Safe vs Safer: Engineering Framework for Resilient Housing in Colombia

Anna Pavan – Build Change

Safe vs Safer: Engineering Framework for Resilient Housing in Colombia

Build Change

Anna Pavan

BUILD CHANGE

Anna_Medellin

30th November 2016

1st day in the Office

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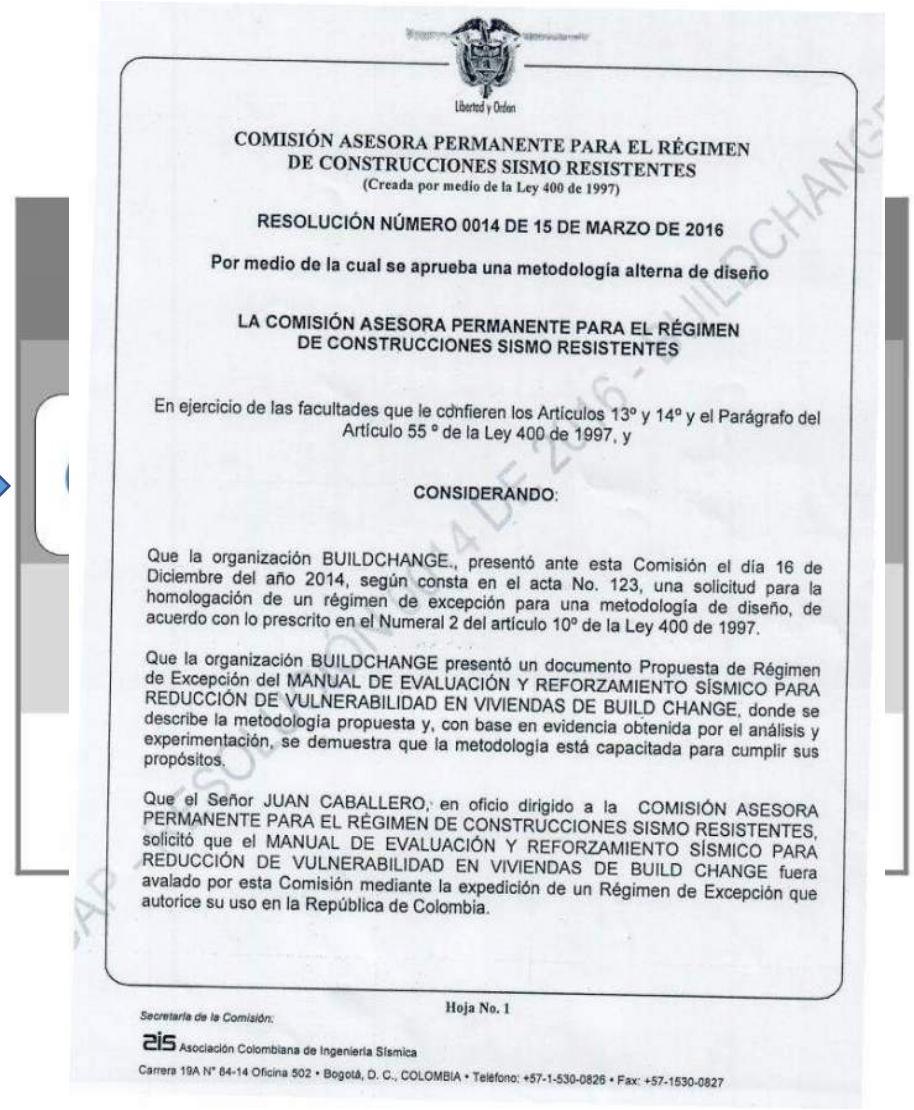
Where We Started…

ASCE 31 & ASCE 41

+

NSR-10



Libertad y Orden

COMISIÓN ASESORA PERMANENTE PARA EL RÉGIMEN DE CONSTRUCCIONES SISMO RESISTENTES
(Creada por medio de la Ley 400 de 1997)

RESOLUCIÓN NÚMERO 0014 DE 15 DE MARZO DE 2016

Por medio de la cual se aprueba una metodología alterna de diseño

LA COMISIÓN ASESORA PERMANENTE PARA EL RÉGIMEN DE CONSTRUCCIONES SISMO RESISTENTES

En ejercicio de las facultades que le confieren los Artículos 13º y 14º y el Parágrafo del Artículo 55 º de la Ley 400 de 1997, y

CONSIDERANDO:

Que la organización BUILDCHANGE., presentó ante esta Comisión el día 16 de Diciembre del año 2014, según consta en el acta No. 123, una solicitud para la homologación de un régimen de excepción para una metodología de diseño, de acuerdo con lo prescrito en el Numeral 2 del artículo 10º de la Ley 400 de 1997.

