The Composite Building Sketch

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Abstract

This works in progress paper describes the development of an alternative method for teaching building technology using the composite sketch concept borrowed from police forensics. The composite sketch utilizes individual components and assemblies of construction in various combinations to explore the design implications of materials and connections on form and surface. To enhance the usefulness of the composite sketch, in-depth case studies of specific buildings are linked to the digital assemblies of the composite sketch so that students can see the basic concepts in actual buildings. The project currently models more than 500 combinations of components and includes approximately 200 catalogued images of buildings under construction.

1 Introduction

Having taught construction technology to large groups of students over the past years I have experimented with several methods for presenting what is often considered the most mundane topic in an architecture curriculum. Reviewing the student course evaluations (and perhaps taking them a bit too seriously) has resulted in an annual ritual of reformulating the course syllabus, exercises and teaching methods to address the negative comments lodged by the students. Consequently, virtually every technique has been explored to present the material in a meaningful and memorable way so that when confronted with a similar situation in their studio the student would actually consult their notes as a reference without being asked. A summary of the frustrations I've had with the necessary but evil lecture format of the large class can be categorized into three distinct topics.

1.1 Inadequacies of Traditional Media

The traditional media for teaching construction relies heavily on two-dimensional drawings done on the blackboard or overhead projections complimented by slide images of "in situ" examples of systems or assemblies. Sketching assemblies and principles on the board is dynamic but time consuming. Images prepared ahead of time for projection on the screen are often criticized by the students as going by too fast and impossible to take notes from. Furthermore, the static nature of prepared sketches or drawings makes it difficult to dissect them further when confronted with a question that probes beyond the image offered and our administration frowns upon using a marker to draw over an image of a slide on the screen.

While a great deal of product literature is readily available on the web and in the library much of it is myopic in its focus and offers either too much technical information for the sophomore mind to absorb or is too general and simplistic to be of any real help in the design studio. Product samples and full scale partial construction assemblies are also often integrated into the course but the cost of obtaining, constructing and storing these materials coupled with space limitations for their permanent display makes this method impossible to accomplish in our school and I would assume equally difficult to achieve at many other schools.

1.2 Class size vs. field trips

Due to the large class size at the undergraduate level of our curriculum, field trips to buildings under construction are nearly impossible to organize and orchestrate. The 50 minute Monday, Wednesday, Friday class time is less than ideal for including travel time not to mention trying to get

the attention of 120 students in hard hats to point out a connection detail while balancing on a plank that spans over the excavation next to a foundation wall. For obvious reasons, visits by a class this large are discouraged by contractors fearing litigation should one of the 120+ students get injured on the site. While the site visit represents one of the best opportunities for students to develop a three-dimensional understanding of the complexity of construction, the technique simply fails for a class size of more than 20 to 25 students.

1.3 Internalizing and Integrating First Principles into Design

Regardless of how succinctly material is presented, most sophomore students seem to have difficulty in developing a diagrammatic understanding of complex assemblies. Despite the introduction of "first principles" the mindset of the typical second year student seems to be focused more on what it takes to get an "A" in the course rather than trying to internalize the choreographic nature of design and construction. While the studio setting is ideally suited for this type of integrative exercise it is not guaranteed that the departmental teaching assignments allow for the construction teacher to simultaneously teach the parallel sophomore studio. This makes it difficult to have input on the course development and to assess the integrative aspects of the design projects. Furthermore, the lecture course by definition covers more construction methods and assemblies than a single studio exercise could ever hope to integrate in one academic term. Consequently, students are forced to develop a basic understanding about a full range of principles presented in the construction class and may only have an opportunity to deploy a few of them in the parallel studio offering.

2 The Composite Sketch and Case Study

This work in progress describes my latest attempt to address the difficulties outlined above. The current reformulation of the sophomore construction course integrates computer modeling into the construction classroom in a dynamic and interactive way and incorporates two techniques for organizing and presenting design situations based on construction realities. The two techniques are the Composite Sketch and the Case Study and are discussed in the following sections.

