"How high's the water, Mama?"

Disaster Resistant Designs with Insulating Concrete Forms and Reinforced Concrete

QUAD-LOCK

"*Quad-Lock Building Systems, Ltd.*" is a Registered Provider (#J265) with ***The American Institute of Architects Continuing Education Systems (AIA/CES)***. Credit(s) earned on completion of this program will be reported to ***AIA/CES*** for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

This program is registered with ***AIA/CES*** for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

2

Course Description & Objectives

Introduction to ICF/Concrete structures designed for disaster resistance
- ICF Concrete Walls, Elevated Floors & Roofs
- How do they work? What can I build?

Governing Codes and Standards
- International Code Council
- American Concrete Institute
- American Society of Civil Engineers

Case Studies of Disaster Resistant ICF Structures
- Louisiana School FEMA Rebuilds & S.F. Residence
- H.C. Moore Library & Delaware Beach Home

3

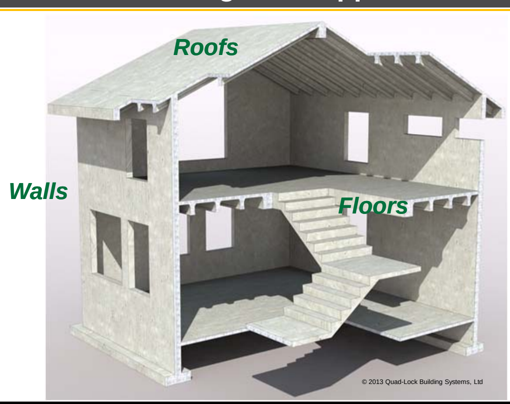
Large Natural Disaster Statistics

Impact:	Sandy 2012 Disaster #1	Katrina 2005 Disaster #2	2011/2012 Tornados (USA) Disaster #3
# Lives Lost	132	1836	622
$ Damage	$50 Billion	$81 Billion	$44 Billion
# Homes Destroyed	72,000	340,000	100,000 (est.)

Insulating Concrete Formwork

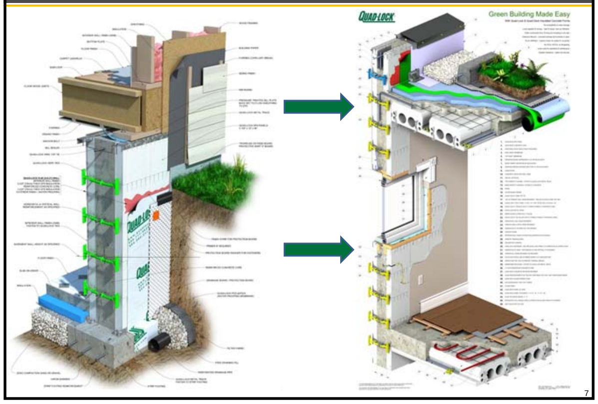
5

ICF Building Shell Applications



6

ICF Progress in the Market



7

ICF Concrete Wall “Survivability”

8

PCA Lateral Strength Analysis (ASTM E564-95)

	Wood Frame	ICF & Concrete	Concrete % Advantage
Global Lateral Stiffness (lbs/in)	18,500	708,000	+3,827%
Load at First Major Damage (lbs)	3,500	8,500	+243%
Displacement at First Major Damage (in)	0.51	0.06	+850%
Maximum Lateral Resistance (lbs)	4,553	34,254	+752%
Displacement at Max. Lateral Resist. (in)	0.89	2.66	+299%

Test performed by PCA based on ASTM E564-95

9

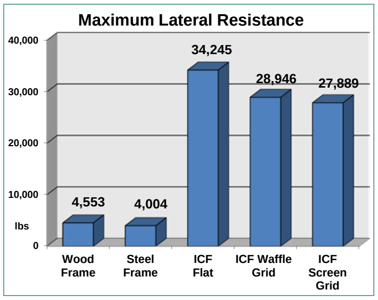
PCA Lateral Strength Analysis (ASTM E564-95)

Forces could result from:

