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CONCRETE AND MODERNISM: TECHNOLOGY AND CONSERVATION

Preservation Technology Dossier 14 - 2018

International committee for the
documentation and conservation
of buildings, sites and neighborhoods of the
modern movement

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INTERNATIONAL SPECIALIST COMMITTEE/TECHNOLOGY DOSSIER 14

CONCRETE AND MODERNISM: TECHNOLOGY AND CONSERVATION

Proceedings of the Docomomo International Specialist Committee/Technology sessions during the 3rd annual Docomomo US National Symposium.

Minnesota, USA
June 4-7, 2015

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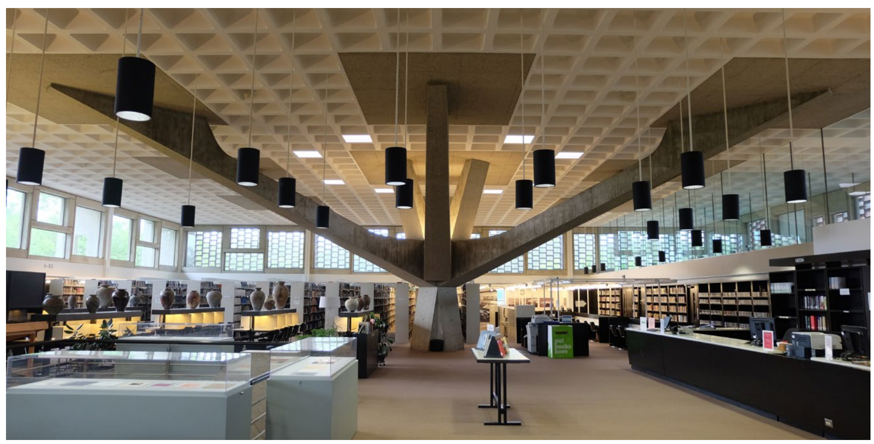

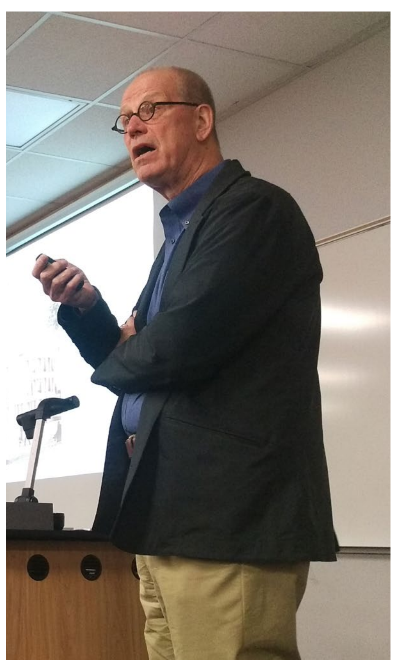

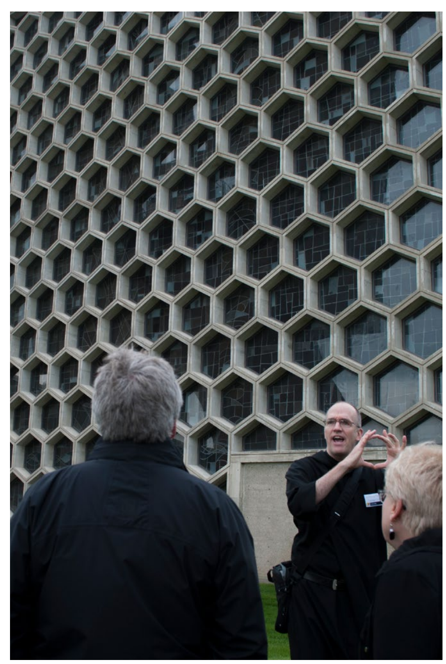

MODERNISM ON THE PRAIRIE

DOCOMOMO US NATIONAL SYMPOSIUM

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JUNE 4-7, 2015

Explore the Symposium Archive at
http://www.docomomo-us-mn.org/archive.html

FRI JUNE 5TH

CONCRETE AND SCHOKBETON
University of Minnesota, Rapson Hall

SCHOKBETON HISTORY - ZWIJNDRECHT
Lucas van Zuijlen

SCHOKBETON PRECAST SYSTEM/ ARCHITECTURAL PRECAST CONCRETE TECHNOLOGY STEERING DESIGN
Jack Pyburn

Watch a video of the presentation at
http://www.docomomo-us-mn.org/concrete-and-schokbeton.html

SAT JUNE 6TH

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St. John's Abbey & University, Minnesota

MODERN RELIGIOUS ICON: LE CORBUSIER'S RELIGIOUS HERITAGE
Pierre-Antoine Gatier

Watch a video of the presentation at
http://www.docomomo-us-mn.org/concrete-and-religious-modernism.html

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RENOVATION OF THE CENTENNIAL HALL IN WROCLAW, POLAND
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Paul Gaudette, David Patterson, Deborah Slaton

DURABILITY ASSESSMENTS OF MODERN CONCRETE ICONS - PREDICTING PERFORMANCE FOR A PRO-ACTIVE REPAIR APPROACH
Gina Crevello

Watch a video of the presentation at
http://www.docomomo-us-mn.org/concrete-conservation.html

INTRODUCTION

Of all the building materials associated with modern architecture, concrete is the oldest and most ubiquitous material worldwide and technologically both simple and complicated as evidenced by its use in developed and developing countries alike. Its material conservation continues to present us with philosophical, aesthetic and technical challenges. The presentations at a recent Docomomo International Specialist Committee on Technology (ISC-Technology) workshop highlighted a number of these material conservation issues.

In 2015, in the context of its third annual symposium entitled, "Modernism on the Prairie," Docomomo US together with Docomomo International ISC-Technology hosted a workshop with a series of lectures on concrete, including its technology and approaches for conservation. The lectures and presentations took place on the second and third days of the symposium respectively at Rapson Hall of the University of Minnesota in Minneapolis and at the magnificent (concrete) St. John's Abbey in Collegeville, Minnesota designed by Marcel Breuer.

The program for the ISC Technology was divided in two days and included a total of seven presentations by both international and US specialists. On the first day of the workshop, the program was dedicated to Schokbeton, the Dutch precast system, which during the three decades immediately after WWII found application worldwide including the US. The lecture by Lucas van Zuijlen and Ronald Stenvert appropriately titled "Schokbeton: Zwijndrecht" dealt with the history of its development at its facility in Zwijndrecht in the Netherlands. Jack Pyburn in a paper entitled "Schokbeton in the USA," explored the relationship between precast concrete and design including the application of the Schokbeton system in the US by well-known American architects like Marcel Breuer, John Johansen and Philip Johnson.

On the second day of the program, the keynote presentation entitled "Modern Religious Icons: Le Corbusier's Religious Heritage" was given by Pierre-Antoine Gatier. This presentation discussed the design and the conservation of Le Corbusier's concrete churches and other buildings presented against the backdrop of Breuer's concrete St. John's Abbey. The setting and presentation provided a broad technical and philosophical context for the conservation of significant religious and secular concrete buildings.

The final part of the program addressed conservation issues related to specific case study projects. Jadwiga Urbanik, a member of ISC-Technology from Poland, presented "Renovation of Centennial Hall in Wroclaw, Poland", a World Heritage site since 2006. This magnificent reinforced concrete building designed by Max Berg between 1911 and 1913, just before World War I, has been the center of considerable concrete conservation efforts. Fernando Diniz Moreira and Fernando Herbster Pinto examined the restoration and conservation efforts for the headquarters of the Companhia Energetica de Pernambuco (CELPE) in Brazil. Moreria and Pinto focused this case study on the philosophical and practical conservation issues to be considered and choices to be made when addressing heritage buildings with exposed concrete. Their paper was entitled "Restoration Procedures on Surfaces of Exposed Concrete and Values of Modern Architecture: The Case of Headquarters CELPE Building – Energy Company of Pernambuco".

The two final presentations were entitled: "Concrete Conservation of Morse and Ezra Stiles Colleges, Yale University" by Paul Gaudette, David Patterson, and Deborah Slaton, and "Durability Assessments of Modern Concrete Icons: Predicting Performance for a Pro-Active Repair Approach" by Gina Crevello. The Morse and Ezra Stiles Colleges project was an example of a careful and conscientious conservation of the exposed concrete work as envisioned by Eero Saarinen, the original architect. The paper by Gina Crevello presented a systematic approach to investigating and predicting the lifespan of modern concrete structures as an aid towards conservation and repair.

In this Dossier 14, four of the presented papers are included. As noted in the table of contents, three are available digitally through their listed URLs.

Docomomo US wishes to acknowledge the remarkable papers and presentations of the ISC-Technology members. These are important contributions towards understanding the challenges and opportunities facing us in the conservation of this quintessential modernist material: concrete.

The publication of Dossier 14 is in part funded by the generous support of the Historic Preservation Education Foundation.

Theodore Prudon
President, Docomomo US

Kyle Normandin
Chair, ISC Technology, Docomomo International

SCHOKBETON: ZWIJNDRECHT / THE NETHERLANDS / INTERNATIONAL

Lucas van Zuijlen and Ronald Stenvert

INTRO

At the 13th international DOCOMOMO conference in Seoul, Wessel de Jonge presented a paper about his recent restoration of the Cygnus Grammar School in Amsterdam. The facades of this building, realized in 1956, were constructed with Schokbeton elements and Wessel stressed the high quality of the material. For the lesser repairs of the material, he found out the lack of knowledge about good restoration with regards to the color and finishing. Because of the international application of the material, a good database with knowledge exchange should be created.

Back in 2003 we did an introduction of the research on the history of the Dutch company. In 2004, Jack Pyburn presented a paper at the conference in New York. In 2007, I started with Dutch historian Ronald Stenvert to exchange material. In 2012, we organized a meeting at the conference in Finland with the ICT technology members, Susan McDonald and Kyle Normandin. In 2013, I presented a paper in the Lausanne Polytechnical school of Franz Graf and talked with Professor Bruhwiler about restoration possibilities, of the Technical University Delft.