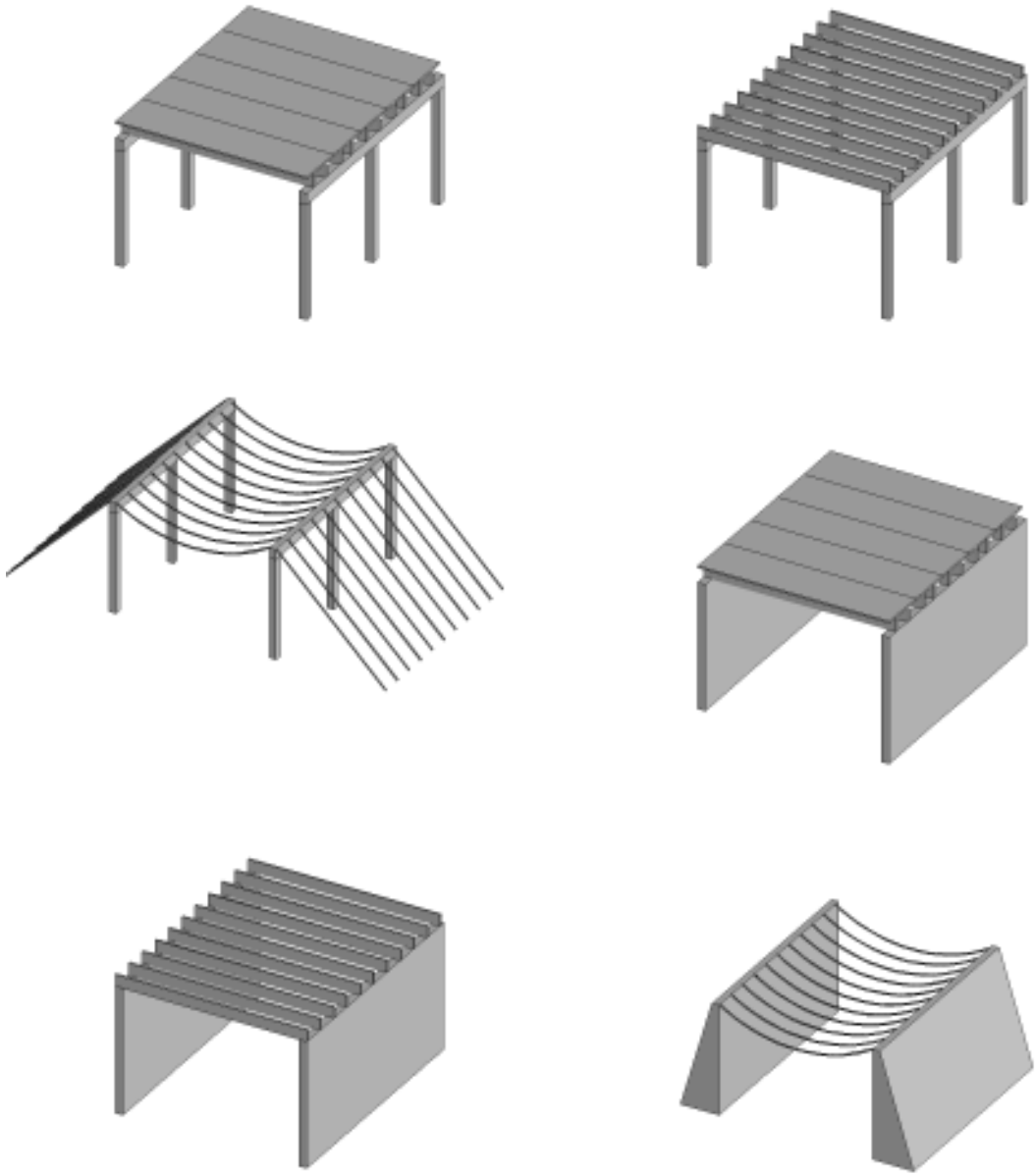
2.1 The Composite Sketch Concept

Using a "standard" building size, various systems and their components are modeled in form-Z and dynamically interchanged to explore the design implications of combining various structural, envelope, and mechanical systems. These interchangeable components and assemblies form the basis of the Composite Sketch Concept, borrowed from forensic police work. For example, a pair of concrete frames can be shown to support simple wood joists or precast concrete "Ts" or even a series of cables. Alternatively, bearing walls could support these spanning elements with modifications to accommodate the thrust. (Figures 1a to f).

