PRESS RELEASE

To the press

Jun. 23, 2020
NejiLaw Inc.

NejiLaw and IHI Have Started Joint Development of "CB-zeROBO"

A robot that embodies CB theory of concrete bubble elimination
and enables us to implement it in our society.

NejiLaw, Inc., hereinafter referred to as "NejiLaw"(CEO: Hiroshi Michiwaki, Headquarters: Bunkyo-ku, Tokyo, Japan), has signed a joint-development contract of the commercial production model of "CB-zeROBO" (the photo below) with IHI Corporation (President: Tsugio Mitsuoka, Headquarters: Koto-ku, Tokyo, Japan), and has started the development work. "CB-zeROBO" embodies the "CB (Concrete-Bubble) Theory" which theorizes about the mechanism of elimination of air bubbles. The robot automatically eliminates concrete bubbles by applying a variable inertia force to the fresh concrete during the placing process in the formwork.

※Conceptual drawing of CB-zeROBO

CB Theory is a theoretical system of concrete bubble elimination mechanism advocated by Hiroshi Michiwaki, the representative of NejiLaw as well as an inventor. It is validated through research and development of a series of basic technologies and the patent was granted as CB-zeRO technology. After a joint research with the IHI Group, his treatise was published in the IHI Technical Bulletin" IHI Technical Report (Vol. 59, No. 1, 2019)".
In September 2019, CB Theory was verified using basic research device CB-zeRO CUBE made by NejiLaw and presented at FY2019 National Meeting sponsored by Japan Society of Civil Engineers held at Kagawa University. As a result, CB Theory was compiled and publicized in three treatises. "CB-zeROBO" is a robot which controls the generation of concrete bubbles while placing concrete, and enables to produce high quality concrete secondary products with high efficiency.

I. What is Concrete Bubble problem?

Concrete Bubble is the enemy of concrete.

Air bubbles are also called [Pockmarks] or [Honeycombs], that cause deterioration of durability, in addition to strength and aesthetic issues. Repairing surface bubbles is expensive.

Air bubbles inside cannot be eliminated.

Unsolved problem for 5,000 years

Concrete was already used in the Roman Empire around 2nd century B.C.

Even after the birth of conventional concrete in the 19th century, there has always been air bubbles problem.

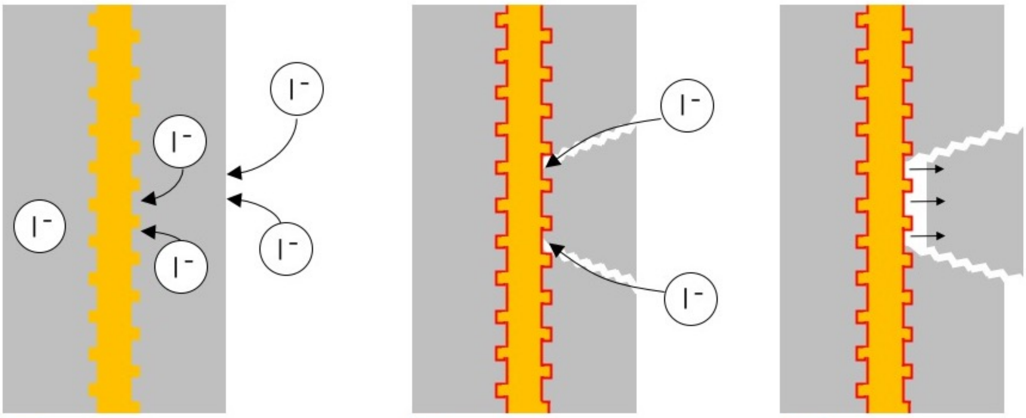
Specimen of actual size precast concrete product

