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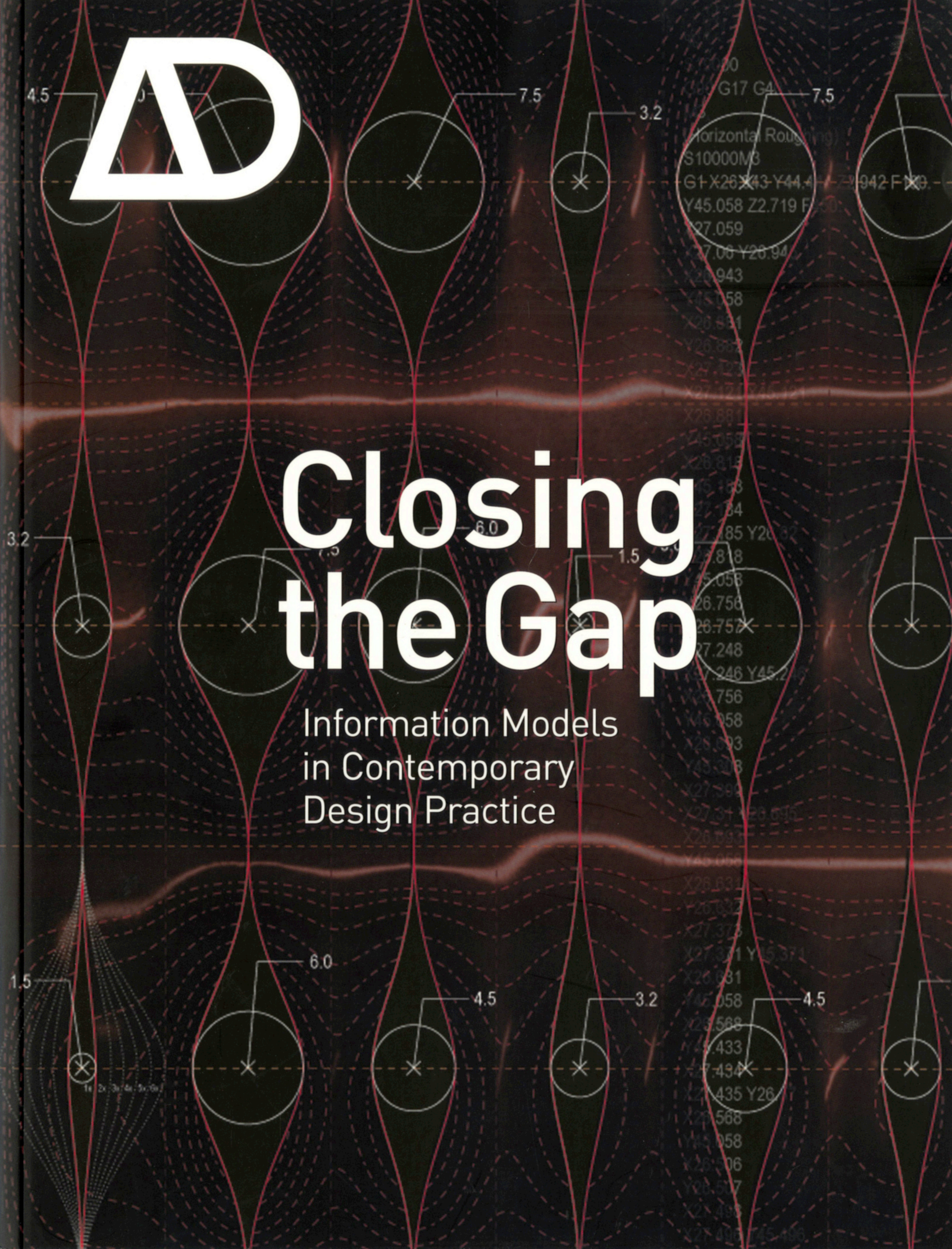


Closing the Gap

Information Models in Contemporary Design Practice

C^2 Building, Fashion Institute of Technology

New York, 2009-

SHoP Architects

By SHoP Architects

The proposed building is highlighted by a multilayered glass and metal facade, within which are nested the primary circulation, review and exhibition spaces that connect the building's design studios with the sky-lit student quad on the fifth floor. Just as a loom builds form and structure simultaneously, this new kind of building allows structural systems, environmental technologies and visual permeability to be interwoven in new construction concepts.

The C^2 Building is centred on the creation of a new, urban, vertical Student Life Hall that is open to students all year round. Two 49-metre (160-foot) long steel trusses span between the east and west cores of the building creating an uninterrupted open floor-plan for the hall. This design strategy establishes a highly flexible three-storey space supporting diverse student activities such as casual gatherings, music performances, lectures and fashion shows.

Flexibility, communication and leading-edge technology are what underpin the C^2 Building, which it is hoped will be a unique and inspiring example of future design, creating a transformative environment for students, faculty and alumni as well as the people of New York.

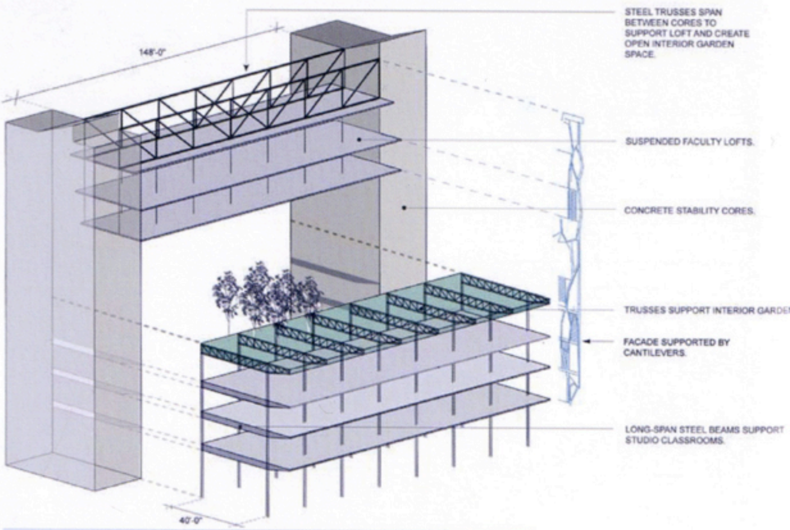
The new 10-storey, 9,132-square-metre (98,300-square-foot) C^2 academic building.