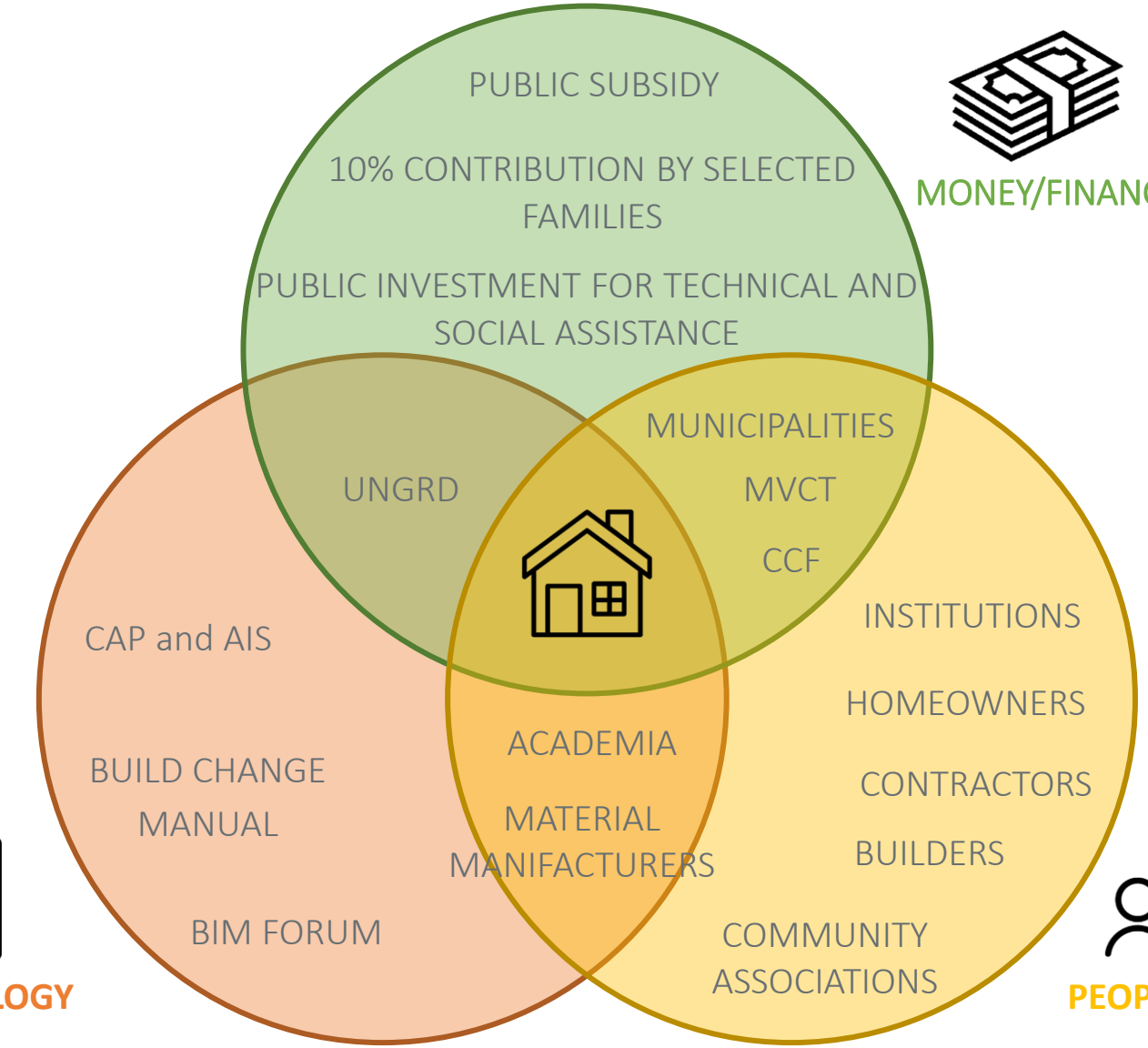
Que la organización BUILDCHANGE presentó un documento Propuesta de Régimen de Excepción del MANUAL DE EVALUACIÓN Y REFORZAMIENTO SÍSMICO PARA REDUCCIÓN DE VULNERABILIDAD EN VIVIENDAS DE BUILD CHANGE, donde se describe la metodología propuesta y, con base en evidencia obtenida por el análisis y experimentación, se demuestra que la metodología está capacitada para cumplir sus propósitos.

