shipping containers as a building material in affordable housing

FHCC Day 2 Workshop - Container Housing

Presenter: Stephen Bender, AIA, bndr, llc

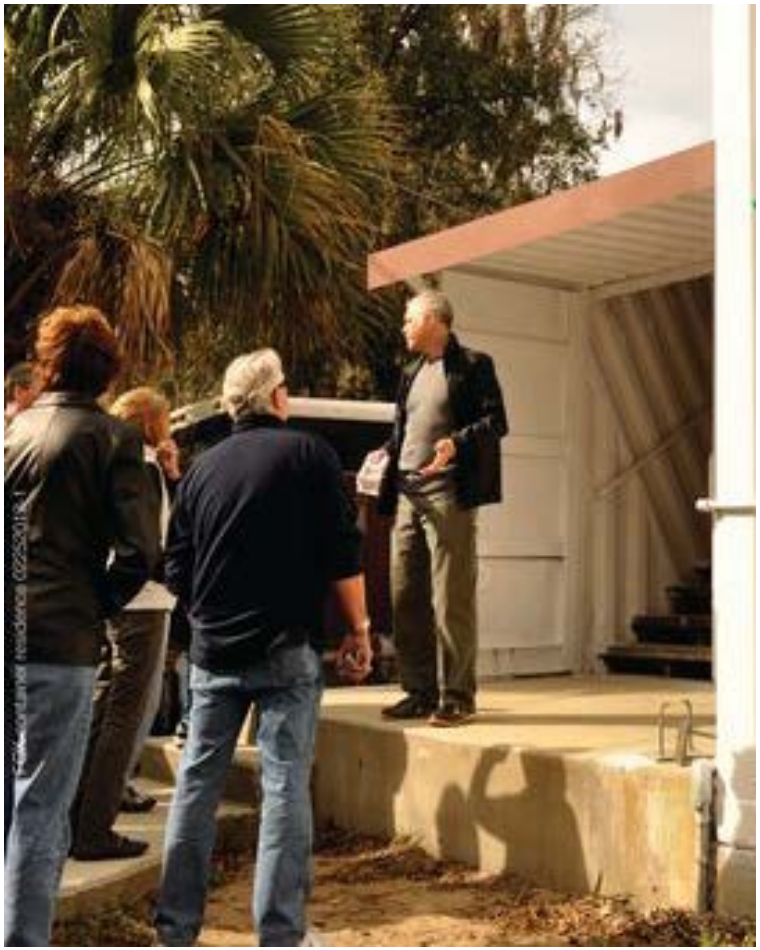
SEPTEMBER 13, 2016

introduction

Stephen Bender, AIA, Adjunct Assistant Professor Architecture, UF CityLab Orlando

I am…

- **Architect** (Specializing in Sustainable Design with Shipping Containers)
  - Bndr, llc www.bndrd.com
- Representing my client, **Crisis Housing Solutions**, http://crisishousingsolutions.org/
- **Professor** (University of Florida Program currently located at UCF in Parramore) https://dcp.ufl.edu/architecture/graduate-school/master-of-architecture/citylab-orlando/



introduction

Fox Container Residence, Gainesville, FL. 2012. bndr, llc.

Fox Residence, Gainesville, 2012

- 2450 square feet of conditioned space
- 1200 square feet garage and workshop
- 12 containers upcycled
- LEED for Homes Platinum Certification and FGBC Certification

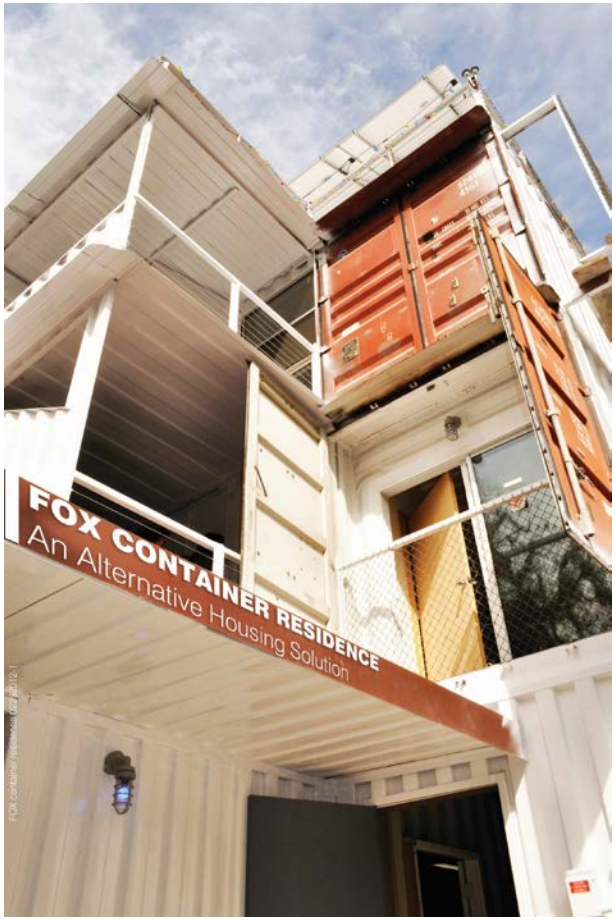
$83/sf conditioned area

$55/sf when figured total area

*not reproducible due to self-performed labor, friend-equity, recycling

"I built this house to give people the idea that we can all help solve our biggest problems by changing the way we think about our most important physical investment, our home."

- Tom Fox



shipping containers as a building material

multifamily structures

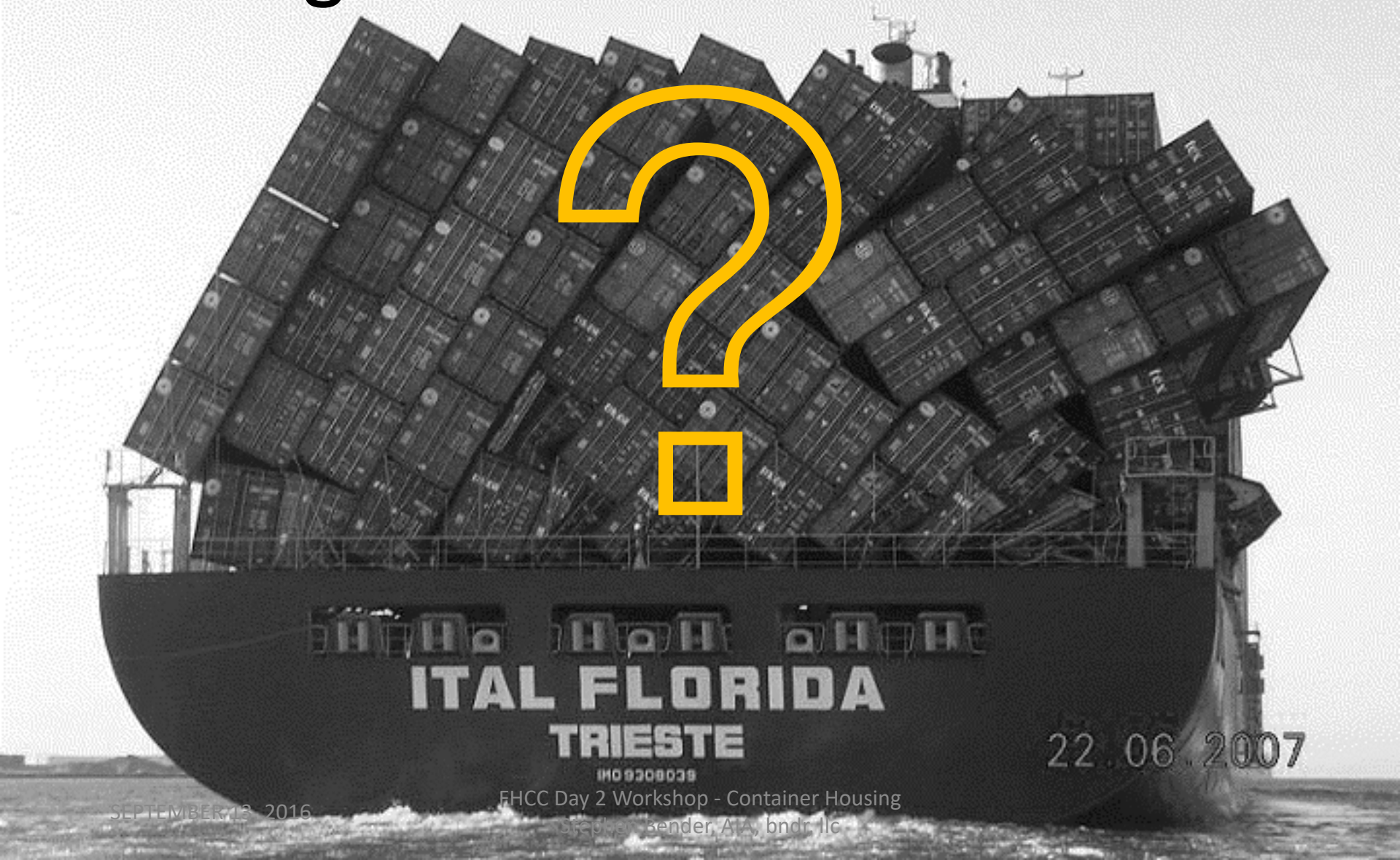
bndr, llc for CHS, 2015

http://www.bndrd.com/

single family structures

bndr, llc for CHS, 2015

is it a good idea?



CHS Feasibility Study Multifamily Design

Total Square Footage:

36,800

Location of Project:

Anywhere, Florida

Type of Project**:**

Affordable Housing

Container Commons is an affordable multifamily housing prototype consisting of 44 mixed size units totaling 36,800 square feet. The client desires to satisfy increasing demand for affordable housing in Florida cities and site the units close to jobs, amenities, public transportation and services. While this version of the design is sited on a block in downtown Davie, Florida, the design should be interpreted as a prototype that can be adapted to a typical block in many cities, approximately 2.25 acres. Currently, the development threshold unit count for affordable housing is 200. This precludes urban infill developments. This design is targeted to fill this development gap. This design was created for a recently completed feasibility study, commissioned by the client, that found the shipping container concept to be cost-competitive with housing built conventionally using reinforced concrete block with wood floor and roof trusses. This is an important finding because the benefits accorded to this project over conventional affordable housing designs are significant. Direct benefits to residents include community scale covered outdoor areas (sheltered courtyards), increased above grade outdoor spaces (terraces) adjacent to units, and low operating cost (energy efficient, low maintenance). Sustainable benefits include low carbon footprint due to upcycled and recycled material, highly durable building envelope, and design for disassembly and recycling.

CHS Feasibility Study Multifamily Design

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Site Plan – Davie, Florida Location

400 feet

N W E S

CHS Feasibility Study Multifamily Design

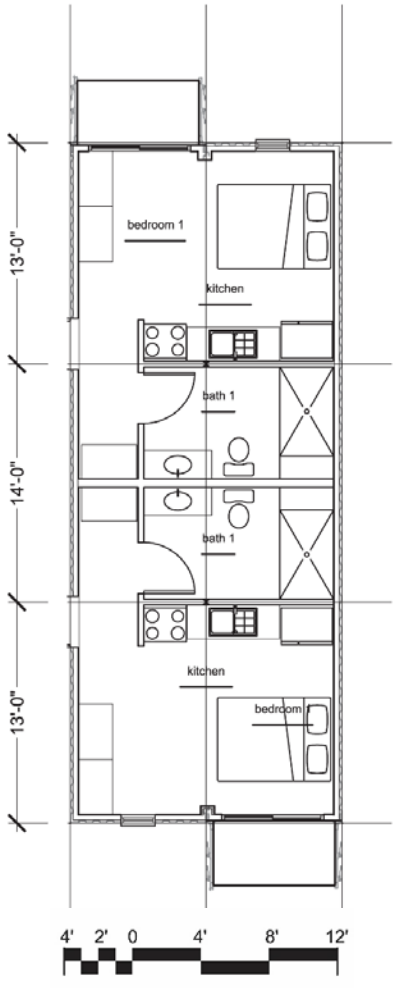
Stacking shipping containers to create multifamily housing offers unconventional but socially valuable exterior spaces such as large outdoor covered breezeways and wide upper level decks. These adjacent outdoor spaces offer opportunities for community connection that are not offered in conventional housing.

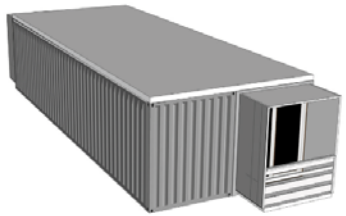
CHS Feasibility Study Multifamily Design

1e

efficiency unit
1 bedroom / 1 bathroom

320 sf each





Container doors are fixed into open position and fitted with covered balconies. These create deep openings suitable to shade interiors from south, east and west exposure.

The project features a mix of unit types ranging from 320 square foot efficiencies to 1260 square foot 3 bedroom. These unit sizes are comparable to market rate units forming a clear basis for comparison.

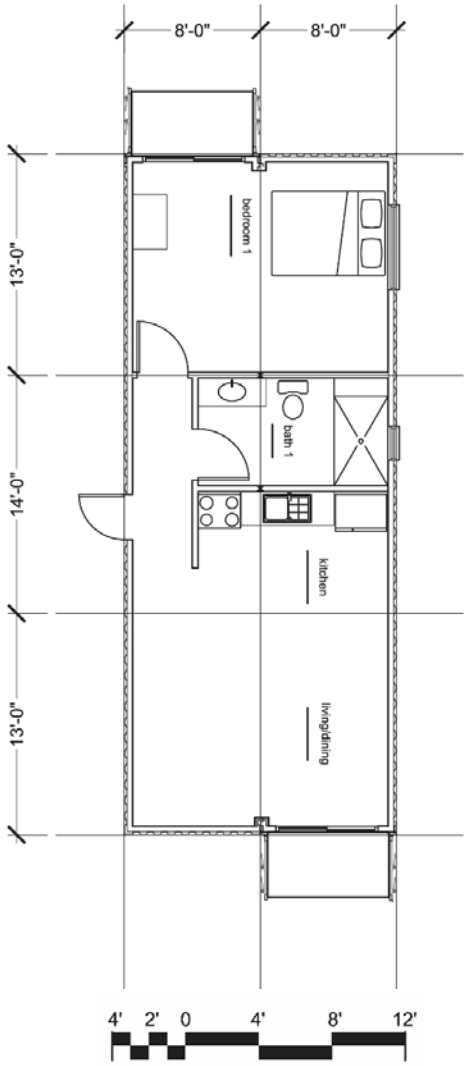
CHS Feasibility Study Multifamily Design

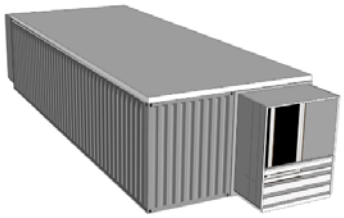
1/1

one bedroom unit
1 bedroom / 1 bathroom

640 sf each

In order to make use of the container unit for housing modifications must be made. Since a container is designed to do its job with the minimum amount of material, its loads are distributed over the chassis. Removing material compromises the structural integrity of units and requires reinforcement. Additionally, metal fabrication is expensive relative to other trades. Therefore container modifications must be strategic, systematic and minimal. Unit types are conceived with this in mind.