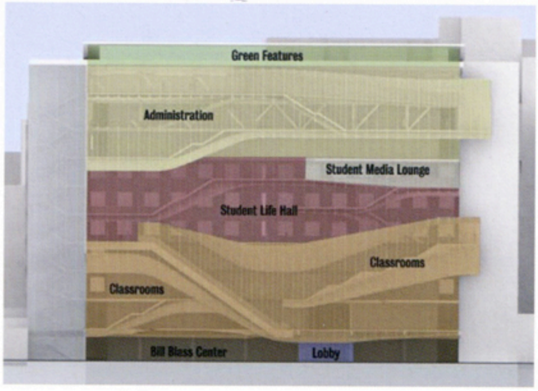
As the main establishment for fashion and design education in the US, the Fashion Institute of Technology is unique in that it is located directly in the heart of the fashion industry it teaches. However, the school lacks a clear sense of place within the city. One of the primary goals of SHoP's design for the new C^2 academic facility was therefore to create an iconic building that would form a lasting identity for the school, and one that would also functionally link existing academic spaces within the adjacent campus buildings with new classrooms, faculty and administration offices, and a sunlit student hall for gatherings and events.

The new building is highlighted by a multilayered glass and metal facade, within which are nested the primary circulation and the review and exhibition spaces, connecting the design studios with the skylit student quad on the fifth floor. An express escalator takes students directly from the street lobby to this floor, which is also the point at which adjacent buildings on the campus connect.

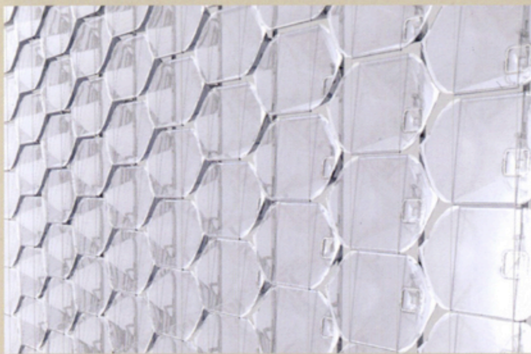
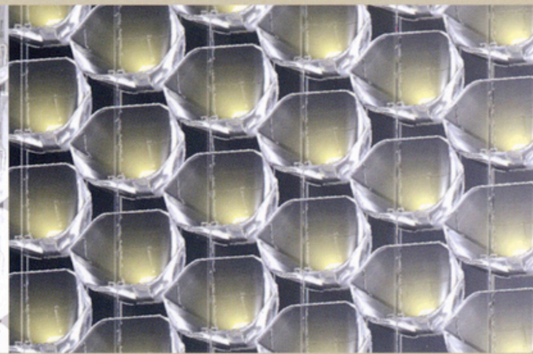
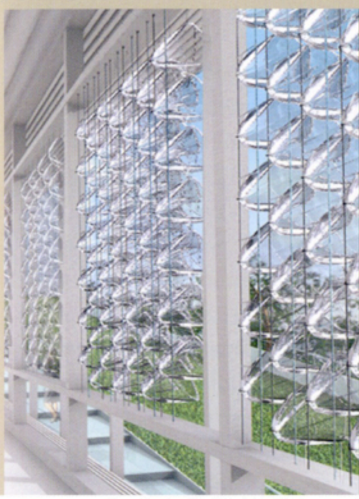
The C^2 addition will be a LEED-certified project and, in a state-sponsored initiative, the upper portion of the south-facing facade of the atrium will house a new and experimental dynamic solar curtain-wall system to reduce heat gain and control glare.

Just as a loom builds form and structure simultaneously, this new building type allows the simultaneous interweaving and construction of its structural systems, environmental technologies and visual permeability.

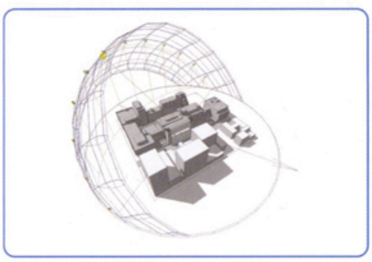
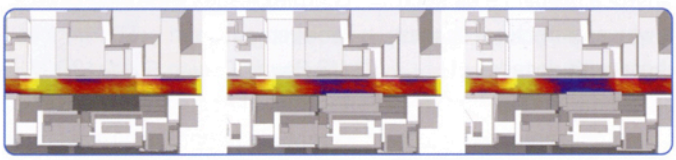
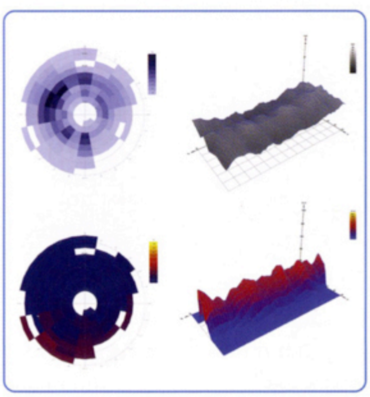
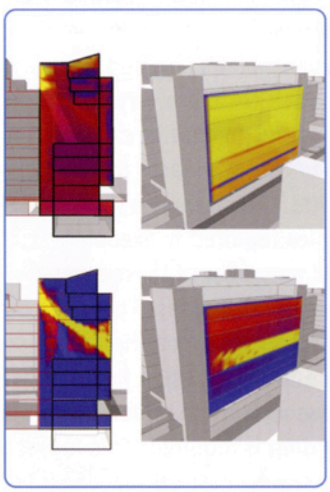
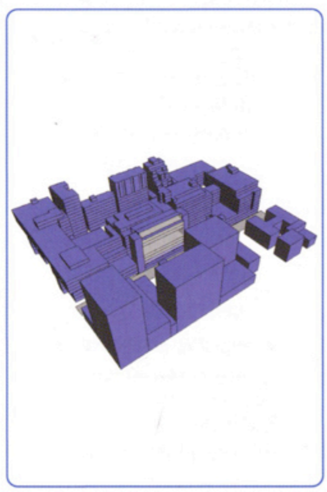




The structure consists of four main parts: the lower-level framing system that houses classrooms and laboratories; the vertical trusses that contain the building's cores and supports; the long-span steel trusses that bridge over the column-free fifth-floor student lounge; and the cable facade that encloses the primary building circulation.

