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The Transition of Demolition Techniques for Reinforced Concrete Structure in Japan

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1. Introduction

When considering the history of demolition, we have to accept that there are very few written records regarding demolition until about 1965, except for summarized stories of those affiliated with an architectural job. Contrary, there is a long-written history of wooden construction as well as records of the application of reinforced concrete on newly built constructions. In addition, it was after 1955 (Showa Year 30) when the full-scale demolition of a reinforced concrete construction was carried out.

2. Outline of Demolition for a Reinforced Concrete Structure

The demolition of reinforced concrete structure started with the use of chipping method in the 1950s. Although demolition of chimneys was carried out during the World war II, the demolition of reinforced concrete structure started much later than the new constructions that were built after World War II. A chipping hammer in Japanese is called, Gen-no which is a large hammer with both hands that weights from 5 to 20kg.

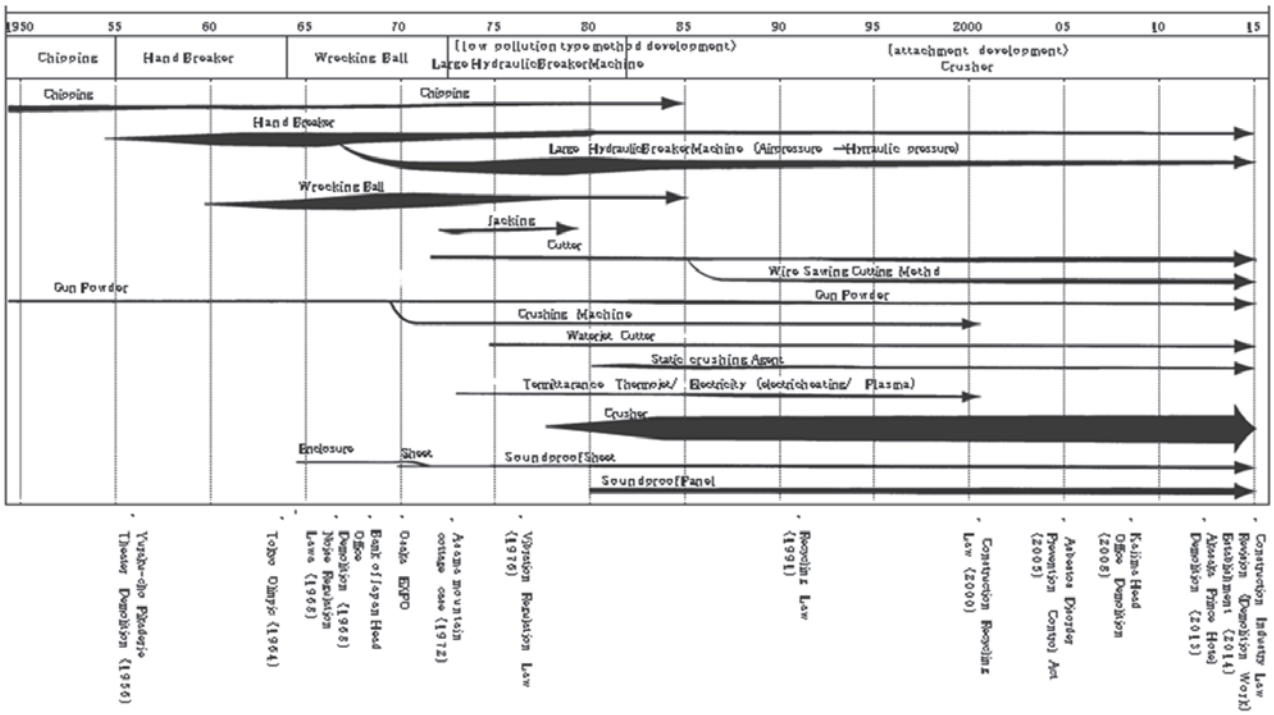

Fig. 1 Transition in Reinforced Concrete Structure Demolition Method

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The hammer drives an arrow (wedge) into the concrete and breaks it into pieces. During the demolition of the Yurakucho Pikaderie Theater in 1958, around 50 demolition workers (known as Yamaya: a quarryman) worked day and night using this method. This method of demolition was utilized in a large-scale mobilization of labor. The beam was knocked off the stirrup by flat chisel from above, and a rod was driven between the axial main bars. The column was laid down and then the hoop was cut. Here, the reinforcing bar inside the concrete was taken out neatly.

