RICE UNIVERSITY
Dirty Assemblies

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Abstract

This thesis is a critical analysis of the existing building culture in Houston, including the material choices and lifespans that make up the current conditions. Rather than accepting the anonymity of construction materials and practices, this project disrupts the seemingly inevitable inertia of these norms. This project speculates about an alternative future of building working within the framework of the seemingly banal existing construction assemblies through the exploration of a case study house as a lab of living building materials, capturing a testing ground in a moment of transition.
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Part 1: Preface

Introduction

Existing Construction Culture

Alternative Approaches

Figure 2: Physical model showing facade application of biomaterials.
Introduction

As architects we are called to study multiple disciplines to compile them in our own hierarchy of the world we both shape and live in. Is the role of an architect to autonomously show the public what can be achieved even if it seems improbable, or does it lie more along the lines of accommodating every whim of a demanding client? I believe that architecture never stands alone: therefore, it does not belong to either of these extremes. It is too interwoven and embedded in our lives and inherently must draw on its own sensibilities and lineage while simultaneously incorporating the latest technology, social and cultural aspects, and tangible construction considerations.

In today’s construction world, are architects at the behest of industry, with material markets ultimately driving what is built by what they offer and make the most profit from? Or is architecture purely a service profession where the customers drive design? Where is the agency of the architect in this system? Instead of accepting the inertia of the current construction material criteria and ubiquitous material catalogs, how can architects challenge the existing criteria and change the taste range of customers?

Coupled with these pressing questions are the looming effects of the construction waste stream. In the last 30 years, waste from construction and demolition has increased threefold in the U.S. alone, and construction waste is responsible for as much as 40% of the estimated 250 million tons of American consumer solid waste generated annually. Buildings are unique in the way they decompose, as succinctly defined by Stewart Brand’s “shearing layers of change:” because of the different rates of its components, a building is always tearing itself apart. There is an interdependence across these various layers that bears reexamination.

Dirty Assemblies changes the contemporary relationship between design and construction materials. Rather than accepting the current disconnect between material procurement processes and design, with materials selected from a pre-determined catalog, or pursuing performative aspects of material experimentation for exhibitions, this thesis project will bring these two worlds closer together. It will examine both specific materials, construction processes, and the criteria in which materials are selected and used today.

This project asks: How can we expand definitions of construction materials as the built environment confronts questions of limited lifespans, resources, and supply? How can we as designers question norms of the current construction market and our understanding of contemporary building practices? How can we rethink our design process to include considerations of disassembly, reuse, and bio-materials?

Dirty Assemblies examines contemporary material culture and practice. It challenges the existing framework for material sourcing, composition, lifespans, and reuse. It examines the origins of the current material procurement methods and looks for the relevancy of alternative material processes through the lenses of design, culture, and environment. It surveys the existing body of alternative materials and focuses on how to undertake similar processes in a specific case study with a focus on the available resources and cultural understanding of the site. The ultimate impact of this study is to challenge the existing paradigm of construction materials and redefine the criteria of material selection.
Existing Construction Culture

This thesis is a critical analysis of the existing building culture in Houston, including the material choices and lifespans that make up the current conditions. Rather than accepting the anonymity of construction materials and practices, this project disrupts the seemingly inevitable inertia of these norms. This project speculates about an alternative future of buildings working within the framework of the seemingly banal existing construction assemblies through the exploration of a case study house as a lab of living building materials, capturing a testing ground in a moment of transition.

As designers, we work with a pre-existing catalog of building materials and methods. Large building suppliers and model home companies epitomize this through endless combinations of the same materials over and over. This project asks what this standardization tells us about our building culture and what agency designers have in this realm to expand the options beyond the typical residential materials of stone and brick facades. Often, these materials are combined in set styles that attempt to evoke certain American architectural movements but the narrow range to draw from results in very few novel design solutions. While there is a set palette of materials that make up typical American building, they are sourced from all over the world, furthering the anonymity of the buildings produced.