IC Solar Facade is a next-generation photovoltaic facade system that produces three to four times the amount of energy of the best photovoltaic technology currently available. Its electrical efficiencies are the result of the innovative use of Fresnel lenses in conjunction with advanced solar-tracking algorithms. In addition to its noteworthy power production, the system also reduces building cooling loads, improves daylighting efficiencies and generates hot water that can be used throughout the building.

Design research for the project focused on replicating, analysing and scrutinising the predicted environmental performance of the C[2] Building. This work concentrated on three specific topics: site and climate analysis, daylighting analysis and thermal analysis. The resultant models provided the means by which designing through iterative analysis could be carried out, and laid the foundations for a highly intelligent parametric DNA from which the building could be designed. This model formed the basis for re-creating these efforts in advanced software packages so that an Energy Cost Budget model could be developed in accordance with ASHRAE 90.1 standards. ⅅ

Automated Assessment of

Building information modelling (BIM) is a powerful tool for clients and architects alike, particularly when clients have ongoing complex programmatic requirements. **Chuck Eastman** describes how with his team* at the AEC Integration Laboratory at the College of Architecture at the Georgia Institute of Technology he was commissioned by the US federal government's General Service Administration (GSA) to automate the design guidelines for all US courthouses in such a way that preliminary designs by architects could be assessed and checked against specific criteria.

Early concept designs are hugely important in determining the eventual success and impact of a project. The work of Louis Kahn, Alvar Aalto and Frank Gehry, among others, has shown how their initial concept sketches eventually determined the final project, in terms of creativity, costs, support for the building's functions, visual impact and other more general factors. Further development and detailing later on in the process can refine and elaborate a good early concept, but can only partially ameliorate a bad one.

Until now, concept design has been a largely mental exercise of generating various spatial concepts and assessing them intuitively, based on the designer's knowledge and accumulated expertise. Reliance on such expertise is perhaps one reason why architectural success has traditionally come only to those with decades of experience who are able to bring to bear the wisdom required to assess and select design concepts worthy of being fully developed.

While the importance of early concept design has long been recognised, digital tools to support this stage of the design process have been sparse and largely unsuccessful. Perhaps the only significant exceptions have been 3-D sketching tools such as Sketch-up and form-Z, which allow the development of concepts in three dimensions rather than two. However, while such tools substitute a 3-D sketch for a 2-D one, they do not help designers when it comes to augmenting expertise.

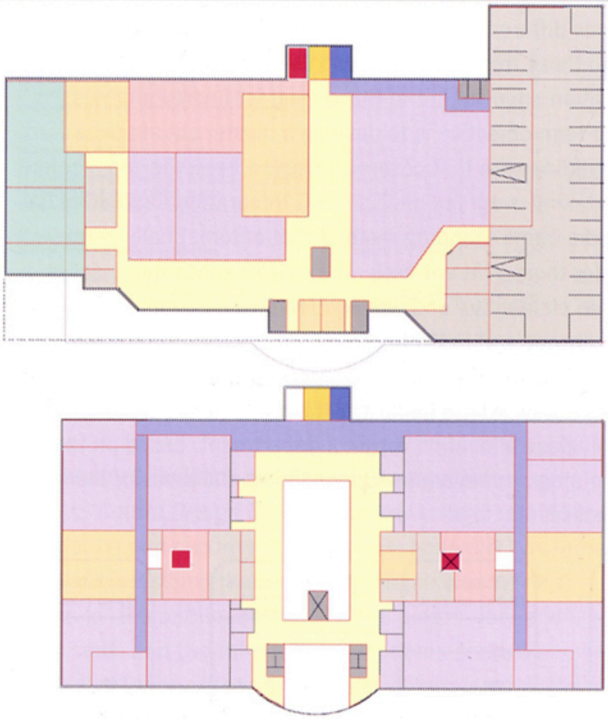
The construction industry is undergoing a revolution in terms of data representation. Twenty-five years after the transition began in the aerospace and manufacturing sectors, architecture and construction are now following suit and relying on digital parametric models of the designed product.[1] Another capability developed in manufacturing was interoperability between applications using ISO-STEP exchange standards; the equivalent in construction are the Industry Foundation Classes (IFC).[2] Thanks to the groundwork carried out by these other industries, the transition of architecture, engineering and construction to what has been coined building information modelling (BIM) will probably be much faster as they select from, adapt and add to the methods already developed. More than half of all architectural firms in the US now claim to be using BIM.[3]

Members of the AEC Integration Laboratory at the Georgia Institute of Technology's College of Architecture have been working to advance digital design practices within the process framework defined by the US federal government's General Service Administration (GSA), which is the real-estate management arm of the Department of Commerce. The GSA is one of the main facilitators of the building industry's move to BIM and is responsible for the design and construction of all US courthouses.[4] A courthouse provides the space necessary to carry out the functions of the US judicial system, and the design thus entails complex issues regarding circulation and security. The programmatic requirements and best practices for courthouses are spelt out in the *US Courts Design Guide* (2007), a 400-page document that outlines the spatial and environmental requirements, circulation, communications, security and other factors particular to courthouse design.[5] The AEC Integration Laboratory was commissioned to begin automating these aspects of the design guide and to work on the design reviews required for courthouse planning.

