EE14-3 Why a mock up - because the owner expects it done right

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Abstract

With building facades becoming more complex in design and new materials being designed to interact with each other, it is more important then ever to build and test mock ups. Perhaps the largest benefit to the mock up is the lessons learned from failures discovered through the various types of tests performed. It is here in the failures that tradesmen and architects learn how to construct and design better buildings and create easier "dummy – proof" details.

Most owners find it difficult to pay for this procedure, yet expect perfection by tradesmen during the construction of their building. In educating the owner on the benefits of a mock up, and how it can; increase the life cycle of there building, improve its energy efficiency, and increase the knowledge of the installer before installing products on their building, an owner will have the right information to decide if a mock up is necessary for their project.

Mock ups may be built and tested in the field, as an actual part of the building, or in a testing lab. There are benefits and disadvantages to each of these. However, functional testing of the installed materials and how they transition into each other should be the main purpose for all mock ups. This presentation will focus on actual case studies of on site and lab tested mock ups, provide test procedures, discuss how mock ups can changed building sequences, alter details and help ensure the product was properly installed on the owners building the first time.

Keywords; mock up, functional testing, life cycle

The benefits of mock-up

The benefits of constructing and testing a building enclosure mock up are rarely understood or explained to building owners. This paper discusses these advantages and benefits while also providing some insight on where to build and what tests to perform on the mock up.

Constructing and thoroughly testing a building enclosure mock up provides assurance the specified materials will function as designed under maximum loads and conditions, that difficult details are able to be properly constructed, and that hand off points between trades are clearly understood. This process helps establish the proper installation sequence of materials and ensures the accuracy of the construction schedule. Finally, mock ups provide installers an understanding of potential issues and causes of failures from "normal" or traditional installation techniques prior to assemblies being constructed on the actual building.

What do we know today, that makes constructing and testing a building enclosure mock up so valuable and important? Current research has shown buildings consume 40% of the overall energy (Energy Information Administration, *Annual Energy Review 2008*) used in the United

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States. The building's primary energy usage is in the form of heating and cooling followed by lighting demands. In June 2005, the NISTIR7238 Report noted buildings in northern climates can lose up to 35% of their energy through the building's enclosure. One of the main contributing factors to this loss is uncontrolled air movement between the conditioned interior space and the exterior. A tested mock up helps locate these potential issues prior to materials being installed onto the actual building. In identifying these items and learning how to install materials properly the building enclosure is capable of helping a building owner reduce their annual energy cost, provide better indoor air quality, and increase thermal comfort to their occupants. Also, these small openings found in "typical" building enclosures can result in costly repairs due to water infiltration, condensation, and potential mold issues.

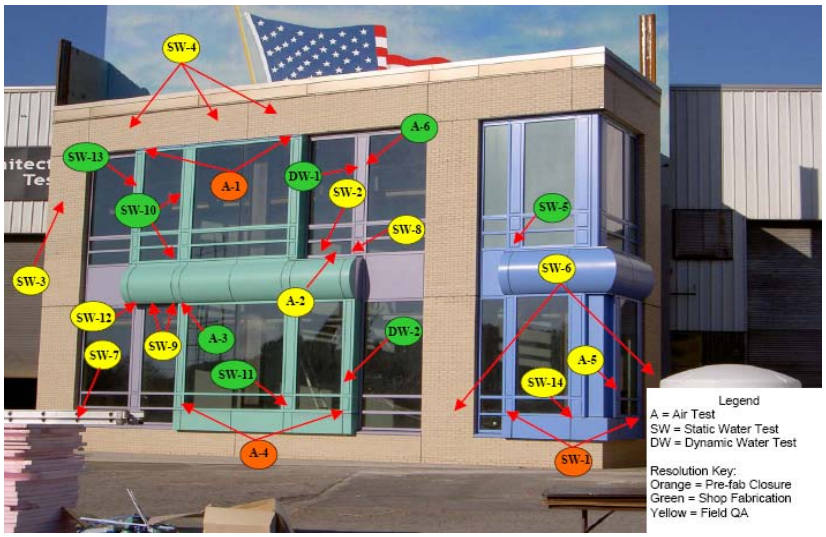

Figure 1: Design and installation issues discovered through the constructing and testing of a mock up

As potential projects move closer to reality, it is crucial for architects to discuss the importance and benefits of a mock up with the building owner. Some points of discussion should include: how traditionally built enclosures have been found to use up to 35% more energy (NISTIR 7238), how 90% to 95% of building enclosure mock ups fail at some point during the testing process, that mock ups allow for discovery of questions and potential constructability issues prior to assembling the materials on the building which could lead to schedule delays and costly rework, and finally that new materials are continually being introduced with many of them focusing on sustainability and the mock up allows for review and "hands on" training of these newer materials.