Fig 5: Architectural “styles” offered by a residential general contractor.
The typical American residential building uses wood-frame construction due to its ease and speed of assembly. An abundance of timber in the U.S. has made this method easy to source and sustain. A standard residential wall section consists of 2x4 timber framing, batt insulation, plywood sheathing, a housewrap such as Tyvek, and an exterior siding material. Each of these layers has a different lifespan, but because the wall section is so compressed it is impossible to change out an interior layer without affecting the other layers.

This project both criticizes and takes advantage of the element of time as a design tool. As each layer or system reaches the end of its lifespan, it is replaced with a bio-material. This acceleration and change in types of maintenance demands a different way of living-with, rather than just living-in our built environment.

Fig 6: Axonometric section of a typical residence with individual material lifespans.
Humans have a long history of building with local materials, from adobe to tree branches to animal hides. Regional availability of resources determined building components and architectural styles. Industrialization and subsequent globalization led to a wide variety in building material type and origin. With coupled with rampant consumerism and waste, this becomes an environmental problem. The acquisition, sourcing, production, and transportation of building materials contribute greatly to local pollution and emissions levels.

When researching alternative materials (i.e., building materials not typically used in the United States), I categorized the projects into material definitions and construction strategies. This was a helpful way to condense the vast world of materiality and ultimately each category was represented in the final thesis project.
Bio-Materials

This category considers cultivated building methods. Most materials that fall into this category can be composted after original use and become the base for the next generation or generations of building materials in a continuous cycle, creating a compostable architecture. These materials have the potential to be grown where needed, reducing the need for intensive transport, and also actively absorb CO2. There is an acknowledgment of a limited lifespan, but the nature of bio-materials couples growth cycles with replacement cycles.

Drawbacks include growing time, limiting factors of growth, and limits on lifespan. There are also questions of utility: waterproofing, fireproofing, and adherence with other standard building guidelines.
Reuse

This category deals with the reuse of existing building components, taking advantage of the previous intensive manufacturing and transportation that brought these building components together. This continues the lifecycle of smaller components even if the original building no longer exists in its initial state. This also brings up the concept of urban mining which makes no distinction between waste and supply. An example of this concept would be using local buildings as a source for concrete aggregates. This was a common practice until the beginning of the twentieth century, when the rise of industrialization and highly specialized components and adhesives made it more difficult to reuse materials.3

Potential drawbacks include the careful labor that goes into dismantling buildings in a way that allows for reuse of components, and if the original construction allows for this to happen easily. This also requires designated storage space and equitable access.

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3 Carly Jacobs, Katie Souliere, Susan Sawyer-Beaulieu, Abir Sabzwari, and Edwin Tam. 2022. “Challenges to the Circular Economy: Recovering Wastes from Simple versus Complex Products” Sustainability 14, no. 5: 2576. https://doi.org/10.3390/su14052576

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Fig. 15: RotorDC disassembles and salvages materials from existing buildings. The tiles from the floor of this building will be used in another project.

Fig. 16: The cooperative boasts 4000 sqm of reclaimed building materials.

Fig. 17: Pavers and other exterior materials.

Fig. 18: Block Architects, Vegan House, Ho Chi Minh City, Vietnam 2014

Fig. 19: This type of shutter is widely used in Vietnam for its excellent ventilation capacity.
Re-purposed

This category contains materials that are built from components of raw waste that are reconfigured and rearranged, tapping into the implied possibility of changed form. This continues a long tradition of building with local materials; in this case the materials are human generated waste, primarily single use plastics.

Potential drawbacks include concerns about toxicity for both humans and non-humans and questions of longevity.

Fig. 20: Plastic Bottle Village - Recycling Plastic Bottles with Eco-homes.
Fig. 21: Gjenge Makers, Plastic Bricks. Nairobi, Kenya
Fig. 22: Earthship Biotecture, Taos, New Mexico.
Fig. 23: Project: DWG & LOOS.FM / Enschede, The Netherlands, 2014
Tool Kits

This category further considers the idea of circular buildings by focusing on the idea of assembly, disassembly, and reassembly. Parts in these kits would be designed and constructed in a way that considers the future use and reuse of each component in the initial design.

Potential drawbacks include highly specialized unique building connections or components.