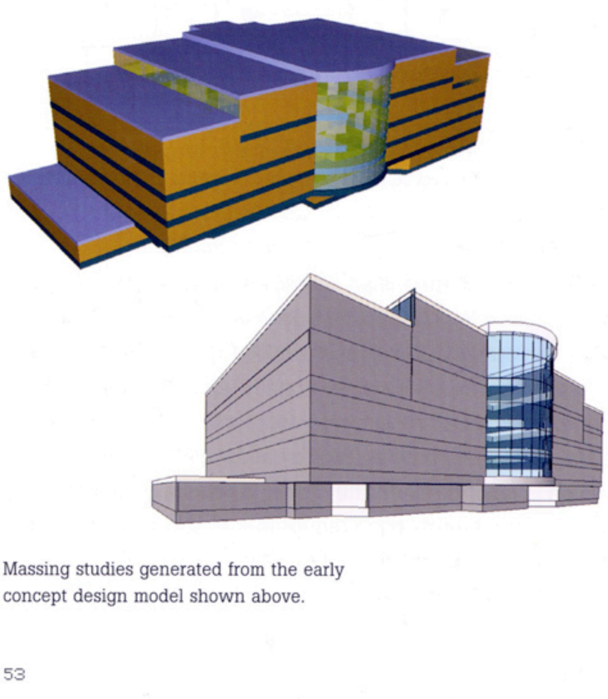
The GSA has a very well-defined design process for public buildings, including courthouses, that is spelt out in its *P-100 Facilities Standards for the Public Buildings Service* (2005) design guide.[6] This sets out the process, deliverables, reviews and iteration cycles required to execute a new design and construction project, and a number of these steps are now being modified to adopt BIM-enabled processes. The guide outlines the planning and feasibility steps for a project prior to the contract being awarded to an architectural design firm. These include the development of a Housing Plan that identifies all of the space for which federal funding is required. This initial plan is then refined and expanded to generate a cost estimate that forms the basis for the application for congressional authorisation and funding. Once funding is approved, the architects and engineers for the project are selected.

Upon selection, the architectural firm gains information from many sources, including the *US Courts Design Guide* and also CourtsWeb, a case-based website of courthouse design issues.[7] It is from these, and through discussions with the relevant court and GSA staff, that the initial design concepts are generated.

Early Concept Designs



Two floors of a test building model for early concept design. The models consist of 3-D departmental-level spaces laid out on floor slabs without interior separating walls, but with exterior walls for each floor level.



Massing studies generated from the early concept design model shown above.

The *P-100 Facilities Standards for the Public Buildings Service* design guide defines the content of the Preliminary Concept Designs that are to be submitted by the architects-engineers for review. These provide a narrative overview of the site – its setting, history and context – and also outline general considerations regarding visual style, site characteristics such as local density and proposed building height, and materials. Along with the general context, the architectural firm generates multiple spatial concepts. The GSA requires at least three, and more are usually generated through refinements and iterations.

Preliminary Concept Designs traditionally consisted of a site plan that showed the enclosed and outside parking and floor plans of a building, with elevators, stairways and mechanical spaces, so that the gross and net areas of each floor could be assessed. Floor-to-floor and ceiling heights of the spaces were also required, providing 3-D information that was presented as massing studies and renderings of the design concept. In this pre-BIM world, these early designs were presented in paper format, as floor plans, diagrams and renderings. The GSA appoints a design review board and carries out background studies of each submitted design concept, in terms of its relation to the space programme, codes and standards (including fire regulations and access) and compliance with the *US Courts Design Guide*. It also generates preliminary cost and energy use estimates to determine whether a proposal is within the scope of the government's budget allocation and energy-efficiency targets. All this was previously done by hand, by GSA staff or consultants, and involved days of tabulation.

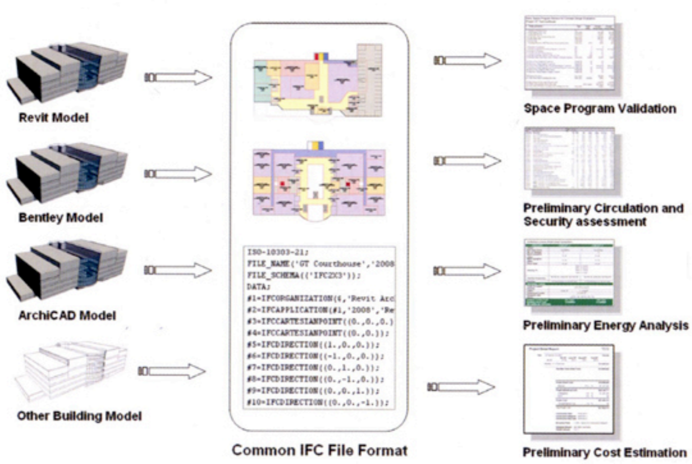
More recently, architects have begun to submit Preliminary Concept Designs in the form of 3-D building models, which means their proposals can be partially assessed automatically. The concept design can now be generated using any of the GSA-approved BIM design tools. Currently these include Revit, Bentley Architecture and ArchiCAD, but others such as Digital Project, Vectorworks and Allplan are also being considered. However, they must include the following, as set out in the 'GSA Preliminary Concept Design BIM Guide' (2008)[8] prepared by the AEC Laboratory at Georgia Tech:

- floor slabs defined with target thickness and floor-to-floor distances – also used for the roof;
- a composition of 3-D space objects, carefully named, on each floor slab, with height designating ceiling height;
- exterior walls with no construction, but with per cent glazing and R-values;
- building placement on the site, with orientation and above- and below-grade designation.

