advances are generated from their research. In addition, the move towards integration appears to be leading to oversimplified buildings, lower fees and shorter design schedules rather than to the quest for the perfect jewel of a project. It is therefore necessary to question what this revolution strives to accomplish.

Does a small and inventive firm (or a large firm that thrives on model building and sketching to generate magic) risk losing its mojo by relying on a software platform designed for the larger sector of the industry? Does the drumbeat towards more standardised BIM software overwhelm some of the more exciting opportunities for integrated design being promoted in small firms and academia? Can the promise of very advanced proprietary BIM software developed by large architectural and engineering firms be harnessed by generic software for use across the whole industry? And will the industry embrace the liability and responsibility inherent in the world of BIM?

BIM and High-Performance Design

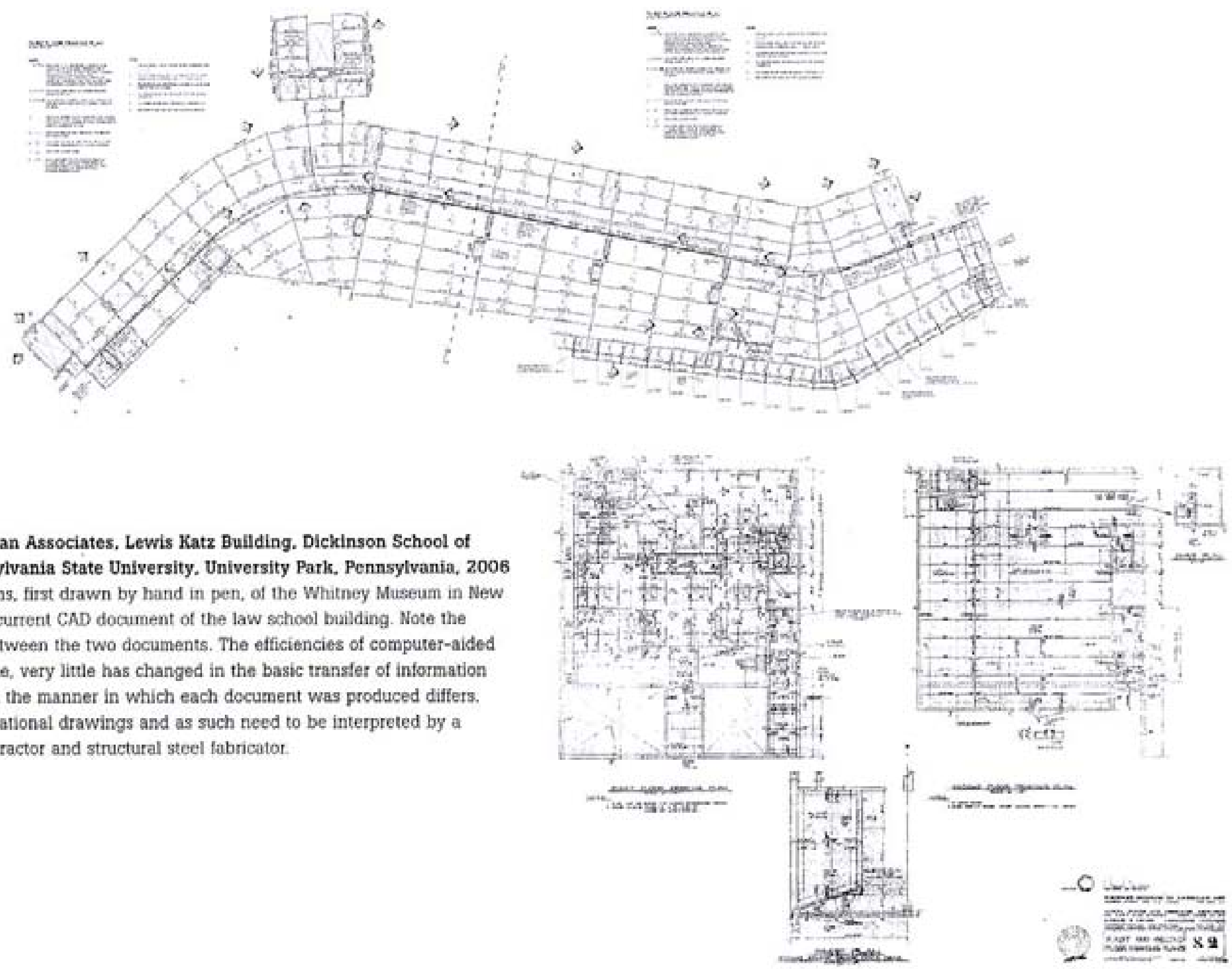
In asking these questions and looking at alternative futures – as opposed to the shiny ones most often promoted within the BIM community – high-performance (green) design offers a cautionary tale from which to learn. Analogous to BIM, the heart and soul of successful green design depends on the collaborative and integrated effort of the entire design team. However, the definition of 'success' in green design (LEED excellence versus carbon neutral, etc) has remained a moving target within the industry. In the same way, one can ask what the true definition of success in BIM is. Is it simply a more streamlined design and production effort with fewer conflicts between architecture, structure and mechanical systems, or is it a truly integrated, unique building where concept, drawing production, fabrication and, ultimately, building management systems are all tightly integrated, with primary control held by the design team?