Fig. 1 shows the transition of the demolition method for reinforced concrete structures. After that shows the breaker method, the wrecking ball method and the larger breaker method. These are all types of destruction methods which proceeded but due to environmental issues and concerns, the use of wrecking ball methods have declined and larger breaker methods have gradually changed from pneumatic pressure to hydraulic pressure. When entering the 1970s, using the cutting method, disassembly by parts, use of static cracking agents, electrical indirect crushing methods and jacking methods were tested. Currently, the crushing method is considered the general-purpose method, replacing the wrecking ball methods and larger breaker methods (Fig. 1). It has been said that the speed of progress in the methods of demolition reinforced concrete structures were fairly slow, and the main reasons are speculated to be as follows:

1. Demolition work on reinforced concrete structure has a short history, and development research on the demolition method started in 1970 or later.
2. In the past, local residents did not often make complaints about the environmental concerns (pollutions, etc.).
3. Demolition using the wrecking ball methods and breaker methods were really efficient.
4. There were many issues with the ordering system of the demolition work. In other words, in order to receive orders for construction post demolition, it is often the case that the contract's highest priority to be extremely lowly budgeted and done in a short duration. Concerns regarding pollution control was a secondary priority that came after that.
5. Reinforced concrete is a strong material and is hard to demolish due to the following properties:

(a) It is difficult to cut with a normal blade, such as boring (drilling a hole and enlarging an existing hole).
(b) The mass and volume are very large and it is difficult to handle.
(c) Would not burn and has a high melting point.
(d) Even though acids and other chemicals can be invasive, it is extremely difficult to change the properties in a short time and the permeability of the liquid is small.

6. The amount of demolished material (by-product) is large and there is a limitation when reusing the material.

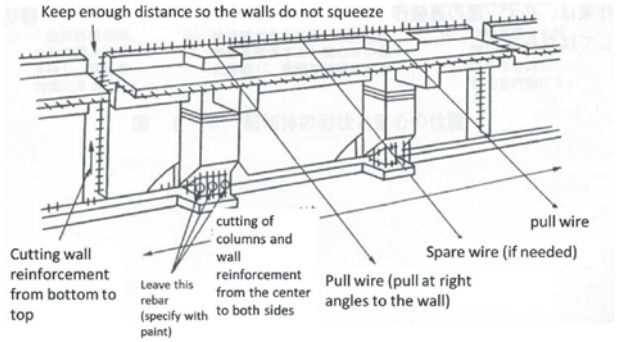

Fig. 2 Schematic diagram of pulling down outer wall

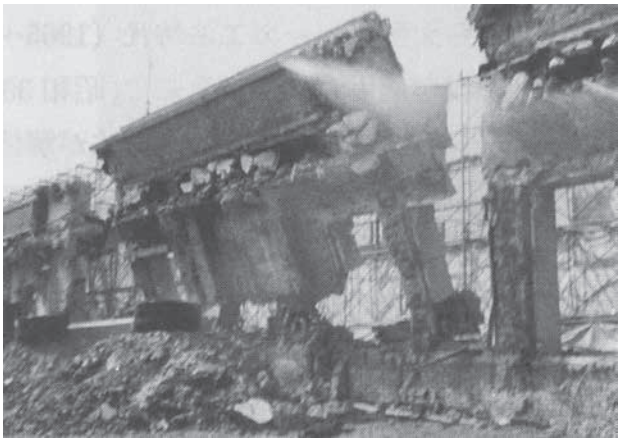

Fig. 3 Demolition due to pulling down (around 1963)

3. Year 1955-1966 (Development of the Era of Hand Breaker Method)

During this period, the overturn of the structure was incorporated where the floor slabs and beams were destroyed and the walls and the columns were pulled down (**Fig. 2, Fig. 3**). At the time, this method was named "Ootashi (=overthrow", where demolition expertise would describe this as a "man's flower", meaning a man's pride, proving their spirit and skills. On the other hand, pick hammers have begun to be used to shave/chip the floating slab foundations (slab-on-grade) and rooftop cinder concrete slab structures.

After the Korean War, breakers were also used for demolition work. Initially, the breakers were loaned by the US military and weighed around 45kg. Eventually, the demolition work was finally mechanized.