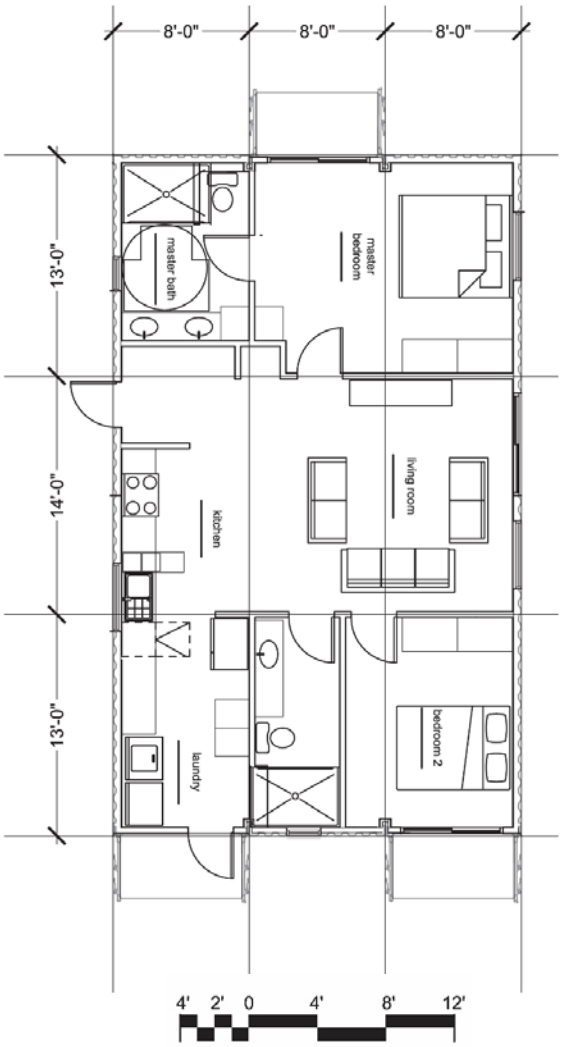


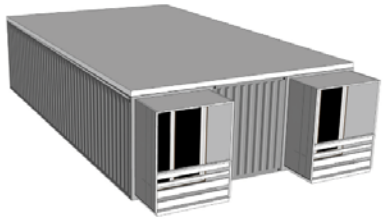
CHS Feasibility Study Multifamily Design

2/2

two bedroom unit
2 bedroom / 2 bathroom

960 sf each





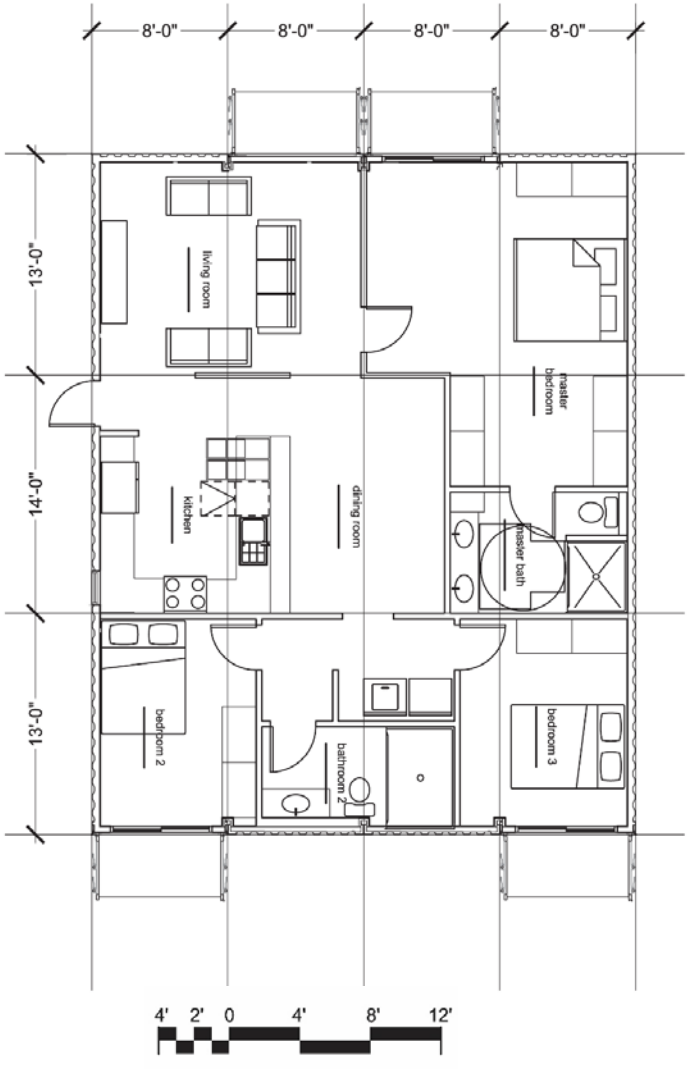
Because the design is based on modular units the number and type of units can be easily rearranged to accommodate different populations: low-income, elders, veterans, work-force, students... All units are designed to meet accessibility requirements.

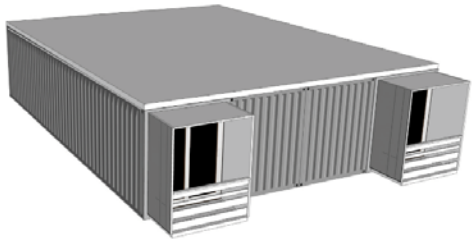
CHS Feasibility Study Multifamily Design

3/2

three bedroom unit
3 bedroom / 2 bathroom

1280 sf each

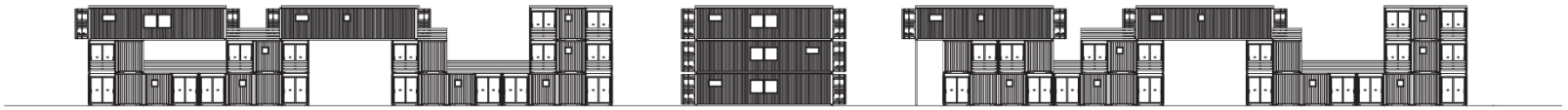


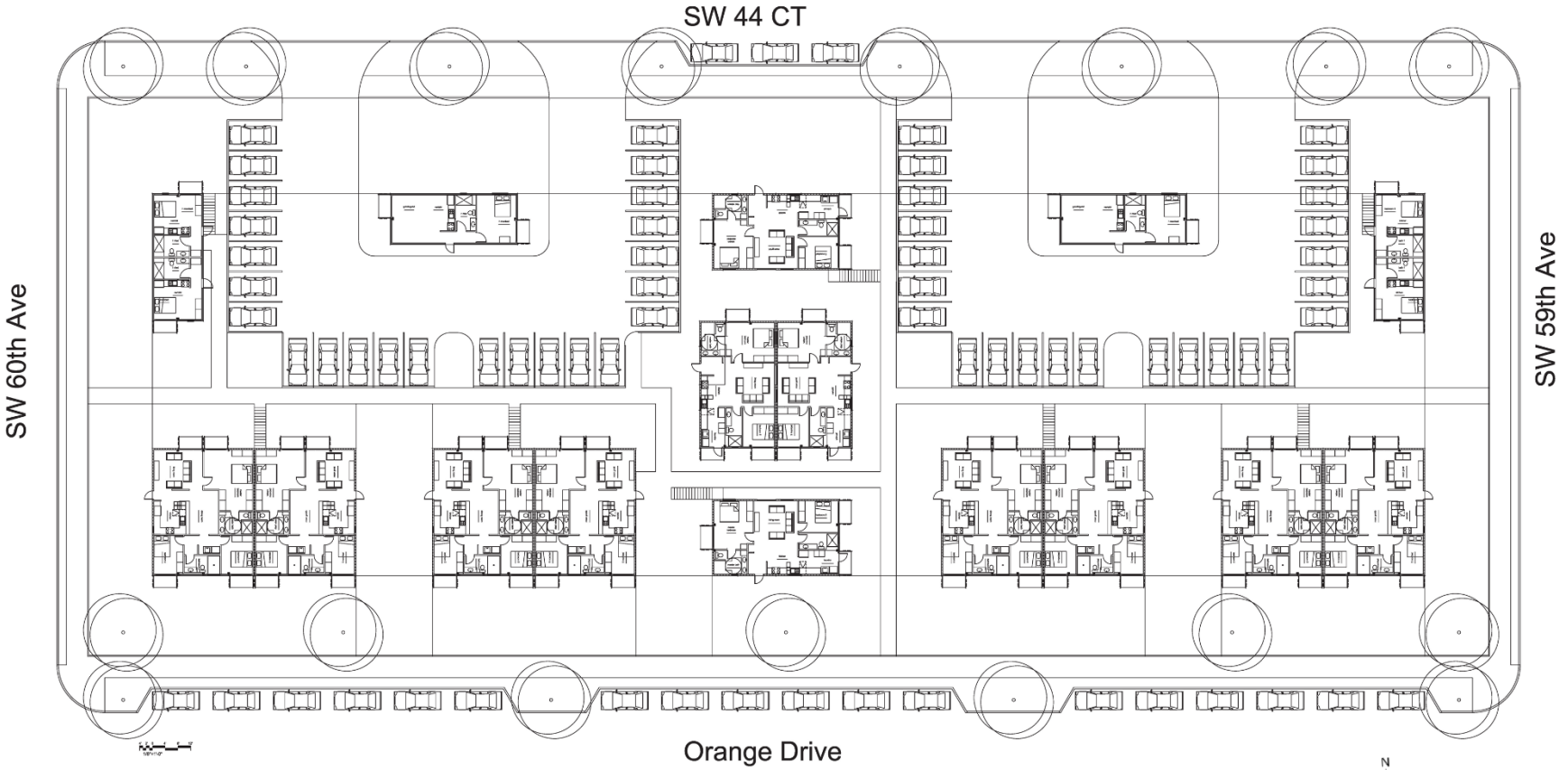


There are only three primary modified container types used in the design: right side removed, left side removed, both sides removed. Wall panel is removed completely from the side, steel columns are added and the entire span is reinforced. The added steel shapes are chosen to combine with the existing container steel to create efficient stable bearing members. The reinforcement is strong enough to allow partially prefabricated units to be transported to the building site. Units arrive modified, insulated, and prepped for building systems.

Because the design is based on modular units the number and type of units can be easily rearranged to accommodate different populations: low-income, elders, veterans, work-force, students... All units are designed to meet accessibility requirements.

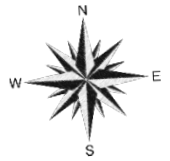
CHS Feasibility Study Multifamily Design





CHS Feasibility Study Multifamily Design

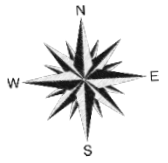
64 feet



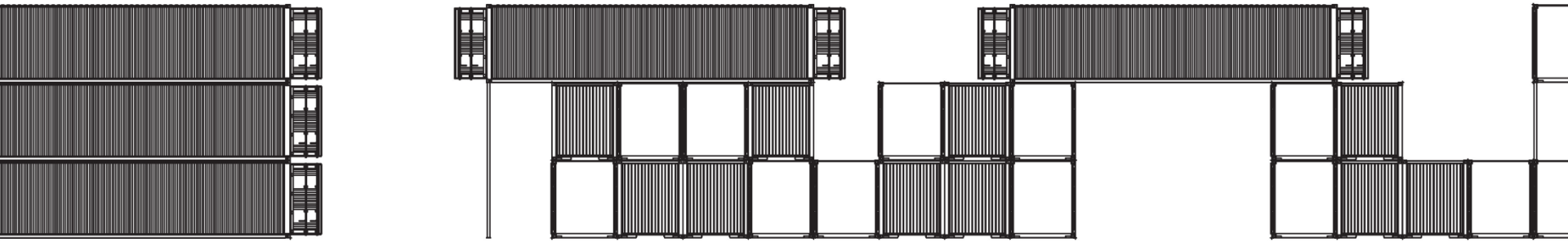
CHS Feasibility Study Multifamily Design

THIRD FLOOR PLAN

64 feet

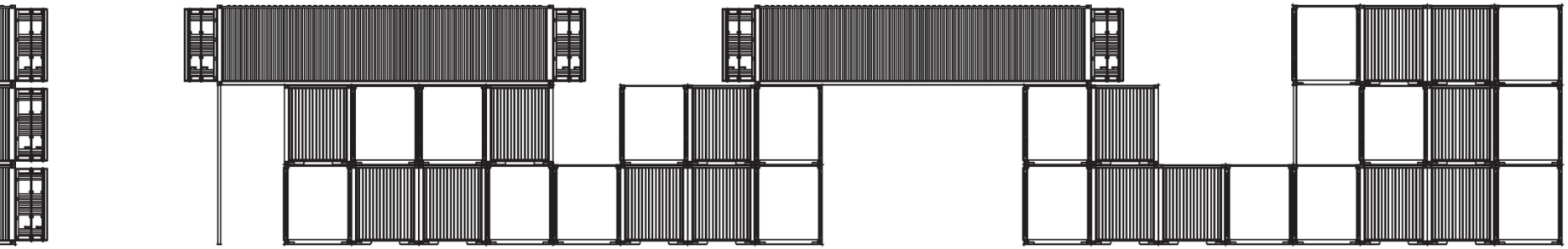


CHS Feasibility Study Multifamily Design



affordable housing concepts utilizing

shipping containers



workshop outline

shipping containers as a building material in affordable housing

- adaptability
  - durability
  - resiliency
- availability
- sustainability
- efficiency

Container City™ / Nicholas Lacey Architects 2001 – Phase two in 2003

http://www.containercity.com/projects/container-city-I

adaptability

Standardization is the key.

Shipping containers are made to standard **specifications**, including measurements. As such they provide **modular** elements that can be combined into larger structures.

Standardization and modularization, including the ability to prefabricate some elements increases construction efficiency making shipping containers an ideal low-impact construction material.

Keetwonen, Student homes, Amsterdan, NL. 1034 modules (housing + common areas + cafe + laundry). Tempohousing. 2006.

adaptability

Standardization - Modular

1950s. The International Organization for Standardization (ISO), based on US Department of Defense specifications standardized the shipping container:

8 feet wide x

8 feet 6 inches high x

20 feet or 40 feet long.

Put in housing terms, that's 320 square feet of floor area.

There are other standardized sizes but we will primarily address one other, known as the **high-cube**, which is

9 feet 6 inches high.

They are the most numerous.

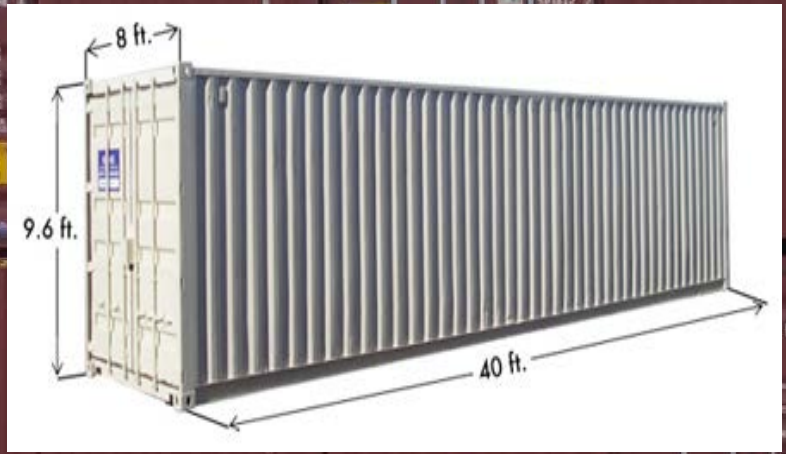
adaptability

Standardization - Modular

By the end of 2013, **high-cube** 40 ft containers **represent**ed almost **50%** of the world's maritime **container fleet**.