At this point in the history of high-performance design, the market looks to the LEED credit worksheet as a way to control the chaos inherent in any design and, while there is great value in these worksheets, they frequently dumb down the process and turn the lofty goal of green design into one of bean counting and horse trading. LEED has recognised that it cannot be everything to everyone and has begun to separate its worksheets into different categories. But there is still the overall simplification of design that has at times hurt the overall advancement of new technologies and real change within the design of buildings and the way energy is used.

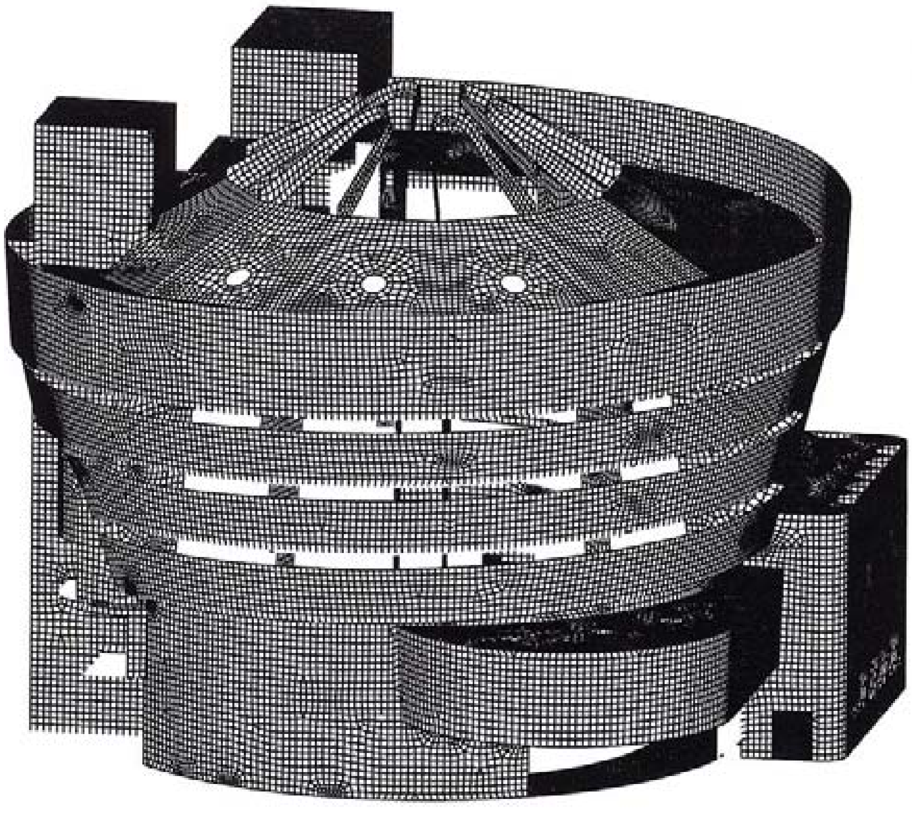
The Prehistory of CAD and BIM

With the rise of CAD came the power to harness ink and mylar into a much more precise version of the same drawing. This moved the field of document production into the digital age in a two-dimensional way, by simply bringing the standard drawing alive as a series of lines and symbols. The proof that the shift to CAD was just a digital adaptation of the old industry standard lies in the fact that many engineering offices still have a drafting department (retrained in CAD) and still separate the task of engineering from the task of drawing.

BIM, by its very nature, gives life to the lines and symbols on the sheet and works to reintroduce the engineer to drafting, and the drafter to engineering (traditional drafters were able to put together many components of a standard set of drawings without input from engineers – a skill that has disappeared over the last 20 years with the loss of



Robert Silman Associates, Lewis Katz Building, Dickinson School of Law, Pennsylvania State University, University Park, Pennsylvania, 2006
Framing plans, first drawn by hand in pen, of the Whitney Museum in New York, and a current CAD document of the law school building. Note the similarity between the two documents. The efficiencies of computer-aided drafting aside, very little has changed in the basic transfer of information even though the manner in which each document was produced differs. Both are notational drawings and as such need to be interpreted by a general contractor and structural steel fabricator.



Robert Silman Associates, Solomon R Guggenheim Museum, New York, 2007
A 3-D finite element analysis model of the Guggenheim's main rotunda showing stresses in the original concrete structure. Finite element analysis virtually stresses a material or structure to analyse how it performs under loading, and allows components to be optimised. At the Guggenheim, Robert Silman Associates was asked to analyse a series of stress cracks in the concrete structure that had occurred over time and make recommendations to lessen the impact of such structural irregularities.