※Reference image

The conventional concrete is a rigid-body composition like the earth crust, that hardens through a process called hydration. This process is used for Portland cement which reacts with water to form a cement paste that functions as binder for fine aggregate, coarse aggregate, admixture, etc. and this creates a fresh concrete mix. The fresh concrete mix will be placed in the desired formwork and hardens through hydration. Characteristically, it shows chemically a strong alkalinity and is physically highly resistant to compression and it has high rigidity. On the other hand, it is brittle and weak in tension. A general structure of conventional concrete was invented as a contrivance for compensating for this weakness of being weak in tension. These composite structures, embedding the rebar in concrete are called reinforced concrete.
This utilizes the characteristic of iron, which is extremely strong against the pulling and thus is the perfect reinforcement structure to compensate for the week tensile strength of concrete.
Furthermore, iron does not rust in pure concrete which is highly alkaline, and it is said, concrete and iron have complementary relations. This is how reinforced concrete succeeded in compensating for the weakness of tensile strength of unreinforced concrete. It has made it possible to realize girder bridges with long spans and skyscrapers.
However, it is known that the lifespan of reinforced concrete that compensates for the weaknesses of unreinforced concrete is not so long due to another issue.
This is because coarse and irregular air bubbles called Entrapped-Air that are generated when concrete is mixed or poured, are randomly generated inside or on the surface of concrete. These concrete bubbles, of course, directly affect the concrete strength, but it is possible to reinforce it by securing the safety factor of strength with sufficient cross-sectional area. Yet, there were many cases where reinforced rebars, which should not rust in concrete, rust inside.

Items that regulate the lifespan of reinforced concrete

Originally for densely built concrete, rainwater is almost impermeable.
However, in windy and snowy or cold and warm environments, the concrete repeatedly vibrates, expands and contracts, that causes minute cracks and the like. Corrosive gases and liquids in the atmosphere penetrate through these minute cracks. Eventually, the corrosive components (corrosive ion, etc.) reach the rebars inside the concrete, causing corrosion and expanding the rebars due to rust. This expansion creates an internal pressure in the concrete surrounding the rebars, and a tensile force is generated between the molecules forming the inside of the concrete. In other words, concrete has a mechanism where expansion from the inside effects the tensile strength and it becomes impossible to maintain the body itself.



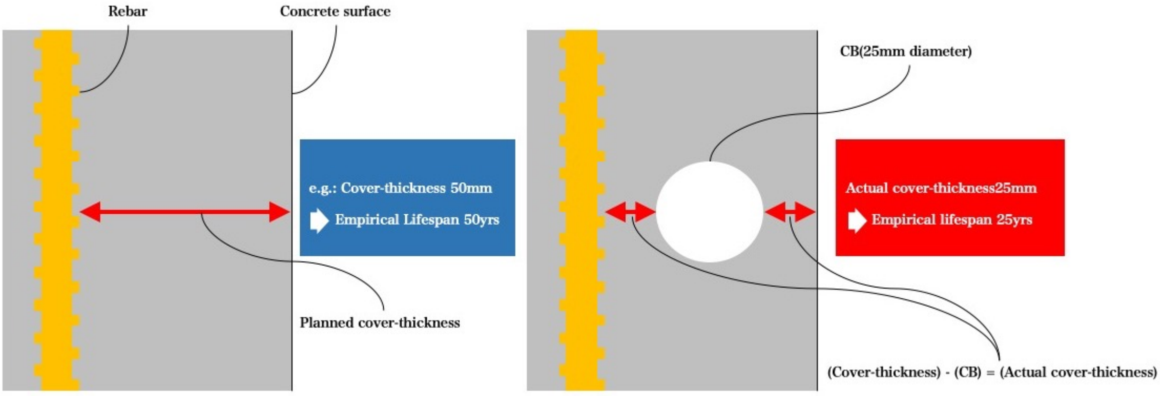
1 In addition to ※sea sand contained in the material, corrosive ions are supplied from acid rain and the atmosphere that eventually penetrate into the concrete.The passivation film formed on the rebars breaks and rust occurs.

2 The rusting causes the rebars to expand, which causes cracks in the concrete and corrosive ions directly infiltrate and accelerate the progress of rust.