Two distinct types of composite sketches are being developed using this simple technique of substitution. The first concentrates on the overall effects of structure and site on the building form with an emphasis on overall design principles. For example, the outward thrust of an arch structure may be resolved by tension members, mass or repeating the form of the arch. Each has a different impact on the exterior form, site as well as the interior volume of the design. Issues of site, stability, etc. are also modeled and mined in class for design opportunities and implications on form and function. (Figures 2a to g).

The other type of composite sketch considers a more detailed integration of various elements and develops insight into the design of the joints between materials. These composite sketches focus on more specific design implications and uses the construction of a partial corner of a building as the site for investigation. The sketch begins with variations of "wall" and moves up and down from there. The wall is chosen as the point of departure since the body has the most direct relationship visually and physically with this element of architecture. From the wall, floor and foundation structures are explored followed by upper floors and roof assemblies. Variations in spanning members and the implications on the foundation walls are systematically explored. Additionally, the relationship between envelope/structure and site are explored and mined for design implications and opportunities. Several examples of the detailed assemblies are shown in Figures 3a to n.

Unlike the police forensic equivalent, the anomalies in the composite sketch are mined for inconsistencies and used to present basic concepts and general solutions to problems. For example, the addition of a masonry veneer to a steel frame results in an odd situation at the foundation that was modeled to hold up only the simple steel frame. The floating masonry opens to the exploration of a variety of envelope/frame design opportunities. (Figures 4a and b)



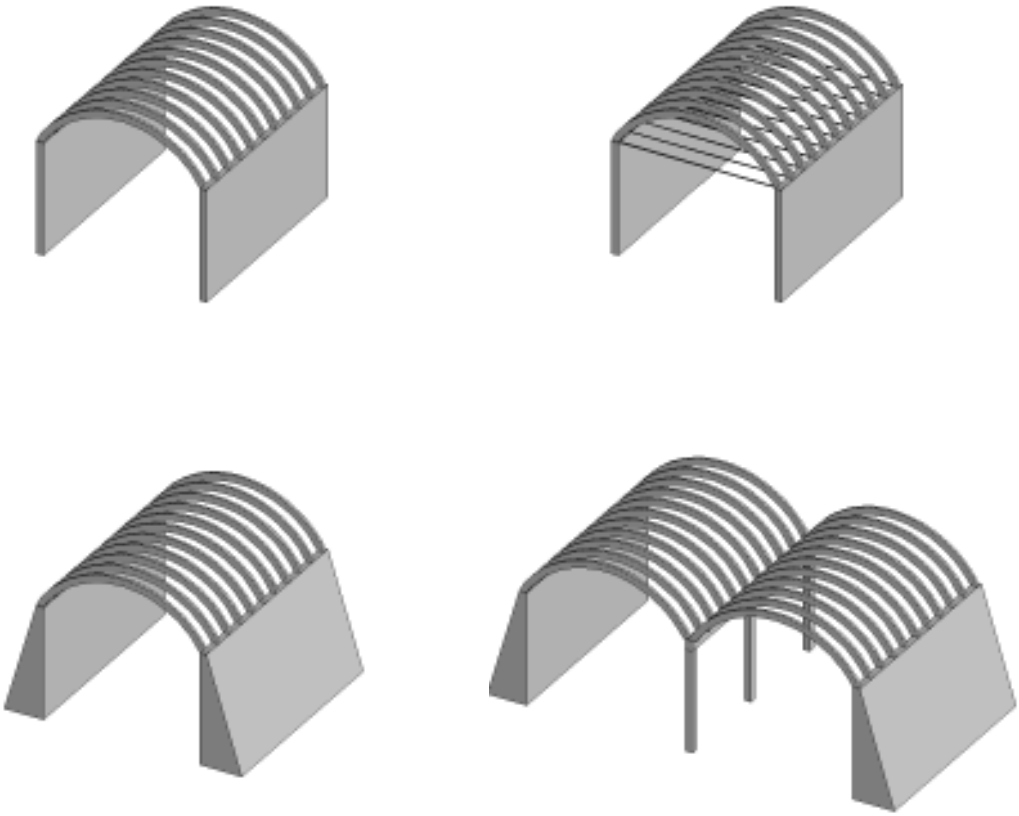
Figures 1a to f: Interchangeable components of construction used to develop a composite sketch of a building.