THE PRE-PREFAB ERA

The origin of concrete as a building material lies in Europe and more specific in Italy. The Romans used a type of concrete when building their roads. The dome of the Pantheon (27 B.C.) is made of concrete. Only from the middle of the nineteenth century onwards was modern concrete used in combination with iron and steel as reinforced concrete. Gardner Joseph Monier was the first in 1867 to use metal thread to reinforce his concrete flower boxes. François Hennebique demonstrated in 1892 that the combination of concrete and iron led to a truly monolithic construction in which the concrete absorbs pressure and iron traction.

While most of the development of concrete building technology took place in France, Belgium, Germany and the USA, in the Netherlands the use of reinforced concrete only started from 1890 onwards, although the first building entirely made of concrete dates from 1902. The first railway viaduct in this material, known as the Hofpleinviaduct, was erected in 1900-1906 in Rotterdam, while the first concrete dome for a church, Heilige Landstichting Groesbeek, dates from 1914. After that a long sequence of viaducts, bridges and water locks were constructed while the majority of the bigger buildings to be built were fitted with a reinforced concrete skeleton. Because of the common use of masonry for constructions and facades in Holland, the adaptive use of concrete for housing lagged somewhat behind. After World War II, in the reconstruction and building boom that followed (1945-1965), concrete was also used for the large housing estates.

The Hofpleinviaduct was the first monolith concrete construction. The railroad stretches from the Rotterdam city centre outwards into the direction of The Hague and the sea. The first two kilometres consists of a series of concrete arches on which the elevated track was laid. The noise made by the iron railway bridge nearby motivated the use of concrete, resulting in more hushed sounds coming from the newly erected structure. Nevertheless, the material of the viaduct was not yet accepted as such in its natural appearance so the upper part got a decorative plastering and the lower part was embellished with natural stone.

The first and well-known office buildings with a concrete skeleton but clad on the outside with natural stone or brick were the new city hall of Rotterdam (1914-1920) and the former bank Mees & Zn at the Blaak (1930-1934). Another important building of that time was the Nederlandsche Handelmaatschappij at the Vijzelgracht in Amsterdam (1919-1926). Architect K.P.C. De Bazel designed this building. The concrete construction was calculated by a specialised bureau Brothers van Gendt, but the architect made the outside of the building look like a huge brick building.

The first big exposed concrete construction was a civil building for a direct radio connection with former colony Indonesia, the Dutch East Indies. Due to technical restrictions regarding emitted energy from radio waves, brick could not be used for the building of the new transmitter station. Smack in the middle of a large heath, an impressive cathedral-like structure in concrete was erected in 1921-1922 to house the actual transmitting machine. In this case, concrete was used in its own right, pure with the still visible imprint of the board formed on the surface and with small decorations cast in the same material. Even inside, decorations in gold colored concrete were used.

1930 PREFAB CONCRETE

Two important Dutch buildings of the Modern Movement, selected as UNESCO heritage, are landmarks of the use of reinforced concrete in combination with steel windows and lots of glass. The construction of both buildings - the Van Nelle Fabriek in Rotterdam and the Sanatorium Zonnestraal in Hilversum – was started in the same year, 1928. The two buildings were designed by different combinations of architects, but in both cases they were assisted by the same engineer, Jan Gerko Wiebenga, an expert in the field of calculating concrete constructions. Born in Indonesia in 1886, his father brought him back to Den Haag in 1903 where he continued his study to become a civil engineer in Delft. He finished his studies on the Technical School in 1912 and started to work with the progressive constructor company Stulemeijer in Breda. In 1924 he didn't have enough work in the Netherlands and went to the USA. In New York he worked with consulting engineer A. Marjey and from May on was contracted at the Electric Bond and Share Company where he designed a chemical factory and an earthquake proof office building for Guatemala. From 1925 on he worked for consulting engineer Alexander Potter and designed water plants in several districts around New York. Because of the illness of his wife he was forced to return to the Netherlands later that year.

Both buildings were started just before the outbreak of the global financial crisis. Two of the first concrete buildings of the Zonnestraal complex were finished in 1929 and the third was started in 1931. In this last case, architect Jan Duiker used prefabricated concrete parapets containing cast channels for ventilation

The period of transition from in situ cast concrete constructions to the use of pre-fabricated elements is an important one. As a part of the World Fair in Antwerp in 1930 an additional fair specially dedicated to technical matters was held at the same time in Liège, Belgium. During this fair, the First International Congress for Concrete and Reinforced Concrete took place. As early as 1928 a call for papers was issued in the Dutch specialist journals for building and architecture. In all, one hundred papers were presented at this first congress, only ten of them from outside Europe and none from the USA. Imported papers came from Dischinger on thin concrete shells and from Freyssinet on pre stressed concrete. Six papers were Dutch contributions, of which the one of Jan Duiker and G.J. Meyers turned out to be the most important, stressing the truly international expression of concrete as an international material. Remarkable was the absence of any paper on the subject of pre fabrication.

SCHOKBETON EARLY YEARS

It was however in the same year that an invention of great consequences was made by accident in the small village of Zwijndrecht. It played a interesting role in the use of precast concrete. The Schokbeton process was invented just after the outbreak of the worldwide economic crisis. However, its development as a viable precasting system was not hampered by the economic challenges of the time. Quite the contrary, the crisis stimulated the quest for new and cheaper building materials, due to the fact that cement was the most expensive fraction of the concrete mix. Bringing down the amount of cement would be profitable. A method to fabricate more dense concrete of the same strength using less cement and water was sought after. For producing such a product shaking of shocking or the mass turned out to be essential.

This specific method of making precast building material, which was called Schokbeton, was stumbled upon when the Zwijndrecht based concrete-worker G. Lieve found out that shocked concrete out of damaged wheelbarrow was much stronger than regular concrete. Together with construction manager M.E. Leeuwrik in 1932 he elaborated on the process of shocking the concrete mass instead of shaking to get a more dense product. The two of them started the firm Schokbeton and borrowed 2000 guilders from Lieve's wife. They obtained their patent license in 1934. From this time on until 1980, with the exception of World War II, Schokbeton expanded rapidly to a international company with branches in more than thirty countries.

The patented shock technique consisted of the idea that, at the start of the hardening process during the pouring, the concrete mass would get more dense when the concrete mould would fall several times over a distance of 8 to 25 mm. This compression by way of impact the shocked elements were 1.3 - 1.4 times slimmer than regular elements of the same strength or as turned out to be 1.7 times stronger to products of the same dimensions.

Small concrete elements were produced in a labor intensive way, but of high quality and made in a factory under perfect conditions. The company found the balance in mass production and custom made elements for small scale projects in spite of the bad economical situation of that time, the firm prospered. Not in the least this was due to the fact that wooden elements like windows became more and more expensive to make, while concrete elements to replace them became a cheaper alternative. In publicity campaigns the company stressed the fact of the costs needed to maintain wooden windows, while concrete ones would require almost no maintenance and almost looked the same.

Apart from a sound and profitable business model, the Schokbeton company was born in the proper country where through the ages the Dutch reclaimed much land from the sea to transform it into arable land. The latest impressive feature at that time was the closing of the Afsluitdijk a 32 km long dike separating the Zuiderzee from the North Sea. The work started in 1927 and the dike was finished in 1932. Shortly afterwards, reclamation started of a large part of the sea, which became the Wieringermeer polder, 28.000 ha of new land on which about 500 farmhouses were to be built. A commercial for concrete windows attracted the attention of the new land planners, and in this way Schokbeton got its first large volume contract.

The first prewar work in which schokbeton was used as a part of the overall architecture was the Minervahouse in Rotterdam in 1937 designed by the city architect A. van der Steur. He had already used floors from Schokbeton for the museum Boijmans in Rotterdam two years earlier. For his new brick building, the National Technical Institute, near the city centre, he used window frames and other prefab concrete elements. These Schokbeton elements were introduced by the name of shockcrete, which can be seen as a kind of artificial stone. During the fabrication process on the surface of the concrete mass, a layer of more expensive natural stone grit was added, resulting in a skin imitating natural stone. In these prewar years, a number of buildings were built with shockcrete window frames and ornaments. Some examples are the already mentioned Minervahuis (1939) at the Meent and the Sociale Verzekeringsbank (1941) at the Schieweg, both in Rotterdam.

Two important Rotterdam architectural icons of that time were made by using Schokbeton elements an integral part of the overall architecture. These were the Rotterdam Trade Centre (Beurs) at the Coolsingel and the Blijdorp Zoo. A special feature of the Beurs, designed by J.F. Staal in 1936, was the big roof of the central hall covered by Schokbeton elements containing round disks made of glass. In the Blijdorp Zoo, designed by architect S. van Ravensteyn and built in 1939-1941, he used several kinds of Schokbeton-elements, like plain Schokbeton-windows, but also column-like shockcrete-prefabricated parts with a yellowish or light purple coloring obtained from specially selected natural stone grit. Its famous feature was the 47 meter high viewing tower using a steel structure clad with Schokbeton-elements. Regrettably the tower was demolished in 1972, but, together with architect Cees Rouw, we are looking for funds to reconstruct this landmark.

The first known uses of Schokbeton outside of the Netherlands was in the former colony of the Dutch East Indies where they used lamp poles and electricity masts made of Schokbeton, and even a chimney of a rice-husking plant. Some of its uses were published in architectural periodicals in 1938.

The first real use abroad was the application of Schokbeton-elements for walls and windows in the Pleasure Beach Casino in Blackpool, England. It was designed in 1939 by Joseph Emberton. As yet, it is unclear how the Zwijndrecht based firm obtained this particular contract.

In our opinion, the success of the Schokbeton company was a result of some early company decisions.

The first is an early division of the Schokbeton activities into a separate company for the production of the predominantly architectural elements and a separate company for the engineering parts like concrete piles for foundations. The two former factories are still standing as neighbors in the factory district in Zwijndrecht. Also, there was a separate but own transport company, called TRAMOS (TRansport and MOntage of Schokbeton), which stands for the transportation and assembly of Schokbeton-elements. The second asset was an eye for good promotion and design, with a considered home style and keen publicity. A third reason is the quality the company provided for its employees by way of organizing excursions, giving information and issuing its own company periodical. Last but not least the company had also a keen eye for creative needs of the architects, resulting in tailor-made buildings. In their numerous leaflets, Schokbeton always mentioned the names of the architects involved.

On what happened to the company during the German occupation between 1940 and 1945, not much is known.