Prior to then, demolishing one floor took about a month, which was a slow pace. However, along with the trend of shortening the duration of construction period, demolition work gradually moved toward mechanization. Picks and breakers during that time seemed to have been used mainly

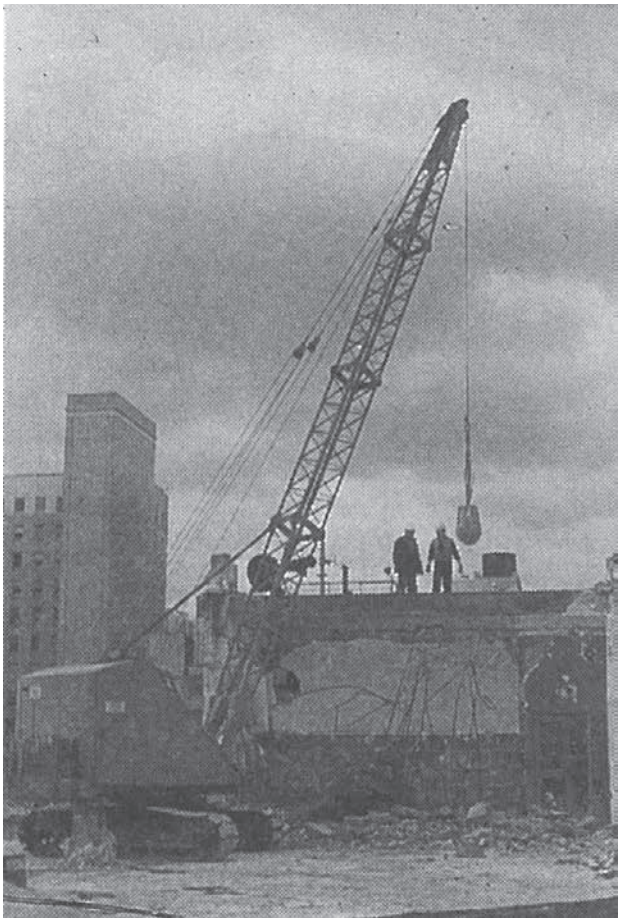

Fig. 4 Demolition due to a wrecking ball (Bank of Japan Head Office around 1970)

for demolition of foundations, floating slab foundations (slab-on-grade) and pavements. On the other hand, attempts were also made to drop the wrecking ball by using a triad (three-pronged) structure, and it seems that the reinforcing bars in concrete were often collected after separating concrete into small mass. Along with this came the domestic production of picks and breakers that were light and durable.

4. Year 1965-1980 (From Wrecking Ball Method to Larger Breaker Method, and an Era of Pollution-Free Demolition Method)

Around 1965, among crane trucks and other large machineries, the use of wrecking balls as a demolition method has been more so established. In other words, it is a method of hitting the floor slab from the upper floor in subsequent order, pulling out the beams, cutting the beams, and finally pulling down the columns and walls.

During the demolition work of the head office in the Bank of Japan from 1968 to 1969, a crawler crane/truck crane was used to vertically drop or shake a 1-2.5-ton weight (wrecking ball) to knock down concrete parts. (**Fig. 4)**. In addition, a thick and

Fig. 5 Demolitions due to a hand breaker (Bank of Japan Head Office around 1970)

Fig. 6 Jacking Method

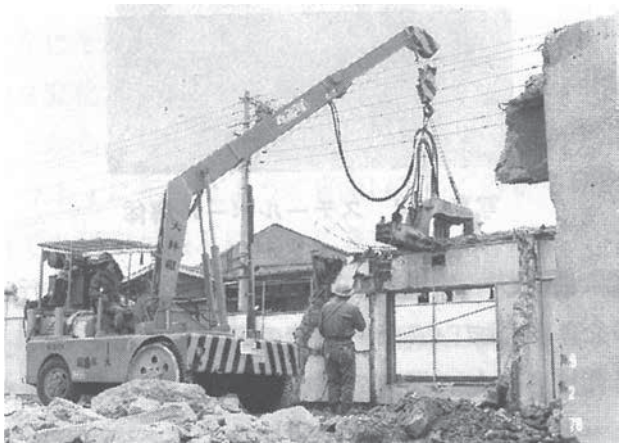

Fig. 7 Crushing Method around 1978

heavy hose was laid around, and concrete was broken using many of the hand-held pneumatic breakers (**Fig. 5**). In this demolition work, iron mesh concrete in the vault (8mm wide and 6mm thick expanded metal sheets were stacked at intervals of about 25mm and pea gravel concrete was poured) were demolished. However, since around 1970, due to the social changes accompanied with an increase of vibration, noise and dust pollution, demolition methods of reinforced concrete structures using wrecking balls has become more desirable and fit.