Wind

Seismic

Flood

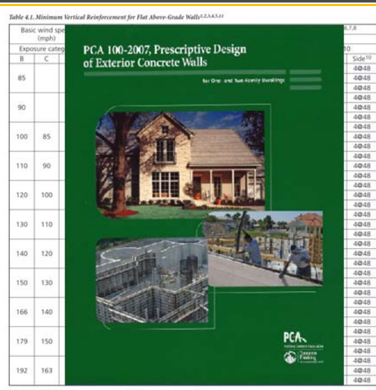


10

IRC Prescriptive Designs

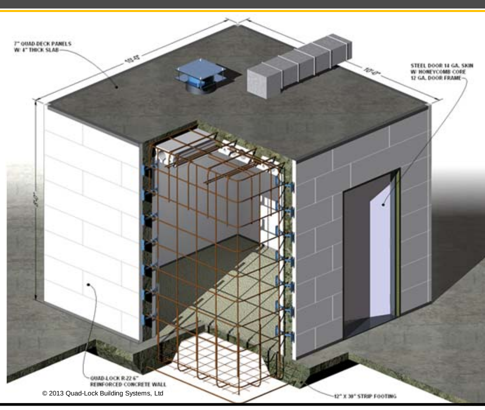
ICF/Concrete Wall Reinforcement

Prescriptive Designs to 150 mph *(all exposures)*



11

ICF Storm Shelters



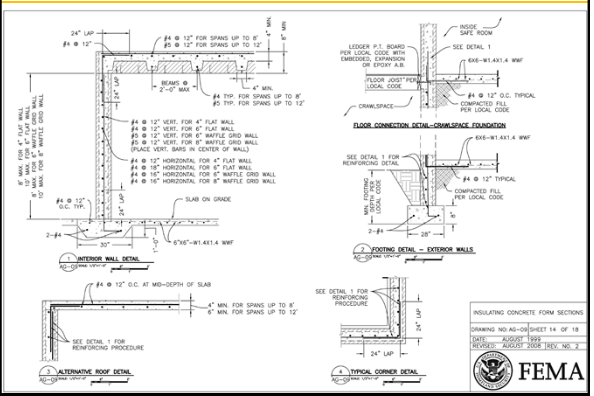
© 2013 Quad-Lock Building Systems, Ltd

12

ICF Storm Shelters

13

FEMA ICF Shelter Design



ICF Storm Shelters

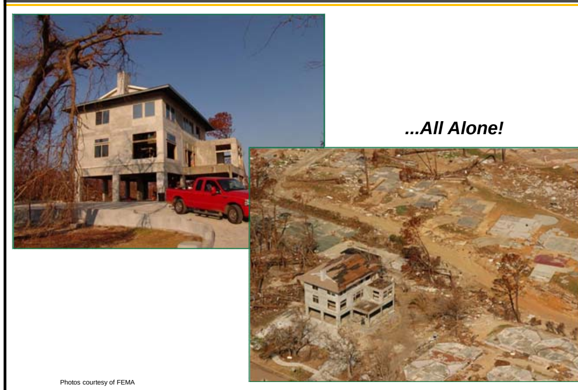
15

ICF Buildings Become Hardened Shelters

Oceanfront Residence
Vero Beach, FL

16

Elevated ICF Structure Survives Katrina



...All Alone!

Photos courtesy of FEMA

17

Bringing Efficiency to Slab Design

18

Achieving Design Objectives

Design Objective:

1. Maintain building shape and integrity while safely carrying expected loads
2. Minimize acceleration of high mass elements under shock loads
3. Minimize cost and space requirements of supporting structure
4. Reduce Cost

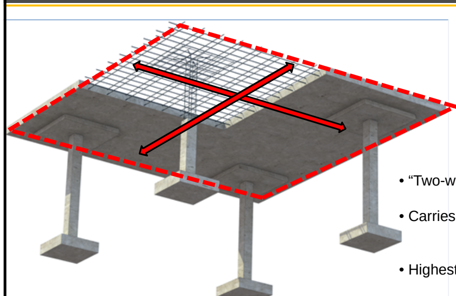
Designer's Task:

- *Efficiently resist shear and bending forces*
- *Create lighter & stronger elements*
- *Create long spans*
- *Minimize need for additional materials and labor*

Two Important Design Concepts:

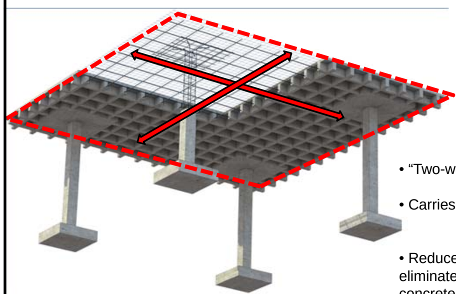
- **"Two-way" versus "One-way" slab reinforcement**
  - ***Where is the load carried to?***
- **"Flat-plate" design versus "Voided" slab**
  - ***Can we eliminate unnecessary materials?***

Conventional Suspended Slab



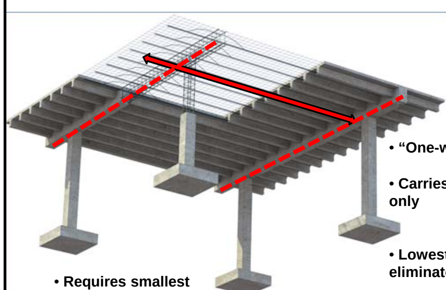
- "Two-way reinforcement
- Carries loads to all edges
- Highest mass option
- Largest supporting elements

"Voided" Elevated Slab



- "Two-way reinforcement
- Carries loads to all edges
- Reduced mass option eliminates unnecessary concrete
- Requires smaller supporting elements

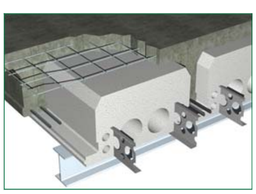
"One-Way" Voided Elevated Slab



- **"One-way" reinforcement**
- **Carries loads to two edges only**
- **Lowest mass option eliminates more concrete**
- **Reduces steel consumption**
- **Requires smallest supporting elements**

Best overall efficiency in design: Functional and cost-effective

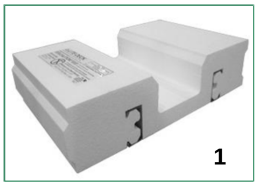
ICF Voided Slab Designs

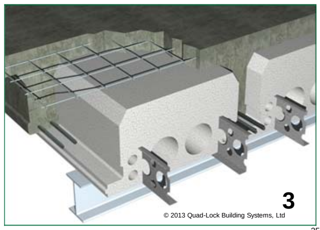


24

Three Voided Slab ICF Designs

1. Cut foam with steel insert
2. Moulded foam over engineered steel joist
3. Moulded panel with integral steel stiffener

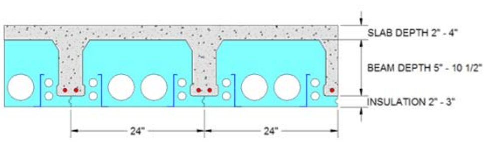




25

How Does it Work?

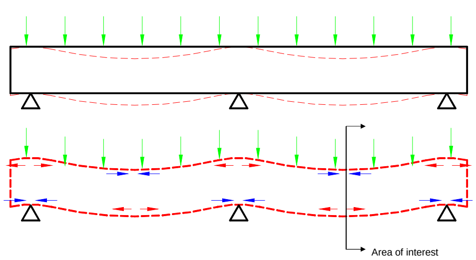
A "Pan Form" for T-Beam Slab Construction