Founder and director Gerrit Lieve went into hiding and died after a short illness in 1944. The company continued to produce prefab windows and electricity poles and such. Even elements for concrete shelters could have been made. Before the war they introduced their own kind of air raid shelters. All in all, after the building freeze of 1942, not much happened at the factory in Zwijndrecht until 1945.

POSTWAR DEVELOPMENTS

Due to the substantial war damage in many cities, concrete and prefabricated concrete was in high demand, not only for the rebuilding of lost buildings, but also to tackle the immense housing problem. This resulted in a surge in the amount of orders. During the war, engineers of Schokbeton prepared a building system based on a number of Schokbeton frames which could be assembled into a structure of which the holes in the frame were filled with special concrete panels. The system was called Raatbouw and was originally meant for housing. These houses could be assembled in just three days by unskilled laborers. This system turned out not to be not that successful for housing, but was useful for defense purposes. Around 1950, throughout the Netherlands 160 air defense towers were built in Raatbouw, of which a mere 13 still exist. The Raatbouw system was also used for building structures in the Antarctic region of Greenland.

Some projects were developed for this way of housing in Africa, but it is unknown to which extent it was realized. The same was the case with the houses in the Netherlands. The realized model house in Kampen has disappeared. An adapted version was developed by Wijlmer & Breukelmans in Rotterdam consisting of four blocks of a total of 144 houses. They could be built in quite a short space of time.

One of the most important orders Schokbeton got in their career was the realization from 1947 onwards of the total of one thousand farm barns in the newly developed Noordoostpolder. This huge area of reclaimed land was intended to become the granary of the Netherlands. These prefabricated barns with a construction of laminated wooden trusses consisted of on average 180 prefabricated parts. These barns could each be erected within a week with the aid of only one crane. In all, Schokbeton designed seven types of barns. They were produced in the newly erected factory in the nearby city of Kampen, a factory four times bigger than at Zwijndrecht.

From the early fifties onwards Schokbeton grew to a total of four factories and a front office in the centre of the Netherlands. This schedule shows the growth of employees in the first 18 years since the birth of the company.
Apart from this important order in de polder, many Schokbeton buildings can still be seen in the city of Rotterdam, about twenty kilometers from Zwijndrecht. This city had suffered considerably during the second World War. In the rebuilding process, Schokbeton was much in demand.

A selection of Dutch postwar buildings with typical Schokbeton facades:

- Postwar housing Overschie (1949-1951)
- Eneryplant Geerttruidenberg (1950)
- Groothandelsgebouw (1951)
- Airport Schiphol (1951)
- Kazerne Geerttruidenberg (1951)
- Neherlab (1953)
- Energyplant Harculo (1953) and Veenendaal
- IPRO keien (1953)
- Station Arnhem (1954)
- Kantoor Schokbeton (1955)
- Technical University Eindhoven and Delft (since 1956)
- Cygnus Grammer School (1956)
- Hospital Dijkzigt (1958)
- Apolistische Kerk Utrecht (1960)

INTERNATIONAL EXPANSION

In Europe Belgium was the first country to regularly order wall-elements in Zwijndrecht for buildings in Luik (Liège) and Antwerp and later on for big office buildings in the city centre of Brussels. Because of the small distance Belgium never realized Schokbeton factories.

BELGIE (SINCE 1953):

- Housing Luik and Antwerp (1953-1954-1956-1958)
- Bank Lambert (1959)

Soon after, more European countries like France, Denmark, Germany, and Spain followed with their own shock-factories.

Denmark (factory since 1952):
Duitsland (since 1954):
Curacao (1954)
Frankrijk (since 1955)
Ireland, Switzerland, Spain, Finland, Sweden

Besides the delivery of the Raatbouw system in Ivory Coast in 1952, there is information in the annuals about a factory in Pakistan (1951), Costa Rica, Australia and Japan. Many buildings using the shock technique were produced there with the supervision of Dutch agents. Some countries are still paying their patent to the new owner of the company that has the former legal rights on the Schokbeton patent. It is unclear if there are factories nowadays still exist and/or still use shock methods. This could be interesting for the renovation of reproduction of Schokbeton elements.

COMING TO AMERICA

Before Schokbeton was utilized in the USA, the material was used for setting up buildings for the US defense Air Force in Greenland (1954). Because of the lack of indigenous labor force, infrastructure for large scale construction projects and the difficulty of using cast in place concrete in a permafrost environment, a precasting system was selected to erect the complex of buildings. The Dutch Schokbeton technical agent Ab Geelhoed was employed there and became later the agent for the new factories in the USA.

Works, communication and art of Geelhoed will also be displayed in the exposition we organize later this year in Zwijndrecht to get a good overview on the Dutch and international history. The first wooden shock table will be shown for the first time to the public. In 2016 the expo will be added to the International Architecture Biennale in Rotterdam.

NB: I would like to stress that the research we did was not supported by any institution or company. There is not yet any Schokbeton archive or organization that is collecting (international) material on this subject. The archive of the Schokbeton-firm itself due to changes in management, is predominantly lost and only some scattered information was gathered during the last ten years. With two ex-workers from the Schokbeton company, three historians, including Ronald Stenvert, and the Historical Association Zwijndrecht, we have been preparing an exposition on the subject of Schokbeton since the end of 2014 to open December 2015. Ronald and I are also preparing a publication and therefore want to study as many possible international archives on this subject. We will start a foundation for dealing with personal documents and possessions from former Schokbeton employees in cooperation with the municipal archive in Dordrecht, in which the archives of Zwijndrecht are collected.

The knowledge and archives of Ab Geelhoed are in the Netherlands and USA and will be a necessity in the historical link between the Netherlands and the USA/Canada.

ABSTRACT: SCHOKBETON PRECAST SYSTEM / ARCHITECTURAL PRECAST CONCRETE TECHNOLOGY STEERING DESIGN

Jack Pyburn

The following outline organizes the presentation on the development of the Dutch concrete precasting system, Schokbeton, from two vantage points: its origin in the Netherlands, researched and presented by Lucas van Zuylen and Ronald Stenvert, and its arrival and production in the US by Jack Pyburn.

The presentation introduces the lay preservationists and preservation professionals to the basic characteristics of concrete and precasting followed by a focused survey of the early development of architectural precasting and its evolution in the 20th century. This evolution will be set in the context of competing precasting technologies and will finally focus on Schokbeton, its significant qualities and its impact on design and construction of important 20th century buildings across the globe.

The following outline is organized to draw from the recent research of van Zuylen/Stenvert in the Netherlands and Pyburn in the US.

Orientation to Precasting of Concrete:
This introduction will present basic characteristics of precasting that distinguish it from cast in place concrete (JPY/Lv)

- Characteristics of Precasting
- Benefits/Limitations

Particular Characteristics of Schokbeton System (JPY/vZ)

- Vibration / Mixing / Mold Making

The Origins of Schokbeton and its spread globally (vZ)

- Europe / Schokbeton,
- Other? I know there were systems in France using vibration. I seem to remember one is referenced in Dutch patent for Schokbeton.
- Elsewhere Internationally? (vZ)

Schokbeton System Spreads around the World (vZ+R)

- Focus on exporting to Africa, the Middle East and Asia (vZ) (JPY has some info on this subject)

Restoration/Treatment Challenges of Precasting and Schokbeton (vZ)

- Dutch Experience of Wessel de Jonge (vZ)

Schokbeton Comes to America (JPY)

- Context for Precasting in the US
- Kahn System
- West Coast System
- Mo-Sai
- Precast Building Section Inc.
- Schokbeton Comes to America/ Story of How Schokbeton Came to US
- US Buildings/
- Glass House Estate Folly, Philip Johnson
- Philadelphia Police Headquarters, GBQC, August Komendant
- State University of New York, Ed Stone
- Louisville Office Building, Taliesin Associates
- Buildings in Europe by US Architects
- Banc Lambert, Brussels, Belgium, SOM
- US Embassy, Dublin, Ireland, John Johansen
- Torrington Corporation, Belgium, Marcel Breuer

LITERATURE

Title: History and Development of Pre cast Concrete in the United States
Author(s): J. L. Peterson
Publication: Journal Proceedings
Volume: 50
Issue: 2
Appears on pages(s): 477-496
Keywords: no keywords
Date: 2/1/1954

ABSTRACT:

Some of the first uses of precast concrete are described. Early designers used precast concrete for reasons of safety, economy, and savings in time of construction. Descriptions of projects built before 1920 which used precast concrete untis weighing up to 75 tons are given. Development of the use of precast concrete for bridges, buildings, and marine construction is described. Introduction of modern methods of precast concrete and lift-slab concrete construction is discussed. Future development of precast concrete is predicted.
DOI: 10.14359/11773
http://repository.upenn.edu/cgi/viewcontentcgi?article=1099&context=hp_theses

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ADDITIONAL:

1. EXPO SCHOKBETON IN ZWIJNDRECHT 2015-2016

An important step in raising awareness and obtaining research material is an exposition in the hometown of Schokbeton Zwijndrecht in September-November 2015. At the site of the original factory precast concrete products are still produced. A temporary information point for visitors, creates the perfect opportunity to get in touch with old employees of Schokbeton and by doing so systematically gather information, both orally and in other forms, like documents and materials of another kind.

With the team we are planning to research the rise, production and fall of the Schokbeton company for a period of 3-4 years. Partners in this process will be the Municipality Zwijndrecht, various funds and concrete producers.

PROJECT STAFF

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SCHOKBETON IN THE USA

Jack Pyburn

INTRODUCTION

The story of Schokbeton, an innovative Dutch architectural precasting system, in the USA is one of a simple but highly effective idea for its time, technological innovation to act on the idea, war, hot and cold, entrepreneurship, the relationship between design and craft, and technology, globalization of construction and architectural and engineering innovation.

Concrete is one of the three major materials (concrete, steel and glass) that transformed the built environment in the 19th and 20th centuries. Engineering and machine technology determined the capabilities of each of these materials. Precasting concrete for building enclosure and architectural finish represents a final major evolutionary stage in the production and manipulation of concrete. Precasting afforded the control of the material necessary to achieve reasonable consistency in finish to compete with competitive building products. The story of Schokbeton illustrates both the qualities and processes required for precasting, and particularly architectural precasting, as well as illuminates the relationship between building technology to design in the middle part of the 20th century.