technically trained drafters). This is a very valuable collaboration tool within any office. However, the sceptic sees the current stage of BIM, in its most common usage, as just a more powerful version of CAD where it is primarily used to coordinate all trades within a design but not necessarily to create. Does this suggest that purveyors of custom architecture, therefore, should not waste their time with the current versions of BIM software? Far from it: as with CAD, it was the proficiency of the industry and the widespread acceptance that eventually made the true shifts in the construction documentation process possible. Proficiency in the use of BIM, therefore, will likely lead to more creative uses of the platform in the future.

In examining the current state of BIM, it is interesting to remember that CAD came out of CAD/CAM and the promise of the full automation of factory fabrication. The software originally developed to make perfect pieces of machinery was co-opted by the architectural industry essentially to make beautiful drawings. Will BIM be the paradigm shift that brings architectural drawings to life by moving seamlessly from concept to integration to fabrication, or will it fall apart in a wave of liability fears and take root as yet another tool to make better documents instead of better projects?

Atypical BIM Usage

As a sample of the atypical uses of BIM at Robert Silman Associates, the following three case studies offer a glimpse into the successful application of integrated design and project delivery. Each project gives a sense of the potential of BIM beyond the perfect set of documents and how much background work is behind any successful project. In addition, all demonstrate the human energy that still underlies the success of any integrated design.

Managing Existing Building Information: The Guggenheim Museum

While much has been said about the power of BIM to coordinate trades within a new building, less has been made of the power to re-create existing conditions and the ability to then analyse existing structures with more precision.

In 2005, Robert Silman Associates was asked to solve the issue of recurring cracks in the facade of the Guggenheim Museum in New York City. The engineers were tasked with determining what was causing the cracks to reoccur after each previous repair campaign and, if it was structural in nature, to assist the restorers on the project in selecting the appropriate material to be used as a filler and coating. To do this, it was first necessary to create a full-scale, as-built structural model of the Guggenheim – a monolithic, non-orthogonal, concrete structure.