26

Concrete Beams

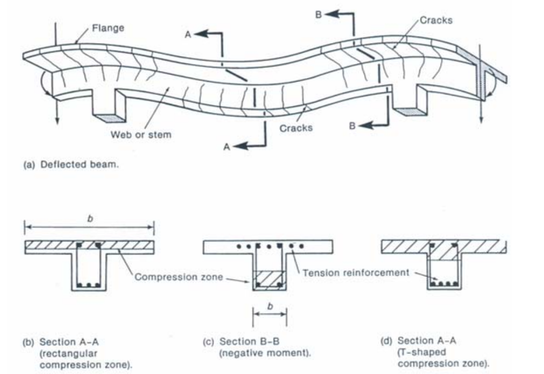
Superimposed Load – Concrete Beam



- Steel works in tension
- Concrete works in compression

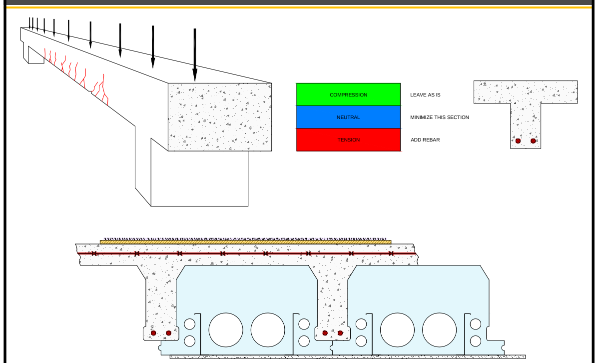
27

Positive & Negative Moment Regions in a T-beam



28

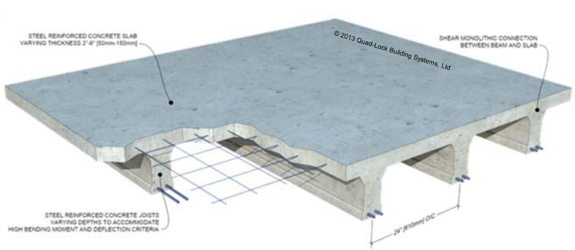
T-Beam Evolution



29

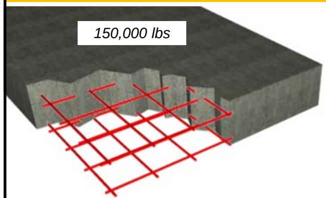
Achieves Design Objectives

- Safely carries expected loads
- Maintains building shape and structural integrity
- 40% lower mass reduces accelerated loads
- Long span capacity

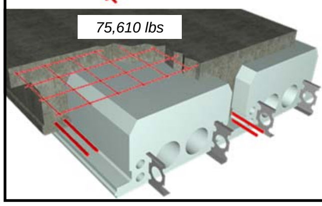


30

Compare Concrete Slab vs. ICF T-Beam



25'-0" Single Span: 8" Concrete Slab @ 50 psf LL		
Concrete needed		**37 cu.yd**
Top Reinforcement	#4 @12" O.C. E/W	1872 LB
Bottom Reinforcement	#6 @12" O.C. E/W	4209 LB
		6081LB

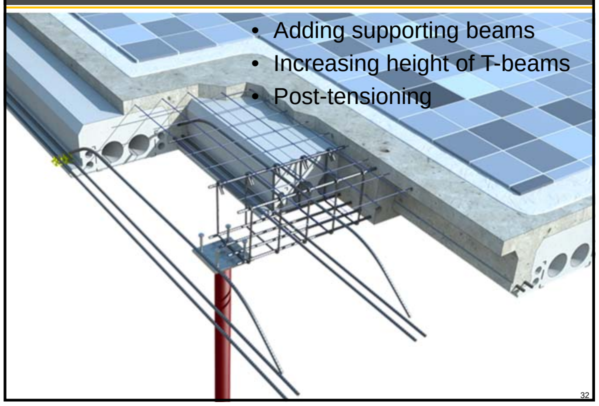


25'-0" Single Span: 11" QD + 2.5" Slab @ 50 psf LL		
Concrete needed		**18.4 cu.yd**
Top Reinforcement	6x6 WWM	288 LB
Bottom Reinforcement	2-#6 @ 24" O.C.	2883 LB
Quad-Deck Z-Strips	Spaced @ 12" O.C.	900 LB
		4071 LB

31

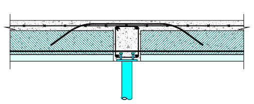
Increase Spans By:

- Adding supporting beams
- Increasing height of T-beams
- Post-tensioning

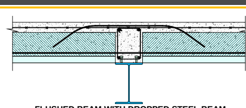


32

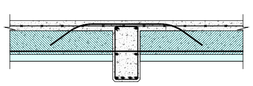
Beam Configurations:



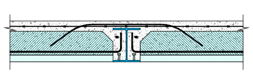
FLUSHED BEAM WITH OR WITHOUT COLUMN SUPPORT



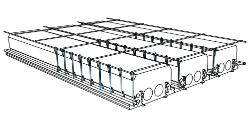
FLUSHED BEAM WITH DROPPED STEEL BEAM



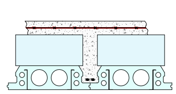
DROPPED BEAM WITH OR WITHOUT COLUMN SUPPORT



FLUSHED BEAM WITH INTEGRATED STEEL BEAM



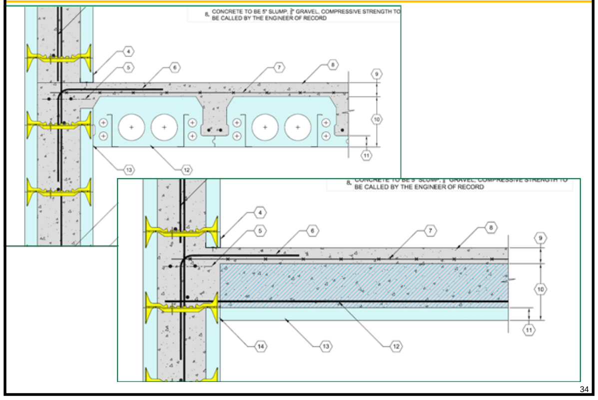
STIRRUPS FOR SHEAR REINFORCEMENT



TOP HATS INCREASE CONCRETE JOIST DEPTH

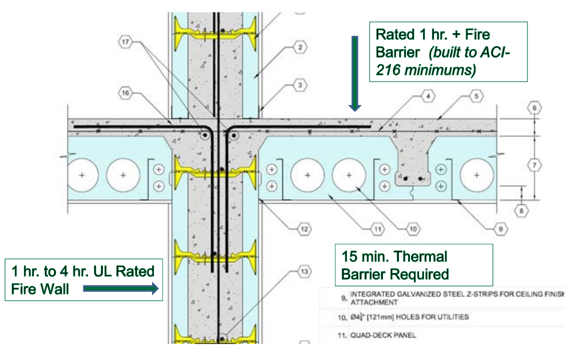
33

Typical Floor-to-Wall Connections



34

Multiple Family Occupancies



35

Disaster Resistant Designs

36

Desired Characteristics of Building Shells

Desired Characteristics *** Code Mandated*	Wood Frame	Steel Frame	Conv. Concrete	ICF Concrete
Moisture Resistant**				
Wind Resistant**				
Seismic Resistant**				
Thermal Continuity**				
Fire Resistant**				
Safe/Non-toxic**				
Impact Resistant				
Adaptable to Design & Utilities				

↓ *"Low or No Capacity"*

$$ *"High Added Cost"*

"Yes" *"Inherent To Design"*

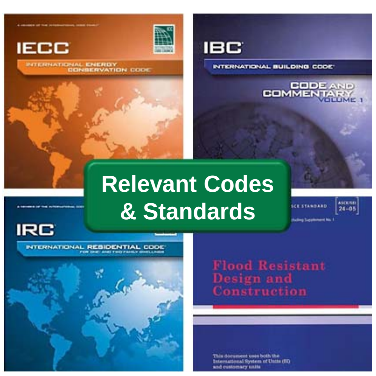
37

Desired Characteristics of Building Shells

Desired Characteristics *** Code Mandated*	Wood Frame	Steel Frame	Conv. Concrete	ICF Concrete
Moisture Resistant**	↓	$$	Yes	Yes
Wind Resistant**	$$	$	Yes	Yes
Seismic Resistant**	$$	$	Yes	Yes
Thermal Continuity**	$	$$	$$	Yes
Fire Resistant**	↓	$$	Yes	Yes
Safe/Non-toxic**	Yes	Yes	Yes	Yes
Impact Resistant	↓	↓	Yes	Yes
Adaptable to Design & Utilities	$	$$	$$	Yes

