Precast, solution for the global housing crisis

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1. SUMMARY

1. The current housing crisis is severe, global, worsening.

2. The crisis is a human tragedy. It is a permanent matter of life and death for tens of millions of people; 2,000 of them die every day! The situation is desperate since there is no prospect of solution in sight.

3. The physical support of housing is the house itself. Methods of construction are therefore a fundamental factor of both the crisis and its solution.

4. Current construction methods failed to prevent the crisis. They cannot reverse the trend either.

5. The artisanal character of current construction methods is the root cause of the crisis. Construction has yet to undergo its industrial revolution.

6. The Precast Frame Structure, as it is implemented by the company Precast-First, meets required conditions for being an industrialized construction method.
It can help to quickly and dramatically increase offer of affordable houses anywhere in the world.

Houses become:
a) 4 times faster to build.
b) 2 times stronger.
c) 1.25 times more affordable.
d) 2 times more environmentally friendly.

2. AN OVERVIEW OF THE CURRENT GLOBAL HOUSING CRISIS

UN-Habitat
“Approximately 2.8 billion people worldwide face housing inadequacies, from homelessness to substandard and unaffordable homes."
"A recent study by Habitat for Humanity International shows that equitable access to adequate housing could reduce preventable deaths of 730,000 people annually."
730,000/year means 2,000 preventable deaths/day!

United States
"The United States currently has a housing shortage between 4 and 7 million homes.
“Nearly 7-in-10 Americans are concerned by rising housing costs."
"We are facing a massive housing deficit”.
“Even if constructions immediately double, which is unlikely, we still need 5 to 10 years just to catch up with the current demand."

India
“India is estimated to have a cumulative affordable housing shortage of 31.2 million units by 2023, with a potential market size of Rs 67 trillion” ± $ 800 billion!

France
« Nearly 15 million people are affected by the housing crisis (health risks, risk of eviction, inadequate comfort, or disruption to their daily environment and family life.”

Nigeria

“Nigeria faces a severe housing crisis, with a deficit exceeding 17 million units that is projected to grow due to rapid urbanization, with 700,000 new units needed annually.”

United Kingdom

"Right now, there are 8.5 million people in England who can't access the housing they need. This includes two million children in England living in overcrowded, unaffordable or unsuitable homes."

The housing crisis and birth rate decline

“The U.S. birth rate plunged to an all-time low in 2024 after being on a downward trajectory for roughly 20 years, with soaring housing costs widely cited as a major contributing factor.”

3. THE ROOT CAUSE OF THE CRISIS

Facts:

Fact #1. The housing crisis is severe, global, worsening, and there is no prospect of solution in sight.

Fact #2. The physical support of housing is the house itself. Methods of construction are therefore a fundamental factor of both the crisis and its solution.

Fact #3. Current construction methods failed to prevent the crisis. They cannot stop it either.

Fact #4. The artisanal character of current construction methods is the root cause of the crisis. Construction has yet to undergo its industrial revolution.

4. PROSPECT OF SOLUTIONS

The major cause of the crisis being the artisanal character of current construction methods, solutions necessarily involve industrialization of construction, which has 2 main requirements: simplicity and the right material in the right place.

4.1 Simplicity

Industrialization generally refers to production in series, which requires standardization, and makes mechanization an efficient option. The simpler the units are, the more efficient industrialization is.
Therefore, the first step is to find which construction technique allows an advanced breakdown of its components, with appropriate methods of assembly once on construction site.

There are two types of structures:
The structure frame: the frame must withstand vertical and horizontal loads - that is all. Walls complement it by defining spaces and protecting the occupants.

The load-bearing walls: In addition to their irreplaceable role of defining spaces and protecting occupants, walls must withstand vertical and horizontal loads as well.
Combining these functions does not facilitate optimized industrialization.
In addition, loadbearing walls are limited in number of floors. Urban housing, especially the one aimed at resolving the dramatic current crisis, should not start with such limitations.
Offsite production of concrete and wood loadbearing walls didn't prove to be particularly fit to industrialization.