Concrete is a unique structural building material that acquires its structural properties during construction. Precasting in an enclosed plant away from the job site facilitates better quality control of the product than could be achieved on site where environmental conditions produce challenges in efficiently and uniformly mixing, forming, placing, curing and finishing concrete intended as a finished condition.

HISTORICAL BACKGROUND

From its well documented rediscovery as a reliable building material in the mid-1800's, concrete quickly drew the attention of inventors and entrepreneurs seeking to discover, advance and exploit its potential. Recognizing early that concrete was structurally excellent in compression but relatively poor in tension caused a focus in exploration on ways to overcome this limitation. Steel with good tensile qualities and a similar coefficient of expansion and contraction ultimately provided the solution to concrete's tensile limitations. This inventive period for concrete from the third quarter of the 19th century to the middle of the 20th century was rich with ideas and experimentation. The knowledge of concrete and the exploration of its potential spread rapidly internationally. A 1909 American study, primarily focused on Europe, documented 144 concrete related "systems" in development.[1] Over half of the systems identified were from Germany and France. Six were from the USA.

The internationalization of concrete systems, that is the exporting of engineering and machine technology, was taking place by the late 19th century. François Hennebique, as is widely documented, stands out as one of the most successful international inventors and entrepreneurs of reinforced concrete. His fellow Frenchmen, Louis Lambot and Joseph Monier, are two of the earliest documented concrete precasters. Lambot casting reinforced boats and Monier flowerpots in the third quarter of the 19th century. With the turn of the 20th century, the level of understanding of and experience with reinforced concrete facilitated the systemization of precast concrete building systems. Hennebique was prolific in Europe and eventually exported his design methodology to the US and beyond. In the USA, Earnest Ransome, an English born US immigrant, starting on the west coast and migrating east in the early 20th century, along with the Kahn brother's Albert and Julius from Detroit represented the strain of systems engineers and architects who were perfecting and producing primarily structural as opposed to architectural precast concrete.

In the USA in the early 20th century, James Earley, an artist in Arlington, VA adopted concrete as a sculptural medium. With his son John, James and his Earley Studio staff evolved from the use of concrete as a sculptural medium to a finished architectural precast material. A primary focus of the Earley Studio's interest in precasting concrete for architectural purposes was to disguise or transform the raw typically

[1] Colby, Albert L., Reinforced Concrete in Europe, 1909.

gray, rough and monolithic qualities of concrete by exposing aggregate on the visible surfaces of castings. In doing so, the goal was to have cast concrete visually appear to be stone. By the 1930's the Earley Studio was becoming quite advanced in its ability to reliably produce exposed concrete panels and by 1942 patented their process in partnership with the Dextone Company, a construction company from New Haven, CT. The first major project for this partnership was the David Taylor Ship Model Basin for the US Navy. They called the precast product "Mo-Sai" to reflect its origins of use by Earley to produce mosaics by manually embedding stone and other objects in the surface of concrete and later to expose aggregate as a finish by mechanical means.

The experimentation with and evolution of the Earley Studio's "Mo-Sai" architectural precasting process in the US paralleled the creation and evolution of the Schokbeton process in the Netherlands in the 1930's. As identified in the accompanying paper by Lucas Van Zujlien on Schokbeton, its Dutch inventors focused on a process to achieve consistency in strength, compaction and finish in precast concrete rather than evolving a precasting process to achieve a particular aesthetic outcome as was the case with Mo-Sai. The Schokbeton (or shocked concrete) process was patented in 1934 in the Netherlands. The primary advancement for its time was its approach to vibration as a means of achieving an output from a production process that was exceptionally consistent in compaction, high in strength and uniform in finish.

By 1960 Mo-Sai was the dominant architectural precast system in the US. However, there continued to be a diverse range of experimentation with the potential of precasting for structural, enclosure and aesthetic purposes through the middle decades of the century. The LeTourneau Company, a company that made earthmoving equipment in Peoria, IL, Longview, TX and Tacooa, GA, adapted motor-grader earthmoving equipment to hold a mold the size of a small house. This device could cast an entire house and drop it like an egg on a subdivision site, moving to the next site to repeat the feat. Grosvenor Atterbury a New York architect with an interest in low and moderate income housing explored precast concrete for structural and architectural housing applications, most notably in the community of Forest Hills, Queens. François Hennebique's enterprise in the USA and the Kahn brothers in Detroit also were continuing their development and marketing of propriety concrete systems. Of particular note is that through the first half of the 20th century there were generally no commonly adopted industry or building standards or uniform specifications for architectural precast concrete production and construction. Consequently, systems of production, assemblies, and components were typically patented and proprietary.

As is seen in the early evolution of concrete technology and experimentation summarized above, it is not unusual for advancements in knowledge and capability to be taking place in parallel, with or without the benefit of formal or informal communication. This phenomenon is at play in the evolution of architectural concrete precasting.

THE SCHOKBETON PROCESS

While from its initial discovery in the 1930's the inventors of the Schokbeton precasting system pursued precision at every step in the precasting process; mix design, mixing, mold building and finishing, casting, stripping, finishing, transport and erection, Schokbeton's unique feature was a shock table, a steel frame table approximately the size of an over the road trailer that was motorized to raise and lower ¼" two hundred fifty times a minute. The sharp and intense shocking of a concrete containing mold produced by this dramatic action accomplished several qualitative objectives including exceptional strength, uniformity in placement and opportunity for creativity in design. The shocking allowed for the use of zero slump concrete that produced consistent and exceptionally high strength precast elements. The shocking action facilitated the production of unique, sometimes sculptural, shapes. The intense shocking assured concrete reached the most remote and eccentric areas of a mold.

In addition to the innovation of the shock table, Schokbeton sought out and used glass mixing equipment in lieu of then industry standard concrete mixing technology as glass production required more precise mixing and consistency than could be achieved by the art concrete mixers available in the second and third quarters of the 20th century. Computational mix design tailored to the objectives of each project complemented the rigor of the mixing process.

SCHOKBETON IN THE USA

Schokbeton came to the USA in 1960, 26 years after it was patented. Its arrival was likely delayed by WWII. However, its arrival was ultimately aided by and a product of the rebuilding of Europe by the Allied countries led by the US and British governments under the European Recovery

Program, also known as the Marshall Plan.[2] The Joint Export Import Agency (JEIA) in the Office of the Military Government (OMGUS) under the Marshall Plan was responsible for encouraging European manufacturers to produce goods for export and promoting those goods as a contribution to the rebuilding of the European economy. It was a byproduct of this program that Schokbeton came to the USA. Through contacts with a Dutch bank, the then Director of the JEIA, George Santry, became aware of and interested in the capabilities and potential of the Schokbeton precasting system. Through that interest and the available economic development programs, Schokbeton was selected to provide precast concrete for the construction of the Thule Airfield in Greenland, a top secret U.S. Department of Defense cold war project constructed between 1951 and 1953 by North Atlantic Constructors (NAC), a consortium of U.S. contractors led by the Midwest construction giant of its time, Kiewit Construction. Precasting was selected in part due to the inability to cast concrete in place in the permafrost conditions of Greenland. The Thule Airfield was to serve as a refueling stop between the USA and Europe after WWII and before jets had the capacity to traverse the Atlantic Ocean without refueling. Working on the Thule project for NAC were a young Brooklyn Polytechnic civil engineer, Don Rothenhaus and Abraham (Ab) Geelhoed, a young Dutch engineer representing Schokbeton NV. Ab Geelhoed provided technical guidance on the production and placement of Schokbeton's precast units. The NAC engineer Rothenhaus was responsible for receiving, handling and placement of the Schokbeton precast.

Santry returned to the USA after his time at the JEIA with the North American rights to license the Schokbeton system. Rothenhaus returned to operate Grosvenor Atterbury's Precast Building Section Company[3] in New York City and Ab Geelhoed followed Schokbeton to the USA as the technical representative of the Dutch company responsible for quality control, marketing and development. As told by Don Rothenhaus, George Santry met Phillip Johnson while in Europe. On telling Johnson of his plans to bring the concrete system to the USA, Johnson advised Santry to move to New Canaan, CT as it was a hotbed of modernist architects with great promise. Santry headed Johnson's advice. After a stint with Precast Building System, Inc., Rothenhaus with partners purchased the first license for the Schokbeton process in the USA and established Eastern Schokbeton in 1960 in Boundbrook, NJ. One of the first projects produced by Eastern Schokbeton was the ¾ scale architectural precast folly on the pond at the Glass House in New Canaan, CT.

CRAFTSMANSHIP AND TECHNOLOGY

The first mold maker hired by Eastern Schokbeton in 1960 was a Scottish pattern maker who had recently emigrated to New York City. This is a significant point that illustrates the continued co-dependence between craft and technology in 20th century construction history. To capture the potential for creativity expressed in precast concrete, molds had to be equally creative in their design and precise in their construction. In addition, for the Schokbeton process to be effective the molds had to be structurally capable of withstanding the intense impacts delivered by the shock table. Consequently, the Schokbeton process was dependent on both technology and craft to realize its potential.

GROWTH AND EXPANSION

Over the decade of the 1960's Schokbeton was licensed across the USA and in Canada by George Santry. The business of cast in place concrete is inherently local due to the fact that it acquires its structural properties during the construction process and that the requirements for mixing, placing and curing are time sensitive once water comes in contact with cement. Precasting expanded the market radius for local producers but exchanged the challenges of casting in place for the logistical challenges of precasting in a plant and transporting large heavy cast pieces, susceptible to impact damage, over distances.

Mo-Sai Associates was a loosely organized group of precasters applying the Earley approach to precasting whose objectives were to share technical knowledge and distribute the cost of mutually beneficial marketing. Mo-Sai had a virtual monopoly on architectural precasting in the USA up to 1960 when Schokbeton arrived. This monopoly created an opportunity for a new comer to the US construction market. At that time there was a significant number of local and regional concrete firms to market the new system

[2] The European Recovery Program, also known as the Marshall Plan for General George Marshall who was the architect of the WWII victory and led the American program to help rebuild Europe after the war through technical assistance and economic development.