Fig. 24: Structural Xploration Lab (SXL) Corentin Fivet / EPFL (Swiss Institute of Technology Lausanne)
Fig. 25: The Circular Building ARUP / 2016 London Design Festival
Fig. 26: All components needed to be implemented and utilized to their full potential and for the duration of their life cycle.
Part 2: Dirty Assemblies

Cultural Context
Site
Assembly

Fig. 27: Physical model showing interior and interstitial application of biomaterials.
Fig 28: Site map comparing the urban sprawl of Houston to individual residences found within the city.
A different way of design emerges with a careful assessment of overlooked materials as seen in these maps detailing plant and soil life in Harris County. To explore these themes, I looked specifically at Houston building culture and natural resources. Plant grass varieties are abundant as is clay and loamy soil.

Fig 29: Harris County Vegetation. Courtesy of Texas Parks and Wildlife.

Fig 30: General Soil Map of Harris County, Texas. Courtesy of University of North Texas Libraries Government Documents Department.
By considering existing materials within a site, we change our understanding of the world we live in and question the divide between the natural and built environment. By treating this thesis as an experimental laboratory to test multiple conditions and interventions, it then contributes back to the material catalog with alternative methods.

I chose dirt as a major material component to think about soil as a living thickness, making use of the cultural and biological energy of the land. As architectural theorist Helene Frichot describes in her book *Dirty Theory*, “dirt demands that we listen to the environment-worlds in the midst of which we lose and find ourselves, becoming and unbecoming.” In other words, dirt subverts order and opens up new possibilities.

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By choosing materials that require more active maintenance by the user, this changes our understanding of how we live in the world and relate to both our natural and built environments.

Buildings are unique in the way they decompose, as succinctly defined by Stewart Brand's "shearing layers of change:" because of the different rates of its components, a building is always tearing itself apart. There is an interdependence across these various layers that bears reexamination.

Fig. 32: Stewart Brand’s Shearing Layers of Change diagram.

This exploration of an alternate architectural reality is focused on a case study house in southeast Houston. This area has a mix of residential and low density industrial spaces common to the mixed programming throughout the city. While the natural material chosen is plentiful in Houston, the cultural context and existing construction practices would be a challenge to overcome. The intent is that this case study house will show what is possible and generate interest within the city. This case study would go on for one year with careful documentation. Then the design method would be revised and applied to multiple buildings of different programs.
Sited within a residential neighborhood, this single family home embodies the typical sprawl of Houston, and many other American cities. Modest mid century homes sit on large lots. The homes in this neighborhood have gone through a few rounds of typical home maintenance: replacing roofs, updating siding as needed. Many have been raised to mitigate flooding damage.
The case study house acts as a laboratory to test multiple systems in one place that will then be studied and more broadly applied. This is in a similar vein to the Stock Orchard Street House⁶, in which many conditions and material systems are tested in a familiar setting of a single family home. These interventions also consider the ontological nature of the home: what its inner life and experience might be and how to think about buildings this way while designing rather than continuing with a false sense of a tabula rasa. Due to its deep lot size, much of the material used in this case study house can be found directly on its site.

6 Matthew Barac and Sarah Wigglesworth, Around & About Stock Orchard Street (Routledge, 2011).
This house has already been through several maintenance life spans: it has been expanded, a second story was added, and it was raised to prevent flooding per city ordinance. The built environment as we see it today encompasses many changes and ideas: this project investigates a further step forward.
One departure point for targeting interventions in the case study house was a typical thermal assessment that reveals that the roof and south and west facades receive the greatest amount of heat throughout the day. This was a starting point to inform the application of interventions that can be more targeted when applied to other buildings.

Fig. 39 Graphic interpretation of sun exposure on summer solstice.
Taking into account these maintenance timelines and thermal considerations, there are many sites within the house that I targeted for material and assembly investigation. For the scope of this thesis, I focused most on the three sites of the facade, roof, and floor. Because this house acts as a lab, each of these areas would be further studied and tested in similar ways. These interventions combine elements of familiarity with atypical materials to explore new conditions and how unexpected spaces and experiences are produced.
Each of these interventions focus on the addition of thermal mass in unexpected ways. By blurring the interior and exterior, what is typically solid poche becomes inhabitable, bringing the exterior in and interior out. By adding space and air, I am interrogating the threshold of enclosure and the perceived divide it creates.
These diagrammatic plans emphasize the strategic thickening of walls as different materials and assemblies are applied. By the extreme thickening of the walls, the user experience and awareness of the interior environment changes. Using dirt to create new poche changes the perception of a divide between natural and built worlds. The dirt is now inhabited both by humans and non-human critters.