While the images presented in this paper are static, the model presented in class is dynamic. The 3-D assembly is rotated, rendered, exploded and otherwise manipulated to respond to questions from the students in the front row of the lecture class. To serve as a reminder of the lecture and as a study guide, labeled images of in-class explorations are mounted on a class web site. These images list many of the terms students are expected to know and illustrate the three-dimensional relationships between the elements as shown in Figure 5. Many students download these images and add them to their class notes as well.

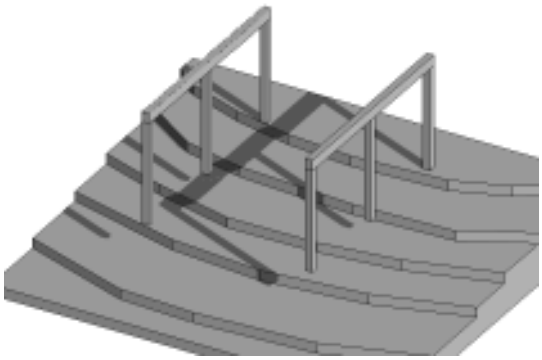
2.2 The Case Study

Linked to the Composite Sketch are a series of case studies of specific buildings. Currently, images of buildings under construction are stored in a database and retrieved by topic. The focus of development is now turning to dynamically linking the various images to the topics and presenting them simultaneously to the specific composite sketch assembled. For example, the composite sketch assembly of a concrete frame with precast, double T spanning members will have specific example(s) of this assembly shown at the same time as shown in Figures 6a and b.

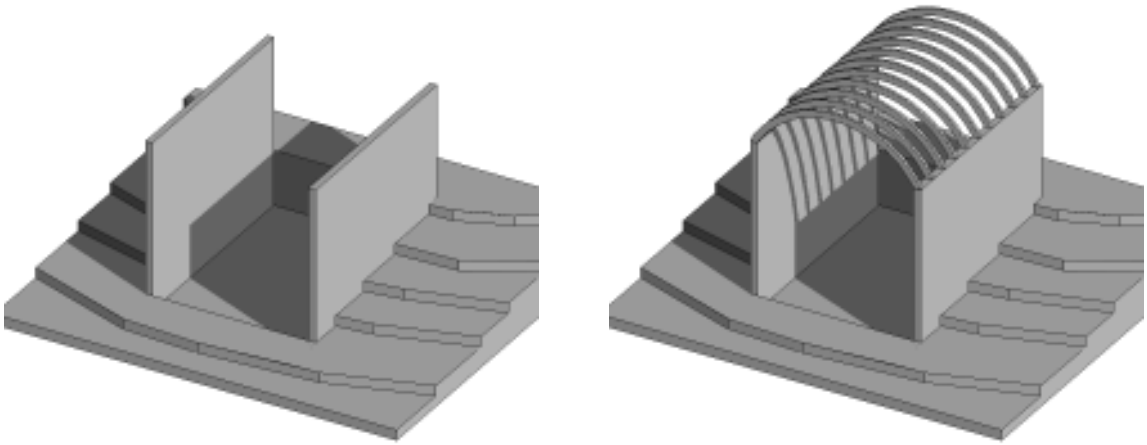
An additional intent is to link these specific images of the buildings back to the broader overall



Figures 2a to d: The composite sketch used to explore overall building form and first principles.



Figures 2e to g: The composite sketch used to explore site and form relationships.