Que el Señor JUAN CABALLERO, en oficio dirigido a la COMISIÓN ASESORA PERMANENTE PARA EL RÉGIMEN DE CONSTRUCCIONES SISMO RESISTENTES, solicitó que el MANUAL DE EVALUACIÓN Y REFORZAMIENTO SÍSMICO PARA REDUCCIÓN DE VULNERABILIDAD EN VIVIENDAS DE BUILD CHANGE fuera avalado por esta Comisión mediante la expedición de un Régimen de Excepción que autorice su uso en la República de Colombia.

Hoja No. 1

Secretaría de la Comisión:
AIS Asociación Colombiana de Ingeniería Sísmica
Carrera 19A N° 84-14 Oficina 502 • Bogotá, D. C., COLOMBIA • Teléfono: +57-1-530-0826 • Fax: +57-1-530-0827

MTP for Retrofit of Informal Houses in Colombia



- **AIS:** Colombian Association of Seismic Engineering
- **BIM:** Building Information Modeling
- **CAP:** Permanent Advisor Committee
- **CCF:** Family Compensation Fund
- **INSTITUTIONS:** CVP, ISVIMED
- **MVCT:** Ministry of Housing
- **UNGRD:** National Unit for Disaster Risk Management

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Direct Implementation in Colombia

Maria de Jesus Ortiz's House, Comuna 6 Medellin

Maria Fatima Rios,
Comuna 8, Medellin

Implementation with Local Partners

AMVA - Maria Fatima Ríos's House, Medellin

ISVIMED - Rosa Mejia's House, Medellin

IDIGER – Technical Staff Training in Bogotá

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Investigation with Local Universities

- Nine full-scale shake table tests at EAFIT University, Medellin
- 23 full-scale pseudo-dynamic tests at EAFIT University in Medellin and Julio Garavito Engineering School in Bogotá
- Several diagonal compression tests at EAFIT, Julio Garavito Eng. School and Nueva Granada Military University in Bogotá