The above information is the minimum required to define a Preliminary Design Concept, but is detailed enough to generate meaningful assessments. Each of the GSA-approved BIM design tools supports the file export of a design model in IFC format, the international standard neutral representation of building model data. The file is read in an application suite developed with Solibri Model Checker[9] as a platform that supports the following automated assessments based on data read from the IFC file:

1 Spatial validation of the layout, comparing target counts and areas of the courthouse project space programme with those of the proposed concept design.
2 Circulation analysis of the layout, based on the courthouse-specific criteria of the *US Courts Design Guide*.
3 A preliminary energy assessment, using the EnergyPlus analysis tool.
4 A preliminary cost estimate, using the PACES cost-estimating system.

The results provide a uniform set of assessments, guaranteeing that the same assumptions and criteria are used for the different variations and iterations of the same concept design and, over time, across multiple projects.

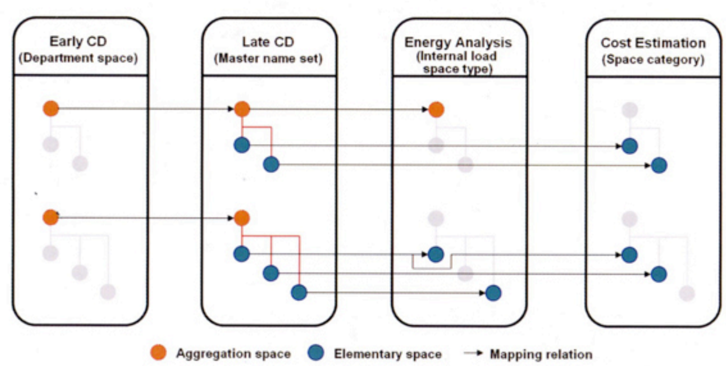


The general configuration of the GSA Preliminary Concept Design assessment tool. Most of the BIM design tools can generate Preliminary Concept Design models and export them to IFC. The IFC model can be automatically interpreted to support four assessments: for space programme validation, circulation and security analysis, preliminary energy analysis and cost estimation.

As a general syntax- and content-checking application, the Preliminary Concept Design prechecking review tool assesses whether the submitted building model has the correct elements, naming conventions, properties and other structures needed for full assessment. It returns diagnostic reports of the submitted model, and determines if and what corrections are needed. Prechecking in this way ensures that incorrect building models do not lead to meaningless analyses.

Space Names for Preliminary Concept Design Assessment

The spaces within a building are named differently according to application needs and life-cycle stage. Each of the supported applications has different naming conventions: rentable space names are different to those from the *US Courts Design Guide*, and those used for cost estimation are different to those used for energy analysis. While the long-term objective is to develop a master set of space names for a building type that covers all uses, it could be years before such an undertaking is agreed on. The AEC Integration Laboratory has thus developed a name-mapping method that automatically maps space names for their different uses. The master space name-set is categorised into elementary and aggregation space names. Departmental spaces and individual base spaces are often mixed in a concept design, and the Preliminary Concept Design review tool can accept such mixtures. Where departmental spaces are shown, the percentages of space allocation within a department, based on the building space programme, are used to estimate the areas of the individual spaces.



Mapping relation of space names. Names are mapped to their most disaggregated base spaces, and then re-aggregated into the classes needed for departments, circulation and security analysis, energy analysis and cost-estimating applications.

Space Programme Validation

The Space Validation application is an adaptation of the Late Concept Design Spatial Validation BIM application developed by Solibri for GSA. The application applies GSA-specific rules for area calculation and reconciles a design with the Congressionally authorised space programme. For early concept design models, the AEC Integration Laboratory developed a version of the space validation application to deal with the given level of detail of the model. This compares multiple alternative layouts to the target space requirements of the space programme and includes the efficiency and adequacy parameters traditionally used by the GSA to compare alternatives.

The review presents the given building model's space programme in an architect-friendly form; for example, number of spaces, gross area, usable area, building efficiency and so on. The figure here shows one of multiple space reports generated.

Early Space Program Review for Concept Design Evaluation
Project: GT Test Courthouse

#	Design parameter	Type	Target Value	Concept 1 Actual Value	Concept 2 Actual Value
1	Number of Building Floors	EA		6	6
2	Total building gross area	Area (nsf)		197,269	201,005
3	Inside parking area	Area (nsf)		10,319	10,380
4	Total gross minus inside parking area	Area (nsf)		186,950	190,625
5	Total usable area	Area (usf)		159,317	161,100
6	Atrium area	Area (nsf)		622	622
7	Building Efficiency (USF/Total gross minus parking area)	Ratio (%)	67%	85%	82%
8	Number of Courtrooms	EA	9	9	9
9	Number of Special Proceedings/Appeals Courtrooms	EA	0	Not found	Not found
10	Number of Chambers	EA	11	11	11
11	Number of Inside Parking Spaces	EA	24	22	24
12	Number of Elevator Spaces on the 1st Floor	EA	TBD	6	6
13	Elevator Ratio (Total Gross Area / Number of Elevator Spaces)	Area (nsf)	25,000	32,878	32,878
14	Floor to Floor Height for Courtroom	Height (ft)	20	20	20
15	Maximum Ceiling Height of Courtroom	Height (ft)	16	14	16
16	Floor to Floor Height for Sp. Proceedings/Appeals Courtroom	Height (ft)	-	Not found	Not found
17	Maximum Ceiling Height for Sp. Proceedings/Appeals Courtroom	Height (ft)	18	Not found	Not found
18	Floor to Floor Height for Office Space	Height (ft)	14	14	14
19	Maximum Ceiling Height of Judges Chamber	Height (ft)	10	10	10
20	Building Skin Area	Area (nsf)		99,579	100,422
21	Total Gross Area to Building Skin Area	Ratio (%)	45-55%	50%	49%
22	Main Entrance's floor level (Ground Level)			Level 02	Level 02
23	USMS Administrative Office's floor level		2nd or upper	Not found	Not found
24	Gross Area of Prisoner Circulation and Holding Cell Area	Area (nsf)		14,902	14,902