Conclusion: **The structure frame** is the most appropriate choice for an industrialized approach.

4.2 The right material in the right place

4.2.1 **The structure frame**

Concrete has no competitor for load transfer in underground and ground level structures. Its use can be extended to above-ground structures without major objections: columns and beams, slabs, and stairs.

4.2.2 **Connections**

For simple buildings, connections are not stressed at an alarming level. That is why conveniently wood uses wood connections, concrete uses concrete connections, and steel uses steel connections.

However, most wood constructions appropriately shifts to steel connections at a certain height of buildings. For example:
. Ascent, USA, a hybrid high-rise apartment building, 25 floors.
. Mjostarnet, Norway, a timber high-rise commercial building, 18 floors.
. Bullitt Center, USA, a five-floors commercial building.

However, concrete construction didn't, in a similar way, adopt the right joint material for multi-story buildings.
There is no viable alternative to steel for creating moment-resisting connections between structure frame elements.
Concrete is the dedicated construction material for all foundations independently of the construction material used for the above ground structure. The same way, steel should be dedicated for all connections, independently of the construction material used elsewhere in the building.

4.2.3 Walls

Walls represent the most significant building component in terms of volume and weight. They should be constructed using locally available materials: bricks, wood, cement blocks, etc.

We took the best from the main construction techniques:
From wood construction, we took the technology: posts and beams and joists floors.
From concrete construction, we took the material: concrete.
From steel construction, we took connections.

At this stage, the best choice for industrialized construction is the concrete frame structure, also said posts-and-beams structure, with connections made of steel, and walls of locally available materials.

4.3 Why not cast-in-place concrete?

Cast-in-place concrete construction was ruled out for several reasons:

4.3.1 Outdoor work

Cast-in-place concrete is performed on construction site. Then in outdoor conditions. Too low temperatures in cold season, and too high temperatures in warm season. Construction can be interrupted, and/or quality affected.

On the other hand, offsite fabrication is performed in controlled environment, with positive effect on quality and operation continuity.

4.3.2 Problematic sequence of operations

Let's consider a farmer who undertakes to plant five cornfields.
He has two options.

Option 1: Sequential cultivation: planting one field after another, in series.
1° He plants the first field, then waits for the harvest.
2° He plants the second field using seeds harvested from the first field, then waits again for the second harvest.
3. And so on, up to fifth field.

Option 2: Simultaneous cultivation: plantation of all 5 fields in parallel.
Gather enough seeds to plant all five fields at the same time.

The analogy applies to construction. A contractor wishes to construct a five-story building.

Option 1: Sequential construction: building one floor after another, in series.

1° He builds the ground-floor low beam: fabricating reinforcement cage; setting formwork; pouring and vibrating concrete; formwork deshuttering; 28-day watering for curing.

2° He builds the ground-floor columns: fabricating reinforcement cage; setting formwork; pouring and vibrating concrete; formwork deshuttering; 28-day watering for curing.

3° He builds the ground-floor upper beam: fabricating reinforcement cage; setting formwork; pouring and vibrating concrete; formwork deshuttering; 28-day watering for curing.

4° He builds the 1st floor concrete slab: fabricating reinforcement cage; setting formwork; pouring and vibrating concrete; formwork deshuttering; 28-day watering for curing.

These sequences are repeated for each floor. In total, there will be 5 x 4 = 20 sequences, with curing period between them. Curing period is theoretically 28 days, but it can be shortened by using accelerator admixtures.

Option 2: Prefabrication of all elements in a precast facility.
The contractor purchases all structural elements required for the entire building in a precast facility. He immediately starts assembly without interruption until the project is finished.

These respective operations sequences explain by themselves the enormous difference in execution times between a cast-in-place construction method, on the one hand, and a precast one, on the other hand.