38

Disaster Resistant Designs



39

Relevant Codes and Standards

- **International Residential Code**
  - Chapters 3, 6 & 11
- **International Building Code**
  - Chapters 16 & 19
- **International Energy Conservation Code**
- **ASCE 24-05**
  - Flood Resistant Design & Construction
- **ACI 318**
  - Building Requirements for Structural Concrete

40

Topical Code References

1 Foam & ICFs	2 Structure & Design	3 Disaster Resistance
Protection Requirements	Residential Design	Wind Resistance
Fire Characteristics	Multi-family & Commercial Designs	Seismic Resistance
Acceptance Criteria • *Insulating forms* • *Foamed plastics*	Concrete Structures	Flood Resistance
Evaluation Reports	Evaluation Reports	Fire Resistance Rating

41

Topical Code References

1 Foam & ICFs

- IRC Section R611
  - R 611.4
  - R 302.9
- IBC Chapter 26
  - *Section 2603*
- AC 353
  - *Foamed Plastic Insulating Forms*
- AC 12
  - *Foamed Plastic Insulation*

⇨ Use of ICFs/foamed insulation in residential buildings

⇨ Use of ICFs/foamed insulation in commercial/multi-family buildings

⇨ Acceptance criteria for Insulating Concrete Forms

⇨ Acceptance criteria for foamed plastic insulation

42

Topical Code References

2 Structure & Design

- IRC Chapter 3
  - *Section R301*
- IRC Chapter 6
  - *Section R611*
- IBC Chapter 16
  - *Section 1614.3.1*
  - *Section 1612*
  - *Section 1609*
- ACI 318
- Evaluation Reports

⇨ Residential design requirements

⇨ Prescriptive designs for ICF buildings

⇨ Design requirements for multi-family and commercial buildings

⇨ Code requirements for concrete

⇨ Designs using proprietary products

43

Topical Code References

3 Disaster Resistance

- IRC Chapter 3
  - Section R322
  - Section R323
- IBC Chapter 19
- IBC Appendix G
- ASCE 24-05, ASCE 7
- ACI 216
- ICF Evaluation Reports

⇨ Requirements for residential designs

⇨ Requirements for multi-family & commercial designs

⇨ Flood resistant designs for construction; Loading requirements

⇨ Fire resistance of construction materials

⇨ Individual Fire Resistance Ratings

44

Disaster Resistant ICF Designs

45

Harry C. Moore Library – Bahamas

Harry C. Moore Library – Bahamas

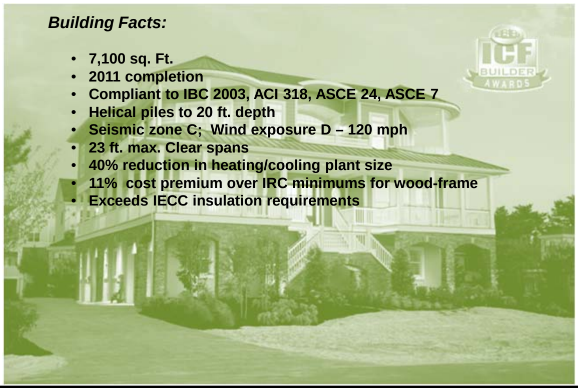
Building Facts:

- **60,000 sq. Ft.**
- **85% radius wall surfaces**
- **Integrated reinforced columns 3 stories high**
- **Specified & designed as National Disaster Relief Center (Category 5 hurricane threat)**
- **2011 ICF Builder Awards *"Best in Class"* (Heavy Commercial)**
- **Exceeds IECC insulation requirements**

"...one of the largest and most sophisticated public buildings in the Caribbean"