As a result, jacking method using hydraulic pressure

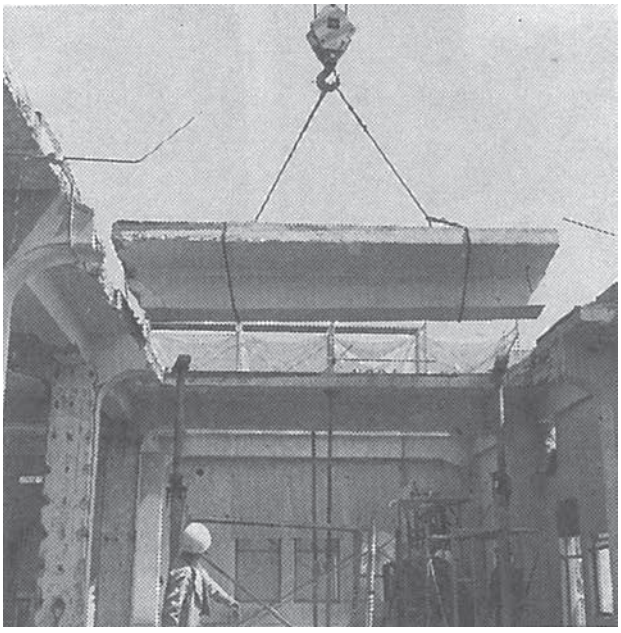

Fig. 8 Parts demolition using a cutter

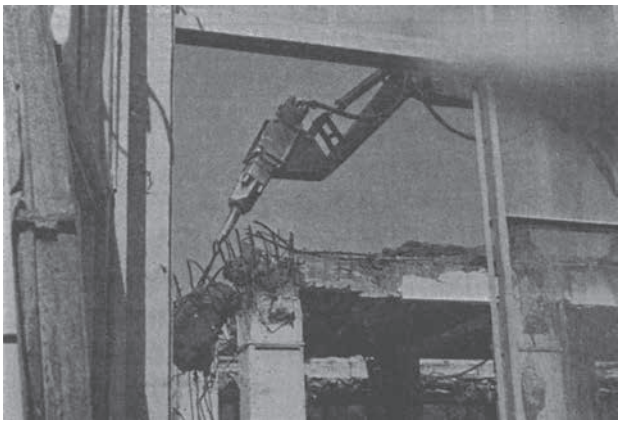

Fig. 9 Demolition using a large breaker

Fig. 10 Current crushing attachment and heavy machine

(construction method of breaking up the beam/slab from below with a jack: **Fig. 6**), crushing method (**Fig. 7**), and cutting each material with a concrete cutter (**Fig. 8**), have been devised and utilized. However, since these construction methods were slightly expensive in practice and unrealistic, they were demolished with wrecking balls and large breakers (**Fig. 9**) with soundproofing measures. During this time period, the Japan Building Industry Association created the "Guideline for Pollution-Fee Destruction of Reinforced Concrete Construction". Research related to construction methods using a crusher with slow detonation (slow explosive), methods using static crushing agents, water jet methods, electric heating methods, wire sawing cutting methods, has been developed among with connections to the method of demolition of the reactor vessel robot.