3 The expansion in the rust increases, cracks extend, and then cover concrete peels off.

※ In addition to using sea sand as a material, corrosive ions are also supplied from the atmosphere, exhaust gas, acid rain, etc., which penetrate into the concrete and rust occurs due to defects in the passivation film of the rebars.

Now, the problem starts here. Since this mechanism works in principle, as a countermeasure, the larger the distance from the concrete surface to the internal rebars (hereinafter referred to as cover-thickness), the longer the permeation time of the corrosive gas into the rebars. The period until corrosion is extended and the lifespan of reinforced concrete can be extended. However, if the cover-thickness is made too large, the unreinforced region from the concrete surface to the rebars becomes too wide, resulting in a decrease in strength. Therefore, the cover-thickness must be set to a certain amount or less, for example, several tens of millimeters or less. This cover-thickness is the main factor that determines the durable lifespan of reinforced concrete. This is where the previous issue comes into play. That is the existence of coarse concrete bubbles that form irregularly inside and outside the concrete, namely, Concrete Bubble (hereinafter referred to as CB).
The location, size and shape of CB in concrete are all irregular. Now, it is assumed that the size of the maximum diameter of a certain CB towards the depth direction is 25 mm and it exists between the concrete surface and the rebars. On the other hand, it is assumed that the planned cover-thickness is 50 mm and rebars are completely, densely embedded in concrete. The actual cover-thickness becomes 25 mm = (Planned cover-thickness 50 mm) — (CB diameter 25 mm), and the empirical lifespan is shortened to 25 years. This causes a large lifespan decrease.



1 The lifespan of reinforced concrete depends on the concrete cover-thickness.
It is assumed that the planned cover-thickness is 50 mm and the empirical lifespan is 50 years.

2 If CB with a maximum diameter of 25 mm exists between the concrete surface and the rebars, the actual cover thickness becomes (50 mm-25 mm=25 mm), and the actual lifespan expectancy shortens to 25 years.

The Conventional Countermeasures against CB

Since CB greatly shortens the lifespan of reinforced concrete, all of CB should be eliminated. As a countermeasure against CB, until now, a high-pressure air stream was sprayed to the concrete surface with an air gun, and the hidden CBs were also squeezed out, and then each CB that came out from inside was filled with a putty-like object to make the surface more even and smoother. Such countermeasures by human-wave tactics have been performed routinely.

II. CB Theory

CB Theory=Countermeasure Technology against CB <Related Patent Pending>
Established a new theory of CB elimination mechanism
Improving the durability and quality of structures with densified concrete
The first ever CB-less Concrete is Born
Realized products with the principle of reducing bubbles

Concrete "CB-ZERO" was born with no entrapped air on either surface or inside

Mechanism 1 (Chain of disintegrated fluidity and low friction due to fluctuating inertia force)

- By applying the fluctuating inertia force, it instantaneously becomes zero gravity and the frictional force among each constituent material becomes almost zero.
- When the vibration peak is reached, the constituent materials contact with each other and are repositioned again.
- During this process, the concrete flows in a liquid phase towards its stabilization.
- By repeating this process, the bubbles reach the upper surface and are released into the atmosphere.

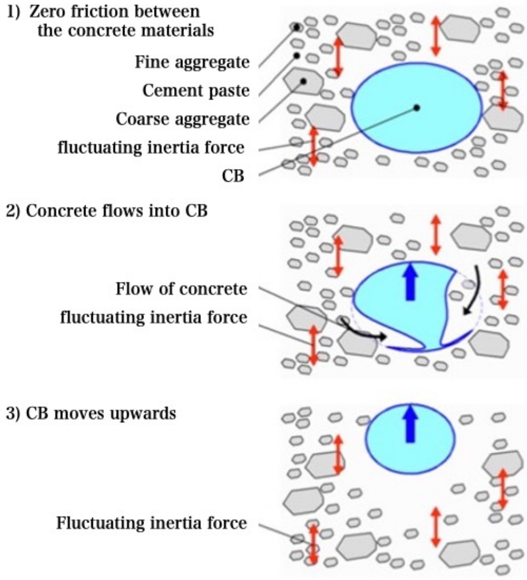
Mechanism 2 (CB fragmentation・subdivision by fluctuating inertia force)

- By applying the fluctuating inertia force, CB disappears due to the difference in inertial force between CB and concrete.
- CB is split into secondary, tertiary and higher-order to achieve the desired CB size.
- Is it theoretically possible to change coarse entrapped air into entrained air by advancing higher order?