Detailed studies and testing are being conducted to understand how heat, air, and moisture interact between the outdoor environment and interior conditioned space through the building's enclosure. Studies continually prove the old theory of "letting a building breathe" (a leaky enclosure) in fact creates issues with indoor air quality, thermal comfort, and increased energy usage (Straube, Air Flow Control in Buildings). With these findings individuals are now focusing on how to best stop air flow through the enclosure assembly and control the movement of moisture. Peel and stick and spray applied air vapor retarder / barrier products are prime examples of materials (which work to stop air movement and control moisture) that are being introduced and or constantly refined by manufacturers. These products require individuals to be properly trained in order to install them correctly, and a mock up provides the construction team

an opportunity to review installer's ability, establish expectations, and provide example's of acceptable workmanship.

Once an owner understands the benefits of a mock up and agrees to incorporate one into their project, the next step is to discuss where to build it. The two most common places are at a certified testing facility, or on the construction site. All of the same tests may be performed at either place. Some of the benefits of a lab include: allowing for construction and testing of the mock up in a controlled indoor environment (reduces over all time on the mock up), the ability to add tests, or alter sequencing of the test because all of the equipment required for testing are at the labs immediate disposal.


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Figure 2: Mock up built and tested indoors at a certified testing facility

Also, a lab location is generally more conducive for providing tests related to condensation resistance and dynamic pressures. The dynamic pressure test requires space for the fan and a machine (see figure 3) to ensure the fan is stabilized. Some of the negatives to testing at a lab include; time limitation as to when you may start and or finish the mock up, extra cost for travel while working on the mock up, and difficulties in getting the exact crew and lead man for the project to install the material at the testing facility.

Site built mock ups are typically constructed out doors near the area where the building will be constructed. This can create some difficulties in the construction and testing schedule because of weather issues and delays. However, positive aspects to this are: it allows for an installation in the exact climate and conditions as will occur on the building, the tradesmen are normally local and therefore there is no extra travel cost, and if constructed with the selected colors for the project it functions as an aesthetic mock up for owners and architects to easily review. Finally, if left in place during actual construction, it can be used for setting expectations and review of difficult details.

Figure 3: Dynamic water test being performed at an on site mock up

With the number of various trades involved in constructing the building enclosure and the fact that their materials often intersect and overlap, it is important to determine and understand where the hand off points are between trades. These transition points may not be clearly defined in the details, shop drawings may conflict (the infamous “by others” note), or multiple disciplines may include installation of the same material in a detail. Construction of a mock up and installing the materials allow for the discovery, discussion, and resolution of these potential issues. A preconstruction meeting should take place with all of the enclosure contractors together to discuss the details and ensure the anticipated construction sequence is accurate.


Figure 3: Mock ups help determine contractor sequencing and discover potential issues prior to actual installations on the building

Details to be included in the mock should consist of any difficult three dimensional transitions and areas with more then two products interfacing, as these are the details that often require refining. As programs like BIM become more common, and three dimensional transitions can be more clearly depicted, drawn, and scrutinized, less detail changes are anticipated.

When a mock up is required for a project, then the overall project documents and specifications should include the test procedures, plans, and details for the mock up. The test procedures should include specific tests to be performed, what order to conduct them, the pressures and limitations the mock up should be tested to and what the qualifications for passing and failure are. This allows for the cost of the mock up to be part of the original bid and typically

accounts for a lower over all cost to construct the mock up. It also provides subcontractors a chance for questions and concerns about the mock up while allowing for expectations to be discussed during the pre bid meeting.

Some of the typical tests for a mock up include; ASTM E 283-99 for Air Infiltration, ASTM E 331 -00 for static water pressure resistance, AAMA 501.1-83 for dynamic pressure water resistance, ASTM E 330-97 for structural performance, ASTM E 1186 Smoke Tracer Test, along with thermal cycling and condensation evaluation. Of these tests, the dynamic water and thermal condensation evaluation are typically not performed at on site mock ups. As a substitute for the thermal condensation evaluation, computer thermal imaging reports may be used.

Figure 1: ASTM E 1186 Smoke Tracer Test at a mock up to locate air leakage locations

The type of enclosure system used for the project can help determine when to run the tests. For instance, buildings using a rain screen principle may want to consider performing some of tests prior to the final installation of the rain screen material. This allows easier accessibility for locating and repairing any issues discovered at the primary air vapor retarder / barrier seal during testing.

Figure 5: Static water test performed prior to rain screen material being installed at a on site mock up

Once testing is completed and all of the criteria met, lessons learned program should be put together and presented to all tradesmen working on the project. The presentation can be trade specific and should review any issues discovered during installation and testing, good installation techniques, and areas where work from different trades intersect. The program should also establish final installation expectations for their products and allow for questions and concerns from the tradesmen.

It is imperative that today's facility owners understand how enclosure mock ups can benefit their project. Mock ups help ensure details are constructible, materials are correct for the project requirements, installers understand the proper sequence of construction, and expectations of the final product are understood. All of which helps create a tight, energy efficient, sustainable building for the owner.

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