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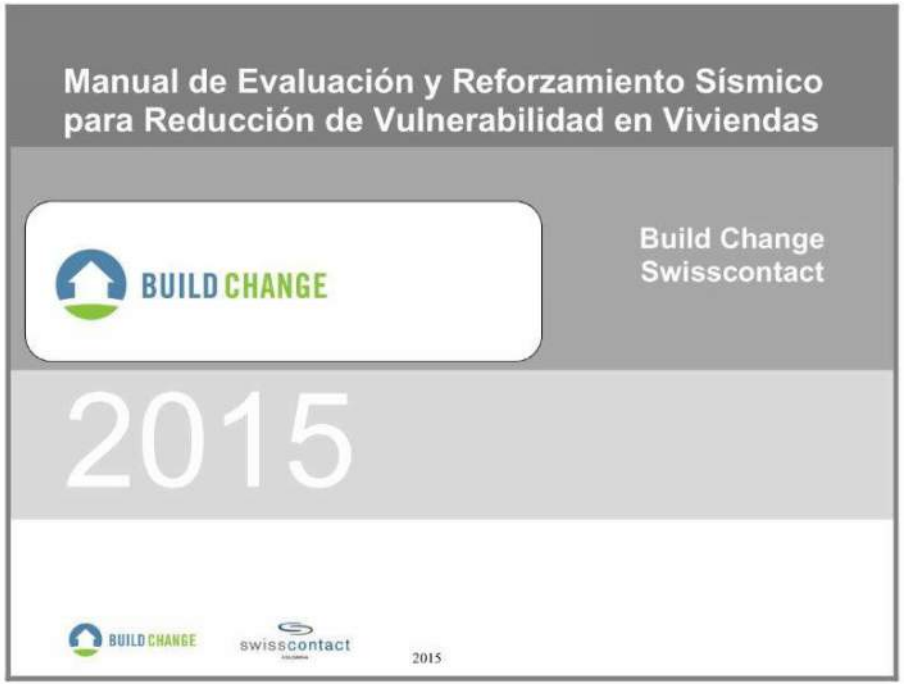
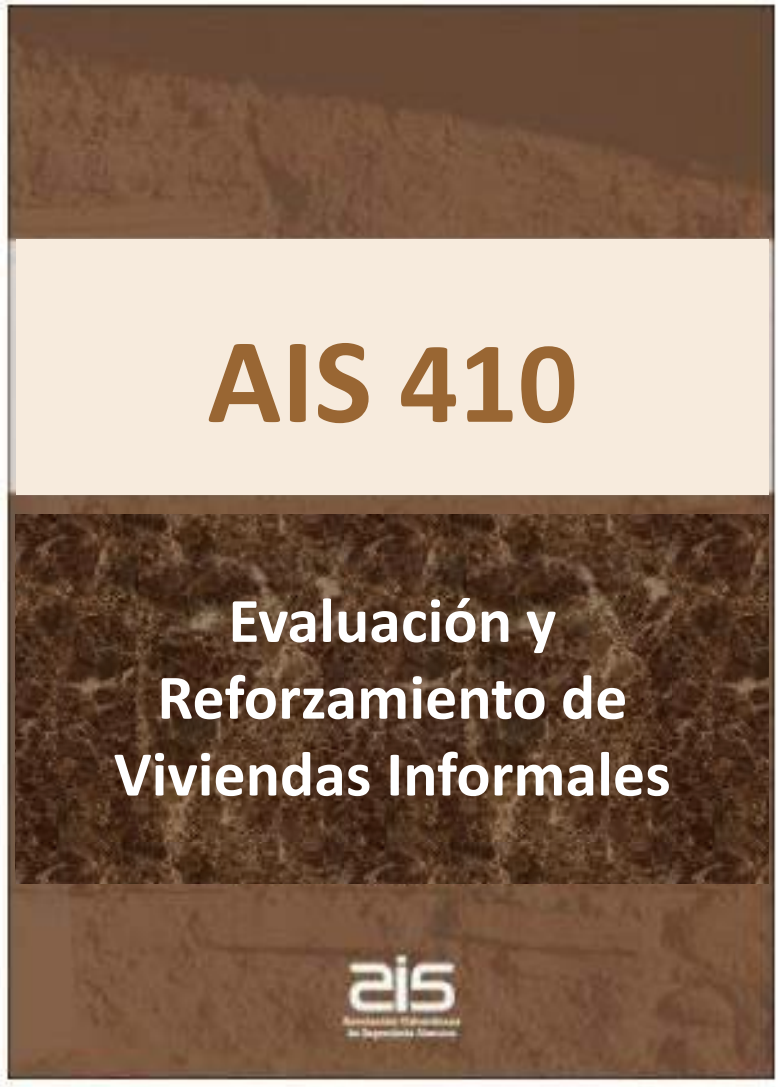
Where We Are Moving…