[3] Grosvenor Atterbury was a successful architect in New York in the first half of the 20th century, primarily known for palatial houses on Long Island for wealthy clients. However, Atterbury was also interested in addressing the need for low and moderate income housing and had a long standing relationship with the Sage Foundation in New York City, a charitable organization with a focus on social issues and solutions to them.

to, the most capable of which could quickly adapt to the Schokbeton system. The most capable precasting companies in many cases were already Mo-Sai licensees. Consequently, several of the Mo-Sai licensees became Schokbeton licensees as well. Schokbeton was ultimately licensed to over a dozen regional companies across the USA and in Canada.

The story of Otto Buehner Company in Salt Lake City is a significant example of the Dutch precasting invasion of the USA. By 1960 Buehner was considered one of the premier if not the premier precaster in the US. They had a highly skilled, predominantly Mormon, workforce and access to an array of aggregates with which to produce a spectrum of finishes not as readily available in other parts of the country. Combined with sound business practices, Buehner was by all accounts exceptional. The company were featured as the cover story in the September 1964 Concrete Products magazine, a national industry publication, as "The Nation's Best Known Precaster." Buehner was a leader of Mo-Sai precaster's trade association..

When George Santry identified candidate licensees for the Schokbeton system, Buehner had to be on the top of his list. His initial approach to Buehner was rejected, whether out of loyalty to the Mo-Sai group, the economics of adding a new system that duplicated somewhat what the Mo-Sai process could produce or lack of appreciation for the potential of the Schokbeton. As an astute concrete man, it was likely not the latter. However, on his second approach Santry informed Buehner if he did not become a Schokbeton licensee Santry would open a competing operation in his region. Buehner became a Schokbeton licensee and a successful one.[4]

ARCHITECTS & ENGINEERS AS AGENTS

For the Schokbeton process to realize its potential, it required creative agents, the architects and engineers who understood concrete and the unique features of the Schokbeton system and were intrigued by its potential. There were exceptional works of architecture produced in Schokbeton by many of the leading architects in the US. Marcel Breuer is known to have expressed a preference for Schokbeton to fabricate his precast work.[5] Schokbeton produced work for Edward Durrell Stone, Minoru Yamasaki, Phillip Johnson, John Johansen, SOM, Geddes Brecher, Qualls and Cunningham and Taliesin Associates to mention a few of the mid-century architectural luminaries. US architects in fact exported their design using the Schokbeton system back to Europe, a fascinating boomerang effect. SOM's Banque Lambert (1965) in Brussels, a Schokbeton produced building, established the firm internationally and demonstrated that American architecture could be exported to foreign clients.

The exceptional capabilities afforded by the shocking technique are best demonstrated in several projects. The projects identified below represent a significant statement about the state of architecture in the USA and concrete as a medium in the period from 1960 when Schokbeton came to the USA and 1965.

[4] Buehner experience told to author by former upper management employee in a personal interview.

[5] Isabelle Hyman, Breuer Biographer in interview with Author. 2003.

BANQUE LAMBERT

Brussels, Belgium, SOM (1965)

The Banque Lambert project designed by Gordon Bunshaft is exceptional in that it represents a significant project to the internationalization to American corporate architecture. It was like a number of the projects featured here, in demonstrating an innovative engineering feat. In this case the use of the stainless pin joints between panels at mid-span and the use of the exterior precast panels as load bearing elements as well as for their aesthetic value. The precast panels were produced in the Schokbeton plant in Kampen, The Netherlands.

(Photo: Nazar Leskiw, Mimoa.eu)

TORRINGTON PLANT

Nivelles, Belgium, Marcel Breuer (1964)

Concrete was extensively used by Marcel Breuer. A significant design interest of his was the exploration of the use of shadow and light in architectural expression. The Torrington Plant in Nivelles, Belgium takes a simple tilt up construction technique and extrudes an exceptional presentation of Breuer's design intent. While simple in concept, the amount of relief and scale of the Torrington panels could only have been achieved by the Schokbeton process.

(Photo: http://fuckyeahbrutalism.tumblr.com/post/22660311721/torin-corporation-factory-nevilles-belgium)

POLICE HEADQUARTERS

Philadelphia, PA, USA, Geddes Brecher Qualls & Cunningham, (GBQC) (1963)

The Police Headquarters was virtually all precast, in structure and finish. This was one of the first projects produced by Eastern Schokbeton, the first franchisee in the US located in New Jersey. According to Barney Cunningham, FAIA[6], the principal in charge of the project, a variety of structural systems were evaluated to achieve the design objectives for this project. After learning about the Schokbeton process, GBQC decided to use precast concrete. This project, like the Dublin Embassy discussed below, was predominantly round in shape thus capturing one of the economies of precasting, building as few different molds as possible and using them as many times as possible.

It was the team of designers and engineers working with Schokbeton's technical specialists that produced this exceptional work. Robert Geddes was the long time dean of the Princeton School of Architecture while continuing to practice in Philadelphia. August Komendant was Louis Kahn's structural engineer, worked with Moshe Safdie on his exceptional precast Habitat project in Montreal and taught at the University of Pennsylvania. Komendant was known for taking on challenging structural assignments with creativity and determination for achieving the design objectives. The City's objective for the new public building was to present a new progressive image for the Philadelphia Police Department. GBQC's exploration of urban design and architectural language, Komendant's daring engineering and Schokbeton's ability push the capabilities afforded by the shock table, produced a building with exceptional qualities. The headquarters building is virtually all precast. It used post tensioning in a dramatic integration of structure and architecture.

The structural core of the building was two cast-in-place cylinders (each contained the elevator and stair) that received pie shaped precast floor panels. The floor panels were multiple units post tensioned to 60 tons. The outboard most component of the floor assembly was a 12' section cantilevered beyond the outer radiused column and beam line. The outboard edge of the post tensioned cantilevered floor slab supported three story architectural and structural panels that carried two floors above. The exterior panels provided enclosure and were detailed to accommodate windows, piping, power and under-window heating units. This project was accomplished pre-computer. The degree of detail and exceptional execution represented the state of the art at that time.

(Photo: View from the south showing the parking lot and the convex south walls of the Roundhouse. Peter Olson, Police Headquarters. Olson Collection. The Athenaeum of Philadelphia.)

(Photo: Taxiarchos228 at the German language Wikipedia)

[6] Author's interview with Barney Cunningham in the Offices of GBQC.

U.S. EMBASSY

Dublin, Ireland, John Johansen (1962-1964)

The US Embassy shares geometry and its corresponding efficiencies with the Police Headquarters. It also shares being virtually an all precast building. What is exceptional about this building and its use of precast concrete is the sculptural quality of the precast elements, again, produced in a pre-computer age. The building's exterior enclosure was efficiently constructed from three mold shapes. The basic sculptural element of the design served as a structural column, a portion of a spandrel panel and a portion of a balcony railing. In addition to the integration of design and technology, this project and specifically the primary sculptural component of the design was a dramatic example of the linkage between technology and craft at that time. If it had not been for exceptionally skilled craftsmen, this project could not have been done. Without the shock table technology, this project could not have been realized.

The Dublin Embassy was designed in the USA by John Johansen, an American architect, cast by Schokbeton in the Kampen, The Netherlands plant, and shipped from Kampen to Dublin over the North Sea. For any construction project this is a daring set of circumstances. Any mistake in design, coordination and/or delivery would have a catastrophic impact on the project. In the design and production phases of the project Johansen made visits to the Kampen Schokbeton plant to inspect prototypes and work with the mold builders to produce this exceptional project.

(Photo: commons.wikimedia.org/wiki/File:American_Embassy.jpg)

CONCLUSION

While its impact on the history of construction was relatively short, 50 years, the Schokbeton precasting system was special in that it was transitional and transformational in the methods and outcomes that could be achieved through concrete precasting for architectural ends. It was transitional in a migration from craft to technology in construction. It continued to require both as precasting construction technology was ahead of computer-aided design technology at that time. It was transformational in the advancement of concrete technology. Today it would have be no major feat to design the sculptural component of the Dublin Embassy and transport the BIM file into a computerized precasting production system to precisely build the molds and cast the elements. But for the mid-20th century, this feat was exceptional.

Schokbeton, as well as Mo-Sai and others, during this period, provided a pathway for concrete to advance as a finished building material. The oft described "brutalist" characteristics of concrete, viewed as rough, monolithic, and gray, did and to some degree still have the stigma of being unsuitable as a finish material. Schokbeton, in particular, showed that consistent uniformity in finish and color could be achieved that allowed it to compete with other building systems for architectural expression.

Schokbeton afforded an opportunity to explore the potential of concrete's plastic qualities in a manner never afforded the early modernists such as Le Corbusier and his contemporaries. In doing so, the requirements for mold size and the dimensional constraints for transport from plant to job site inherently influenced architectural design strategies, resulting in more patterned and textured elevations, control and variation of finish and attention to connections as a component of the architectural vocabulary, such as seen in the Banque Lambert project.

After it demonstrated the potential for being economically credible and with widening appeal as a precasting system with unique capabilities, Schokbeton, as with other emerging mid-century materials and manufactured building systems, was purchased by a building industry conglomerate, American Metal Climax, seeking an ever larger part of the building supply economy. However, after only a short period of experiencing the realities of the risks of the precasting production, delivery and erection process, American Metal Climax sold the rights to Schokbeton to others with visions of profits more than exceptional architectural outcomes.

The demise of Schokbeton's process and licensing network can be attributed to a series of factors in the latter half of the 20th century. The development of admixtures that produced adequate viscosity to place concrete in molds eliminated the need for the forces produced by the shock table to achieve high strengths. Interestingly the development of a uniform specification for architectural precast concrete was set not at the highest standards of the day but at an inclusive threshold, an umbrella that accommodated precasters with less capacity to produce the level of quality achieved by Schokbeton and its closest competitors. According to Ab Geelhoed, after the establishment of the initial uniform specification, owners and architects expected the quality and outcome that could be achieved by Schokbeton from all precasters. This business environment made Schokbeton uncompetitive due to the extra cost to build molds that could stand up to the forces of the shock table. Less capable precasters were syphoning off important and necessary precast work from Schokbeton and its capable rivals like Mo-Sai in competitive bidding but were often unable to produce the desired result.[7] As a result, Schokbeton lost its qualitative advantage to produce a unique product. The passage of its ownership through several conglomerates ultimately resulted in the abandonment of the shock table technology and eventually the name in the USA and most other jurisdictions around the world, including The Netherlands.