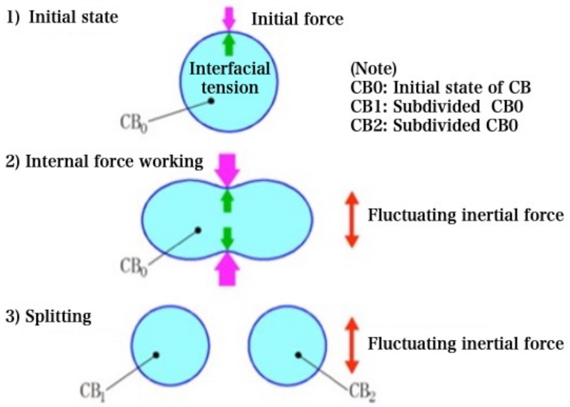
Mechanism 3 (Miniaturization of CB by resonance collapse of Kitora Tumulus type CB)

- Kitora Tumulus type CB is air captured by multiple coarse aggregates.
  →It cannot be destroyed by the first and second mechanisms.
- To resonate the coarse aggregate may be effective by applying a vibration close to the natural frequency of the coarse aggregate.

Mechanism 1



Mechanism 2



Ⅲ. CB Basic Research Equipment

Variable Inertia Force Application Device CB-ZERO CUBE

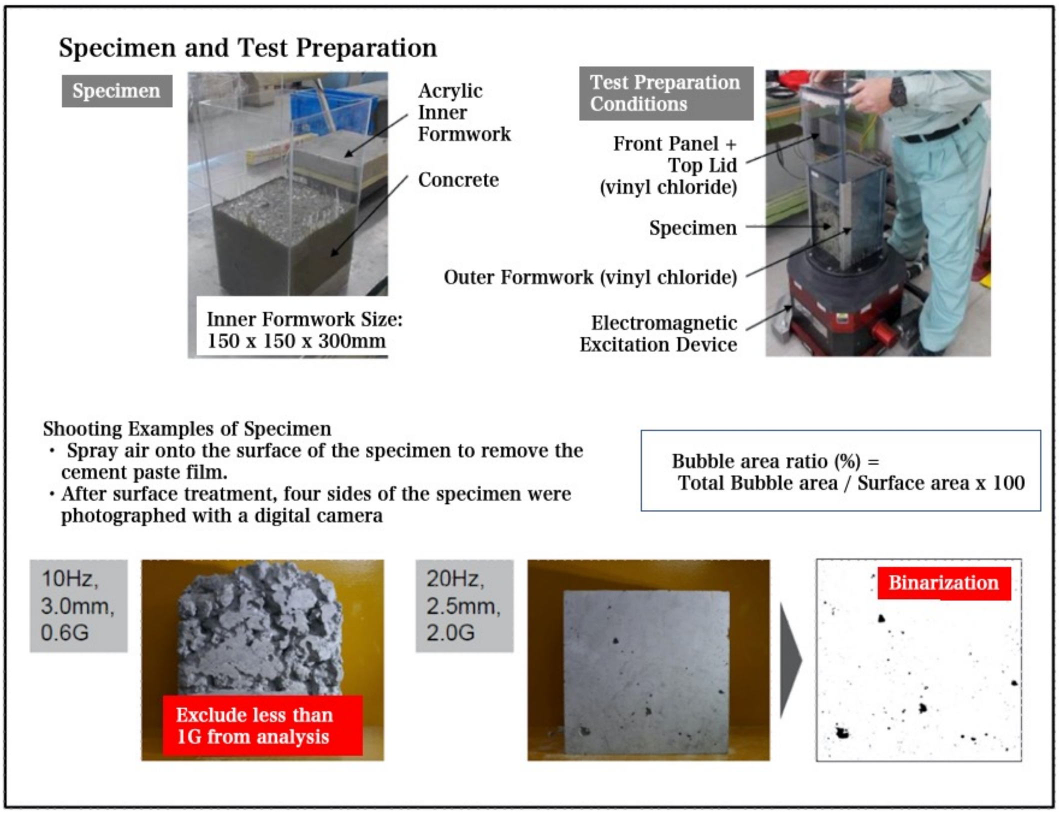
CB elimination device for basic research: Verification of the theory of eliminating CB (Concrete Bubble) generated during concrete placing, discovering new correlations and laws, extract optimal variable inertia force conditions for each blending composition.

