DESIGNhabitat 3.0

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INTRODUCTION

DESIGNhabitat 3.0 is the fourth in a series of collaborations with Habitat for Humanity (HFH). The DESIGNhabitat 3.0 studio was run as a research / design / simulate / design studio which took advantage of Habitat's state resources to focus on an incentive program for HFH affiliates which is aimed at improving the energy efficiency in Habitat homes.

To date there have been four cycles of DESIGNhabitat (Dhab) collaborations - DESIGNhabitat 3.0 being the most recent. Each collaboration has expanded upon the objectives of the prior collaborations via slightly different trajectories. The DESIGNhabitat program, initiated in 2001[1], is an ongoing collaboration between Auburn University's School of Architecture and the Alabama Association of Habitat Affiliates (AAHA) and provides an opportunity for students to design high quality affordable housing locally and across the region (DESIGNhabitat: Overview).

Previous cycles of DESIGNhabitat collaborations have included a construction component that has been utilized as a teaching methodology. In previous cycles this teaching methodology presents a "paradigm of 'learning from doing' [and] has long been an integral part of [the school's] culture (home of an internationally-acclaimed design build program) and was seen as a means to both train architects-to-be with the skills to succeed in practice and as a way to cultivate the values of community engagement, leadership, and service … to prepare 'citizen architects' (DESIGNhabitat: Overview). While the DESIGNhabitat 3.0 (Dhab3) collaboration does not include a construction component (to date), the studio did afford opportunities to integrate building and environmental technologies course work into the studio as well as to focus on the energy performance of the design prototypes via HERS models.

Figure 1. DESIGNhabitat 3.0 urban prototype HERS 66 (Henninger, Petersson, Shows).

DESIGN OBJECTIVES

The Dhab3 initiative was conceived as a research studio focused upon four primary objectives outlined by prior research and new opportunities identified by AAHA:

1. **Energy Performance.** To take advantage of an agreement between AAHA and Habitat for Humanity International (HFHI) to participate in a Sustainable Building grant initiative sponsored by Home Depot[2]. The initiative provides affiliates direct financial assistance to construct homes that meet Energy Star[3] requirements (Home Energy

Rating System – HERS Index of 85) and additional financial assistance to move from Energy Star to High Performance (70 HERS Index) with certification under a national or regional certification standard such as Green Globes, LEED for Homes, or Earth Craft.

2. Improved Spatial Qualities. To calibrate the spatial qualities of the home with passive design strategies.

3. Pre-Fabrication methods + mix. To expand upon prior research into the mix of site and prefabrication delivery methods that were viable Habitat affiliates in the state and region. Responding to the conclusions upon the completion of Dhab 2.1, namely the "challenge of finding the optimal balance between site and factory constructed components of the home, and the challenge of further stretching the design quality potential of the modular construction process" (Hinson and Norman 4), as well as the need to reconcile "factory-based production … with Habitat's volunteer-builder culture and its need for "sweat equity" work by the prospective homeowners" (Hinson and Norman 7).

4. Outreach Design. To expose students to the challenges and opportunities of designing affordable, energy efficient homes in collaboration with a project team, while utilizing their skills in the service of the community.

DESIGN PARAMETERS

The studio teams worked without a specific client family or a specific site. They were, however, given a generic site common to many Habitat affiliates. Using infill lot dimensions common to many municipalities throughout the urban centers of the state and region, a lot size of 50 x 150 was assigned as a physical constraint above those imposed by the fabrication technologies the student teams were to investigate. The students were also given additional parameters, which included Habitat for Humanity International (HFHI) floor area standards for two, three, and four bedroom homes, HFHI homeowner 'sweat-equity', Energy Star minimum performance benchmark, and average construction cost of $60,000 (three-bedroom).

The design of a prototype for an organization that is built around volunteer labor requires a solution that recognizes the importance of the construction process, not just as a means to produce a decent house or increase efficiency, but also as a means to build community. Therefore, the objective of identifying an appropriate mix of site and prefabrication has as much to do with the limitations of the interface of various assembly methods as it does with the size and availability of the pool of volunteer builders.