4.3.3 A deep artisanal method by nature

Let's take an example of a 5-floor, 10 apartments building. It has around 200 identical columns.
In cast-in-place concrete, each of these 200 columns is handcrafted as a unique object, meaning artisanry. Fabricating reinforcement cage; setting formwork; pouring and vibrating concrete; formwork deshuttering; 28-day watering for curing.
All these two hundred times!
If in a small city there are 10 similar buildings under construction, it means that 2000 columns will be handcrafted, and approximately 1000 beams of 5m; 600 of 4.5m; and 400 of 4m.

On the other hand, with precast technology, all these columns and beams are fabricated using around 20 metal molds, infinitely reusable, adjusted once for all, then delivering similar units, of better quality, more quickly, more easily, more precisely, on constant production schedule, etc.

4.3.4 No "structural personality" of joints

Buildings must resist 2 main types of loads: vertical et horizontal loads.
Vertical loads are well known. It is easy relatively to deal with them. Horizontal loads, however, are not well known and are unpredictable. They are increasingly risky for buildings as their height increases.

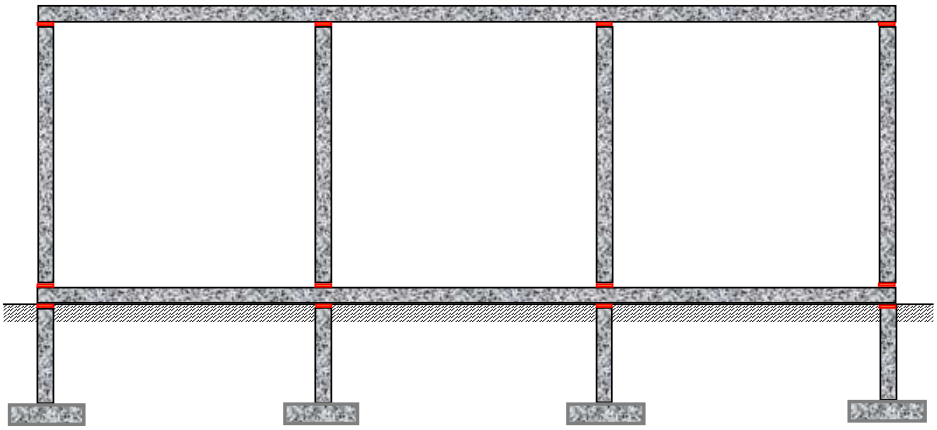
All structural elements are involved in dealing with horizontal loads, but joints are on the frontline! Surprisingly, joints are not specifically designed to meet these challenges in cast-in-place concrete construction. They are just intersections between columns and beams, from which they just inherit characteristics.
It results in great vulnerability of the whole structure to horizontal loads, especially in case of earthquakes.

https://www.researchgate.net/publication/245378123

The palliative solution against horizontal loads is shear-walls. They are especially designed to play the role that well designed concrete joints should have played: withstanding horizontal loads.

4.3.5 Illusion of monolithic structures: cold joints

One of the weakest points of cast-in-place concrete construction are “cold joints”, especially at bottoms and tops of columns.
The whole concrete structure is supposed to be monolithic. It means that it is supposed to be made in one piece. However, the whole concrete cannot be poured at the same time. Adherence between concrete batches which have not been vibrated together is weak.



Cold joints at tops and bottoms of columns

4.6 Conclusion

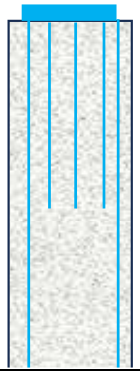
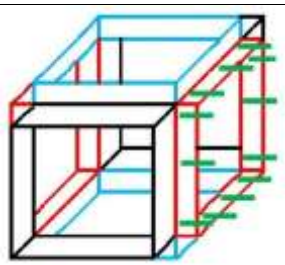
Based on objective facts and observations, it successively appeared that in the perspective of industrialized construction:
1° The frame structure passed the test, but loadbearing-walls structure didn’t.
2° Using the right material in the right place resulted in the frame structure to be made of concrete, with connections of steel, and infill walls of locally available materials.
3° Offsite fabrication of the structure elements.