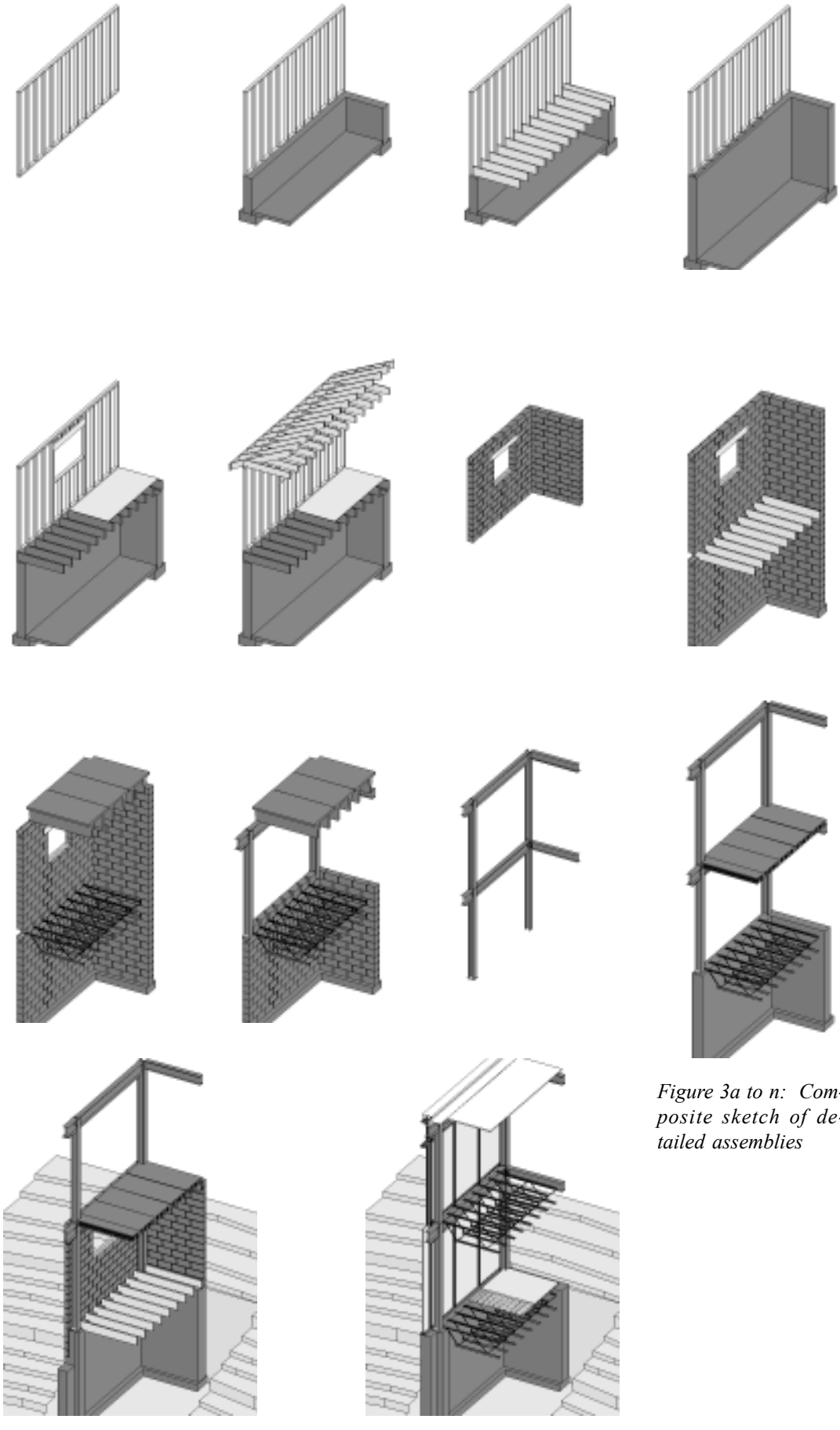
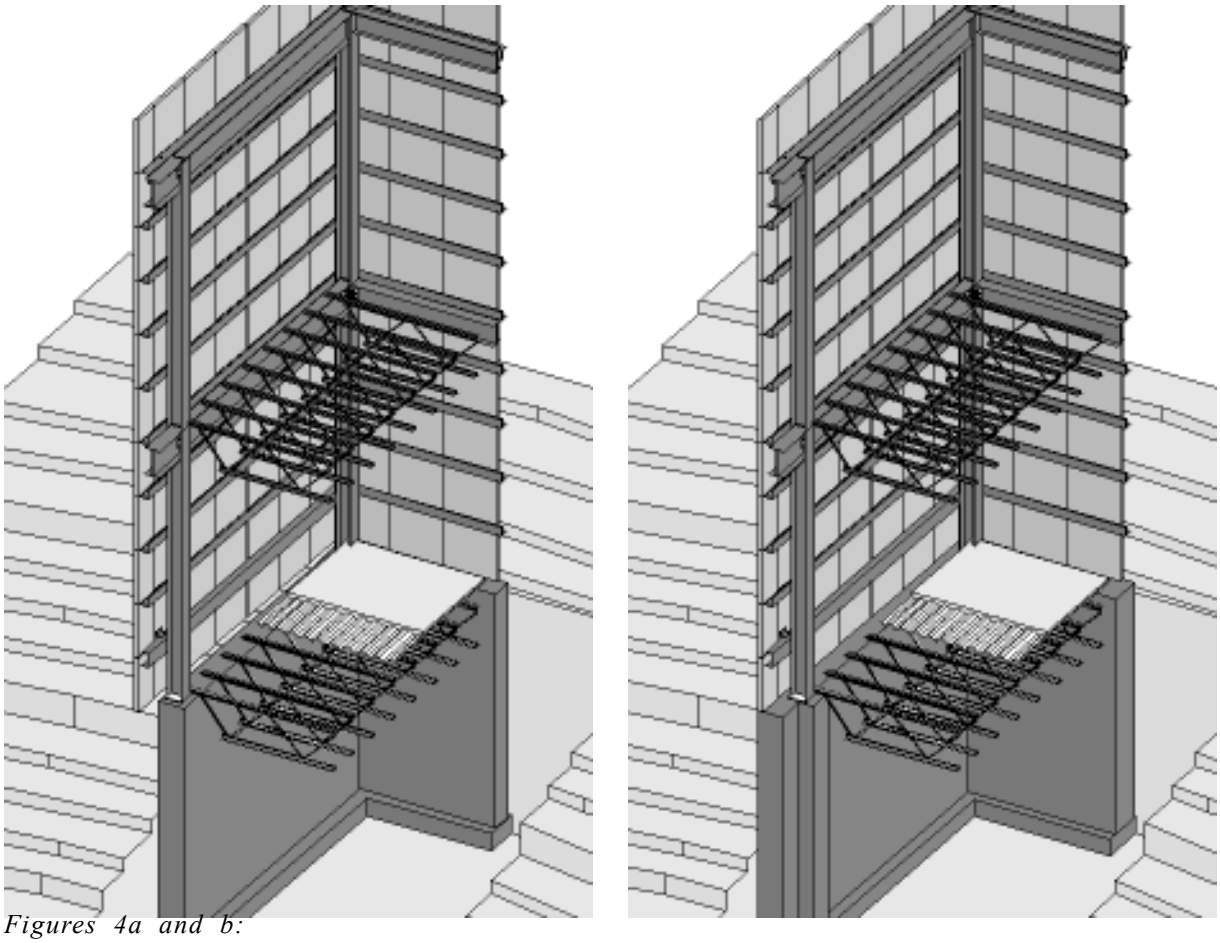