5. Year 1985- Current (Era of Crushing Method)

In 1976, when a "nibbler" was introduced from the UK that chews down bends, a new demolishing machine was built and used by the hands of a demolition specialist/machine manufacturer. This was partly due to the development of the demolishing method, which had been led by construction companies later transferring to the hands of a demolition specialist/machine manufacturer. The crusher, which has relatively low noise and vibration and is highly efficient, drives away wrecking balls and replaces large breakers to become the main stream of demolishing machines. The crushing method is positioned as the most common method of demolition leading up to 2015, today (as seen in **Fig. 10**). Depending on the structure, shape, and location condition of the target structure, either (1) lift the heavy equipment to the upper floor and demolishes each floor from the upper floor, or (2) demolition by a ground demolishing method that demolishes from the upper floor in subsequent order by heavy equipment placed on the ground. Ground demolishing method (**Fig. 11**) has been applied to buildings that scale and height from 3rd to 4th floor buildings since about 1980. However, in recent years, a 40-60m class long-reach crusher boom has been developed, and if there is an open space where a demolition machine can be moved around the building, it can be demolished from the ground up to a height of about 35m. The operator decides to operate the crusher by looking at the Photo of the camera attached to the top of the boom.

The demolition method from upper floor (**Fig. 12**) has been used since around 1980, and is currently being actively applied to the demolition of high-rise buildings in urban areas. With this method, a crane for hoisting the crusher on the top floor is necessary, and when using a crawler crane, it is limited to a crusher with a weight corresponding to its lifting performance. In general, the limit is about 15 tons.