<u>Product Features</u>

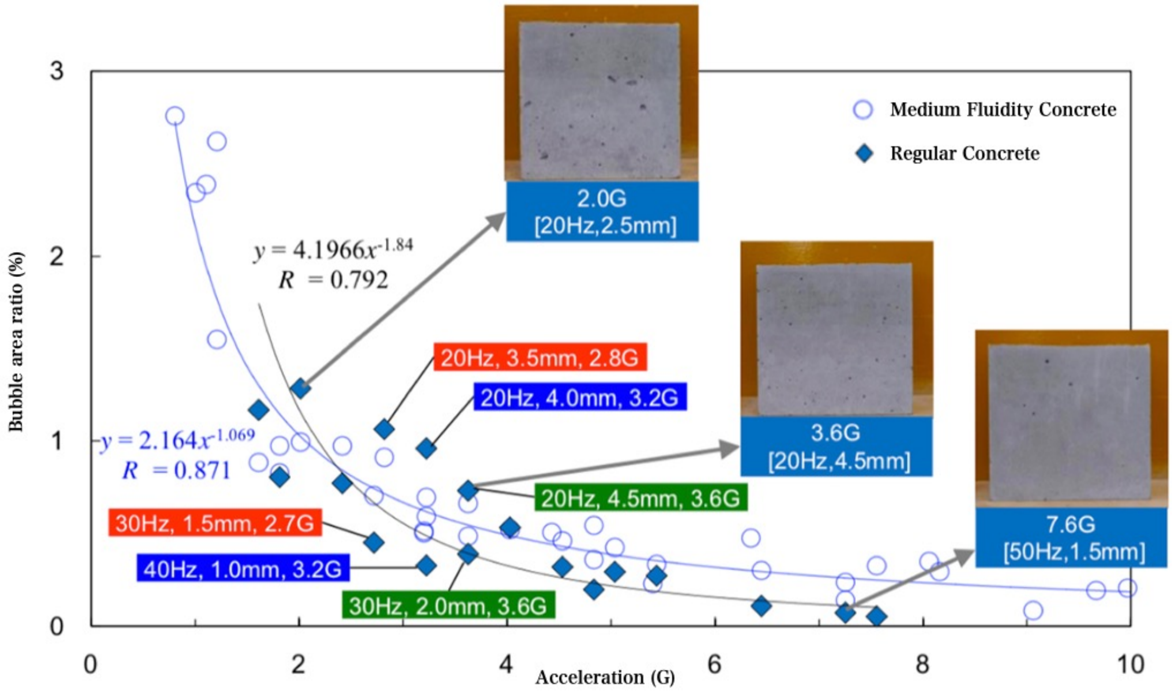
Since it is designed considering usability to conduct tests efficiently, it is possible to produce several tens of concrete specimen with different conditions such as composition and variable inertia force.