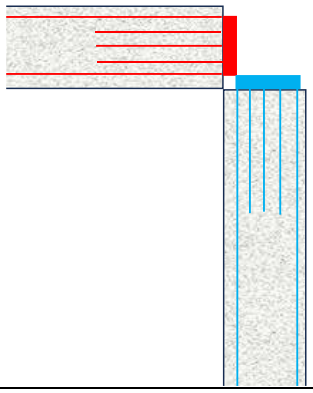
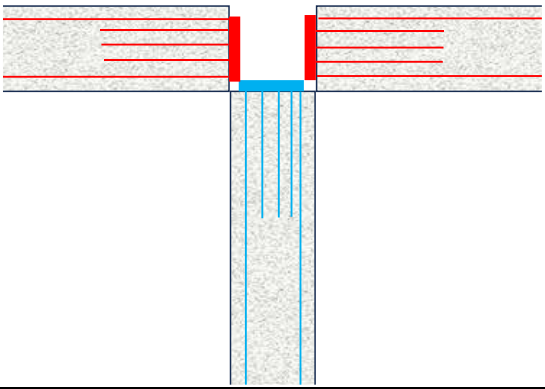
The Precast Frame Structure is the only one construction method which is eligible to industrialized construction in general, and industrialized affordable housing in particular.

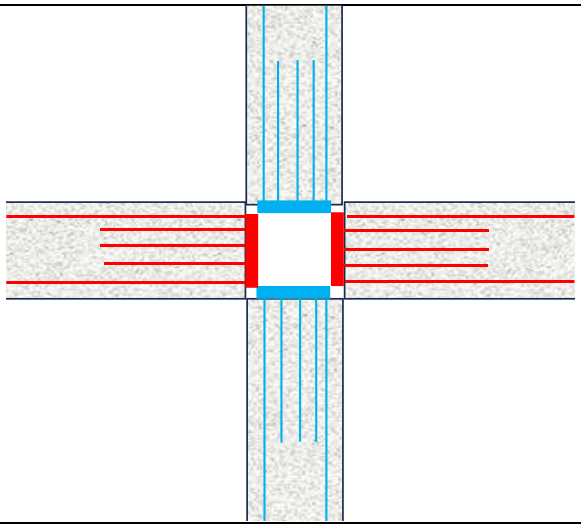
5. DESCRIPTION OF THE PRECAST FRAME STRUCTURE

5.1 Steel connection details

	
Columns and beams are provided with end frames strongly welded on their reinforcements. Flat bar of 30x6mm is used.	Each column and beam is provided with usual reinforcements according to structural design, AND additional end frame “roots”, extending to ± 30 cm. Tests carried out by different laboratories show that the resistance in tension of each welded connection is 4-5 tons. That means 5 x 16 roots and longitudinal reinforcements = 85 tons for the whole joint!

			
Lateral sectional view of end of a beam	Lateral sectional view of end of a column	In blue, 2 frames. One comes attached to the lower column, and the other to the upper column. In red and black, lateral beams.	

	
Connection between 1 column and 1 beam. End steel frames are welded at their contact line. Thus, 2/6 faces of the cubic connection are completed.	Connection between 1 column and 2 beams. End steel frames are welded at their contact line. Thus 3/6 faces of the cubic connection are completed.

	
Connection between 2 columns and 2 beams. End steel frames are welded at their contact lines. 4/6 faces of the cubic connection are completed.	How the steel connection looks like when all the 6 faces are completed: 2 columns and 4 beams. All the 6 end frames are welded at each contact line.

If we “debone” the joint between 1 column and 2 beams, we will see the final constitution of the connection. For conventional concrete on the one hand, and for the Precast Frame Structure on the other hand. The intensive “roots” of the end steel frame, provides its high resistance to the connection. 12mm rebars are added in end frames diagonals and medians, to make the connection even stronger.	

		
Connection between 2 adjacent beams	Connection between 1 column and 2 beams.	Connection between 4 adjacent beams.

		
Similarity: steel connection in wood construction.	Testing 12mm rebar/30x6mm flat bar welded connection	Rebar may break before the welded connection

Steel connections allow concrete to display its full potential in construction.