In recent years, in particular cases, it has become difficult to

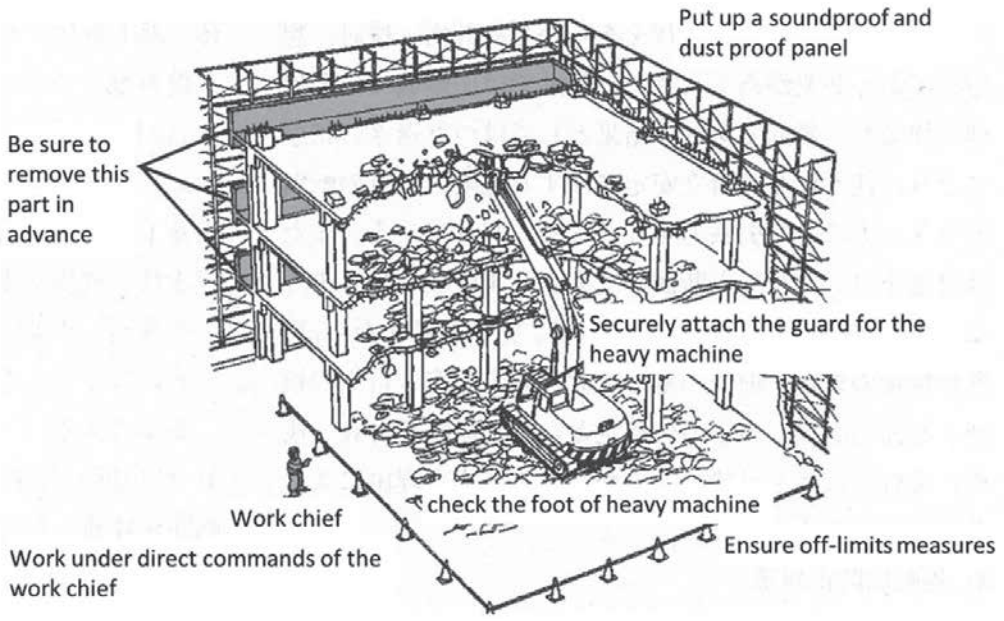

Fig. 11 Work during ground demolition work

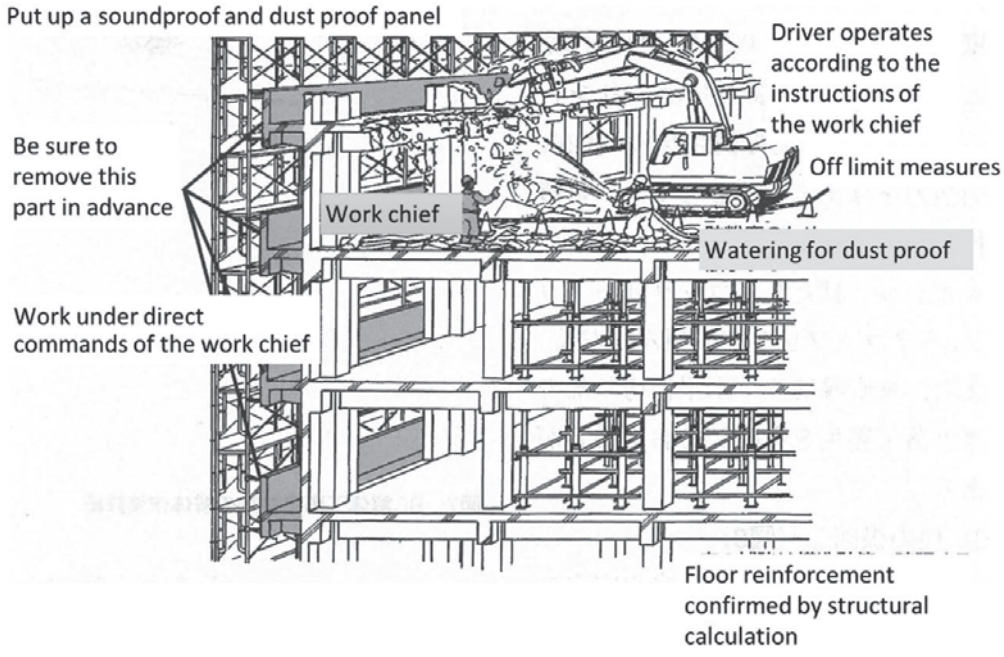

Fig. 12 Work on demolition from upper floors

apply the latest technology, the crushing method, to the construction of new structures. Steel reinforced concrete structure (SRC), concrete filled tube structure (CFT), and reinforced concrete structure (RC) using high-strength and ultra-high-strength concrete are extremely difficult to demolish by the crushing method. These are important issues that must be resolved in the near future. The mass demolition of explosives utilized in the United States can also be seen in Japan as well: it was attempted at the 1988 Tsukuba Expo Dome, the Mitsubishi coal mine Takashima Company Housing (**Fig. 13**), and the 1992 Lake Side Building (**Fig. 14**). However, critics view that the application of the blasting method to buildings in Japan is not simple from the viewpoints of economic efficiency, safety, economic activity limitation, and crime prevention.

It seems that collective demolition will continue to be difficult in the future, and technologies like miniature blasting and micro blasting, which demolishes members and block division levels using as few explosives as possible, seem to be useful. There are hopeful advancements that can be foreseen in the near future in this field.

Fig. 13 Blast demolition experiment at Takashima company house of Mitsubishi coal mine (1988)

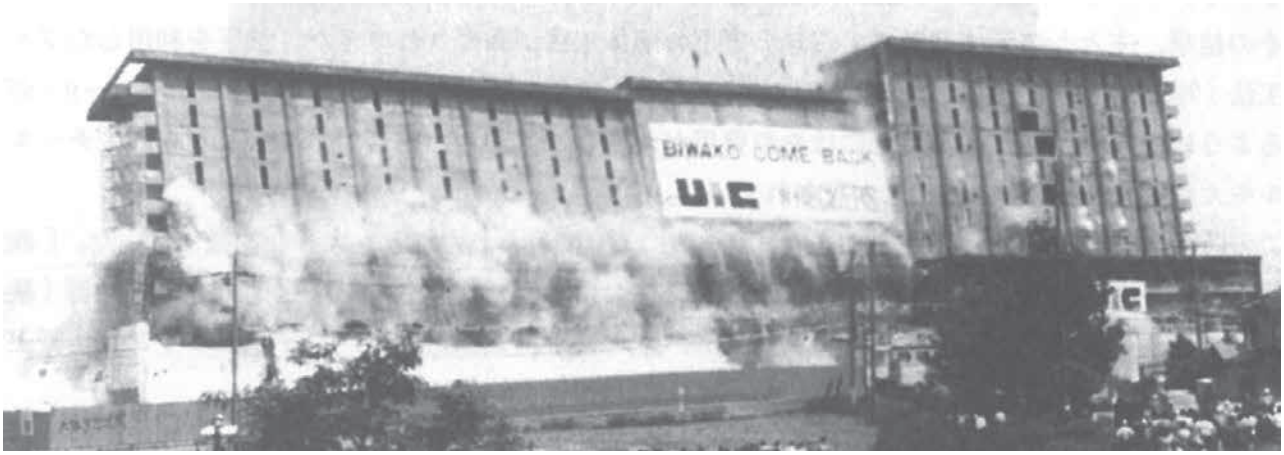

Fig. 14 Blast demolition experiment at Lakeside Building (1992)

6. Ending

This article explained the transition of demolition technology in Japan. The demolition work will be the process of the vacant lot, or the skill of the demolition work: (1) To demolish “safely”, (2) to minimize the damage/trouble for surrounding neighbors in regards to noise, vibration and dust, (3) with regard to the processing of demolishing materials, the most important evaluation is “to not bring the natural environment into destruction”, (4) cheap, and finally, (5) speediness of the work. Those five aspects are considered the axis of evaluation. To put it short, the goal of those involved in the demolition work is to be able to demolish the land in a clean and tidy manner without stressing everyone involved during the process.