Figure 3a to n: Composite sketch of detailed assemblies



Figures 4a and b: Anomalies resulting from various combinations as the site for design intervention. Notice the floating stone panel wall that results from simply applying an envelope to the frame without any other consideration. The image on the right illustrates one of several solutions modeled in which the foundation wall is extended to support the first row of panels. Notice also that rather than making the entire foundation thicker, pilasters are left behind where the steel columns are as the wall moves out to greet and support the concrete panels.

building case study that explores all the systems in that building. From the holistic case study students can examine design decisions and building technology more carefully. Currently, the case studies are being constructed by upper level students in seminar courses and continue to be developed and expanded on from term to term. In some cases, the specific building case studies include digital models diagrammatically showing complex assemblies as well as actual construction photos (Figures 7a and b).

3 Summary and Future Goals

At present, the composite sketch portion of the project includes approximately 80 variations of simple foundation, structure, envelope and roof assemblies. There are more than 500 combinations currently possible with plans to expand this significantly to include more unique types of construction. There are also approximately 200 images that relate to the assemblies modeled with the goal of expanding this to 1000 images within the next year. Another goal for the composite sketch project is to include definitions and diagrams of first principles linked to the building elements modeled. This will serve as a reference and a Lexicon of construction with possible links to product literature and manufacturers.

The case study portion of the project currently has 11 specific buildings with more than 250 images of construction collected and entered into an evolving searchable database. With the framework in place, the goal for this portion of the project is to expand the image database and analysis significantly over the next two years. Anticipating a healthy response to the project I hope to include more faculty over the next year to extend the case studies to include investigations/analysis under their areas of expertise. This will allow the building case study to include other than construction related information such as interviews with designers, post-occupancy evaluations, structural analysis etc. so students may access the full range of issues regarding design.