[7] Author's Interview with Ab Geelhoed.

RESTORATION PROCEDURES ON SURFACES OF EXPOSED CONCRETE AND VALUES OF MODERN ARCHITECTURE: THE CASE OF HEADQUARTERS CELPE BUILDING - ENERGY COMPANY OF PERNAMBUCO

Fernando Diniz Moreira
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ABSTRACT

The conservation of modern architecture is a topic of great relevance for heritage nowadays. Despite the several challenges for conservation of this architecture, preserving the material dimension is still the main problem to be faced and one that provokes more debates among professionals involved. Between 1960 and 1970, concrete was explored as a form of expression of the buildings, and left the spot without any coating. Today, many of these buildings are going under conservative renovation process operations, but the exposed concrete is usually not taken as something valued to be preserved. In this article, we will examine the interventional procedures performed on the surfaces of concrete building headquarters CELPE, Companhia Energetica de Pernambuco, a remarkable example of Brazilian modern architecture of the 1970s, and its contribution to the maintenance of its values.

Keywords: exposed concrete, modern architecture, intervention, CELPE

Conservation processes in modern and contemporary architecture have been undertaken for more than 30 years. Despite having already considerable accumulated experience, one cannot say that this disciplinary field has reached its conceptual maturity. Renovation and updating, instead of conservation, are the most common features when dealing with modern architecture.

Among the diverse challenges the conservation of this architecture faces the preservation of its own fabric is still the main issue. This is because the materials are modern; namely, because of their nature, the way they were used and the lack of an understanding of their performance in the long-term, as indeed was the case with concrete. According to Susan Macdonald, there was a commonly-held belief that concrete would be an eternal material that would not require maintenance. Such optimism, unfortunately, did not materialize, as can be seen by corrosion processes and other kinds of failures that are taking place in various buildings around the world. The recovery of concrete structures is a topic that often appears in debates about the conservation of modern architecture, since this sets great challenges for the maintenance of architectural values.

The conservation of concrete structures almost often changes the authenticity of the material and challenges the theory of conservation. The Church of Notre Dame du Raincy, designed by Auguste Perret in 1923, had to have all of its hollow concrete blocks gradually replaced because they had various cracks and their casing was seriously damaged. Perret´s original design was kept, but very little of the original material. The Penguin pool in London Zoo, designed by Berthold Lubetkin in 1930, had serious problems in its structures. In the restoration carried out in the late 1980s, there was a clear choice for restoring the original design rather than the existing fabric of the building that had irremediably deteriorated. Finally, the solution to preserving the Zonnestraal sanatorium was to remake much of its original structure. These cases demonstrate that radical procedures, which would probably be condemned by the conventions of the discipline of conservation, had to be made to safeguard the buildings.

Concrete was a material of supreme importance for modern architecture not only because it provided architects with a range of new spatial and plastic possibilities, but also because it offered new possibilities of expression by using its surfaces. In the postwar period, the rustic expression of its surface was used by many architects around the world - including Le Corbusier, Marcel Breuer, James Stirling, Paul Rudolph, Kenzo Tange and Artigas, among others – as a way to symbolize their political and social views or simply their aesthetic preferences. There was enough possibilities for architects to experiment with various kinds of aggregates and textures. Concrete was used as a means of expression: being left in plain view without any coating would supposedly reveal an ethical stance, enriching the meaning of the work. This belief can be found in the origins of modern architecture, when a moral and ethical issue could be related to the way architects conceived their surfaces of their buildings. Authors like John Ruskin and Adolf Loos preached an honesty in the treatment of the materials, which were to have their original qualities exposed and prized. In Brazil the exposed concrete was widely used by the public and private companies between the late 1960s and early 1980s, to symbolize economic growth, modernity and monumentality as desired by countries in development.

However, the use of exposed concrete has implications for conservation. Suffering from moisture, concrete structures are commonly exposed to the natural process called carbonation, which occurs from the reaction between the existing carbon dioxide in the air and alkaline compounds present in the concrete. When the concrete is porous or has cracks and fissures, it allows the passage of water, oxygen, carbon dioxide and chlorides that will deteriorate the concrete itself reaching the armor, which starts to corrode. The use of exposed concrete further contributes to this process of degradation because of leaving the surface more susceptible to the elements. Moreover, in tropical regions, moisture printed spots on surfaces, which made the owners and the users clad them with ceramic tiles or other kinds of cladding.

Exposed concrete is undeniably something that adds value to a building as a heritage property. It is an attribute of great importance for modern architecture. However, the reinforced concrete is a building system: the joining of materials of different natures that need to work together to meet the structural needs and, as such, needs constant and preventive maintenance. This means that damaging one of the materials may damage the system as a whole. In the conservation of modern buildings, particularly those in exposed concrete, knowledge of their technical characteristics as part of a building system, is essential for the preservation of their values and their significance. Today, many of these buildings need to undergo repair operations and conservative restoration, including structural recoveries, which affect the exposed concrete surfaces.

Therefore, conservation procedures in reinforced concrete pose some crucial questions for the discipline of conservation: how to intervene in the material so as to conserve the values, integrity and authenticity of the materials and thus of the building? How must the concepts of integrity and authenticity be understood in terms of modern architecture? How does the attribute of exposed concrete contribute to the values of these buildings?

This article aims to show the importance of exposed concrete as an element that adds heritage value to modern buildings. In order to achieve this, we will examine the interventional procedures performed on the concrete surfaces of an important example of Brazilian modern architecture of the 1970s, the headquarters of the Energy Company of Pernambuco (CELPE). In addition to the outstanding quality of the building, such choice was due to the fact that it had gone through structural repair and interventions on its exposed concrete surfaces in the recent past.

Since its inauguration the CELPE headquarters went through some interventions, but most of them superficial, in order to adapt it to organizational changes of the company. However, in order to remedy pathological problems, a more complete intervention was carried out in 2009 aiming to recover concrete structures that suffered deteriorative processes caused by leaks and contamination by environmental agents.

The analysis followed some methodological steps. In the first section, the building will be presented along its main values (artistic, historic, authorship and use). The second section will analyze its main damages, before the intervention, and its main impact on the transmission of the values. Finally, the third section will analyze the intervention and the results according to values. Thus, we intend to advance the understanding of reinforced exposed concrete construction system as an element that adds heritage values to buildings of modern architecture, as well as contribute to the debate about the conservation of the values contained in the material for these works.

1. THE BUILDING AND ITS VALUES.

Designed by the architects Vital Pessôa de Melo (1936-2010) and Reginaldo Esteves (1930-2011), the headquarters of the Companhia Energética de Pernambuco Energy Company of Pernambuco (CELPE) (Fig. 1) is located in Recife and was inaugurated in 1975 as one of the largest office buildings with 19,000 m².

The ensemble consists of four blocks with different heights housing different uses. Its main facades are protected by a "grid" of vertical and horizontal brises-soleil made of concrete (Fig. 2). According to Vital Pessoa de Melo, the building "was made in those principles of expressiveness of materials, the concrete expression". The architects proposed an independent concrete grid attached to the main block facade, thereby creating a facade with depth. The position, direction and inclination of the brises were defined in such way to protect the glass curtain wall more effectively during times of higher solar incidence. The fixing of the brises is made either by independent columns or by beams extending from the façade to support them.

FIGURE 1: CELPE Building. View of the main façade.
Photo: Fernanda Herbster (2012).

This façade performs the basic functions of a window: it frames views of the surroundings, illuminates the interior, and allows the building to breathe. This permeable surface, mediating interior and exterior, works like a loggia shading the façade, filtering light and letting breezes flow. With these devices, the architects created an in-between spatiality in the façade itself, a space which belongs to the exterior and the interior at the same time. Thus, they provided depth to the enclosure. There is an effort to blur distinctions between matter and void, opacity and transparency. The exterior does not unveil the interior completely. It allows glimpses of people moving inside. This facade is clearly derived from the experiences of Brazilian architects with high rises buildings since the late 1930s, such as Lucio Costa and the Roberto Brothers, who rejected the obsession of the European modern architects for inundating spaces with light, which was excessive in the tropics. The building still stands out for exposing, without concealment, parts fittings and expansion joints. Secondary facades are covered with ceramic tiles (4x4 cm each).

FIGURE 2: CELPE Buildings, Detail of the front façade detail of CELPE with vertical and horizontal brises.
Photo: Ana Holanda (2011).

The main block has its facade facing the João de Barros Avenue, getting along for about 100 meters and distant 50 meters from the street. This placement creates a space between the street and the building, which was landscaped by Roberto Burle-Marx, one of the main landscape designers of the 20th century. The garden incorporates spaces for small vegetation and water vegetation, geometrically designed pools, grasses and paths covered by Portuguese stone. The arrangement of paths and the pool establish a series of frameworks of the façade and lead the passerby to a concrete staircase, protected by a cantilevered slab marking the entrance. Going up the stairs one has the opportunity to re-envision the garden in a privileged way.

In addition to the Burle-Marx´s garden, the building stands out for its integrated artistic works, such as sculpture by Abelardo da Hora in the garden and the panels in the public areas, by Paulo Neves, in the underground, and by Francisco Brennand, the ground floor.

The structural system of the CELPE building consists of ribbed slab and concrete pillars, which are arranged in the main façade and the outer wall of the circulation. Therefore, it has a very flexible interior layout, fitting the needs of users and the company.

Its facilities (electrical, hydraulic, air conditioning, cable and telephone) are arranged below the slab of each floor and are covered by ceilings of plaster or aluminum, providing greater flexibility to the plan disposition, which was an innovation in Recife at the time. Office rooms have floors cladded with vinyl materials (Paviflex) and walls with white melamine laminate (Formica). There are areas in the building with a more noble finish, such as the entrance hall, the board rooms, some circulations and auditoriums, where floors are clad with granite or covered with carpet, walls clad with aluminum sheets and ceilings with plaster.

The CELPE building is one of the great examples of modern architecture in Pernambuco, being listed since 1997 by the City of Recife as a Building of Special Interest for Preservation (Imóvel Especial de Preservação, IEP) under Law 16.284, which protects it from demolition or alterations of original features.