Standards:

- ISO 668:2013 Series 1 freight containers-Classification, dimensions and ratings
- ISO 1496-1:2013 Series 1 freight containers-Specification and testing-Part 1: General cargo containers for general purposes

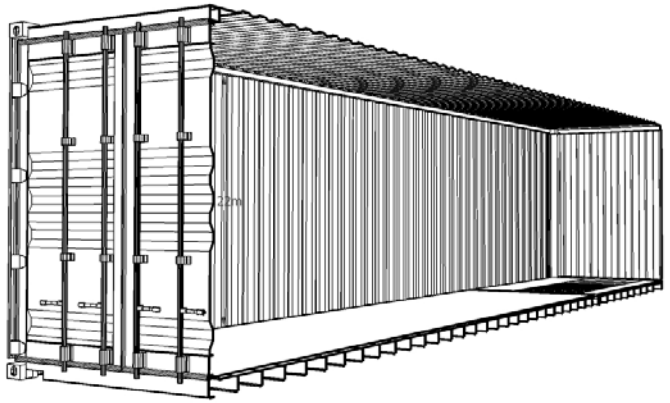


adaptability

Standardization - Capacity

Standardization includes exterior dimensions, interior dimensions, door aperture, internal volume, maximum gross weight, empty weight, net load.

The construction of the unit varies by manufacturer, but must remain within the tolerances identified in the standards.



High Cube Standard Container 9' 6" high								40'
Inside Dimensions			Door Opening		Weights			Capacity
Length mm ft	Width mm ft	Height mm ft	Width mm ft	Height mm ft	Max. Gross kg lbs	Tare kg lbs	Max. Payload kg lbs	m3 cu.ft
12 069 39' 7-1/8"	2373 7' 9-3/8"	2709 8' 10-5/8"	2335 7' 8"	2587 8' 5-7/8"	30 480 67 200	3820 8420	26 660 58 780	77,5 2740

adaptability

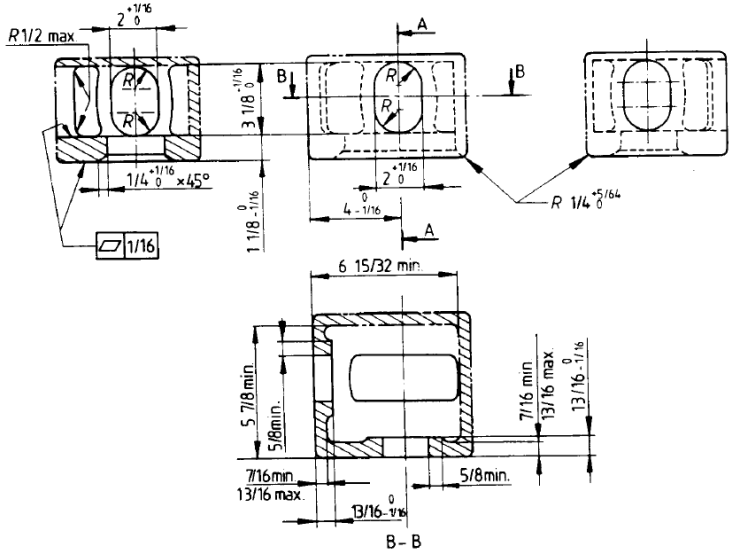
Standardization - Linking

Corner Castings-

Especially important for intermodal utility are the eight 7×7×4 1⁄2 inch corner castings which have a “twistlock” fitting.

This enables **stacking** and **securing** as well as quick connection and release from a host of hoisting and transportation equipment. These "knuckles" enable hooking the box from above, below, or the side.

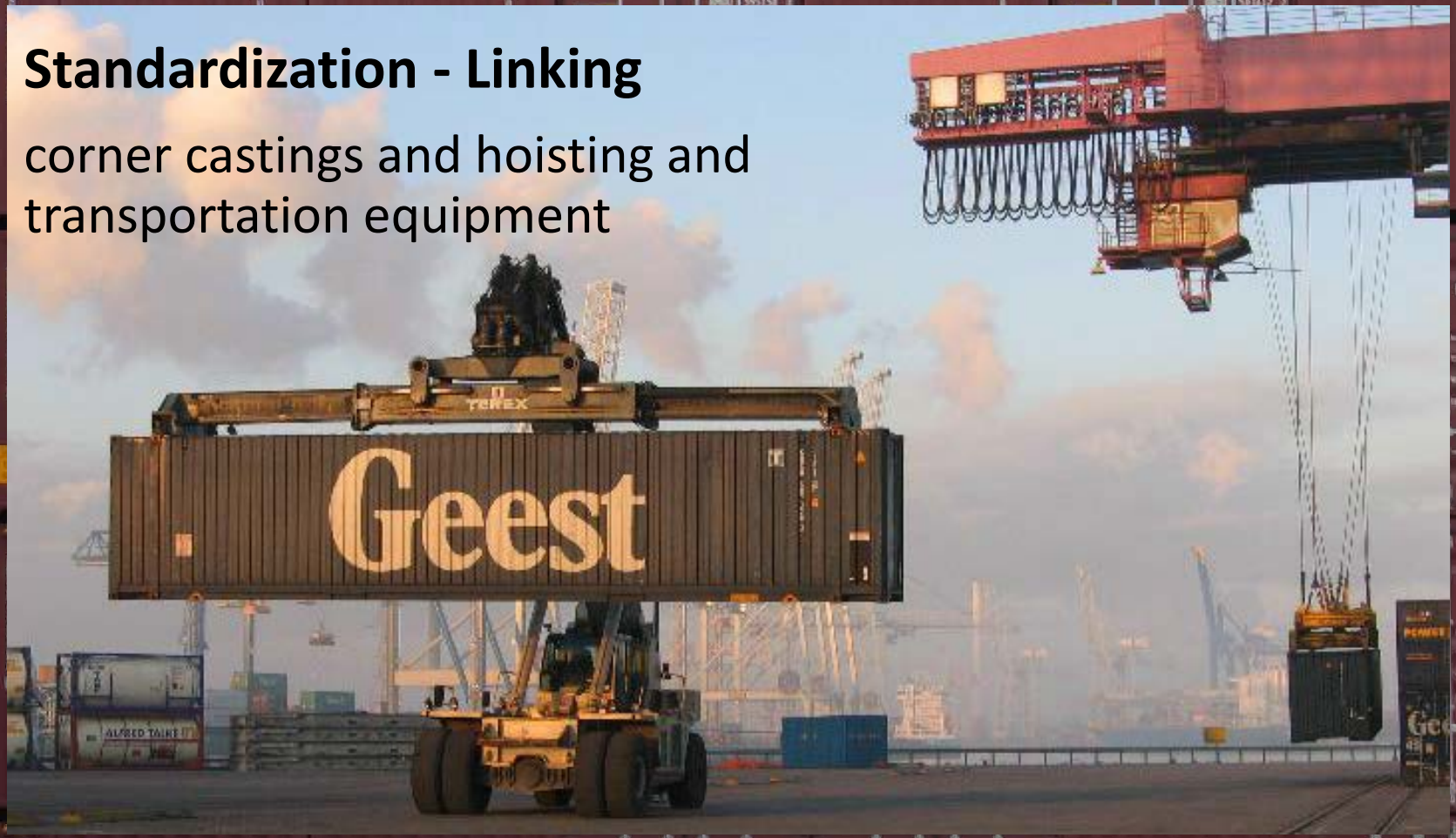
The standard castings on the eight corners of each container. The twistlock proper is done through a larger oval hole on the top or bottom. KMJ at German Wikipedia • CC-BY-SA-3.0



adaptability

Standardization - Linking

corner castings and hoisting and transportation equipment



adaptability

Standardization - Loads

Loads are applied at Corner Castings-

Load Path – pictured, 53‘, 48‘, 45‘, 40‘, and (2x) 20' containers stacked.

Load bearing of container stacking is at the 40 ft knuckles.

https://3dwarehouse.sketchup.com/user.html?id=14080708769653596985481 09

adaptability

Standardization - Loads

Load Capacity-

40 foot high-cube load:

- empty weight 8,380 lb
- net load capacity **57,759** lb.

In terms of housing?

*That's **180** pounds per square foot of live load*. That's 4 ½ times residential live load (40 psf).

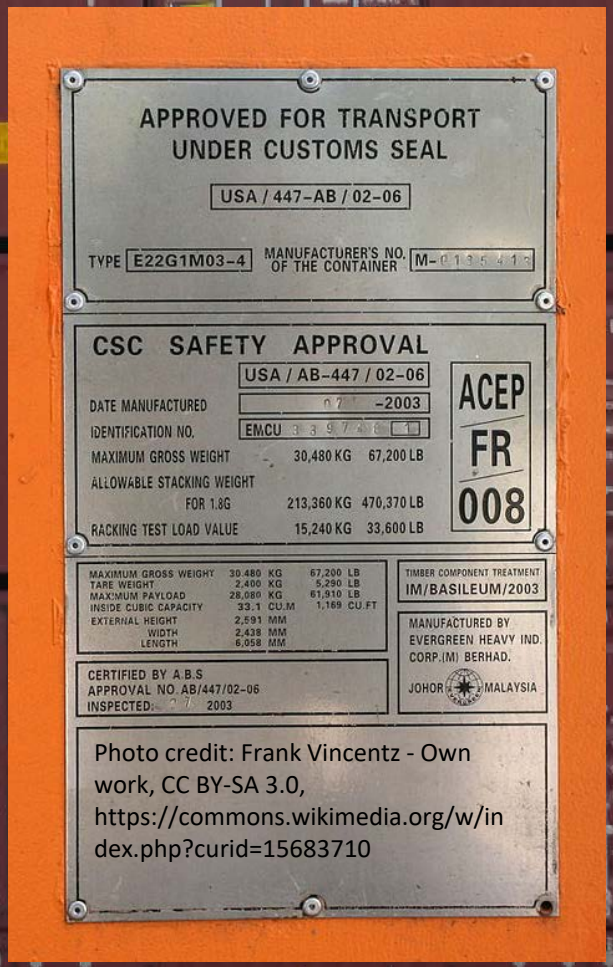


Photo credit: Frank Vincentz - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=15683710

adaptability

F-Store (Freitag) Zurich. Annette Spillmann & Harald Echsl architects.

Standardization - Loads

Load Capacity-

Units manufactured after the 1990 standard can be stacked up to nine units high.

That means that the corner column of the bottom of a stack of fully loaded units is carrying 130,000 pounds.

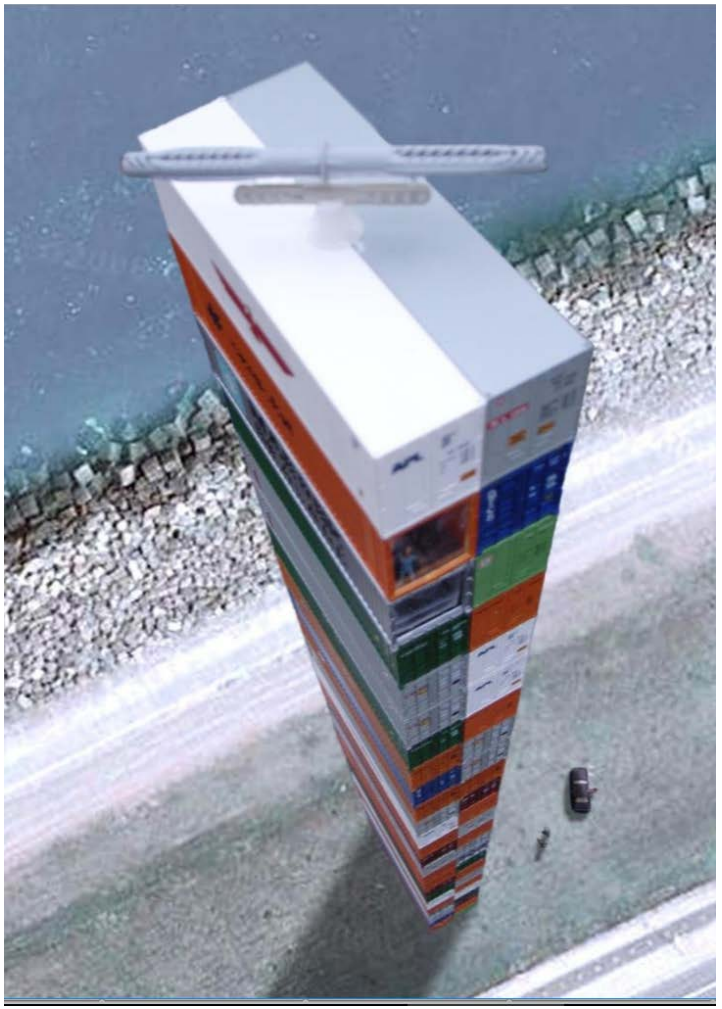
adaptability

Standardization - Loads

Load Capacity-

Using live load for housing and a reasonable dead load for the container and its build-out containers could theoretically be stacked about 30 high (285 feet)!

Landwark Maasvlakte (Competition) unbuilt, Rotterdan, NL, NL Architects. 2009



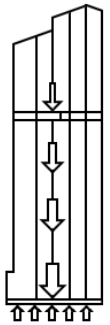
adaptability

Standardization - Loads

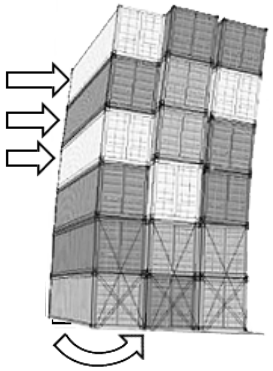
Load Capacity-

Theoretically, because this calculation is based on gravity loads and everyone knows that in Florida we design things so they don't blow over or blow away.

It's **lateral loads** like wind force that determine our building's design. It is likely that lateral loads would temper this vertical enthusiasm.