In addition to these considerations, the students were asked to build upon the premises of Dhab1 and Dhab2 - that refined design (environmentally responsive strategies, increased energy performance, life of mortgage cost analysis of systems, as well as consideration of delivery method) is possible for HFH Affiliates. This diversity of affiliate locations, size of volunteer pools, and capital, presented both design problems and opportunities that the students were asked to explore in their proposals for DESIGNhabitat homes.

DESIGN PHASES

There were three phases of the project, which occurred over the course of the semester. The first phase began with a design research problem, which involved the modification of the first Dhab prototype for a nearby HFH affiliate. This phase served as a useful introduction to HFH affiliate structure. Additionally it provided the students with a successful Dhab model to introduce them to the design strategies which previous classes had utilized.

The second phase was an intense week long research phase during which the students sought to identify innovative approaches to pre-fabrication in residential construction and included: methods of pre-fabrication and assembly, issues of energy performance and rating systems, and precedents in affordable pre-fabricated housing. The students compiled their findings and presented their research to one another allowing all to consider the evaluations of specific assemblies and 'green' rating systems.

The third phase was the design of the DESIGNhabitat 3.0 prototypes. Throughout this phase the students benefitted from workshops with the State Association of Habitat Affiliates Sustainable Building Specialist (SBS), who was instrumental helping the studio evaluating the viability of energy performance options with respect to the ability of habitat's volunteer builders to meet the performance level targeted.

In teams of three, the students began to design a family of prototypes, which required a strategy regarding levels of prefabrication. Many of the teams, and eventually all, decided to use Optimum Value Engineering (ove) framing. OVE framing established a base two foot module for the floor plan, which afforded a realistic foundation for both open panel and panelized systems as well as modular assemblies. After working through a 'parent' three-bedroom scheme the teams were asked to quickly test whether or not that scheme could logically morph into a two bedroom or four bedroom house. After verifying the plausibility of that approach, they were asked to look into the active systems that would support the passive design strategies they had suggested and provide both a cost estimate and energy performance estimate.

Utilizing workshops with AAHA's Sustainable Building Specialist, the students were able to determine the implications of their design decisions upon the energy performance of the scheme and quickly evaluate the results and modify their proposal. This was performed in collaboration with the state habitat sustainable building specialist, who met with the teams to consult on energy performance by using REMRATE to assist in determining HERS index numbers for all of the teams. *See Figure 2.* Additionally, student teams were utilizing other software to test their schemes (primarily HEED and climate consultant). This combined approach to understanding energy performance allowed the students to see the implication of the decisions they had been making incrementally with regard to systems, assemblies, and material selections, as well as the impact of framing decisions. Utilizing multiple software to analyze the prototypes also revealed some limitations of the software (REMRATE) that was used to determine HERS Indices for the designs. These limitations included the inability of the software to asses the benefit of cross ventilation strategies, assessed additional volume negatively (though increased ceiling height allowed for teams to siphon heat out through openings located high on side walls), factor on-site energy generation (though not specified in any of the proposals – many of the schemes determined roof pitches and orientation based upon solar access for possible future installation of solar devices). Future investigations will need to utilize expand the research to include CFD modeling and/or physical modeling to test passive ventilation strategies.

The students made presentations to the AAHA twice before the State Association of Habitat Affiliates Annual Conference. At each occasion student teams were required to present material that described the projects response to the initial objectives, provide a cost estimate, a projected HERS Index, and present a viable path to achieving High Performance certification. The schemes vary but share several common strategies that serve as the general proposal to the affiliate representatives at the conference.