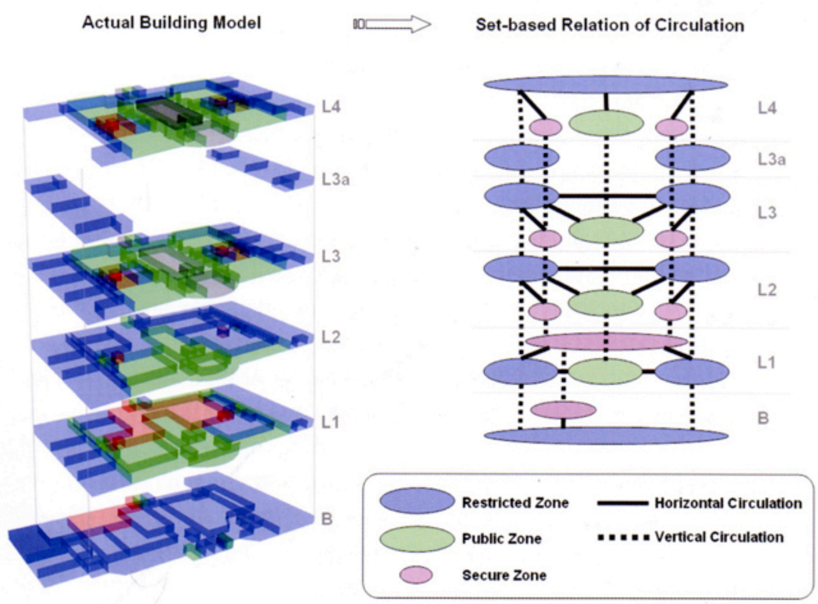
Example space programme validation, assessing two candidate designs against the a priori space programme. Data from multiple alternative models are compared with the requirements in a single page.

Preliminary Circulation and Security Assessment

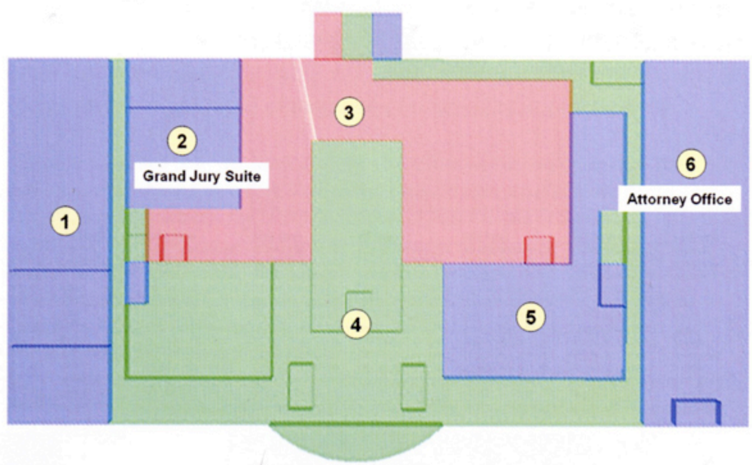
The *US Courts Design Guide* has many criteria related to circulation and security. A courthouse generally has three circulation systems that must not intersect or overlap. One is for the public, another for the judges, jury and court staff, and the third is for defendants and US marshals. These criteria are a major determinant of the form of a courthouse space plan. For the *US Courts Design Guide*, the research team identified 216 different statements defining circulation issues to be checked. These were in the form 'Each appellate court shall have ...', meaning that it applies to all instances of appellate courtrooms. Some of the statements applied to 'All courtrooms shall ...', which means to all types of courtroom. Since a courthouse can often have more than 10 courtrooms of various types, the 216 rules are in this case multiplied many times.

In the Preliminary Concept Design, only the department-level spaces are defined. In most cases, walls inside walls are not defined, thus exact circulation paths cannot be assessed and only a subset of the circulation rules can be applied.

The specific space types have one of three security types: public, restricted, and secure (for defendants and US marshals). Among the 216 circulation rules in the *US Courts Design Guide*, 43 per cent involve accessibility between two spaces within the same security zone. These can be checked simply by identifying their existence in the same zone. In order to check the containment of spaces in a zone, the spaces adjacent and having the same security level are structured as a logical set. The test is almost instantaneous.



In the abstraction used for Preliminary Concept Design circulation analysis, spaces are grouped into sets that are adjacent and have the same security. The connectivity of these zones is represented as solid edges, vertical access as dotted edges. If the specific circulation rule requires accessibility within a security zone and floor, then the vertical connections are disregarded.



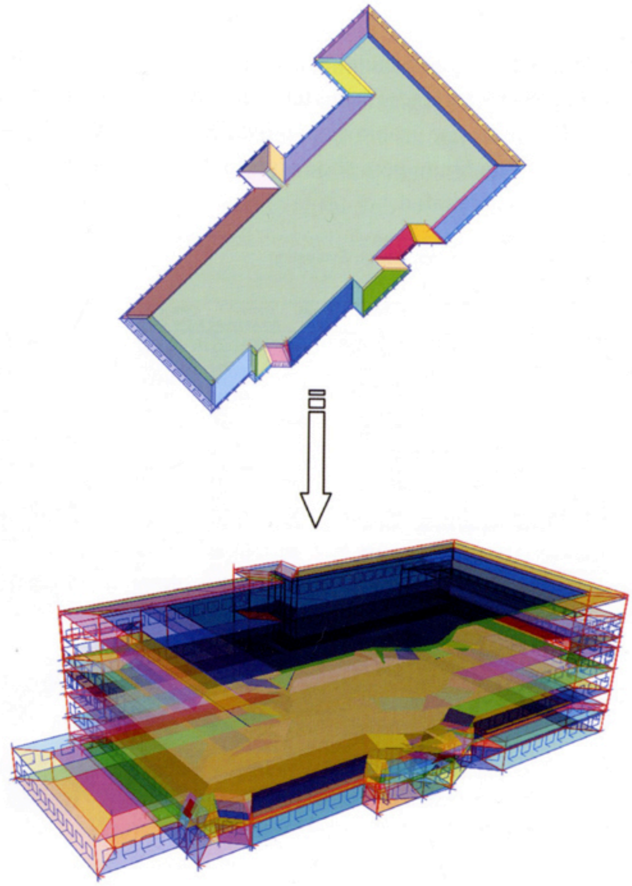
An example circulation-checking rule for courthouses is that the 'Attorney Office' should be accessible to the 'Grand Jury Suite' through a restricted zone. In the test model here, there are six zones according to adjacency and security level. But, even though the Attorney Office and the Grand Jury Suite have the same security level (restricted zone), public zone number 4 is placed in between the two target spaces, violating the circulation rule.