Working with digital survey company, Quantapoint, Robert Silman was able to create the entire structure of the Guggenheim's main

Photograph of an interior radial monitor within a structural cavity of the Guggenheim Museum. A series of string potentiometers mounted on custom brackets was installed to measure movement at the top of the wall. The data was used to generate a mesh information model in which a series of small structural cracks in the structure could be studied. The model could be further stressed, virtually, to predict how the cracking would impact the concrete structure over time.

rotunda in SAP, a finite element modelling software, and model this as a continuous shell. Taking field data of actual movements over the course of a year, the model could be calibrated to events in the field so that the future movements of the building and the impact of any of the design proposals could be predicted.

In the end it took six months of painstaking, analogue-type work (for example, checking the meshing of each node among many millions) to establish the cause of the movement. However, each successive step in the evolution of all of the software used in the Guggenheim project will simplify future efforts, and the experience gained will lead to much better interpretation of the results achieved in future versions of the software.

While it is recognised that this particular use of digital information management and data transfer is quite unique, it is hoped that in future it will be possible to import an existing building into finite element software for full-scale analysis. This will allow such buildings to be looked at in a new light – as an assembly instead of individual elements (which, more often than not, do not meet contemporary code requirements even though the building as a whole has stood without incident for many years) – and perhaps enable us to reach a better understanding of the overall capacities of structures in their entirety.

Front End Versus Back End: The Lewis Katz Building, Pennsylvania State University

While the ultimate integration of design documents and shop drawing within a single BIM platform is already in use, it is the use of BIM by subcontractors to produce well-coordinated and thorough shop drawings that is the more rapidly evolving industry standard. With the design established and the liability for the fabrication strictly in the subcontractors' hands, they can take a set of fully developed drawings and virtually construct the building before erecting it physically.

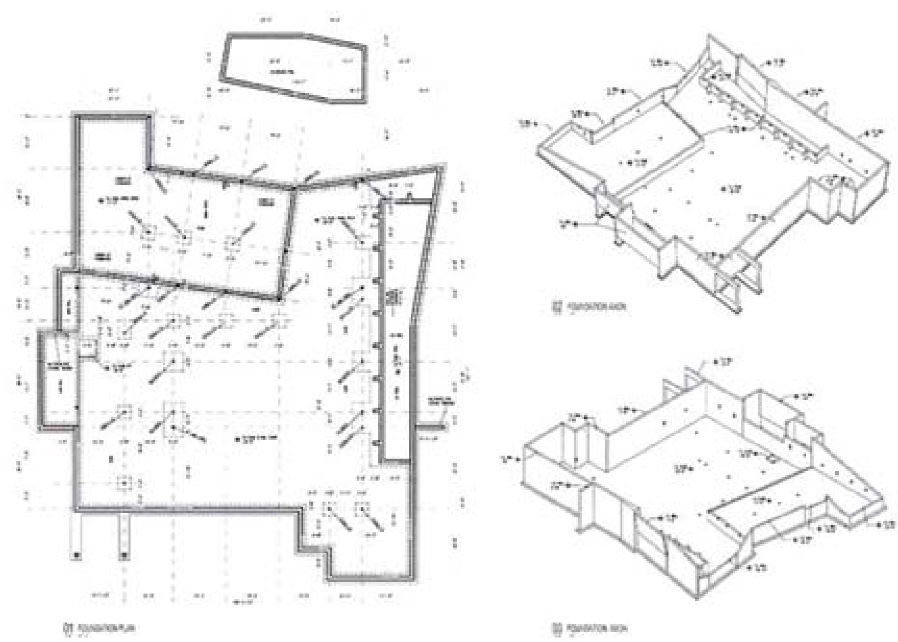
To date, the Lewis Katz Building of the Dickinson School of Law at Pennsylvania State University has been one of Robert Silman's most successful projects involving BIM in this way. The project is a large, complex design with numerous design features and an aggressive schedule. As a testament to the rapid integration of BIM, the design team had not used BIM on the project because it was not fully integrated in their offices when the work commenced two years hence.

For this project, the steel fabricator used BIM software to develop the model of the complete steel frame for production of the shop drawings. In the very thorough question-and-answer stage of their modelling, steel coordination issues were worked through in an efficient and productive way.