An initial, non-structured version of the composite sketch and case study was incorporated in the sophomore building class with good results. Students reported that they enjoyed the interactive nature of the class and that they learned how the joint in construction is the site for design. Some solutions to problems could be solved and modeled in class while those requiring more thought and

time were modeled after class and presented in the following session for discussion. By the next time the course is offered the rapidly expanding database of construction images from the case studies will be linked with the more formalized structure of the composite sketch. The open ended, modular nature of both the composite sketch and the case study allows for expansion and improvement annually rather than reformulating and reinventing.

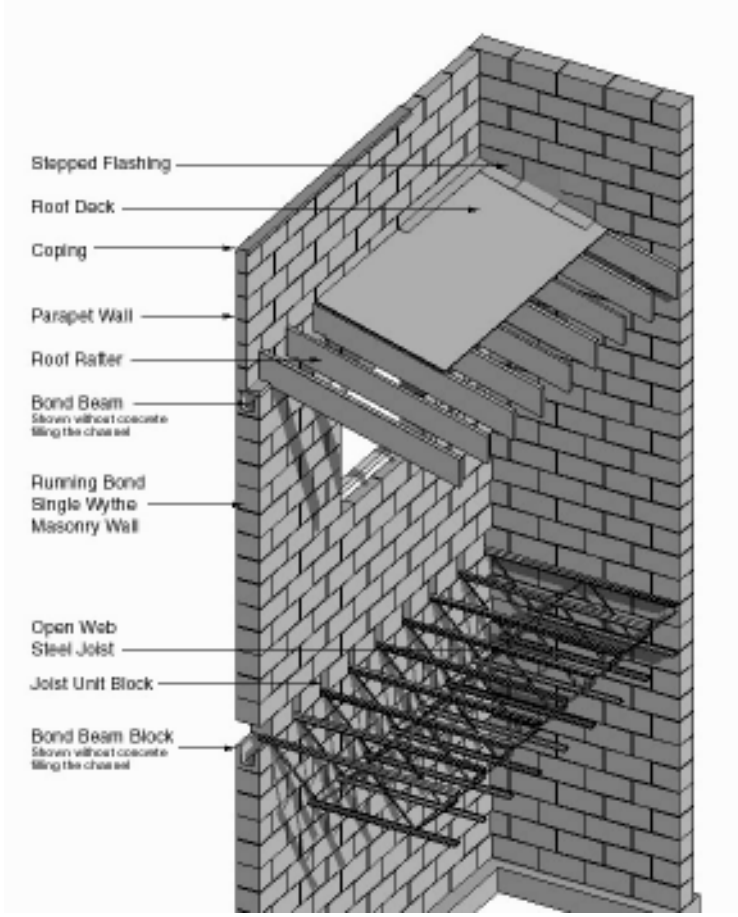
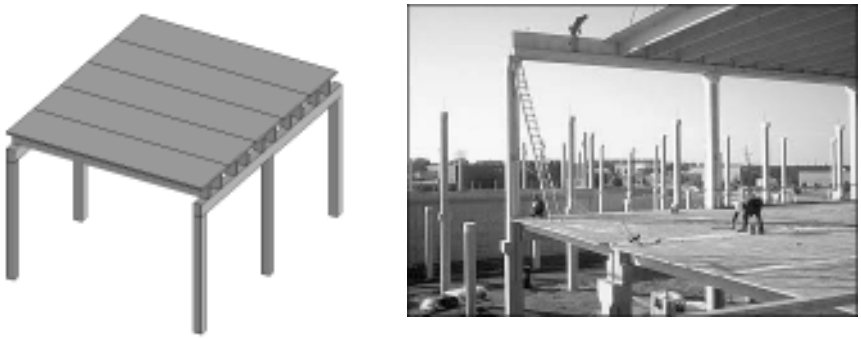
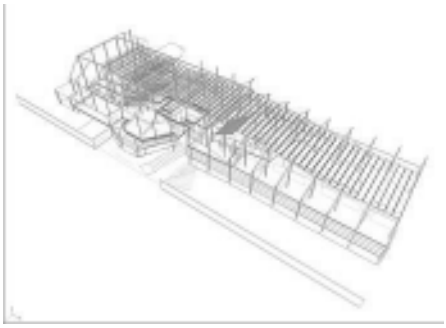


Figure 5: Image captured during lecture, labeled and mounted on the class web site.



Figures 6a and b: Parallel presentation of composite sketch assembly with site photo showing the actual installation of the element.



Figures 7a and b: Example images from the Cincinnati Country Day School case study.