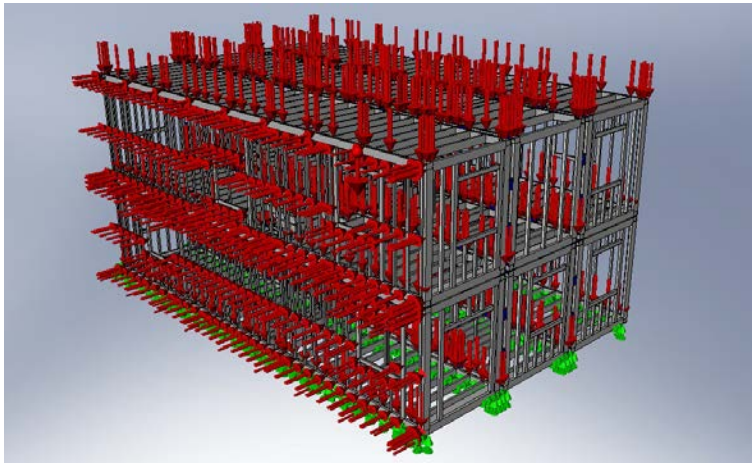


GRAVITY LOADS



LATERAL LOADS

TechDesignix Loads 3D model

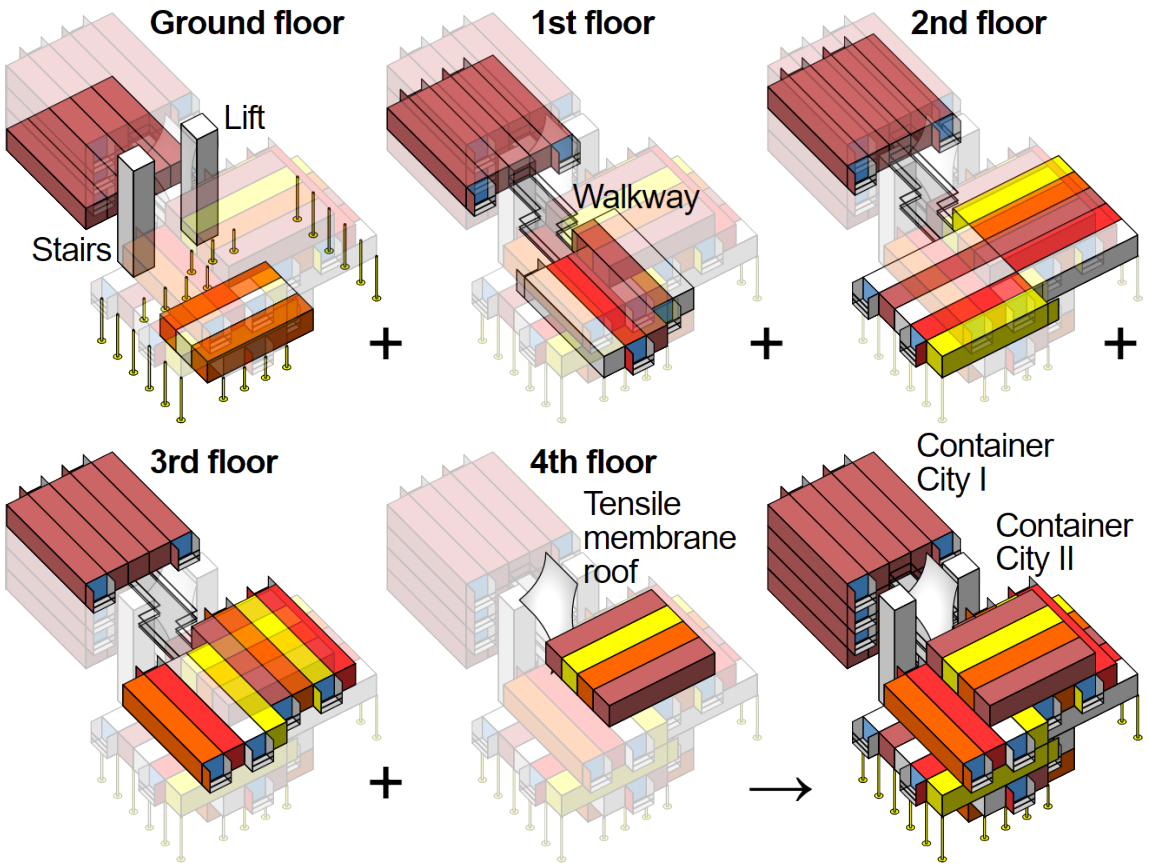


adaptability

Container City, London. Nicholas Lacey Architects
Buro Happold, engineer. 2003.

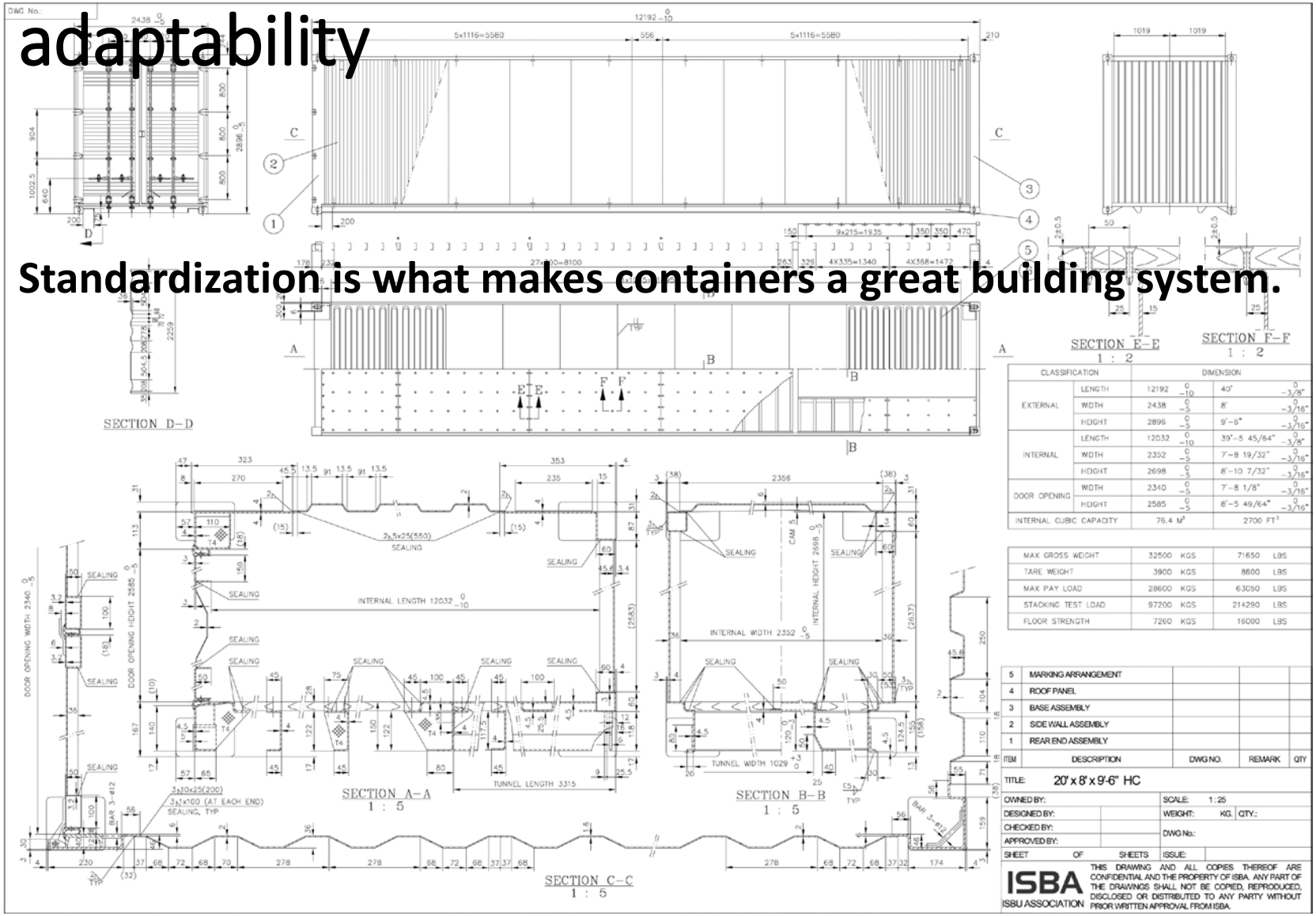
Standardization is the key.

Using an 8-foot by 8-foot grid allowed BuroHappold, engineer for Container City, to criss-cross the containers.



adaptability

Standardization is what makes containers a great building system.



CLASSIFICATION		DIMENSION	
EXTERNAL	LENGTH	12192 $^{0}_{-10}$	40' $^{0}_{-3/8"}$
	WIDTH	2438 $^{0}_{-5}$	8' $^{0}_{-3/16"}$
	HEIGHT	2896 $^{0}_{-5}$	9'-6" $^{0}_{-3/16"}$
INTERNAL	LENGTH	12032 $^{0}_{-10}$	39'-5 45/64" $^{0}_{-3/8"}$
	WIDTH	2352 $^{0}_{-5}$	7'-8 19/32" $^{0}_{-3/16"}$
	HEIGHT	2698 $^{0}_{-5}$	8'-10 7/32" $^{0}_{-3/16"}$
DOOR OPENING	WIDTH	2340 $^{0}_{-5}$	7'-8 1/8" $^{0}_{-3/16"}$
	HEIGHT	2585 $^{0}_{-5}$	8'-5 49/64" $^{0}_{-3/16"}$
INTERNAL CUBIC CAPACITY		76.4 M^3	2700 FT^3

MAX GROSS WEIGHT	32500 KGS	71650 LBS
TARE WEIGHT	3900 KGS	8600 LBS
MAX PAY LOAD	28600 KGS	63050 LBS
STACKING TEST LOAD	97200 KGS	214290 LBS
FLOOR STRENGTH	7260 KGS	16000 LBS

ITEM	DESCRIPTION	DWG NO.	REMARK	QTY
5	MARKING ARRANGEMENT			
4	ROOF PANEL			
3	BASE ASSEMBLY			
2	SIDE WALL ASSEMBLY			
1	REAR END ASSEMBLY			

OWNED BY:		SCALE: 1:25	
DESIGNED BY:		WEIGHT: KG.	QTY.:
CHECKED BY:		DWG No.:	
APPROVED BY:			
SHEET OF SHEETS		ISSUE:	

ISBA ISBU ASSOCIATION

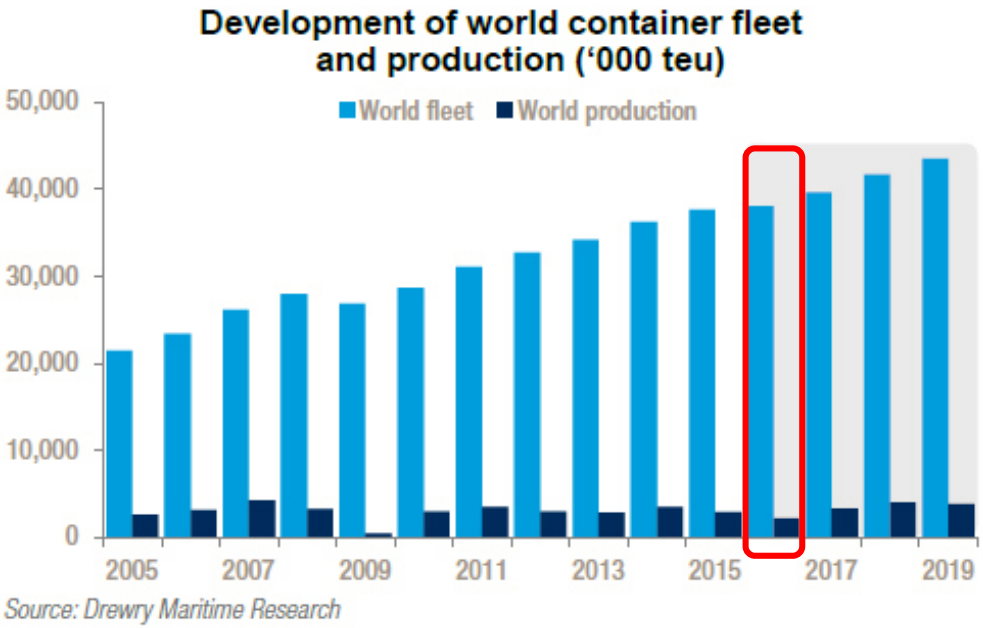
availability

Shipping containers as a building material in affordable housing.

Variables in availability:

- Shipping industry health
- Scrap Steel Prices
- Location
- The Myth of Unused Containers

availability



Variables - Shipping industry health

- Affects container demand.

Right now fleet expansion is slow.

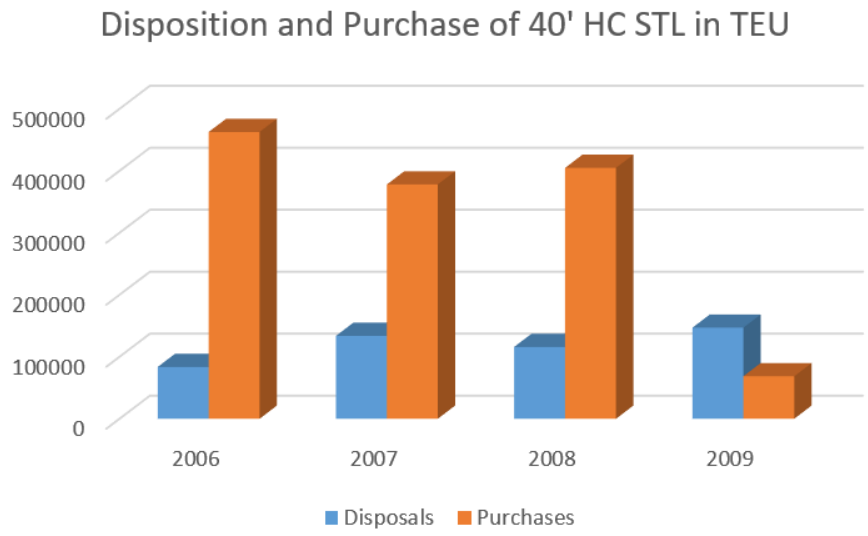
According to Drewry Maritime (London, UK, 24 August 2016) The global container equipment fleet amounted to 37.6 million TEU at the end of 2015, having increased in size by 3.8%, or 1.36 million TEU during 2015. This increase was lower than at any time previously, apart from 2009 when the box fleet actually shrank, and was prompted by the weakening state of the global economy and a further decline in trade demand.

availability

Variables - Shipping industry health

- Aging box replacement

The container leasing industry disposes of more than 100,000 40'HC TEUs per year (50,000+ 40' HCs). New box purchases are roughly triple. 2009 shows the impact of the downturn.



(Institute of International Container Lessors annual reports 2005-2010)

availability

Variables - Shipping industry health

- Declining long-term operating lease (LTL) rates
- LTL rates suffered further erosion in 2015. Mergers of major leasing firms (Triton and TAL) in 2015.
- Leasing companies are dumping old box inventory.

**half of containers are owned by shipping companies and the rest are leased by container leasing companies to shipping companies*

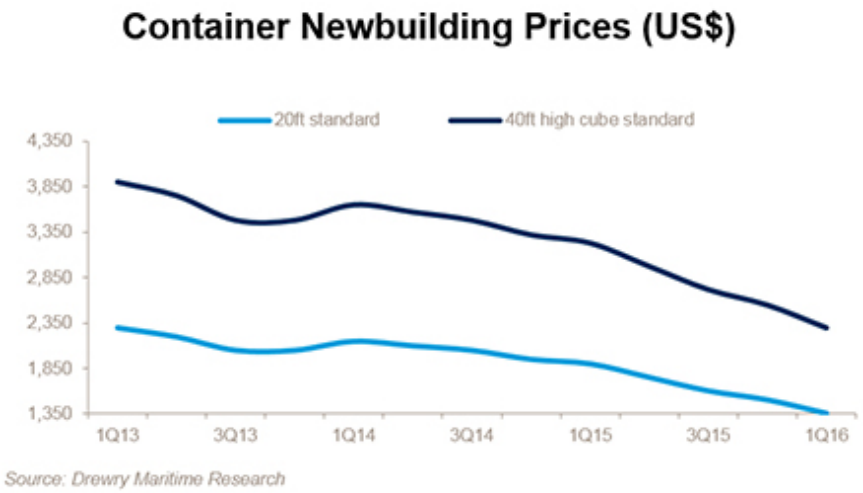
According to Drewry Maritime (London, UK, 24 August 2016)

availability

Variables - Box Cost

- Currently low.

"Prices for new dry freight containers declined to their lowest point since 2002 during first-quarter 2016 and are still going down, according to the latest edition of the Container Equipment Insight, published by the London-based consultant Drewry."