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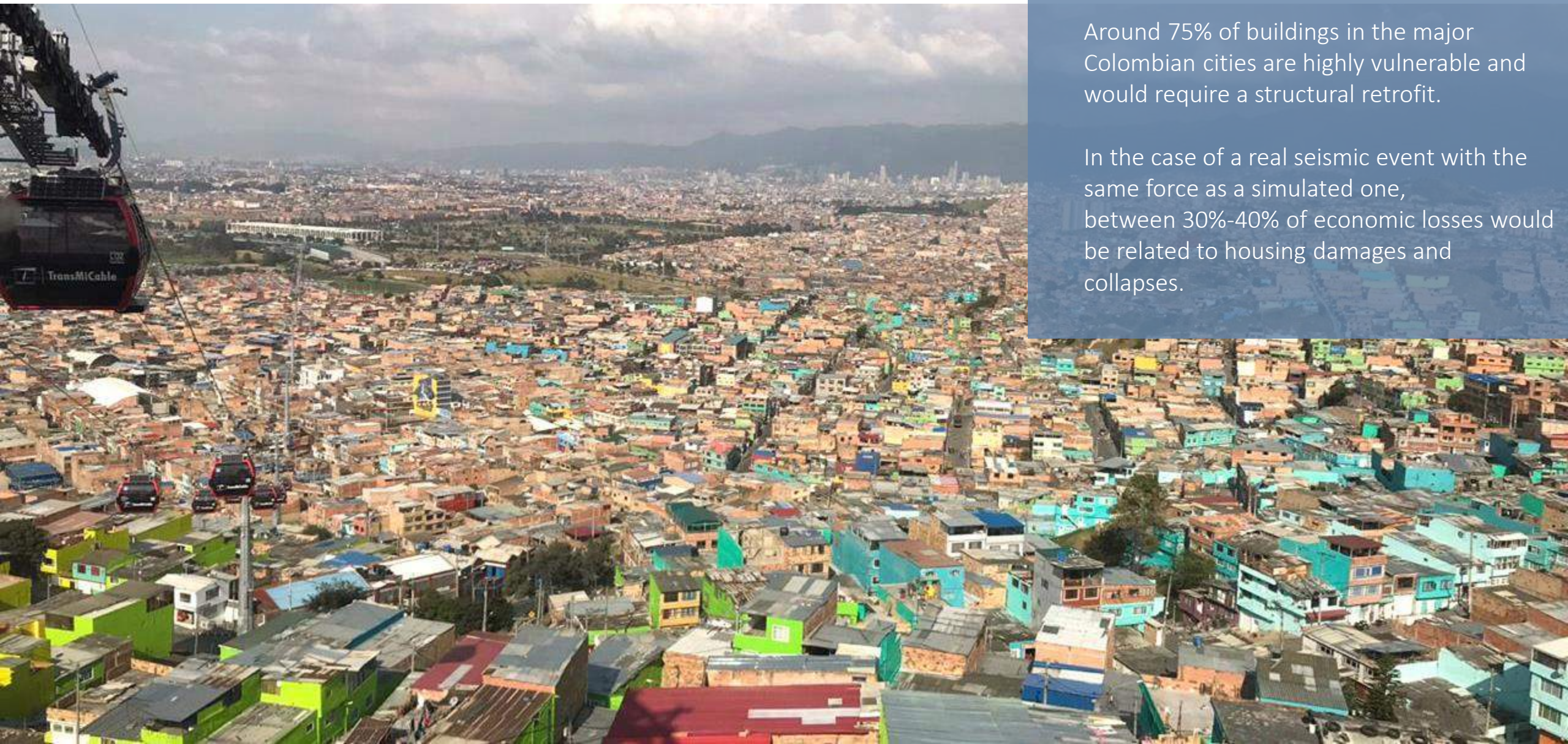
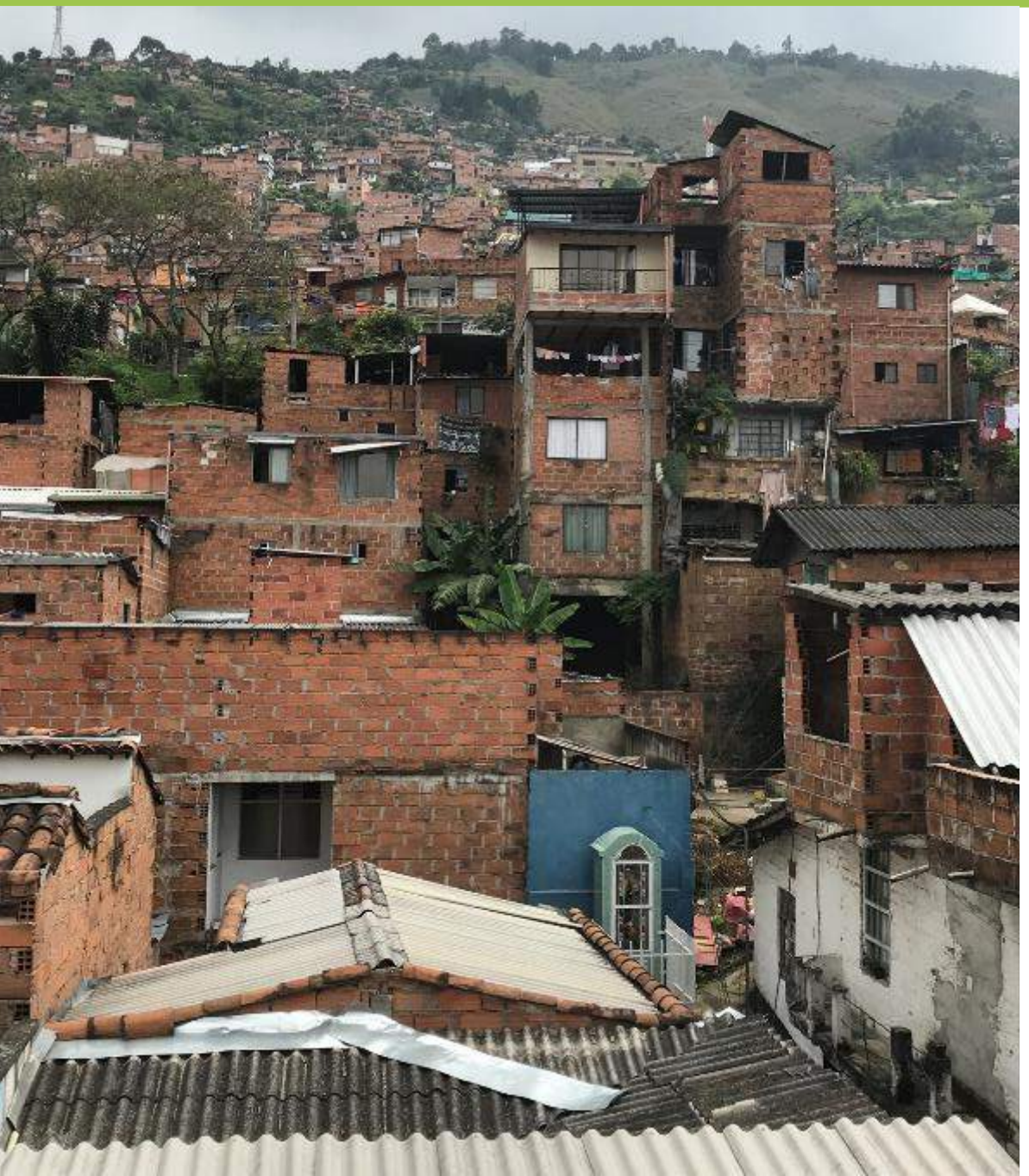
A Difficult Reality