5.2 Precast joint

Option for connection: **Precast joint**.



The precast joint is intensively reinforced and cast with high performance concrete.
Assembly is even faster. It is suitable for structures up to five-floor constructions. Just lifting and tightening bolts and nuts!
Note: Intensive bracing is also applicable here, particularly in seismic zones.

5.3 Industrialized construction


Precast posts, beams, and stairways stringers in a precast facility storage area.
It remains to add steel end frames on posts and beams as above, and then transport them on construction to be assembled.

5.4 Impressive cost reduction

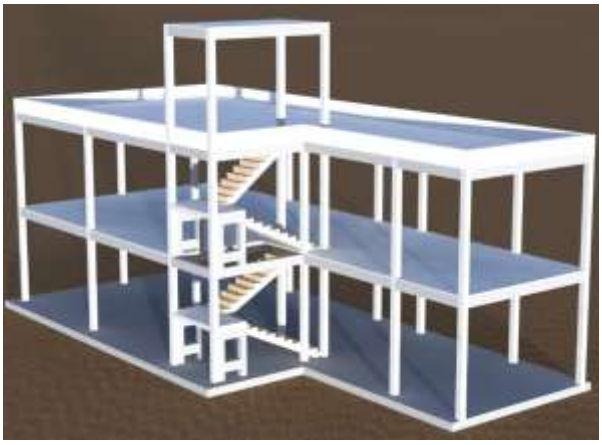
5.4.1 Two different modes of fabricating the same thing

It is 2 - 3 times more difficult to fabricate columns in vertical position on construction sites, compared to fabricating them in horizontal position, in factory!
The same thing for beams, slabs and staircases. Everything is much easier if made in factory: *Preparing the reinforcement cage, setting shuttering, pouring and vibrating concrete, formwork, curing.*

We also get there in the end. But why make it complicated when it can be done simply?

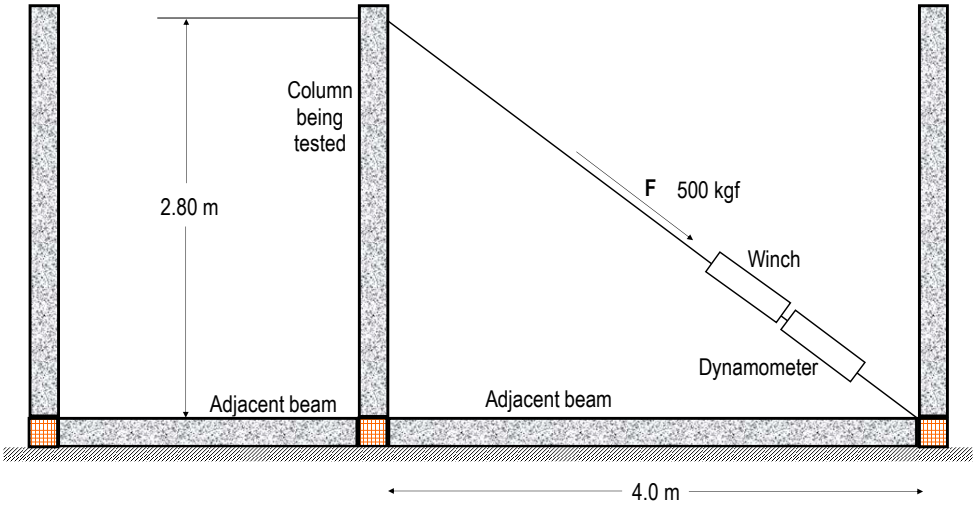
5.4.2 Infill walls

For infill walls, any construction material can be used depending on local availability: bricks, cement blocks, wood and wood-based materials.



An example of a two-floor post-and-beam structure, and bricks infill walls.

5.5 A unique moment resisting joint



A load of 500 kg (1,100 lb) is applied to the top of each column on buildings under construction, to prove its resistance to horizontal loads. With such joints, beams are entered as "**fixed beams**" at the structural designing step. It results in much larger spans all other things being equal.
This test can be compared to a Supreme Court ruling: it is not susceptible to appeal!