Frequency range (Hz)	1～3,000
Maximum amplitude (mmp-p)	10
Maximum acceleration (G)	10
Maximum mass of concrete specimen	10kg
Inner dimension of specimen holder(mm)	156.4 x 159.0 x 318.0

※Appearance is subject to change



Fluctuating inertia force loading test on concrete



NejiLaw aims for “Loc-Tech ‘Advanced Loc-King Technology’”-to improve National Resilience

The Tokyo Olympics and Paralympics will be held again after 57 years since 1964.
Nearly 60 years have passed since infrastructure construction was actively carried out in Japan.
Building life is estimated to be 40 to 50 years and in recent years, decrepit infrastructure is increasing rapidly.
A wide range of social infrastructure, including steel towers, bridges, tunnels and highways, as well as dams, water supply and sewerage systems and railways require countermeasures for their improvement. The need for earthquake resistance, repairs, renovations, and reconstructions has increased dramatically. If they are left unrepaired as it is, the estimated damage amount from a severe earthquake in the near future is 1,410 trillion yen in case of Nankai Trough earthquake and 778 trillion yen in case of directly below Tokyo earthquake, according to the announcement made by The Japan Meteorological Agency (JMA).
The Japanese government formulated the National Resilience Policy and on December 14, 2018, the Cabinet approved the thoroughly renewed Basic Plan for National Resilience Project with a budget of more than 5.3 trillion yen in FY 2019 alone. The government is promoting an ultra-mega measure which is estimated to have a total capital of 200 trillion yen.
Within social capital, there are 730 thousand road bridges across the country, of which 60% are already more than 40 years old (according to data from the Ministry of Land, Infrastructure and Transport). In addition, on the approximately 230km of bridges of the highways in the eastern/central/western Japan, the replacement costs of reinforced concrete floor slabs are approximately 1,650 billion yen (according to data released by NEXCO).
NejiLaw will continue to make a broad-ranging contribution to the society with our "power of emergence" generated by the consistent in-house system: development speed, problem solving system, research/development/mass production technology management/Quality, along with L/R-Neji (bolts and nut), ZaLoc, JicLoc, ShuLoc, VanLoc and other high-grade joining members.

Company Profile

Company Name	NejiLaw Co., Ltd.
Representative	Hiroshi Michiwaki, President & CEO
Headquarters Location	Shoei Building 4F, 3-23-14 Hongo, Bunkyo-ku, Tokyo
Established	July 2009
Business activities	Development, manufacturing, sales, and licensing of Highfunctionality /high-performance industrial fastening member.
Capital	JPY 499,000,000

Award History

FY2009 / Received 3 awards including Most Attractive Award in Business Plan Contest.(Sponsored by MIT (Massachusetts Institute of Technology)-Enterprise Forum.)
FY2010 / Adopted as a new technology development grant project
(Sponsored by Ichimura Foundation for New Technology)
FY2011 / 6 awards including Kawasaki Entrepreneur Award Grand Prize
(Sponsored by Kawasaki Institute of Industrial Promotion)
FY2011 / Good Design Award Gold Award (Minister of Economy, Trade and Industry Award)
(Sponsored by Japan Institute of Design Promotion)
FY2011 / Tokyo Venture Technology Award Grand Prize (= Tokyo Governor Award)
(Sponsored by Bureau of Industry and Labor Affairs, Tokyo Metropolitan Government)
FY2011 / Received Kyu-To-Ken-Shi Kirarito-Hikaru Industrial Technology Award
FY2012 / Adopted as Strategic Basic Technology Upgrade Support project
(Sponsored by Kanto Beureau of Economy, Trade and Industry)
FY2013 / Adopted as the 1st Global Niche Top Grant Project
(Sponsored by Bureau of Industry and Labor Affairs, Tokyo Metropolitan Government)
FY2015 / 14th Japan Innovator Grand Prize Excellence Award
(Sponsored by Nikkei Business Publications, Inc.)
FY2018 / 7th Technology Management & Innovation Awards, Chairman Award
(Sponsored by Japan Techno-Economics Society)

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