Drewry Maritime Research

availability

- Equipment in surplus

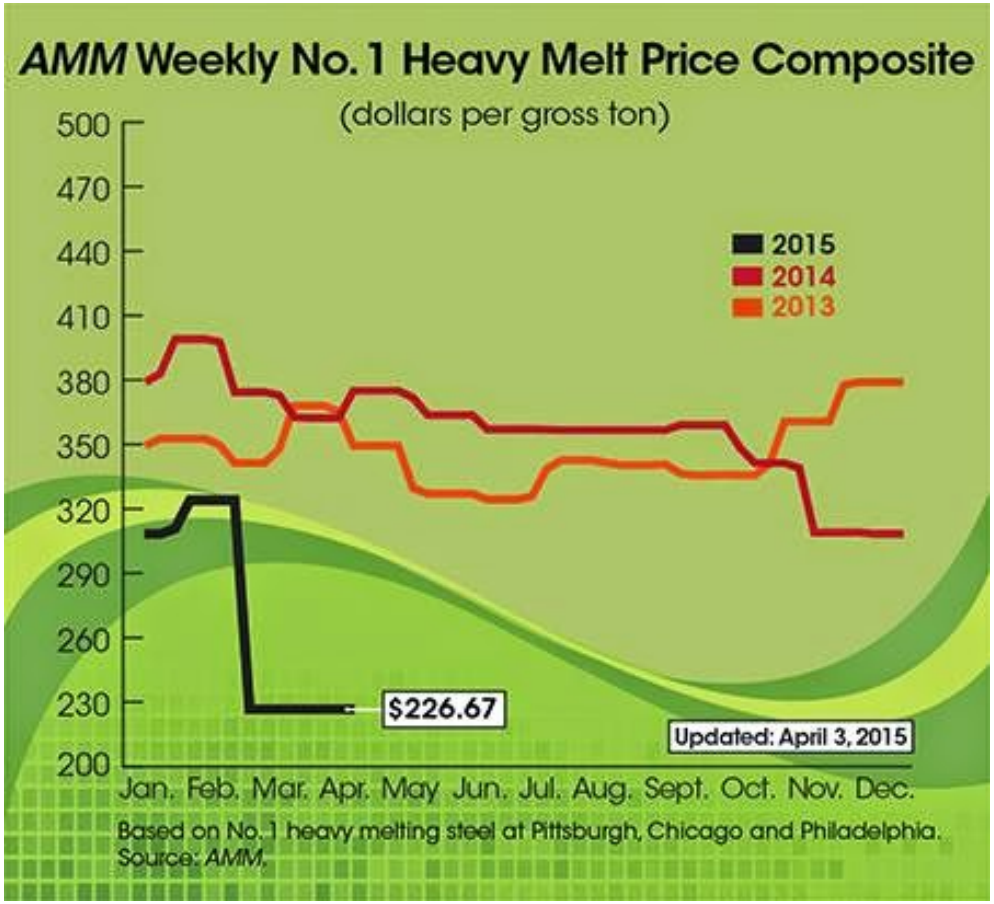
"That suggests 2016 could prove to be the weakest year for box production since the collapse of 2009, with equipment increasingly in **surplus**. Central to the problem is the already sizeable stockpile of new containers at factories in China, including substantial production from 2015 still awaiting collection," said Andrew Foxcroft, Drewry's lead analyst for the container equipment sector.

availability

Variables - Steel Prices

- Currently low.

*"New and used container prices had also fallen to their lowest in more than a decade because of weaker demand and a recent **steep drop in the cost of steel and factory running costs**."*



availability

Variables - Scrap Steel Prices

- Currently Low

#1 Unprepared Steel

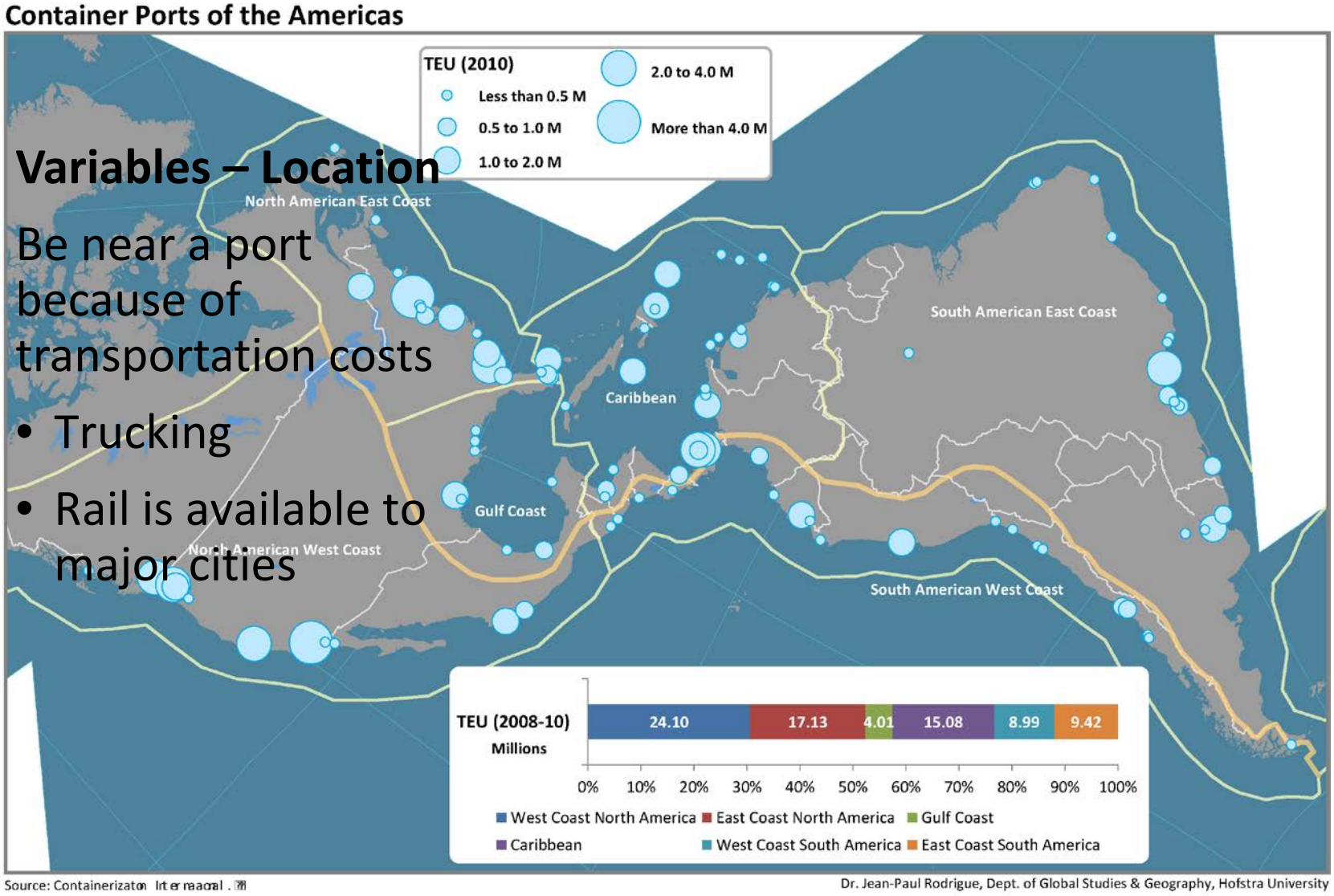
~$70.00 per net ton

40’ HC empty weight is ~4 tons

Scrap Steel from one container is worth only $280

It’s not worth it.

availability



Variables – Location

Be near a port because of transportation costs

- Trucking
- Rail is available to major cities

availability

The Myth of Unused Containers

The story goes that there are there are hundreds of thousands of shipping containers just sitting unused in ports around the globe, especially in the US. This is not true. These are “in use” by shipping companies. Retired containers are found in depots.

Most major shipping lines retire containers after 10 or 15 years based on condition. However, container repair/sale companies assume a container life span of 50-60 years. Of all the containers that they receive from shipping and leasing lines only 2-5% are scrapped due to poor condition (would require excessive repairs; valued less than scrap). The remaining 95%+ are repaired (if necessary) and sold to a variety of users; other shipping lines, trucking lines, military, storage…

sustainability

How do shipping containers compare to other building materials?

- Life Cycle Cost
- Condition
- Construction Methods
- Efficiency

sustainability

How do shipping containers compare to other building materials?

Life-cycle assessment (**LCA**) is a technique to assess environmental impacts associated with all the stages of a product's life from cradle to grave (i.e., from raw material extraction, materials processing, manufacture, distribution, use, maintenance, and disposal or recycling). LCAs can help avoid a narrow outlook on environmental concerns by:

- Compiling an inventory of relevant energy and material inputs and environmental releases;
- Evaluating the potential impacts associated with identified inputs and releases;
- Interpreting the results to help make a more informed decision.

Efficacy of Shipping Container Upcycling: Comparison of Environmental Impacts Between Two Housing Systems. 2012 ACSA Fall Conference. September 29, 2012 - Sustainability Session. Bradley Guy, Catholic University of America and Stephen Bender, University of Florida.

sustainability

Life cycle assessment

- Goal – comparison between shipping containers and equivalent components/assemblies using traditional wood-frame
- Scope – only those components that are unique to the containers or equivalencies in wood-frame to meet functional requirements
- Data – materials take-offs, ISBU on shipping containers, utility data, Athena Impact Estimator Databases Region specific - North Central Florida Region

sustainability

Goals and Method

Question: is shipping container more environmentally efficacious than traditional construction ?

- At what stage of life yes or no?
- Expanded benefits of containers– durability and EOL value, avoidance of demolition waste
- Assume 75 year lifespan
- Include modifications and additional materials
- Four primary environmental impact attributes
- Four scenarios per shipping container life

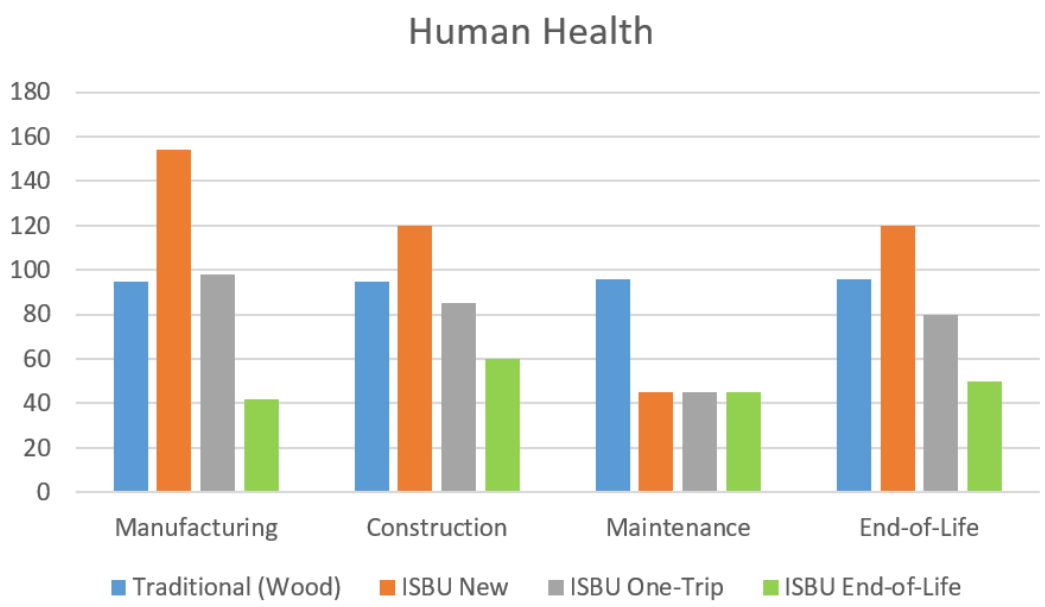
sustainability

Human Toxicity Potential (HTP)

The Human Toxicity Potential, a calculated index that reflects the potential harm of a unit of chemical released into the environment, is based on both the inherent toxicity of a compound and its potential dose.

These by-products, mainly arsenic, sodium dichromate, and hydrogen fluoride, are caused, for the most part, by electricity production from fossil sources.

These are potentially dangerous chemicals to humans through inhalation, ingestion, and even contact. **Cancer potency**, for example, is an issue here. HTP is measured in 1,4-dichlorobenzene equivalents.

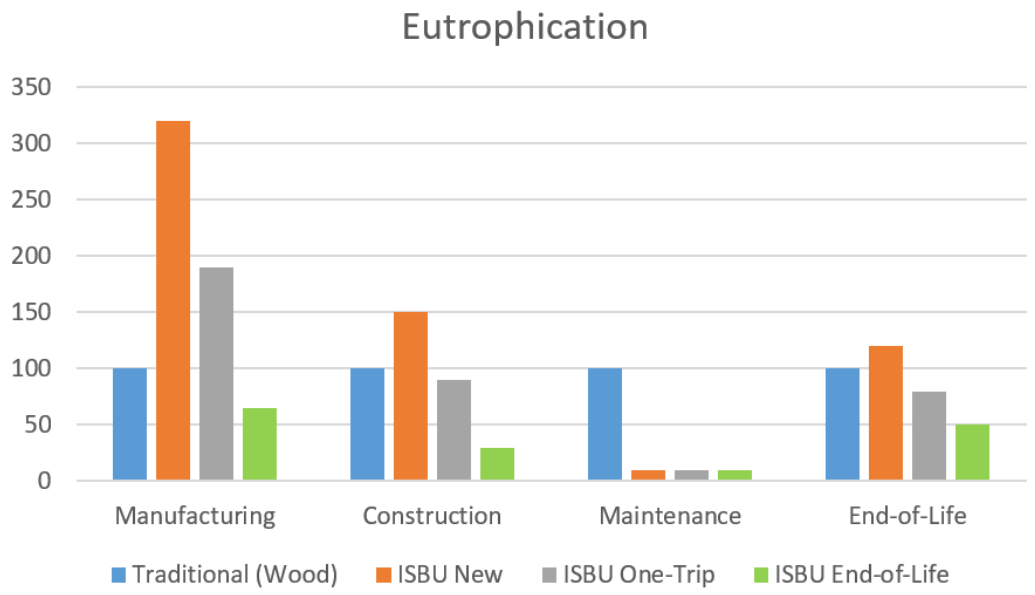


sustainability

Eutrophication Potential (EP)

Eutrophication originates mainly from nitrogen and phosphorus in sewage outlets and fertilizers. Basically, EP is the build-up of a concentration of chemical nutrients in an ecosystem which leads to abnormal productivity.

For example, this causes **excessive plant growth like algae** in rivers which causes severe reductions in water quality and animal populations. EP is measured in phosphate (PO_4^{3-}) equivalents.