Around 75% of buildings in the major Colombian cities are highly vulnerable and would require a structural retrofit.

In the case of a real seismic event with the same force as a simulated one, between 30%-40% of economic losses would be related to housing damages and collapses.



An Alternative Approach

Technically

- Define patterns of deficiencies – the most typical ones
- Use a simple, prescriptive approach
- Advocate for a gradual/partial mitigation of vulnerability when needed

Politically

- Find the conditions that allow exploring new paths

Financially

- Mitigate some of the most hazardous conditions for a lower total cost

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Retrofit Cards

- **Recipes** for **easy mitigation** of some basic vulnerabilities
- They focus on most recurrent deficiencies
- They aim to reduce the risk of collapse of the house
- They have a **strict field of application**

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Retrofit Card – 1 Story Building

	Structural Deficiency	Improvement Activity
1	Lack of Ring Beam	Build New Ring Beam above all walls, to generate closed rings.
2	Lack of Wall Area, Low Shear Resistance	Plaster all accessible wall surfaces. (Mortar mix 1:4, cement : sand)
3	Short/Incomplete Walls	Complete walls up to ring beam or slab level and connect them to the top element.
4	Free Wall Edges	Build a 2-bars column at free edge to give more out-of-plan stability to the wall panel.
5	Lack of Transverse Walls/ Distance between parallel walls bigger than 4m	Build 4m of new wall parallel to the main facade. The total length can be divided in segments, that are at least 1m long each.
6	Lack of solid wall at façade (minimum 1.5m long or 40% of the building overall width)	Shift or partially fill the facade door or window opening, to obtain the required minimum solid wall length.
		Build a new wall inside the building, parallel to the facade, at a maximum distance equal to 20% of the overall building length from it, with a length equal to the minimum one required.
7	Façade Wall Thickness = 10cm	Plaster one surface of the facade wall with a mesh plaster (3cm thick) and the other surface with simple plaster (1.5cm thick).
	Façade Wall Thickness = 15cm	Plaster both surfaces of facade wall with 1.5cm thick simple plaster.