	INITIAL HERS INDEX		DESIGNhabitat 3.0 prototypes				
PLAN	Mobile	Madison City	team 1	team 2	team 3	team 4	team 5
	AAHA Affiliate Ratings						
bedrooms	3	3	2	4	3	3	4
area	1070	1056	939	1196	1060	1036	1407
volume	8560	8448	8838	18642	8046	11136	13355
shell area	3316	3200	3719	5763	4380	4927	4934
glazing count	8	8	**14**	10	11	11	**27**
window:wall	0.119	0.092	0.12	0.027	0.075	0.068	0.131
window:floor	0.013	0.092	0.201	0.08	0.148	0.164	0.259
CFM50	800	800	1302	2017	1533	1724	1727
ELR	0.241	0.275	0.35	0.35	0.35	0.35	0.35
window	u34s30	u38s31	u31s26	u35s31	u60s38	u49s62	u49s62
seer	14	13	15	14	14.5	13	13
surface area:volume	0.39	0.38	0.42	**0.31**	0.54	0.44	0.37
RATING							
Mobile	70	85	79	**68**	77	89	90
Montgomery	73	86	81	70	79	90	93
Huntsville	73	83	80	70	79	90	92

Figure 2. Initial DESIGNhabitat 3.0 HERS Index Report

DESIGN STRATEGIES

The following strategies are common to all of the teams, and while teams explored the strategies with varying intensity the strategies studied can be generally categorized as passive design strategies, fabrication and assembly strategies, mechanical systems strategies, and energy performance strategies.

1. Design to contract the cooling season, orient the building properly, include site evaluation as a prerequisite, maximize opportunities for cross ventilation, increase daylight levels, and select appropriate durable materials and assemblies. *See Figures 3-4.*

2. As a framework for prefabrication the teams proposed to use a two foot by two foot module (OVE framing) which will minimize waste (whether in a factory or on site), reduce thermal bridging, and to allow for a shift from site built to open panel or panelized to modular construction.

The teams also propose to utilize prefabricated roof trusses to increase ceiling height, particularly when the space can be vented through a high opening. *See Figures 3-4.*

3. To utilize best practice in construction methods, and optimize passive design to minimize the size of and need for the hvac systems. Utilize best practice in location of utilities and utility runs. *See Figures 3-4.*

4. To utilize as much donated insulation as feasible and utilize volunteer builders to complete critical tasks such as sealing the envelope, and to specify systems and durable materials and components that will last the life of the mortgage.

5. To design for potential additions and adaptations. All of the teams studied the optimal orientation of their proposals, and a few studied truss profiles based upon solar access for possible future installation of solar devices as well as possible collection of rainwater for site irrigation with a long-term possibility for grey water system integration.

PROTOTYPE DESIGNS

Figure. 3 Prototype Design (Beeker, Mathias, Porth)

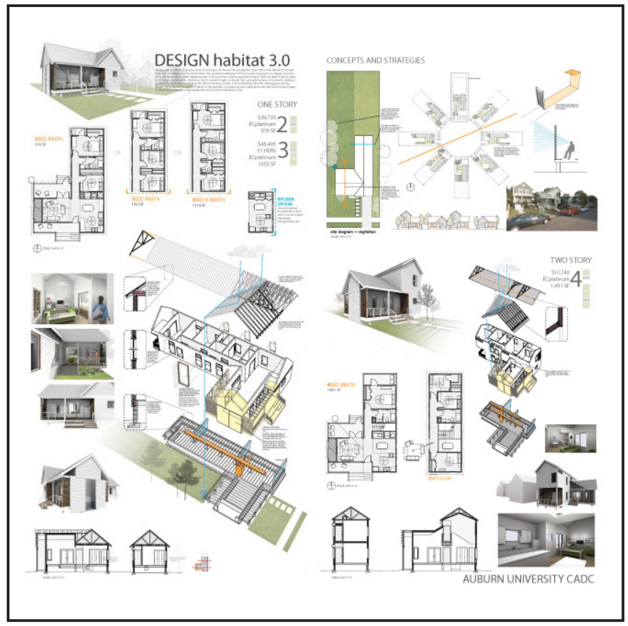

Figure 4. Prototype Design (Henninger, Petersson, Shows)

CONCLUSIONS

As I reflect upon the work of the studio, I can draw some conclusions that will be carried forward as the collaboration evolves.