Preliminary Energy Analysis

An early concept design has features that significantly determine energy-use ranges. These include building orientation, the building shell's external materials, floor-by-floor footprint, insulation and the inclusion of atria, courtyards and skylights. At this stage designers are interested in a proposed building's heating and cooling loads over the year, required to condition the space within a particular comfort zone. The intention is to assess the impacts of these and other features that may significantly affect energy usage, and to facilitate design decisions leading to better energy performance.

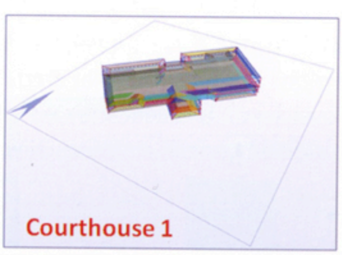
In order to run the EnergyPlus analysis tool with this limited information, default values are provided based on typical values by building type. It is assumed that the courthouse will be in a city or a town, thus the solar distribution is set to that for an urban setting. At this stage the mechanical system is 'idealised' to supply the necessary heating and cooling. Values for internal heat gains such as occupant density, lighting and equipment loads are derived from the spaces in each of the building's thermal zones, such as the courtroom, judge's chambers and clerks' offices.

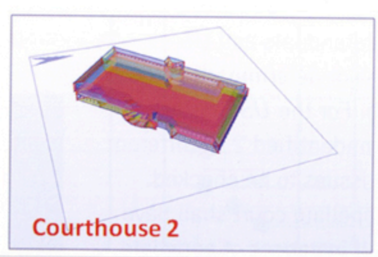
Building zones are an important aspect of an energy model. For preliminary energy analysis, a perimeter and core thermal modelling approach is used. Preliminary reporting samples are shown here.



Example of the current method of automatic thermal zone generation, based on floor-by-floor perimeter zoning.

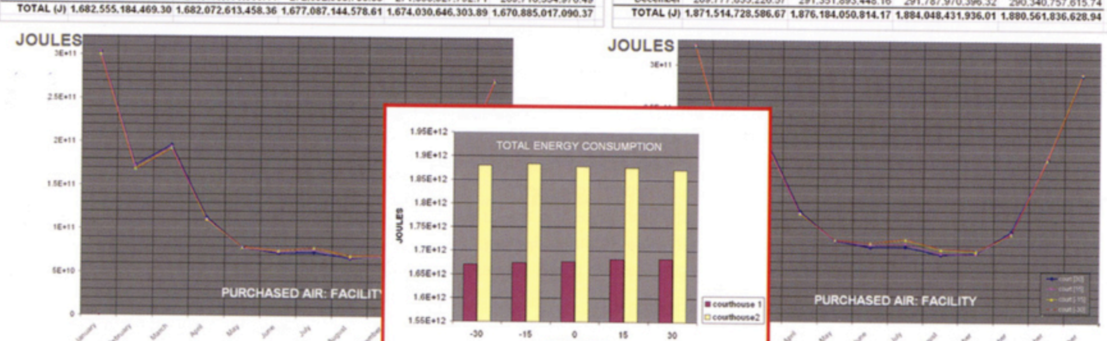
Example feedback from the energy analysis module. The effect of small building rotations is reported to assess orientation sensitivity and month-by-month energy usage for heating and cooling.





Date/Time	test1 [30]	test1 [15]	test1 [0]	test1 [-15]	test1 [-30]
January	303,152,050,799.75	303,949,350,508.26	303,149,390,498.23	301,187,294,058.48	299,308,686,718.31
February	172,304,249,143.02	171,905,272,436.69	170,229,703,861.53	168,717,570,060.43	167,399,165,289.12
March	195,999,546,815.09	194,441,497,850.32	192,537,699,095.94	192,410,348,927.48	191,902,676,487.36
April	112,630,023,894.26	110,801,671,042.42	109,725,289,295.62	110,277,806,783.76	111,253,843,437.67
May	78,344,549,242.66	77,860,280,815.64	77,774,090,390.60	78,282,840,907.41	79,294,460,203.82
June	71,957,926,319.69	73,369,948,172.53	74,589,953,666.62	74,911,218,573.71	75,162,581,191.34
July	73,067,000,840.50	75,474,601,283.84	77,608,475,350.35	78,369,455,065.79	78,454,599,066.50
August	66,605,119,894.51	66,994,085,946.66	67,725,538,624.74	68,979,922,738.35	70,076,717,302.11
September	69,419,145,580.60	68,481,736,923.41	68,023,131,079.01	68,807,689,308.27	70,110,390,801.96
October	90,279,395,166.08	88,728,019,614.70	87,171,298,292.53	86,596,725,836.57	85,881,605,448.20
November	176,752,662,352.58	176,947,452,483.45	175,659,605,666.82	173,893,846,250.91	172,323,936,167.50
December	272,043,514,420.57	273,118,696,380.44	272,892,968,756.63	271,595,927,792.71	269,716,354,976.49
TOTAL (J)	**1,682,555,184,469.30**	**1,682,072,613,458.36**	**1,677,087,144,578.61**	**1,674,030,646,303.89**	**1,670,885,017,090.37**