Fig. 43: Diagrammatic plans detailing thickening of poche and resulting floor plan.
The proposed interventions respond to existing conditions with non-traditional materials and techniques. There is a heavy emphasis on natural and growing materials and how they change over time to replace the current conditions and envelope.
The typical building envelope is responsible for distinguishing between interior and exterior. This project subverts these assumptions with unexpected material choices and compositions that explore both conditions at once.

Fig. 46: Roof plan with material facades shown as flattened lay-downs.
By working within the existing framework of construction, this process will gradually change the current culture of construction rather than fully wiping out current processes.
The case study lab uses a systematic approach adapted to different planes of wall, roof, and floor, mirroring the application of wood framing that is adjusted to support different functions in different planes.

The facade intervention is a thickening of the wall through the application of dirt and plant matter. Strategic carve outs accommodate the existing windows and emphasize the stereotomic qualities of the material. The wall uses construction waste in the form of 2x4 standard-dimensioned lumber as the mold to imitate the lap siding and retain familiarity of material expression. The voids are emphasized with a growing element: in this case a low maintenance plant such as moss. It softens the edges and slowly takes over. This system will slowly expand and consume the existing wall, eventually taking over and composting the existing house. As the original structure is eaten away, so too are the existing assembly logics prevalent today.
In a system similar to that of the wall, earth and plant matter are placed strategically on the roof to replace asphalt shingles as needed. Space within the framing structure is reclaimed with bio matter, and growing organisms, further blurring the boundaries between interior and exterior, hidden and revealed, natural and built.
The intervention for the floor is to add insulation to the floor level between the joists, and build up the floor height. It’s a spin on using hay bale insulation with the use of compacted prairie grasses.
Rather than proposing new construction of a similar process of rammed earth, this project focuses on the transitional space between current building and future new systems. It is a critique of deterioration: rather than rejecting material life spans as something to be immediately remedied with the replacement of the same materials, the acceleration of life cycles means the lifespan of each layer of the house is in constant flux.

Figs. 54-86: Assembly and maintenance diagrams.
*Larger scale drawings and descriptions can be found in appendix.
This new understanding of assemblies, materials, and processes changes the relationship between the natural and built worlds. By creating a messy living situation, we are forced to consider our surroundings and the messiness of living in the world.

Fig. 87 - 88: Cutaways of the case study house after material assembly, showing living condition and tectonics.
As this system takes over the building, it will eventually compost the existing construction. In the same way, this system is eating away at existing practices to transition to a more holistic system of bio materials.
After testing these systems on the case study house, the vision is that these interventions are strategically deployed across many building types in order to slow down the damage of construction while building up a counter-reality. This presentation shows a moment in time a few months past the installation.

The users of this lab house record their experiences in many terms: experiential, thermal, and maintenance. They plan to start similar interventions on other local buildings using these studies to produce a strategic, targeted application of materiality. Although their built environment has been subsumed with the natural, not all buildings using these assembly processes will be quite as heavy in terms of application.
This system is continued on the interior with a similar expression. Dirt infiltrates the everyday use and experience: contaminating bedding, clothes, and bath water. The inhabitants are confronted with the visible existence of their living space.

Fig. 91: Bedroom condition.

Fig. 92: Bathroom condition.
The kitchen and dining room play important roles in the home due to their centrality, elements of production, consumption, activity, and blurring of interior and exterior as products and food are brought in and converted. As the scale of these living walls starts to dominate the interior life and experience, the user exists alongside parallel realities of composition, compost, and lifespans.

Fig. 93: Kitchen condition.

Fig. 94: Dining room condition.
Dirt inundates spaces of work, study, and relaxation. The life of the building and life of the users co-mingle and become inextricable.

Fig. 95: Study condition.