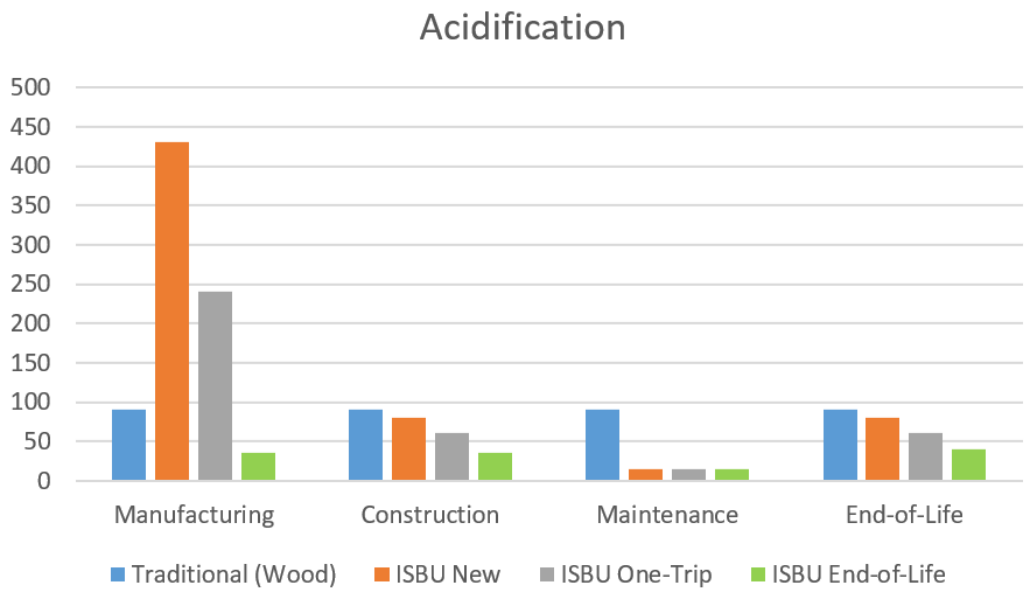


sustainability

Acidification Potential (AP)

The Acidification Potential calculates the loss of the nutrient base (calcium, magnesium, potassium) in an ecosystem, and its replacement by acidic elements caused by atmospheric pollution.

Acidification originates from the emissions of sulfur dioxide and nitrogen oxides. Here the AP is dominated by nitrogen (NO_2) and sulfur dioxide (SO_2) emissions. In the atmosphere, these oxides react with water vapor and form acids which fall down to the earth in the form of rain or snow, or as dry depositions. This affects soils, waters, flora and fauna, and can even damage building materials. **The resultant 'acid rain' is best known for the damage it causes to forests and lakes.** AP is measured in SO_2 equivalents.

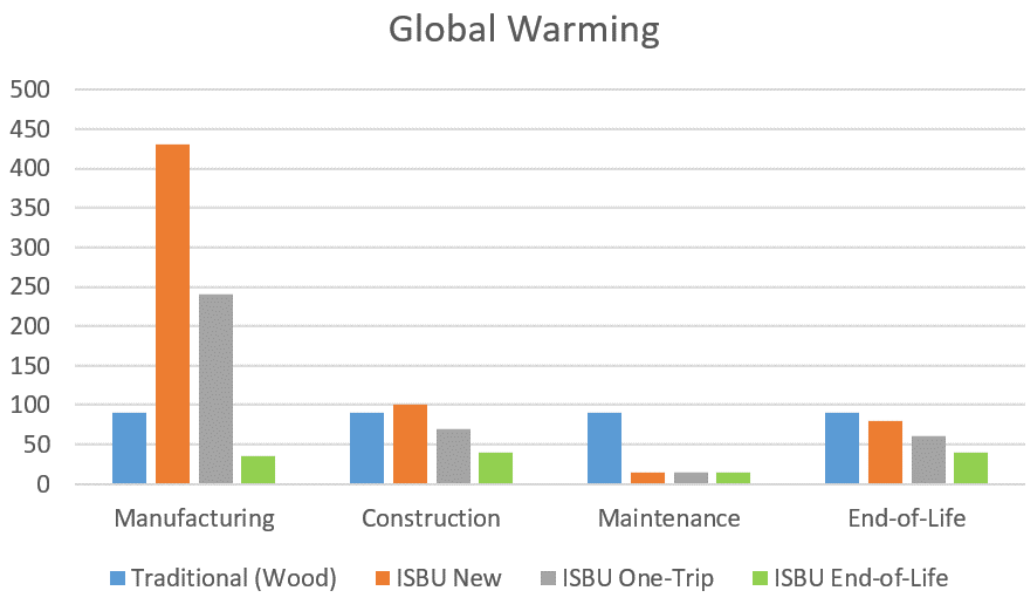


sustainability

Global Warming Potential (GWP)

The Global Warming Potential is an index to measure the contribution to global warming of a substance that is released into the atmosphere.

The GWP is impacted mainly by the emission of **greenhouse gases**, i.e. carbon dioxide (CO_2) and methane (CH_4). It was calculated for a time frame of 100 years. The GWP is measured in CO_2 equivalents.



sustainability

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We choose from these, the best of the worst, at the true end of their first life.

sustainability

Condition

What does an “end-of-life” container look like?

	General Appearance	Dents & Scratches	Superficial rusting on exterior or interior	Understructure	Valid CSC	Meets ISO	Suitability
Grade A							
IICL	Very Good	Minor	Minor	Good	Yes	Yes	Transport / Storage
CW	Very Good	Minor to Medium	Minor to Medium	Good	Yes	Yes	Transport / Storage
WWT	Very Good	Minor to Medium	Minor to Medium	N/A	No	Generally	Storage
Grade B							
IICL	Good	Minor to Medium	Minor to Medium	Good	Yes	Yes	Transport / Storage
CW	Good	Medium	Medium	Good	Yes	Yes	Transport / Storage
WWT	Good	Medium	Minor to Medium	Good	No	Possibly	Storage
Grade C							
CW	Mediocre	Medium to heavy	Medium to heavy	Good	Yes	Yes	Transport / Storage
WWT	Mediocre	Medium to heavy	Medium to heavy	N/A	No	Possibly	Storage
Foodstuff							
IICL	Very Good	Minor	Minor	Good	Yes	Yes	Transport / Storage
CW	Very Good	Minor to Medium	Int / Minor - Ext Minor to Medium	Good	Yes	Yes	Transport / Storage
WWT	Very Good	Minor to Medium	Int / Minor - Ext Minor to Medium	N/A	No	Generally	Storage

C Grade containers will have less curb appeal as they probably have some cosmetic damage and medium to heavy levels of rust and corrosion. This classification of container will probably not meet IICL standards for shipping.

sustainability

Condition

What does an “end-of-life” container look like?

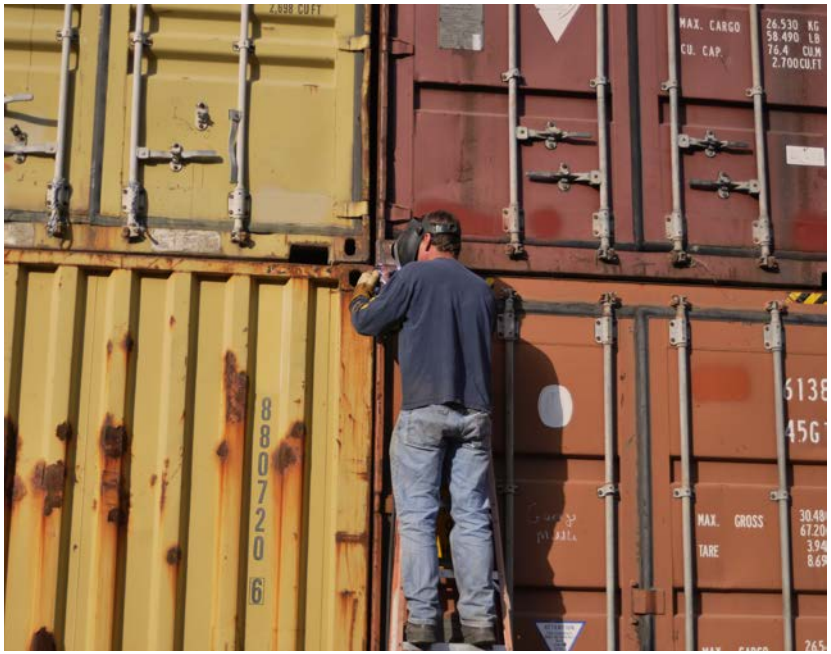
sustainability

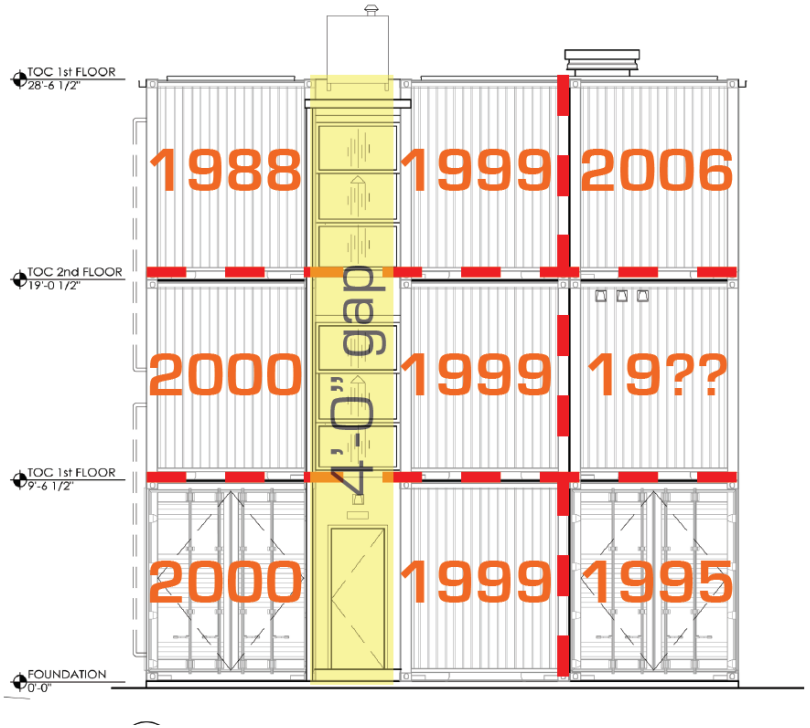
Condition

Dents, scratches, rust, okay. Some have small holes in the roofs at corners. This is okay for our purposes.

sustainability

Fox Residence





north elevation

sustainability

Construction Methods

Containers offer a bridge solution to the fear of prefabrication caused by difficulty in the building industry to successfully (profitably) implement off-site construction. We still build almost everything in situ. Rather than just continuing with systematized onsite construction, containers allow the housing construction industry a jump start into **modular prefabrication**.

sustainability

Use of shipping containers offers the opportunity to:

- Leverage the **lean production methods** and massive scale of production of the container industry to benefit the housing industry.
- Leverage the **upcycling of the container** with it's embodied energy together with less wasteful prefabrication to support a responsible environmental ethic. "Total sustainability."
- Leverage the **implementation of the module** to create a more integrated, quality product to supplant traditional fragmented construction project delivery. Assembly vs. construction.
- Implement other modularized building process experience to **increase off-site construction**, especially for expensive spaces (i.e. Ameripod restrooms).

sustainability

Use of shipping containers offers the opportunity to:

- Leverage the **lean production methods** and massive scale of production of the container industry to benefit the housing industry.
- There have been many recent attempts at using proprietary systems or other existing systems with some success. But none of these have the benefit of participating in an existing industrial standard or upcycling existing material.

sustainability

Use of shipping containers offers the opportunity to:

- Leverage the **upcycling of the container** with it's embodied energy together with less wasteful prefabrication to support a responsible environmental ethic. "Total sustainability."

A container has 8000 lbs of steel which takes 8000 kwh of energy to melt down and make new steel. Redirecting its original purpose and implementing a process of modifying the container into a "higher and better use" takes only 400 kwh of electrical energy (or 5%).

sustainability

Container City, London. Nicholas Lacey Architects. Buro Happold, engineer. 2003.

Use of shipping containers offers the opportunity to:

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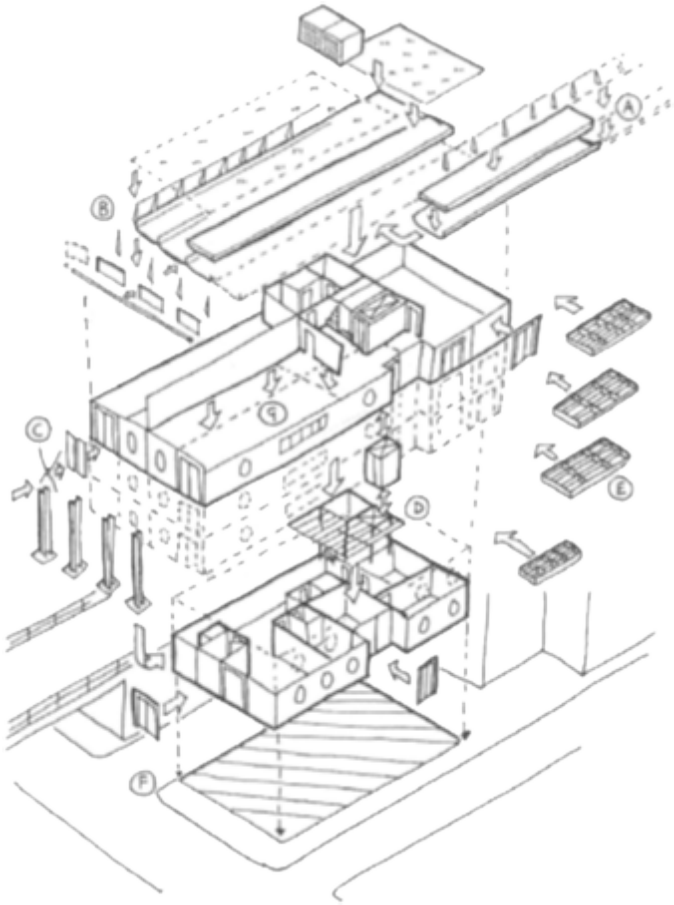


sustainability

Multifamily Concept Design. bndr, llc for CHS, 2015

http://www.bndrd.com/

1e
efficiency unit
1 bedroom / 1 bathroom
320 sf each

1/1
one bedroom unit
1 bedroom / 1 bathroom
640 sf each

Standardize and prefabricate containers. Three types: left side off, right side off and both sides off. Standardize reinforcement for openings.