Date/Time	court [30]	court [15]	court [-15]	court [-30]
January	321,836,663,521.24	323,159,203,147.96	322,718,657,566.26	321,060,864,504.03
February	187,074,505,500.22	187,290,328,751.55	185,105,909,945.75	183,468,189,130.53
March	214,148,515,867.80	212,304,363,008.73	210,108,671,586.46	208,977,045,470.94
April	129,084,719,257.15	127,321,733,257.42	126,617,315,220.25	127,197,822,093.60
May	95,004,422,379.26	95,071,428,366.32	95,977,070,965.10	95,896,018,087.73
June	87,726,318,298.68	89,959,947,660.30	92,893,789,053.43	92,707,488,367.71
July	88,070,381,288.60	91,733,827,684.35	96,977,255,771.51	97,142,496,503.76
August	79,416,253,797.73	80,675,256,196.67	84,981,155,436.07	86,497,375,849.20
September	81,368,207,097.07	80,478,482,223.86	82,663,503,812.27	84,819,579,286.76
October	106,620,824,135.78	104,769,735,284.12	103,250,157,866.11	103,054,718,374.12
November	191,386,082,216.58	192,067,851,784.73	190,966,974,316.49	189,399,481,344.84
December	289,777,835,226.57	291,351,893,448.16	291,787,970,396.32	290,340,757,615.74
TOTAL (J)	**1,871,514,728,586.67**	**1,876,184,050,814.17**	**1,884,048,431,936.01**	**1,880,561,836,628.94**



Preliminary Cost Estimate

Similar to the energy analysis, the intention of a preliminary cost estimate is to determine the effect of particular features of the design, and to gain insight into the value and potential cost of specific design concepts. The cost-estimation module is dependent upon two main components: building model-based data, and cost-driven data. Data from the building model includes all IFC-related information, such as mapped space names and their associated attributes, floor, roof and external wall areas, material properties and so on.

Cost-driven data includes defining cost types for different building types and spaces (for example, the costs for courtroom spaces are different to those for circulation spaces), and cost-calculation methods. The AEC Integration Laboratory uses Earth Tech's Parametric Cost Engineering System (PACES) software platform for this purpose.[10] Designers can specify the location of the building by entering the city and state, as well as the expected date and duration of construction, and fees and other cost data such as inflation, labour and interest rates. All values related to functional space areas, building structure and typical materials are mapped into expected quantities which are then priced according to assumptions regarding cost types, including labour, inflation and local availability. The assumed construction types and materials at the Preliminary Concept Design stage can then be tracked to see how the expected material quantities and costs vary as the design is detailed, providing a means of value engineering as design development progresses.

PROJECT DATA		
Project Name	Courthouse1	
ADDRESS DATA		
City	Jefferson	
State	Missouri	
Country	USA	
BUILDING DATA		
Facility Name	Jefferson City Courthouse	
Model Name	Midrise Courthouse	
Number of Floors above grade	6	floors
Number of Floors below grade	0	floors
Building Gross Area	197269	sq ft
BUILDING SHELL DATA		
Footprint	37303	sq ft
Perimeter	837	ft
Exterior Wall Area	49629	sq ft
Roof Area	37303	sq ft
Floor to Floor Height Above Grade	20	ft
Floor to Floor Height Below Grade	0	ft
Floor to Ceiling Height Above Grade	15	ft
Floor to Ceiling Height Below Grade	0	ft
FUNCTIONAL SPACES DATA		
Building Support Area	49406	sq ft
GSA 00/100 Open/Closed Office	5219	sq ft
GSA Conference/Classroom	759	sq ft
GSA Courtroom Low Rise	12989	sq ft
GSA Enhanced Office Low Rise	73478	sq ft
GSA Holding Cell/Detention Low Rise	7625	sq ft
GSA Joint Use and Retail	4729	sq ft
GSA Judicial Chambers Low Rise	11309	sq ft
GSA Judicial Hearing Room	2795	sq ft
GSA Library	4679	sq ft
GSA Underground Parking	20486	sq ft
Interior Loading Dock w/Exterior Canopy	1329	sq ft
Public Restrooms (Small)	2466	sq ft

Example of building model-based data extracted for use in cost estimation. The cost estimation is based on square footage and surface types and areas.

The Current Status of the Assessment Tool

Modules for the space programme review and the circulation and security review are operational and provide reports in little more than a minute for a five-storey courthouse. Most of the running time of this module is used in capturing images that will be embedded in the reporting document. The preliminary energy analysis module has been successfully integrated with the EnergyPlus simulation engine. The Preliminary Concept Design review tool has been provided with a particularly simple-to-use user interface that requires minimal operations in order to run the energy simulation. The Georgia Tech research team has begun the process of integrating the Preliminary Concept Design review tool into the PACES database. Once completed, this will require minimal or no input from the user to produce cost estimations representative of the analysed design phase.

During its development, the Preliminary Concept Design review tool has been operated solely by the AEC Laboratory team. However, the goal is to provide a tool that can sit on any designer's desktop, making the review process an integral part of the multiple iterations during the development of the preliminary design proposals. This also opens up the possibility for designers to develop their own sets of rules to be checked, which will allow experienced designers to pass on their expertise to those with less experience and make explicit the application of their design intentions for building projects.

Conclusion

The AEC Laboratory's work demonstrates the value of BIM for early concept design. The metrics applied provide quick feedback while designers are undertaking form/programme synthesis. These kinds of tools will not hinder the realisation of buildings with innovative visual character, but rather allow creative design to be better informed and debated. Such tools are also expected to allow younger designers to gain invaluable experience more quickly using virtual architecture assessments, and to facilitate the more rapid emergence of new ideas in practice. ◿

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Notes

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