Although a landmark building for Recife, there are no studies indicating its cultural and artistic importance, with the exception of a few lines of its dossier listing as an IEP and a couple of academic articles rather focused on the work of the architects than on the building itself. Therefore, we had to make an interpretative effort to find out the main values of the building, which can be synthesized into four major groups:

Artistic value: Its curved façade with vertical and horizontal brises demonstrates the concern of the architects with the aesthetic composition of the building and with climate adaptation. Exposed concrete was ostensibly used in the building since it symbolized this new way of building, more rational, economical and appropriate to the new forms of modern architectural thinking, which praised an ethical stance, using materials honestly, without concealment or pretense. Such postures reflect the artistic quality of the complex and the respect and knowledge of the architects of the material. It should also be emphasized the integrated artistic works, such as Burle-Marx´s garden and the artistic panels.

Historical value: The building is a symbol of a time in Brazil in which public institutions and private companies sought to show themselves innovative, modern and committed for the future. Exposed concrete expressed this modernity.

Authorship value: The CELPE headquarters presents elements that define architectural thinking of its authors, Vital Pessôa de Melo and Reginaldo Esteves, two of the greatest architects working in the second half of the twentieth century in Pernambuco. Formed in 1961 and in 1954 respectively, they were part of the first generation of modern architects trained in at the Pernambuco School of Fine Arts, under the influence of masters Delfim Amorim, Acacio Gil Borsoi and Mario Russo, architects who were crucial in the consolidation of modern architecture in the region.

Use value: The building has been used as company headquarters uninterrupted for forty years. Its original design has been maintained and it still has the ability to perform their original functions and absorb to current demands.

2. DAMAGES

2.1 DAMAGE AND INTERVENTIONAL PROCEDURES OVER TIME

The building went through an intervention process between 2003 and 2004, when isolated points of the concrete structure of the façades were retrived in addition to the application of surface protection with water repellent, but to a lesser extent of that realized in 2009 (analyzed in this article). In 2003, the structure had not yet manifestations of pathologies, so the intervention was preventive.

The 2009 intervention included the recovery of elements in exposed concrete, in some cases structural, such as pillars and the main entrance slab, in others compositional, such as vertical and horizontal brises of the facades. The main problems found consist of damages to the reinforced concrete system caused by leaks and the contamination of deteriorative agents existing in the environment (CONCREPOXI, 2009). The main manifestations were:

- Efflorescence stains and cracks, which occur mainly in the main building entrance slab (Fig. 3). Such damages, according to a report provided by the company responsible for the intervention, were caused by a leak that occurred in the slab of the canopy

- Corrosion and detachment of the concrete cover (Fig.3)

FIGURE 3: CELPE building slab canopy damage (efflorescence), detachment of the concrete, brise corroded with concrete detachment. *Photos: Barbara Aguiar (left, center) Source: CONCREPOXI , 2009 (right)*

- Generalized stains on the surfaces of exposed concrete (Fig. 4). These spots were caused both by the acidic soot accumulated on the surfaces of exposed concrete, such as moisture.

FIGURE 4: CELPE building, Stains caused by acid soot and moisture, generalized spots. *Source: CONCREPOXI , 2009.*

- High degree of deterioration of the horizontal and vertical brises of the façade (Fig. 5). Some of the brises had no prospect of recovery and their replacement was the only possible solution.

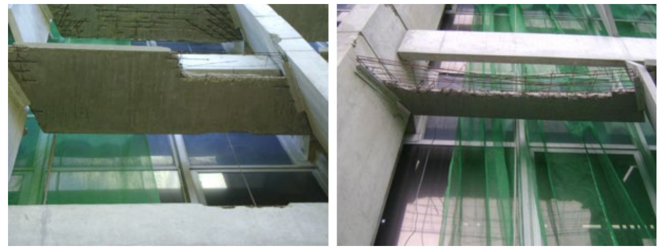

FIGURE 5: CELPE building, brises with high degrees of deterioration (to be replaced). *Source: CONCREPOXI , 2009.*

2.2 VALUES

As seen, the existing damages consists of efflorescence stains, corrosion and detachment of concrete surfaces, general stains on the façades caused by acidic soot and excessive moisture. Based on the damage already, the situation of values well before the intervention will be considered:

Artistic value: The exposed concrete is very important for the artistic features of the building be esteemed. Damage to these structures prevented that its artistic/aesthetic value were fully transmitted, especially those related to their surfaces. In this case, the exposed concrete was not able to convey the artistic value of the building in its fullness, generating losses in its significance, integrity and authenticity.

Historical value: The maintenance of the original fabric would be important so that the building would serve as a witness to the characteristics of the material and the way of applying it at the time of construction of the building. As a physical evidence of the view of the designers, particularly regarding their attempt to express themselves through the treatment of the surfaces and their attention to climate adaptation. However, the extent of damage that affected the structures and the surfaces in concrete in the building meant that this witness function ran the risk of being interrupted. In other words, the exposed concrete, as an element that adds value was loosing their ability to transmit the historic value of the property, interfering with its integrity, authenticity and significance.

Authorship value: As in other works by Pessôa de Melo and Esteves, the CELPE building had in the concrete a great protagonist. Thus, the existing damage to the material prevented these design qualities to be esteemed in its entirety. This also meant a loss for the authenticity and integrity of the property.

Use value: With the presence of the damages, this was one of the hardest hit values for building CELPE. Although there was no interruption in the use of the building, there was a partial loss of their ability to perform functions, since the existing damages to the façade brises, for example, put at risk the safety of building users and passersby.

3. THE INTERVENTION

In order to analyze the intervention in the CELPE building, we considered the exposed concrete as an element that adds heritage value to the building. The analysis focuses on the actions carried out in the intervention– which were analyzed according to reports provided by the company responsible for the work, Concrepoxi – evaluating the impact of these actions on each value of the building, as well as their integrity and authenticity.

The interventions performed included: 1) rehabilitation/ replacement and waterproofing of exposed concrete components of the façade (brises, pillars), and the stairs to the building (Fig.6); and 2) Rehabilitation and waterproofing of the building entrance slab.

FIGURE 6: CELPE building, interventions performed: Recovery of pillars and louvers, slab of the main entrance . *Photos: Concrepoxi , 2009*

3.1 REHABILITATION / REPLACEMENT AND WATERPROOFING OF THE FAÇADE ELEMENTS AND STAIRS

Those were the most important interventional actions taken for the CELPE building because they affect directly the general appearance of the wall, and recover the safety of its members. Of all the elements recovered, the brises were the greater focus of the intervention, because they are striking elements on the façade of the building, and at the same time presented a high degree of deterioration.

These actions provided substantial gains for virtually all building values, especially those related to use. Only for the historical value one can consider that there were losses, including for authenticity, due to the partial loss of the original material. However, as we have seen, exposed concrete is part of the reinforced concrete structural building system, and as such can not be treated as a separated part. The damages affecting their surfaces also affect the system as a whole, and non-intervention can generate greater losses for the property and its significance.

The current appearance of the surfaces recovered or the replaced brises hold some visual conflict with the original ones (Fig. 7). Thus, the recovery of these elements brought gains for the significance and integrity of the building, to the extent that it recuperate the ability of the concrete to transmit its values. Excepting for the material aspect, there were also gains for the authenticity, since the project managers were concerned to document every step of the whole intervention process, and to attempt to adapt the construction methods of today to existing materials, always considering the cultural importance of the building.

FIGURE 7: CELPE building, south facade in 2008 before the intervention. Pillar presenting moisture stains and corrosion and thesame location in 2012. Pillar recovered in 2009 without major visual differences to the original structure. *Photo: Concrepoxi (2008) (left) Fernanda Herbster (2012) (right)*

3.2 REHABILITATION AND WATERPROOFING OF THE BUILDING MAIN ENTRANCE CANTILEVERED SLAB

The recovery of the CELPE entrance canopy brought considerable gains for structural safety. It also brought aesthetic gains, since this slab, placed in an area with a large flow of people, is an important element in building the composition. Its recovery was crucial for the building to fully regain its values. The initial step was to remedy an infiltration that directly affected the canopy. Then, the company used the same recovery technique of brises and pillars on the surfaces of the canopy, plus the treatment of cracks and new waterproofing. However, currently, the canopy is painted with ink on "concrete color", a fact that greatly decreases its rusticity and prevents the material values to be accessed in its entirety. The gargoyle used to drain water from the balcony was a very important point of rehabilitation, due to its high degree of deterioration (Fig.8-9).

FIGURE 8: CELPE Building, main entrance slab in 2008, before the intervention, with its original rusticity of exposed concrete, and in 2012, free from deteriorative processes, but coated with paint, including the gargoyle *Photo: Ana Holanda (2008) and Fernanda Herbster (2012).*

FIGURE 9: CELPE Building Main façade. Differences between the exposed concrete and painted concrete (in the canopy) (rustic) and painted (on the canopy) and the situation of the gargoyle (2008) before the intervention. *Photos: Fernanda Herbster (2012), left and center, Concrepoxi (2008)*

Currently, after the intervention, the CELPE building presents no manifestation that would indicate damage to exposed concrete structures - cracking concrete detachment or corrosion of armor. Evaluating the intervention of 2009, there were many gains in terms of values, mainly for those related to use, aesthetics and authorship, as well as the integrity of the property, because the exposed concrete is able again to transmit its values. As for historical value and authenticity, losses can be reported of the original material, but as this was in stricken by severe deteriorative processes, their stay was also not ensuring the transmission of value. The only alternative was the recovery or replacement of the original material. Such action prevented larger scale interventions in the future and greater losses, which are common in these kind of interventions.

4. FINAL CONSIDERATIONS

For any architectural and cultural property - of any style and period - the operations to repair or restore should be a critical act, never a simple enforcement of rules. It must adapt to the physical, documentary and formal aspects in order to pass the values of the building for future generations in the best possible way. The same thoughts should guide operations for modern architecture in exposed concrete, but some aspects should be raised.

Maintaining the original material of these buildings is a task difficult to accomplish. This is due mainly to the high cost of electrochemical techniques and to the lack of preventive maintenance on structures, which aggravates the extent of damage and requires more invasive interventions. Regardless of time or construction material - a multidisciplinary team for any kind of intervention in assets is needed. Such action will result in more conscious conservation interventions and greater gains regarding the maintenance of its values.