Fig. 96: Living room and back porch conditions.
Feminist activist Sylvia Federici’s writings about often invisible domestic work say that “what we can do is expose what we are already doing, render it politically visible, and force the daily household chores to be recognized adequately as work.”

Drawing on these ideas, this project combines soil and domesticity as two realms of hidden labor that sustain life in many forms: natural, human, non-human, social, routine, etc. The merging of these realms makes each more apparent and forces the user to grapple with both throughout daily life.

7 Sylvia Federici, Wages Against Housework (Falling Wall Press, 1975), 74-87.
Fig. 97: The thresholds of interior and exterior are blurred and subverted with the application of bio-materials.
Introducing the results of the case study house into the mainstream construction market creates new methods and systems that can be broadly applied and eventually replace our existing materials and assemblies. This exploration of a transitional mode of building revolutionizes the value systems and methods that designers and construction professionals use. As we rework this paradigm, it raises the issue of the continuous labor of care and the question of who and what else should be considered in the creation and maintenance of buildings.

By treating soil, buildings, and humans as equal companions, the given paradigm is no longer valid, and the creation of a new system lends itself to an industry of building care.
Fig. 98: The merging of soil and domesticity makes each more apparent and forces the user to grapple with both throughout daily life.
This thesis is a stance on individual and collective relationships with the environments in which we live. A key supporting document is the *Catalog of Dirty Assemblies* which details building processes, experiences and metrics from the case study house, and insight into how to move forward with the findings from the building experimental lab house. It shows how to tangibly confront pressing issues of environment, material, and existing building culture. The catalog offers an accessible framework that makes us deeply examine what it means to inhabit the world today.
Conclusion

This thesis began with a search for an alternative building material or method. When focused into the specific context of Houston, the project was adjusted to acknowledge why the current construction methods have such momentum. Rather than inventing a new solution, a thoughtful application of the environment offers tangible and meaningful change. While it may be seen as a quiet intervention, I believe it is a starting point to a new way of living.

Dirty Assemblies was defended on January 12, 2023. Jury members included Mariana Ibañez, ElDante C. Winston, Scott Colman, Andrew Colopy, Carlos Jimenez, Troy Schaum, and Brittany Utting. Comments included the idea of building interiors pushing outwards, application across non-residential structures, and earth construction throughout history.


Rather than proposing new construction of a similar process of rammed earth, this project focuses on the transitional space between current building and future new systems. It is a critique of deterioration: rather than rejecting material life spans as something to be immediately remedied with the replacement of the same materials, the acceleration of life cycles means the lifespan of each layer of the house is in constant flux.

These diagrams break down the assemblies into specific steps and are further detailed in the Catalog of Dirty Assemblies as a how-to guide that is accessible to anyone who wants to use these interventions.
Fig. 66: Elevated mesh.

Fig. 67: Compacting around a window.

Fig. 68: Local plant matter will be placed around the edges of the frame to anchor the soil.

MAINTENANCE

Fig. 69: This wall system will require active maintenance by the homeowner, changing the relationship of humans and their dwellings. More soil may need to be added when fallout occurs.

Fig. 70: The plant life will also require upkeep and occasional watering.
Fig. 71: The floor intervention will require more height in the floor assembly.

Fig. 72: 2x6 joists create the necessary depth.

Fig. 73: Spacing between the joists.

Fig. 74: Bundled prairie grasses fill in the spaces between the joists and act as insulation.

Fig. 75: A similar process is followed in a building with multiple floors.

Fig. 76: Extra sill plates add depth.

Fig. 77: Spacing between the joists.

Fig. 78: Bundled prairie grasses fill in the spaces between the joists and act as insulation.

Fig. 79: Plywood subflooring is placed above the prairie grasses.

Fig. 80: Typical floor assembly follows.
ROOF

Fig. 81: The roof intervention takes place both in the rafters and on the exterior shingles.

Fig. 82: Soil is compacted into the rafters.

Fig. 83: Plant life such as mushrooms are placed in the soil.

Fig. 84: The roof intervention takes place both in the rafters and on the exterior shingles.

Fig. 85: Soil is compacted to replace shingles.

Fig. 86: Plant life softens the edges of the soil and shingles.