Applicability: any 1-story house, with a regular plan shape, without severe existing damage

Our Experience in Medellin

- 72 designs performed by local technicians (ISVIMED)
- One and Two-Story Buildings
- 1 day training (½ day in class, ½ day on field)
- Average survey and Design time:
  2 hours in the house + 1 hour in the office
  Including:
  - Geometrical survey
  - Social questionnaire to homeowner
  - Bill of Quantities
  - 1 plan for construction
- Average Cost 90 USD/m²

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Evaluation and Design Approach Comparison

Full Retrofit Manual Approach

- Life Safety Performance Level for a Design earthquake
- Design Time: 1-5 days
- Final Review – 4 hours, before submitting for building permit *
- 125 USD/m^2 Average cost **
- 7,500-10,000 USD total**
- Needs Building Permit (7 months***)

Retrofit Card Approach

- Always improves the existing structures, varies in resulting performance
- Design Time: 0.5 days
- Final Review – 1 hour, before submitting for building permit *
- 90 USD/m^2 Average cost ** (~70%)
- 5,400-7,200 USD total**
- No permit mechanism yet

* Average Review Time
** For 1-story building
*** Average Time

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Example Houses

An Average House

- 5-7m wide x 7-12m long
- 60m² - 80m²
- 1 or 2-story, Simple Masonry
- 2.5m Typical story height
- Light-Weight or Heavy Roof*
- Walls distributed on the perimeter and internally (typical floor plan)

A Worse House

- Only minimum wall lengths met, at maximum permitted spacing (1.5m long wall every 4m – as per RF Card)
- Unusually open floor plan

- Based on our field experience in Medellin and Bogotá
- Could represent between 0% and 70% of the informal housing stock, depending on the city

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Expected Performance for "An Average House"

Seismic Hazard:		Low		Medium		High*	
Soil Type:		Good	Worst	Good	Worst	Good	Worst
Average House	1-Story Light-Weight Roof	100%	100%	100%	100%	100%	90%
	1-Story Heavy Roof	100%	55%	85%	40%	50%	35%
	2-Story Light-Weight Roof	100%	45%	70%	30%	Not Permitted**	Not Permitted**

* Up to Region 7 as defined by NSR-10 (Regions 8, 9 and 10 not considered because there is no major city in those regions)

** According to Manual applicability

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Expected Performance for "A Worse House"

Seismic Hazard:		Low		Medium		High*	
Soil Type:		Good	Worst	Good	Worst	Good	Worst
Average House	1-Story Light-Weight Roof	100%	100%	100%	55%	60%	42%
	1-Story Heavy Roof	85%	25%	40%	20%	24%	15%
	2-Story Light-Weight Roof	65%	20%	30%	15%	Not Permitted**	Not Permitted**

* Up to Region 7 as defined by NSR-10 (Regions 8, 9 and 10 not considered because there is no major city in those regions)

** According to Manual applicability

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Engineering Framework for Resilient Housing

Level	Name	Main Driver	Examples
3	Full Retrofit	**Performance:** Driven by desire to meet life-safety in code-defined event	- Manual approach
2	Risk Reduction	**Happy Medium:** Driven by desire to mitigate most hazardous conditions but may not reach full code-level resistance	- Risk mitigation retrofit card approach
1	Structural Home Improvement	**Social and Financial Reality:** Driven by desire to use functionality improvements to house to also improve disaster resilience, and at a minimum, not increase vulnerability	- new light roof - new slab roof - permanent interior partitions - new/modified windows and doors - new wall finishes
0		**Aesthetic,** superficial improvements	

THANK YOU

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