1. Energy Performance. The student proposals provide _AHA a set of prototypes that adapt to the size and skills of local affiliate volunteer builders while maintaining a base Energy Star rating of (HERS Index 85), which allows affiliates to obtain financial assistance from HFHI. The initial 85 HERS Index target, as the students discovered, can be met with added insulation, proper building sealing, and considered assembly and material selections. The benchmark of a minimum Energy Star rating initially made sense as the state for which the prototypes were designed does not have a statewide residential energy code.[4] And as the average US home has an HERS Index of 130, an Energy Star home would conservatively represent a 15% reduction in energy consumption (IECC 2006 = HERS Index 100). Although meeting the Energy Star goals provided a good challenge for the students, low income families in the state and region spend approximately 33% of their income on utilities.[5] A better target (within the constraints of an affiliate budget) would have been an HERS Index of 50.[9] Were the prototypes that were developed subjected to another round of design it is conceivable that a HERS Index of 50 would be feasible as the mean for the studio was 61-62. *See Figure 5.*

DESIGNhabitat 3.0 prototypes	INITIAL	TARGET A	TARGET B	FINAL	TARGET A	TARGET B
HERS INDEX	*initial index**	85	70	*fianl index**	85	70
Prototype 01 _ 3 bedroom 1100 sf	94	+9	+24	57	-28	-13
Prototype 02 _ 3 bedroom 1100 sf	91	+6	+21	64	-21	-6
Prototype 03 _ 3 bedroom 1100 sf	91	+6	+21	66	-19	-4
Prototype 04 _ 3 bedroom 1100 sf	84	-1	+14	60	-28	-10
Prototype 05 _ 3 bedroom 1100 sf	105	+20	+35	66	-19	-4

** projected index as simulatedin REM/RATE*

HERS INDEX 100 = IECC 2006 COMPLIANCE
HERS INDEX 85 = ENERGY STAR COMPLIANCE
HERS INDEX 70 = HFH High Performance Threshold

Figure 5. Final HERS Index Report

2. Improved Spatial Qualities. The prototypes borrow from regional vernacular in order to contract the cooling season by providing tempered spaces (porches) and narrow floor plates that allow for ample cross ventilation and ensure ample natural light. Consequently these decisions improve the energy performance of the homes.

3. Pre-Fabrication methods + mix. First a fully scalable design is not likely, while the students earnestly proposed that this was indeed viable, the schemes at present start from an essentially site built disposition. I feel that this would not have been the case had visits to panel manufacture facilities been conducted. The objective of determining an appropriate mix of site built and factory built components will be tested in a future collaboration.

4. Outreach Design. While the prototypes present viable designs for the client, the value of the endeavor to the students centered on designing for a client group typically not served by the architectural profession. In doing so the students were confronted with the fact that the design decisions they make have a significant impact upon the lives of their clients that extend beyond the spatial and into the fabric of the clients socioeconomic well being. An additional success of the studio was the students' engagement in the design of assemblies and building systems where the performance could be verified by engaging a consultant in the design studio, which allowed the students to respond to the consultant's feedback and incorporate that feedback into the design process.

This simulation of the prototype design's performance forced an iterative process due to the demonstrable failure (the first round of HERS Index scores were instrumental in focusing the students energies) required the students to think holistically about a design proposal and draw upon material that had been covered (though not applied with the degree of precision Habitat demanded) in prior semesters of their education.

REFERENCES:

Hinson, David and Stacy Norman. DESIGNhabitat 2.0 + 2.1: TWO CASE STUDIES IN PRE-FAB AFFORDABLE HOUSING. ACSA Conference Proceedings; Without a Hitch. ACSA Publishers, 2008.

Lechner, Norbert. Heating, Cooling, Lighting: Sustainable Design Methods for Architects. 3rd ed. New York, New York: John Wiley & Sons, Inc., 2008.

ENDNOTES

1. http://www.cadc.auburn.edu/soa/design-habitat/overview.html
2. http://www.alabamahabitat.org/
3. http://www.energystart.gov
4. http://www.energycodes.gov/implement/state_codes/index.stm
IECC states with / without state wide residential codes.
5. http://www.natresnet.org/alabama
The cost of utilities for a home is the highest cost of homeownership outside of the mortgage loan.