5.6 Fast construction

Precast compagnies have available all construction elements ready to be assembled on site: posts, beams and braces; slab joists and boards; stringers, steps and risers for stairways, etc.

A 5-floor, 10 apartments precast frame structure, can be completed in maximum 3 months by 6 welders, 6 laborers, 2 masons and 1 supervisor. Tools they need are mainly welding machines and demountable mobile hand cranes.

Infill walls, doors and windows, plumbing and electricity, insulation and finishing are not included in this time.

With traditional cast-in-place concrete, the same construction will likely take 4 times more time, cost 50% more, and be 2 times weaker!

5.7 Defeating earthquakes and hurricanes

Experts are talking about "**defeating earthquakes**" with triangulated structures, not even mentioning the highly moment resisting joints.
https://www.youtube.com/watch?v=Bg4kSIgn67I&t=3s
Min 0-2:45
Moment resisting joints and intensive triangulation make buildings almost indestructible. Even in case of powerful earthquakes or hurricanes, buildings may suffer at the most, of non-structural damages

In addition to moment-resistant connections and intensive triangulation, roof slabs result in buildings to be closed boxes. They contribute greatly to making earthquake-resistant and hurricane-proof buildings.

5.8 Tidiness and quietness at construction sites

The construction site for cast-on-site concrete is generally noisy, cluttered, humid, long to finish, etc.
Here, nothing to drill, nothing to cut, to nail, to vibrate, to cure, etc. **Just lifting and welding**.
Construction is even quieter, cleaner, and faster than wood construction.

5.9 Fire resistant constructions

Everything is precast and fire resistant: frame, joist slabs, stud walls, stairways and braces.
Roof slabs provide additional protection against flying embers in case of external source of fire.

5.10 Fast approval of housing projects

Currently each construction and/or housing project is structurally and architecturally unique. It requires long personalized calculation for approval.
With precast frame structure, construction projects are structurally almost the same, although architecturally different. In this point of view, the approval process should go much faster.

5.11 Structure vs Architecture

5.11.1 One structure, an infinity of architecture designs

Industrialized construction shouldn't be understood as identical constructions all along streets and cities. What is industrialized is structure but not architecture.

5.11.2 Industrialized structure vs structural monotony

Current structures from cast-in-place concrete can all be realized using precast concrete. The difference between them is only the connection.
There should not be fear of eventual structural monotony with industrialization.
However, depending on local practice, here is an example of the stock a precast facility may hold:
1) Column 20x20x300 cm: 2000 pieces
2) Beam 20x20x500 cm: 1000 pieces
3) Beam 20x30x450 cm: 1000 pieces.
4) Beam 20x30x400 cm: 1000 pieces
5) Joist floor 50x30x400 cm: 1500 pieces
6) Concrete board 3x19.5x400cm: 3000 pieces
7) Stair stringer: 500 pieces
8) Stair step: 500 pieces
9) Stair riser: 500 pieces
10) Brace 10x15x50 cm: 2000 pieces
11) Brace 10x15x100 cm: 2000 pieces
If a building has been designed standardized sizes, the entrepreneur goes to the precast facility, picks up all elements he needs and goes to assemble them. If he has some unstandardized sizes, for example beams of 20x30x437.5 cm, then he places an order and will come back for them after fabrication and cure.
Note: A 5 m long mold can be used to fabricate any size between 0 and 5 m.

6. Patents granted

Patents were granted by the following offices:

1. United States Patents and Trademarks Office USPTO: US 10,494,807 B2.
2. European Patent Office EPO: EP 3310973.
3. Burundi Department of Industrial Property: BI 2015/321.
4. Euro-Asian Patent Office EAPO: EA 034805.
5. China National Intellectual Property Administration CNIPA: CN 4328807.
6. Indian Patent Office IPO: IN 471248.

US010494807B2

(12) **United States Patent**
Nitunga

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(54) **CONSTRUCTION OF THE PREFABRICATED COLUMN AND BEAM TYPE**

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(72) Inventor: **Libere Nitunga**, Bu (BI)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(58) **Field of Classification Search**
CPC E04B 1/2403
See application file for complete search history.