Acknowledgments

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Disclosure

This paper is an extended version of published without examination in Japanese[1)]

References

1) Noboru YUASA: The Transition of Demolition Techniques for Reinforced Concrete Structure, Construction Machine, JAPAN INDUSTRIAL PUBLISHING CO., LTD., 660, Vol.56, No.2, pp.45-50, 2020.2

日本における鉄筋コンクリート構造物の解体技術の変遷

湯浅　昇

概　要

鉄筋コンクリート構造物の解体の沿革を考える時，木造については長い歴史があるものの鉄筋コンクリート造については新築の記録はあっても解体に関する記録はきわめて少なく1965年頃までは，当時の経験者の話を集約する以外に手掛かりがない状態であった。また本格的な鉄筋コンクリートの解体が行われだしたのは昭和30年（1955年）以後のことである。

鉄筋コンクリート造の解体は、第二次大戦中に煙突などの引倒しはあったが、戦後は新築工事より遅れ1950年代に入り、はつり工法によりはじめられた。玄能（両手持の大ハンマ重さ5〜20kgくらい）を用いて矢（楔）をコンクリートに打ち込み、大割りしてこわした。1958年の有楽町ピカデリー劇場の解体では、昼夜50人くらいの解体工（やま屋：元々石切を専門に行っていた業者）が働き、この工法でまさしく人海戦術で解体を行った。梁などでは上からスターラップを平のみで叩き切って、軸方向主筋の間に矢を打ち込み、柱は横倒ししてから帯筋を切り、解体した。ここでは、コンクリートの中にある鉄筋は綺麗に取り出していた。

その後、ブレーカ工法、スチールボール工法、そして大型ブレーカ工法と破壊工法に近い形で工法が進んだが、環境問題等の発生でスチールボールは衰退し、大型ブレーカも次第に空気圧から油圧へ転換された。1970年代に入ると、カッタ工法による部材別解体、静的破砕剤・電気的間接破砕工法、ジャッキ工法などが試みられたが、圧砕工法がスチールボール、大型ブレーカ工法にかわって汎用工法となって現在に至っている。

Biographical Sketches of the Author

Dr. Noboru Yuasa is a professor of College of Industrial Technology, Nihon University. He earned his B.Eng. in 1988 from Hokkaido University and M.Eng. in 1990 from Tokyo Institute of Technology.

After finishing master course in Tokyo Institute of Technology, he moved to Nihon University as a research associate. He promoted to a lecturer in 1998, an associate professor in 2003 and a professor in 2011. He received the degree of Dr.Eng. for "A Fundamental Study on the Quality of Surface Layer Concrete" in 1998 from Nihon University.

He has been studied "The surface layer concrete" in the point of view from moisture content and porosity as life work. And he received The Prize of AIJ 2019 (Research Theses Division) from Architectural Institute of Japan for "A SERIES OF STUDY ON SURFACE LAYER CONCRETE QUALITY" in 2019.

His current research topics include durability of concrete structures and finishing materials, non-destructive testing method, demolition of structures, earthquake resistance improvement for building of developing country and investigation of historical buildings.

He has been participated in several international research projects for Santuario di Vicoforte and L'Hangar per dirigibili di Augusta; 2002-03 and 2006-08, Sant'Agostino, San Silvestro e Torre Civica in L'Aquila; 2010-2014, Italy, Spain, Portugal; 2016-2021. And, he also participates in "Bhutan Project" by the JST/JICA SATREPS (Science and Technology Research Partnership for Sustainable Development).

During he was a lecturer of Nihon University, he was visiting researcher for one year at University of Dundee, England in 2011.

He is a chairman, secretary or research leader of a lot of committees in Architectural Institute of Japan, Japan Concrete Institute, Japan cement association, Japan Society for Finishing Technology and Japanese Society of Non-Destructive Inspection.