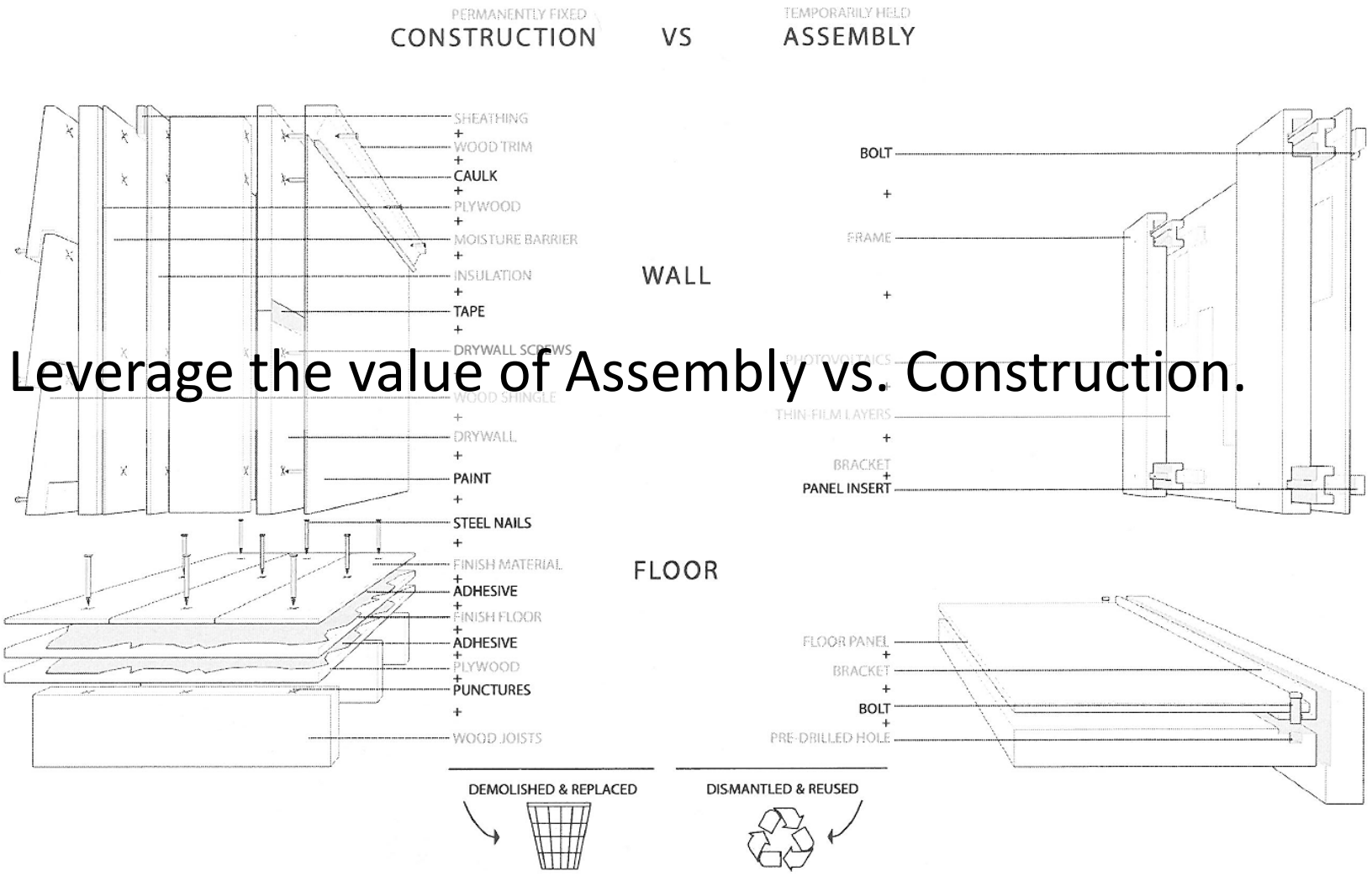
*containers can be selected for best use.

2/2
two bedroom unit
2 bedroom / 2 bathroom
960 sf each

3/2
three bedroom unit
3 bedroom / 2 bathroom
1280 sf each

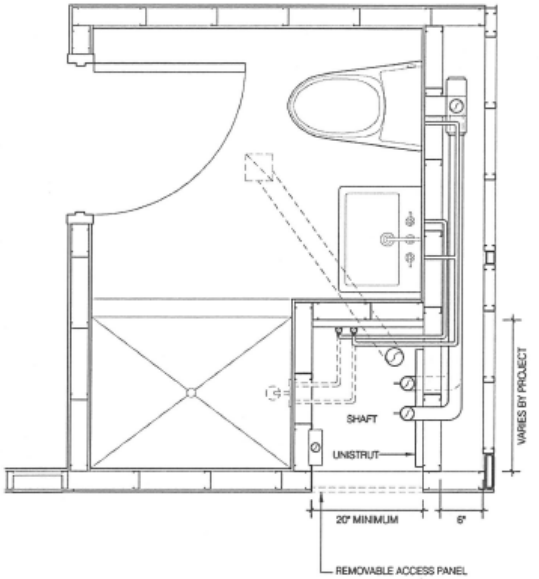
Orange Drive Elevation (South)

sustainability



Leverage the value of Assembly vs. Construction.

sustainability



Use of shipping containers offers the opportunity to:

- Implement other modularized building process experience to **increase off-site construction**, especially for expensive spaces (i.e. Ameripod restrooms).

http://ameripod.com/index.htm

sustainability

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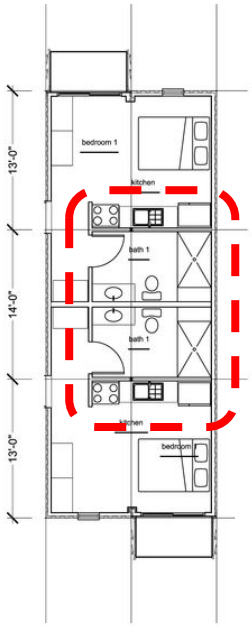

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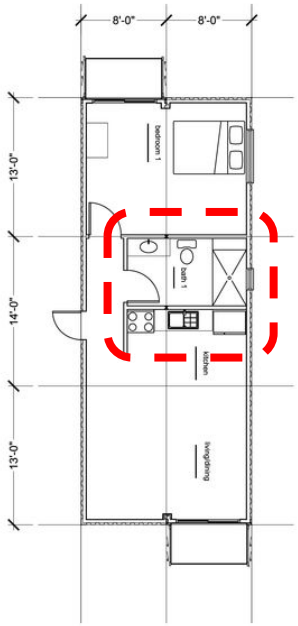


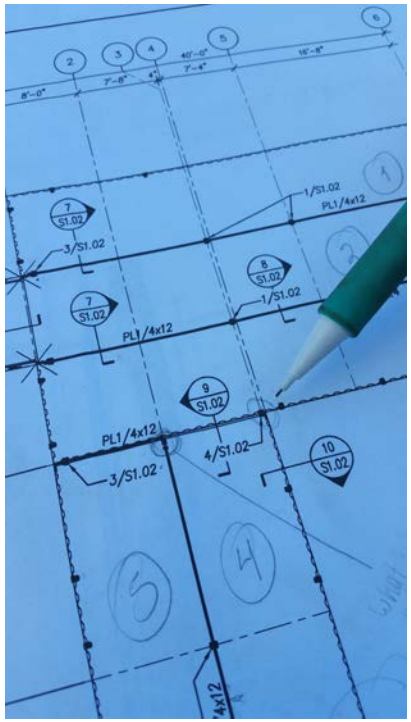
Standardize and prefabricate bathrooms and kitchens. Determine what level of finish is appropriate; rough-in or more?

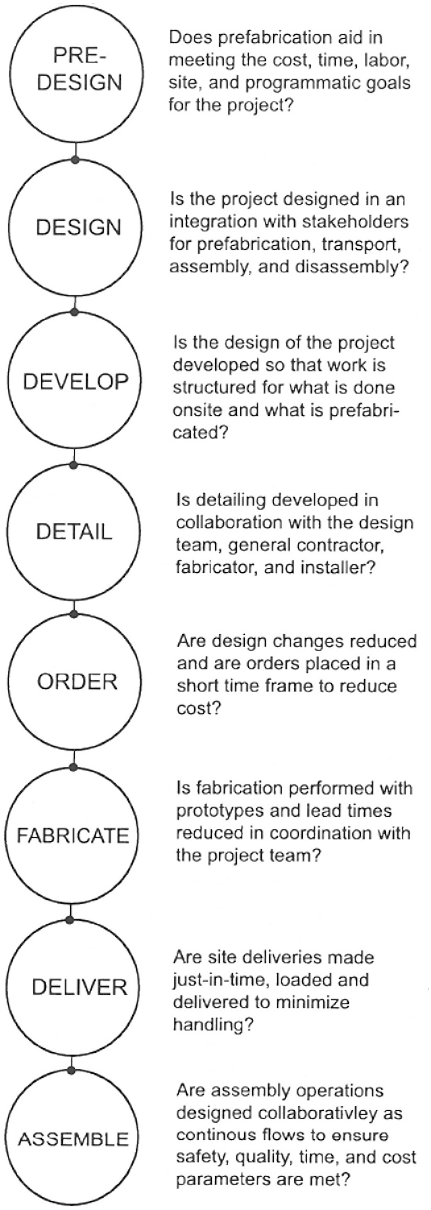
sustainability

implementation of the module

- Prefab aids cost and time of project goals
- Design is integrated with stakeholders; GC, steel fabricator
- Decide what is done prefabricated vs onsite
- Detail project to make most effective use of prefab
- Test and troubleshoot design

* there is no formula. Every project has its own needs.



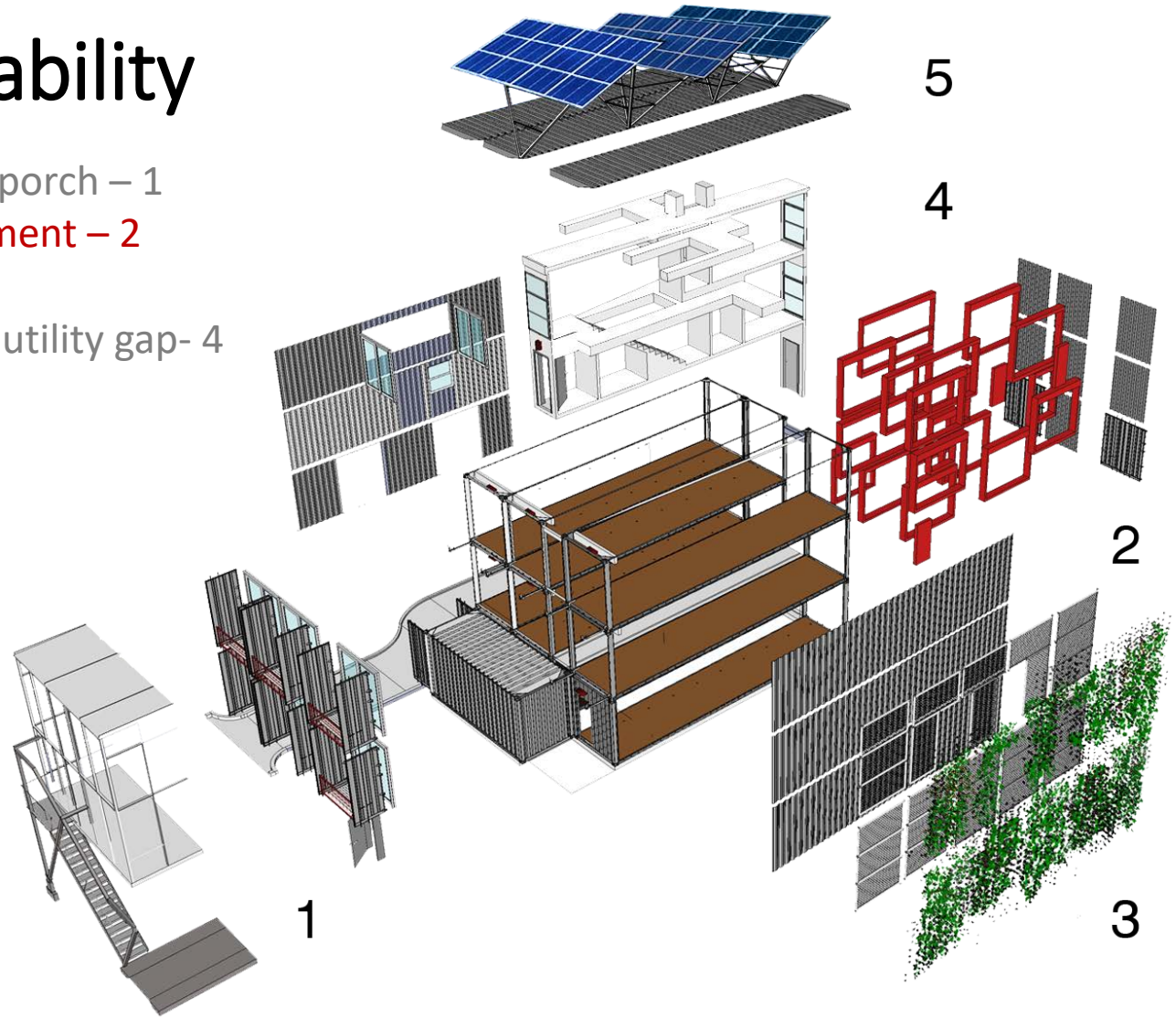


sustainability

implementation of the module – Fox Residence

sustainability

entry stair and porch – 1
steel reinforcement – 2
green wall – 3
circulation and utility gap- 4
solar trees – 5



implementation of the module – Fox Residence

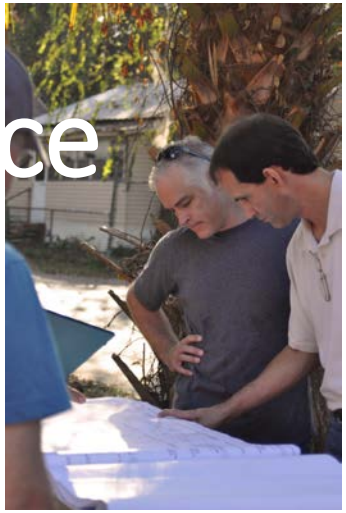
sustainability

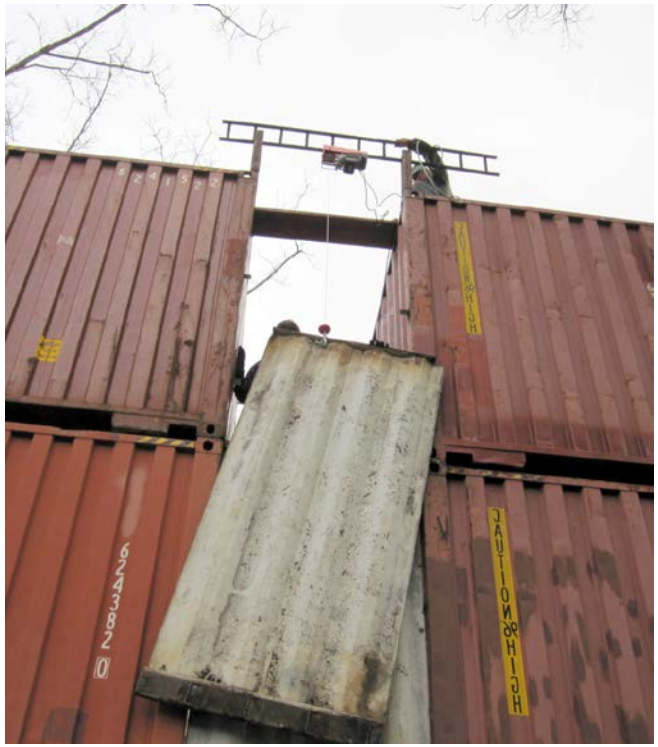
implementation of the module – Fox Residence

Pre-design decisions:

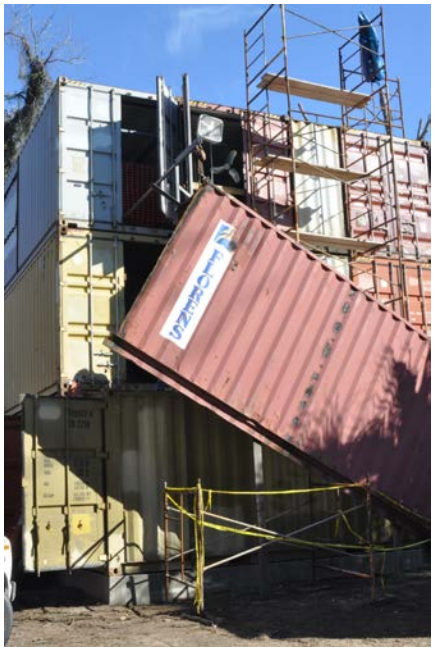
- Very tight site with power. No nearby yard available so no prefab. Avoid two transports.
- Originally detailed for prefab. Adapt details for on-site modification; cut and reinforce (saves steel)
- Coordinate presence of welder and engineer for crane day.