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(74) *Attorney, Agent, or Firm* — Wayne V. Harper

(57) **ABSTRACT**

A system of construction that performs advanced prefabrication of columns-beams type structure of buildings, prefabrication which results industrialization of this type of construction. The main development that allows this achievement in the same technical conditions, even better conditions than in the conventional system, is the massive use of beams as well vertically as horizontally. Such a building system is of special interest in areas where seismic risk is high because the building is very lightweight, constituted of a set of structurally self-sufficient units, heavily triangulated and therefore hardly deformable, all these at an affordable cost.

20 Claims, 8 Drawing Sheets

URKUNDE | **CERTIFICATE** | **CERTIFICAT**

Europäisches Patent | **European patent** | **Brevet européen**

Es wird hiermit bescheinigt, dass für die in der Patentschrift beschriebene Erfindung ein europäisches Patent für die in der Patentschrift bezeichneten Vertragsstaaten erteilt worden ist.

It is hereby certified that a European patent has been granted in respect of the invention described in the patent specification for the Contracting States designated in the specification.

Il est certifié qu'un brevet européen a été délivré pour l'invention décrite dans le fascicule de brevet, pour les Etats contractants désignés dans le fascicule de brevet.

Europäisches Patent Nr.
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Brevet européen n°

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25.03.20

Antónia Campinos
Präsident des Europäischen Patentamts
President of the European Patent Office
Président de l'Office européen des brevets

REPUBLIQUE DU BURUNDI

Ministère du Commerce, de l'Industrie, des Postes et du Tourisme

Direction de la Propriété Industrielle et de la Documentation

Réf. N° 756/ 235 /PID/2015

Certification des spécifications de l'invention telles que déposées

Par la présente, nous certifions que les spécifications ci-jointes sont conformes à celles déposées par Libère NITUNGA en notre office, pour l'obtention d'un brevet d'invention ayant pour titre : Poteaux et poutres en béton armé préfabriqués.

La demande a été enregistrée en date du 28 mai 2015 sous le numéro 321/BI à la Direction de la Propriété Industrielle et de la Documentation, du Ministère du Commerce, de l'Industrie, des Postes et du Tourisme.

Fait à Bujumbura, le 28 mai 2015

Le Directeur de la Propriété Industrielle et de la Documentation

Vianney NIYUKURI

(19) **Евразийское патентное ведомство**

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(54) **КОНСТРУКЦИЯ ТИПА СБОРНЫХ КОЛОНН И БАЛОК**

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(86) PCT/IB2016/053064
(87) WO 2016/189476 2016.12.01
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(56) FR-A-941058
DE-A-1-1509023
E. Badoret, "Traité pratique du charpentier", 8 March 1939 (1939-03-08), Librairie polytechnique, Paris, XP002760189, page 44; figure 153, page 119; figure 247, 348

(57) В изобретении представлена система конструкции одной типа сборно-монолитных колонн-балок, предварительное изготовление которых ведет к развитию производства такого типа конструкций. Основным усовершенствованием, которое позволяет осуществить решение в тех же технических условиях, даже в лучших условиях, чем при обычной системе, является массовое использование распорок как вертикально, так и горизонтально. Такая система строительства особенно интересна в областях повышенного сейсмического риска благодаря тому, что здание возможно, построено из структуры незначимых блоков, и значительной степени прочностирования и таким образом такая деформируема, и все это по относительно невысокой стоимости.

034805 B1

7. Conclusion

1° The root cause of the current global housing crisis is the artisanal character of current construction methods. The solution involves industrialized construction.

2° The Precast Frame Structure technology, patented at an international level, is the only one construction method which meets the requirements for effective industrialized construction.
It is a ready-to-use technique, requiring low investment levels, but capable of quickly increasing availability of houses anywhere in the world.
Houses become:
a) 4 times faster to build.
b) 2 times stronger.
c) 1.25 times more affordable.
d) 2 times more environmentally friendly.