Custom Home – Dewey Beach, MD

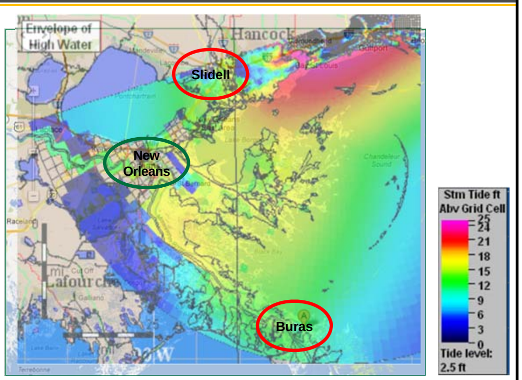
Custom Home – Dewey Beach, MD



Building Facts:

- 7,100 sq. Ft.
- 2011 completion
- Compliant to IBC 2003, ACI 318, ASCE 24, ASCE 7
- Helical piles to 20 ft. depth
- Seismic zone C; Wind exposure D – 120 mph
- 23 ft. max. Clear spans
- 40% reduction in heating/cooling plant size
- 11% cost premium over IRC minimums for wood-frame
- Exceeds IECC insulation requirements

Louisiana High School Re-builds



50

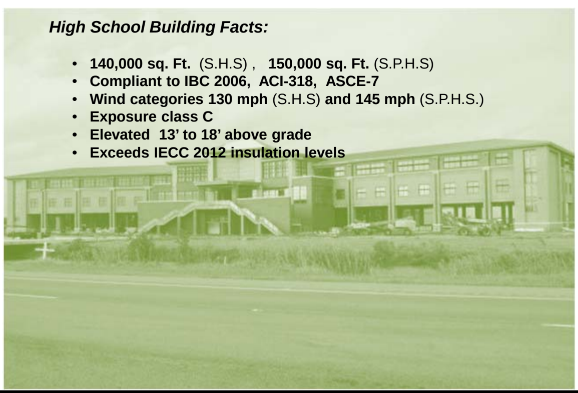
Salmen High School – Slidell, LA

South Plaquemines H.S. – Buras, LA

FEMA School Replacement Projects

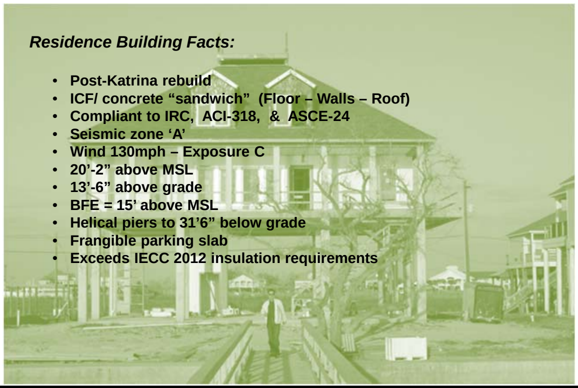
High School Building Facts:

- **140,000 sq. Ft.** (S.H.S) , **150,000 sq. Ft.** (S.P.H.S)
- **Compliant to IBC 2006, ACI-318, ASCE-7**
- **Wind categories 130 mph** (S.H.S) **and 145 mph** (S.P.H.S.)
- **Exposure class C**
- **Elevated 13' to 18' above grade**
- **Exceeds IECC 2012 insulation levels**



Elevated SFR – Treasure Isle, LA

Elevated SFR – Treasure Isle, LA



Residence Building Facts:

- Post-Katrina rebuild
- ICF/ concrete “sandwich” (Floor – Walls – Roof)
- Compliant to IRC, ACI-318, & ASCE-24
- Seismic zone ‘A’
- Wind 130mph – Exposure C
- 20’-2” above MSL
- 13’-6” above grade
- BFE = 15’ above MSL
- Helical piers to 31’6” below grade
- Frangible parking slab
- Exceeds IECC 2012 insulation requirements

Thank You!

This Concludes the ICC Presentation

What Questions Can We Answer for You?

CONTINUING EDUCATION AIA

QUAD-LOCK Building Systems Ltd.

www.quadlock.com

56