Fox Residence





Fox Residence



Fox Residence

sustainability

implementation of the module – Fox Residence

Outcome/Lessons Learned:

- Container use accelerated project schedule. Structure and most of enclosure up in less than a week.
- On-site container modifications lengthened schedule.
- Be careful where and how you cut openings. It results in adding new steel.
- Unsophisticated contractor created ad-hoc changes in the field.
- Adapting to changes resulted in additional steel upcycling opportunities.
- Learned that old containers are crooked and don't always want to mate!

sustainability

implementation of the module – Guest Residence

Pre-design decisions:

- Quiet wooded residential site with power, additional worksite available. So, partial prefab off-site, two transports. Small project, small truck, small $.
- Detail for partial prefab; cut openings, partially reinforced.
- Coordinate presence of welder for crane day. Establish sequencing of activity.








sustainability

implementation of the module – Guest Residence

Outcome/Lessons Learned:

- Partially prefabbed container use accelerated project schedule. Structure and most of enclosure up in one day.
- On-site container modifications were minimal, did not affect schedule.
- Project completed in 37 days (except for exterior paint!)

sustainability

implementation of the module – Kurz Residence

Pre-design decisions:

- Large site with power so prefab on site to avoid two transports (oxymoron, I know!)
- Detail for partial prefab; cut openings but not reinforced (saves steel)
- Coordinate presence of plumbing, insulation and metals for crane day. Establish sequencing of activity.

sustainability

implementation of the module – Kurz Residence

sustainability

implementation of the module – Kurz Residence

Containers deliver to site, staged and cut. Opening reinforcement prefabricated.

sustainability

implementation of the module – Kurz Residence

Precut containers, prepared foundations and plumbing, foam insulation underway.

sustainability

implementation of the module – Kurz Residence

sustainability

implementation of the module – Kurz Residence

Outcome/Lessons Learned:

- Partially prefabbed container use accelerated project schedule. Structure and most of enclosure up in two days.
- Limited on-site container modifications did not affect schedule.
- Designed for complete prefab modifications. Adapted details for limited on-site mods.
- On-site modifications saved some steel compared to complete prefab of modifications.
- Working with sophisticated process and detail-oriented GC and steel subcontractor team was a homerun.

efficiency

The Passivhaus standard is the Generally Considered to be an ultra-low energy building standard performance, characterized by the following fundamental concepts:

- Superinsulation
- thermal bridge-free construction
- compact form
- air tight building envelope
- optimal use of passive solar gains; e.g. orientation, glazing ratios, daylighting
- mechanical ventilation with heat recovery (MVHR)

Hopfe, Christina J, and Robert S. McLeod. *The Passivhaus Designer's Manual: A Technical Guide to Low and Zero Energy Buildings*. , 2015. Print.

efficiency

- Design. Surface area to volume ratio (SA/V). 0.7 or less.
- Airtight envelopes.
- Thermal transmittance.
- Thermal bridging (psi-value).
- Thermal mass. Not desirable for subtropical climates (diurnal consistency).

Hopfe, Christina J, and Robert S. McLeod. *The Passivhaus Designer's Manual: A Technical Guide to Low and Zero Energy Buildings*. , 2015. Print.

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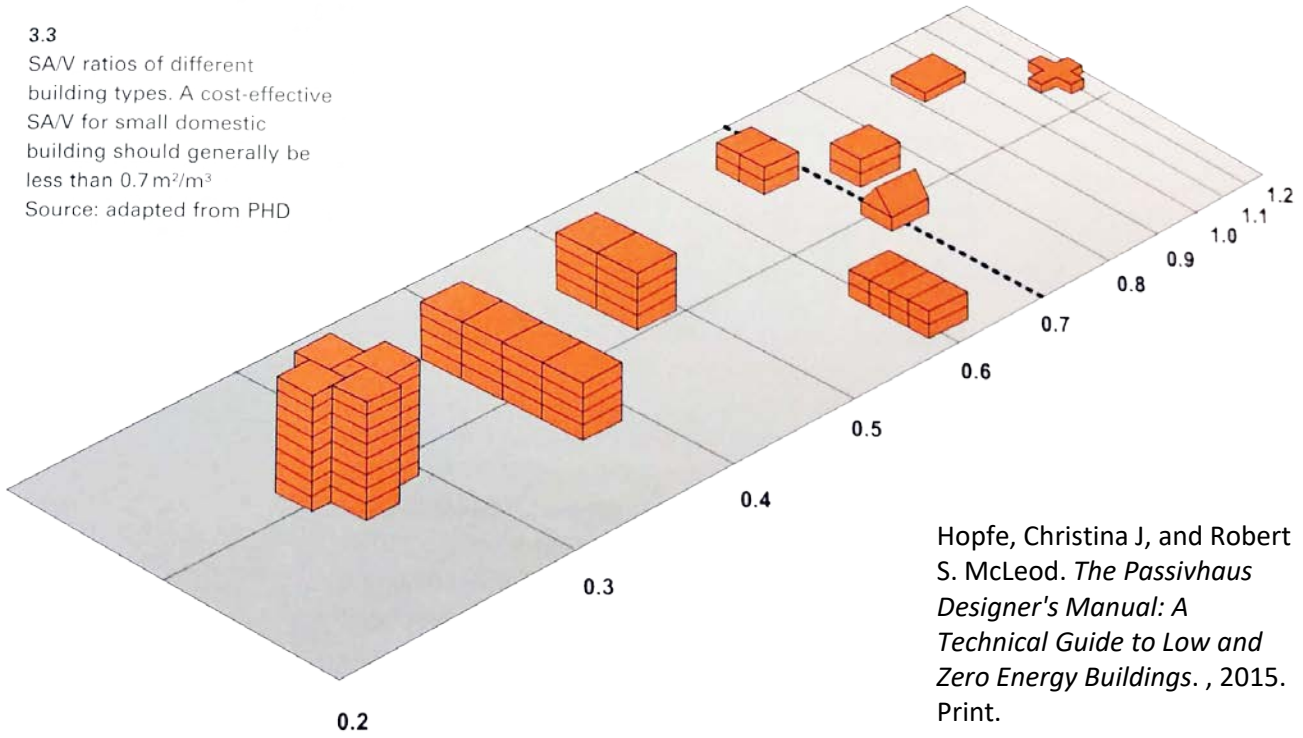


Hopfe, Christina J, and Robert S. McLeod. *The Passivhaus Designer's Manual: A Technical Guide to Low and Zero Energy Buildings*. , 2015. Print.

efficiency

- Design. Surface area to volume ratio (SA/V). 0.7 or less.

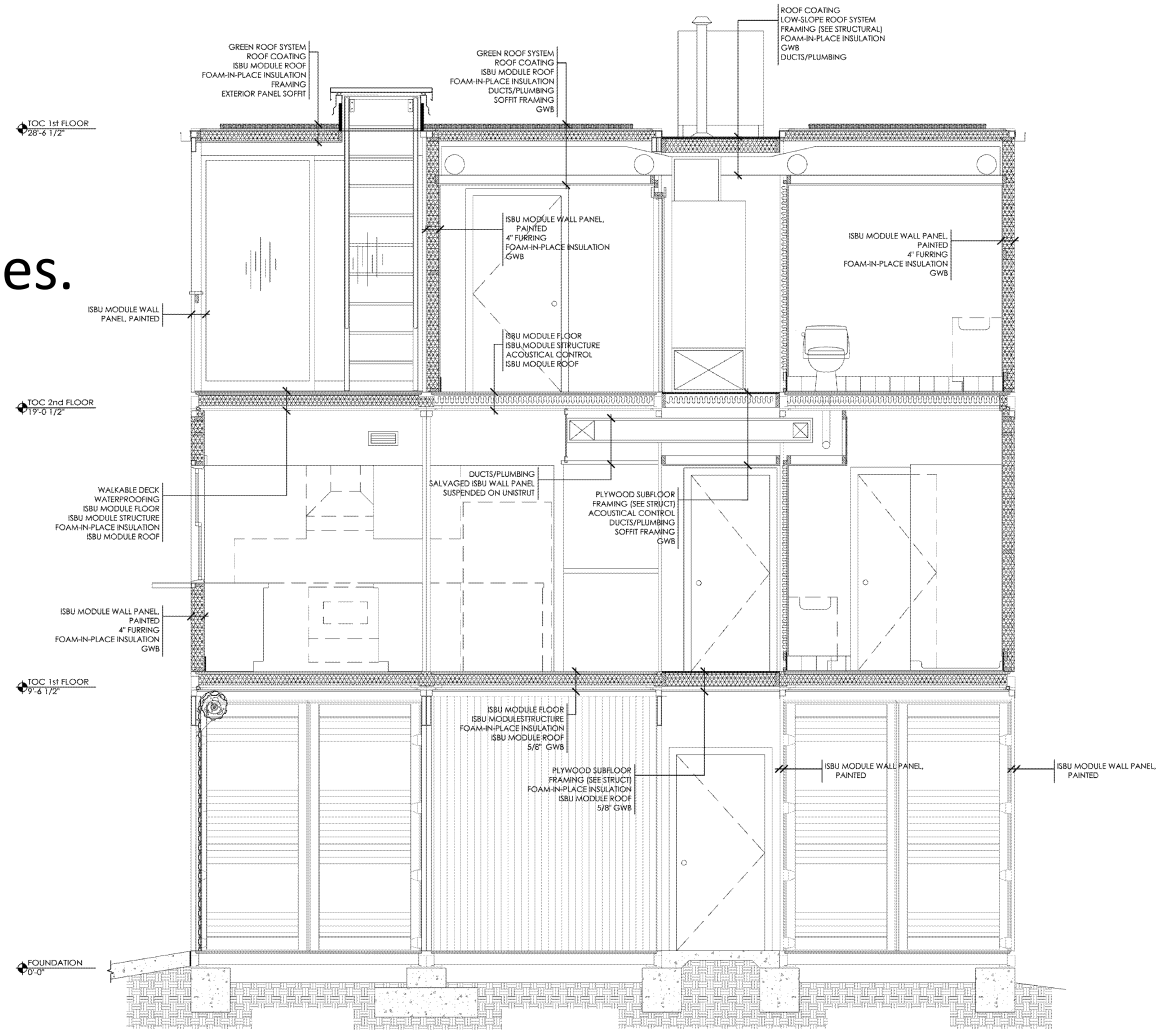
Design also uses deep overhangs and self-shading to overcome Florida solar heat gain.

Multifamily Concept Design. bndr, llc for CHS, 2015

http://www.bndrd.com/

efficiency

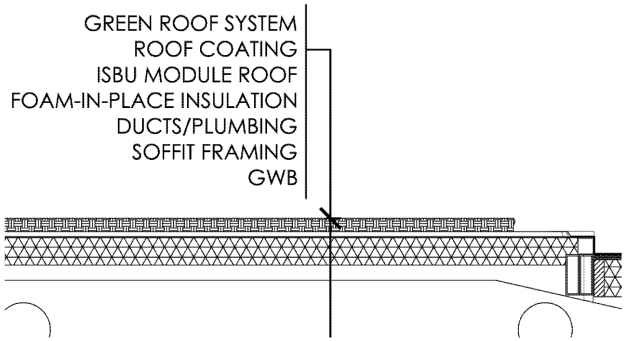
- Airtight envelopes.



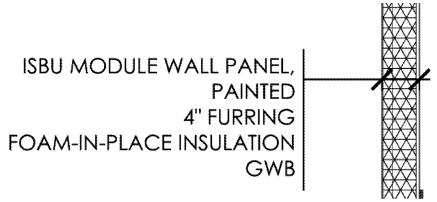
cross section

efficiency

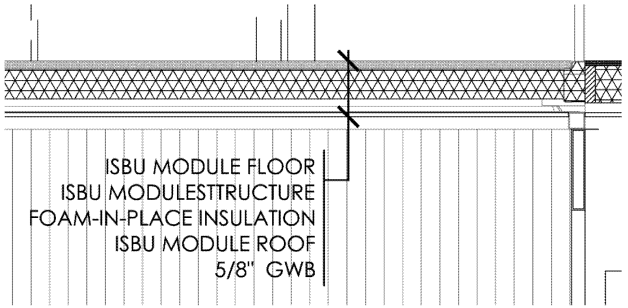
- Airtight envelopes. *Foam-in-place for airtight*
- Thermal transmittance (r-value). *R-40 in roofs, R-19 in walls.*
- Thermal bridging (psi-value). *Careful placement of insulation limits thermal bridging.*
- Thermal mass. *Not desirable for subtropical climates (diurnal consistency). Steel has low thermal mass. It sheds heat.*



roof detail



wall detail



raised floor detail

efficiency

Energy Rating for Fox Residence

The Home Energy Rating System (HERS) Index is the industry standard by which a home's energy efficiency is measured. It's also the nationally recognized system for inspecting and calculating a home's energy performance.

- The U.S. Department of Energy has determined that a typical resale home scores 130 on the HERS Index while a standard new home is awarded a rating of 100.
- A home with a HERS Index Score of 70 is 30% more energy efficient than a standard new home
- A home with a HERS Index Score of 130 is 30% less energy efficient than a standard new home
- Fox Residence HERS Rating was -3. Meaning (better than) net zero energy.

Contributing factors: the envelope details mentioned previously and smart choices to use mini-split AC systems for a whole house solution, all energystar appliances, CF lighting and a solar array.

efficiency

Post-occupancy data for Fox Residence

HERS is meaningful but the test is in use. How did Fox Residence do in its first year?

- 7,000 kw consumed over first 12 months
- compare to ~14,600 kw for average household in Florida. Source: U.S. Energy Information Administration (EIA)
- 11,500 kw returned to grid from 8kw solar array 12 months

Imagine what application of this design to affordable housing means to an occupant's monthly cost of living, even without the addition of solar.

Fox Residence data provided by Gainesville Regional Utilities.

Why containers?

MODULARITY/ADAPTIBILTY

- All shipping containers are made to standard measurements and load capacities and as such they provide modular elements that can be combined into larger structure. Standardization and modularization, including the ability to prefabricate some elements increases construction efficiency making shipping containers an ideal low impact construction material.

STRENGTH

- The Center for Housing Policy advocates for improved housing standards, including Disaster Resistant Housing which includes measures for mitigating severe wind, rain and other significant storm-related damage to homes. Particularly in coastal areas Hurricane-Resistant Home Construction is essential, especially for affordable housing. Shipping containers are in many ways an ideal building material. They are designed to carry heavy loads and to be stacked in 9 high on ships in open stormy seas.

DURABILITY

- They are also designed to resist harsh environments. When used as a building material the units are welded together and reinforced making them ideal for meeting the needs for increased home resilience.

TRANSPORTABILITY

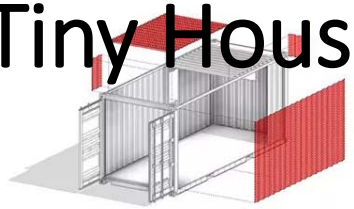
- Prefabricated modules can be easily transported by ship, truck or rail, because they already conform to standard shipping sizes and are fitted with standard clamping holds.

SUSTAINABILITY

- A container has 8000 lbs of steel which takes 8000 kwh of energy to melt down and make new structural steel. By redirecting the units toward housing the entire 8000 lbs of steel is raised to a "higher and better use". It takes approximately 400 kwh of electrical energy (or 5%) to implement the minor modifications. Using an end-of-life shipping container for building is upcycling. Because shipping containers are pre-manufactured structural modules they allow for an accelerated construction timeline reducing overall cost and creating less construction impact on surrounding properties. Shipping containers are a tight envelope and with careful modification and proper insulation they provide a very energy efficient building.

Case study – Tiny House

UNBOXED



Sean Burke (@seandburke)
http://unboxedhouse.com/