This use of BIM is, in itself, establishing a new level of clarity in the construction of buildings. For those members of the design and construction team who had worked in this manner before, receiving a significant number of requests for information (RFI) during the building of the BIM model was not unusual, and meant, ultimately, that when set up correctly, the building frame would go up without incident or a single RFI once the steel was on site. Though everyone on the project recognised that this was the preferred sequence, it still gave pause to those not familiar with the power of BIM when there was a tenfold increase in RFI at the very beginning of the project.

While it goes without saying that full integration of BIM is intended to result in a seamless transition from design to erection, there are concerns that the loss of human communication between the design and construction phase will have unintended consequences on the collaborative process. If we rely too heavily on the black-box solution, we risk losing the vital education that often occurs between design and construction. Recognising that, at some point, this will evolve into a wonderful place where the integration software is robust and allows us

Peter Gluck and Partners, Winnetka House, Illinois, 2006–09
Axonometric drawing by Peter Gluck and Partners detailing the layout of the Winnetka House's poured concrete foundation. The document was generated from an information modelling system that automates dimensioning and is used for bidding. The drawing was transmitted to the foundation subcontractors to reduce the concerns that may occur when an atypical foundation is simply noted in plan and section. As contracting firms further embrace the utility of BIM it will become possible to transmit digital files directly to them for the automated manufacture of concrete formwork and the generation of shop drawings. In addition to the perimeter condition, a series of internal steel columns to transfer point loads are noted.



to concentrate on other things, we should tread lightly over the next few years of working through the bugs to get there.

Peter Gluck and Partners
Robert Silman Associates has worked with New York architects Peter Gluck and Partners for the past 10 years in a way that is unique to the industry. The collaboration is essentially an analogue version of BIM, in that each staff architect is expected to understand the impact of every component of the design, including all structural and mechanical elements. As an extension of this, the office produces all of the documents for the project, with consultants marking up the architectural documents with structural information.

More importantly, Peter Gluck is a true design-build firm, where each staff architect is expected, at some point, to manage the construction of a project and all of the subcontractors. This gives the architects a unique perspective on the importance of coordinated drawings and the management of information. Interestingly, the firm is not yet using BIM to manage its projects. It has achieved its best results by releasing stand-alone structural packages (integrating MEP and architecture) bit by bit as the site needs them, and feels that while each package is highly integrated, BIM, at this time, may bog down this system by looking for an overall integrated solution that is often still in the designers' minds when the early sets of drawings are released to the site.

This demonstrates the current paradox of BIM: with only a small percentage of the industry truly facile at using the software, an integrated firm such as Peter Gluck and Partners with a tremendous reliance on direct hands-on input for all of its projects finds that the software is, in some ways, not facile enough for its needs. In this example, the firm is a very effective living version of BIM, and when it does decide to move into producing project documents with BIM software it will be in a position to control (because it knows the integration of buildings so well) instead of being controlled by the software and told how to integrate based on the algorithm within the code.

Conclusion
The examples here have tried to look beyond the more standard uses and preferred rhetoric of BIM. The basis of Robert Silman Associates' mission is consulting on unique projects that are rarely a repeat of one that has come before. This often means adopting software that is more tailored to the orthogonal and the repetitive, and adapting it to the uniqueness of each project. Experience in this field frequently compels the firm to question the potential of the first version of any software and immediately look at how it can be bent, twisted and adopted elsewhere.

So far, there is nothing to suggest that BIM software does not, and will not, successfully address the issue of uniqueness. And there is no reason why BIM cannot develop along many different paths. However, human nature being what it is, it is still possible that the industry will see only the simplifying virtue of BIM software and thus allow it to define the design rather than the other way round.

As certain parts of the industry awaken to the 'bean counting' downside of LEED spreadsheets and demand more from green design, we are confident that there will be some who will always push this software to do more, and that these pioneers will encourage clients not to accept the simplistic and seemingly perfect in lieu of the truly integrated. AD