Comparing the actions in modern and in previous styles, it seems that the professionals in charge holds different principles. For modern buildings, there is not, in most of the cases, an outstanding concern for conservation. The operations are more guided by remaking than by preserving or restoring. On the other hand, it was revealed that this position is moved further by the lack of knowledge about the values of modern architecture, than by lack of awareness.

For the CELPE building there was consciousness at the time of the intervention to consider the building as a heritage property, even if the main values of the building were not clearly understood and stated. Tests were made on the inserted material (new) to conform as best as possible with the original, with no major interference in the qualities of the exposed surfaces of concrete. We believe that the techniques used to recover the CELPE building were the most appropriate, given the high degree of deterioration of the exposed concrete elements of the facade, especially the brises, as well as surface protection, where water repellent material without glass was used.

As positive points, it is noteworthy that the deteriorative processes were interrupted. Conservative actions taken in CELPE building were of critical importance to its preservation and its heritage values. However, it should be noted that the downside is the difficulty of reversing these actions.

As we have seen, the surfaces of exposed concrete are an integral part of the reinforced concrete building system, and as such, any intervention in this material should consider the stability and security of the building as a whole. On the other hand, it cannot be a justification for the adulteration of building.

For this intervention, there were losses, mainly the original material, but the gains were much larger. Values were recovered and the ability of exposed concrete to transmit these values was restated, enhancing its integrity. For authenticity there were losses, if we consider only the fabric of the property, but damages present in the concrete were concealing their heritage qualities. But considering, in parallel, the recovery of symbolic values, authenticity was enhanced since they were able to restate the power of the façade, its fenestration, relationship between interior and exterior solid and voids.

Other factors should also be raised for this building. At the end of the intervention, there was not a preventive maintenance plan for the conservation of exposed concrete structures, action that may affect negatively the conservation done and contribute to the emergence of new damages. On the other hand, the existing awareness within the CELPE company about the importance of the building as a heritage property, it is a fact that contributes to its preservation.

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MORSE AND EZRA STILES COLLEGES
YALE UNIVERSITY, NEW HAVEN, CONNECTICUT

Deborah Slaton
Paul Gaudette
David Patterson

INTRODUCTION

The Samuel F. B. Morse and Ezra Stiles Colleges at Yale University (1958–1962) were among Eero Saarinen's last and most distinctive works. Instead of using stone or brick, which are more common on the university campus, Saarinen designed the colleges to be constructed with cast-in-place concrete exterior walls. The interior of the buildings has exposed concrete at columns, walls, and roof structure in the common areas.

Morse and Stiles College at Yale University with distinctive rubble wall appearance.

The repair and conservation of the exterior and interior concrete was undertaken as part of a comprehensive rehabilitation program designed by architects KieranTimberlake of Philadelphia. The project included the renovation of 260,000 square feet of existing structure as well as a 25,000 square foot underground addition beneath the existing courtyard. The project included housing for 500 students, renovation of the library and dining halls, expansion of the below-grade common rooms, addition of new skylights and a sunken courtyard that provides daylight for the below-grade spaces, as well as lounges, fitness spaces, art and music studios, a theater, outdoor gathering spaces, and landscape. WJE served as materials and conservation consultant to KieranTimberlake for the concrete and waterproofing components of the project.

DESIGN AND CONSTRUCTION

In his report on the year 1955–1956, Yale President A. Whitney Griswold announced his intention to add to the University's then-overcrowded residential college system. In 1959, architect Eero Saarinen, who had graduated from Yale in 1934, was selected to design two new colleges. The site of Old York Square, located behind the Yale Graduate School, was selected for construction. The project was funded by a foundation established by Paul Mellon, who had graduated from Yale in 1929, with the goal of building new colleges intended to be different in character from the older colleges of the campus—primarily through the incorporation of individual housing units.

Through his years as a student at Yale, Saarinen was very familiar with Collegiate Gothic buildings and quadrangles, many of which were completed during the 1930s. He had also studied historic settings such as the Italian village of San Gimignano and the Campo in Siena. The two colleges, Morse and Stiles, each consisted of four-story dormitory structures with a ten-story and a fourteen-story tower. They featured more private space per student, and a lower ratio of windows to wall surface, than the older residences. The new buildings shared a common dining room and an elevated walkway leading to Payne Whitney Gymnasium—one of several Collegiate Gothic buildings on campus that comprise the setting of the new colleges.

Morse and Stiles Colleges are built on an angular site, with complex, irregular massing tall narrow towers that are reminiscent of Tuscan villages such as San Gimignano. Stepped, winding walks lead between the buildings, which frame a grass-covered courtyard. Through massing, paths, and courtyards, Saarinen sought to relate the new structures to the existing Collegiate Gothic buildings of the campus, including the nearby Payne Whitney Gymnasium, designed by John Russell Pope, and the Hall of Graduate Studies, designed by John Gamble Rogers, both completed in 1932 and featuring tall, narrow towers. Gamble designed numerous Collegiate Gothic residences at Yale between World War I and World War II, which provided the aesthetic and institutional context for Saarinen's design.

Saarinen designed the colleges to be built of cast-in-place concrete, in contrast to the nearby stone and brick buildings of the campus. The concrete incorporates large-scale crushed granite aggregate. Large stones, up to 12 inches in diameter, were placed with the concrete, creating a more monolith, rubble masonry wall character. In the dining halls, Saarinen used intersecting diagonal concrete trusses that related to those of the Collegiate Gothic halls but in a new form. Original construction also included sculptural elements of smooth-finished concrete, embedded in the exterior walls or as free-standing sculpture along walkways and in courtyards.[1]

Concrete sculpture with smooth finish embedded into rubble concrete wall. The sculpture appears to have been mortared in place after construction of the rubble wall.

[1] Drawings and photographs taken during design and construction of the colleges can be viewed at the Yale University Manuscripts & Archives Digital Images database, http://images.library.yale.edu/madid/showthumb.aspx?q=Morse+and+Stiles. These include photographs of the designers examining large-scale mock-ups of the rubble concrete.

The design of Morse and Stiles Colleges was surprising to those familiar with Saarinen's work, in particular as compared to his other structure at Yale.[2] For example, the colleges provide a striking contrast with the David S. Ingalls Hockey Rink, designed by Saarinen and constructed in 1953–1958. The concrete and wood structure, with its sweeping curves and open spans, has a sculptural character recognizable in an icon of Modernism, differently expressed but having some similarity to Saarinen's design for the stainless steel Gateway Arch at Jefferson National Expansion Memorial in St. Louis, completed in 1963. The colleges are quite different from these Modernist expressions, and in his project statement Saarinen noted: "Flatness, lightness, glistening aluminum and glass, smoothness instead of rough texture and the play of light and shade—all these could neither express the spirit we wanted nor be compatible with our neighboring buildings."[3] In another reference to the older residential college buildings, Saarinen spoke of presenting the new residences as ". . . citadels of earthy, monolithic masonry buildings where masonry walls would be dominant and whose interiors of stone, oak, and plaster would carry out the spirit of strength and simplicity."[4]

Saarinen remarked during the construction of Stiles and Morse Colleges that he had embarked "on unchartered waters" in his design. In a modern attempt to capture the spirit of medieval architecture, Saarinen eliminated all right angles from the living areas. This reportedly resulted in two rooms that had eleven walls, none of which was long enough to put the bed against and still be able to open the door. (Right angles were reintroduced into the interior spaces of Morse College during the recent rehabilitation.)

ASSESSMENT AND TRIAL REPAIRS

Morse and Stiles Colleges incorporate two distinctly different types of concrete: the large aggregate, rubble-like concrete that Saarinen selected to recall the character of buildings in Italian

[2] Photographs of Morse and Stiles Colleges taken soon after completion by photographer Balthazar Korab can be viewed at the Library of Congress online Photos, Prints, and Drawings Collection, https://www.loc.gov/.

[3] Eero Saarinen, Project Statement, cited by Julie Michelle Rosen, "Samuel F.B. Morse and Ezra Stiles Colleges, Yale University," February 8, 2011, accessed at http://www.docomomo-us.org/register/fiche/samuel_fb_morse_and_ezra_stiles_colleges_yale_university.

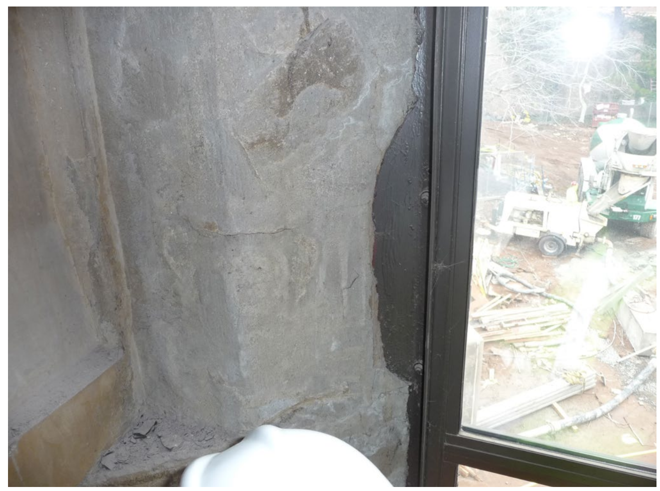
[4] Ibid.

hill towns, and a more familiar board-form finish. Each type of concrete presented different technical challenges in terms of conservation of character and appearance, although the approach and methodology used in meeting these challenges was essentially consistent for both.

Overall view of rubble concrete walls with inset windows.

Board formed concrete walls, slightly battered, that were part of the addition. The original construction also included board form concrete walls.

The field investigation campaign revealed that the existing concrete was generally in good condition, with minor cracking, localized deterioration at the tops of walls and scuppers, and localized spalling adjacent to windows. Soiling, deterioration, and localized freeze-thaw damage were observed primarily at the tops of walls, at parapets, and at suppers, where the concrete elements are exposed to moisture and the elements on multiple sides. Spalling adjacent to windows was found to be related to corrosion of embedded steel window frames. Thus, patch repairs were needed at relatively small and localized areas. The fact that the original concrete was air entrained contributed to its good condition in service. The smooth-finished concrete sculptural elements incorporate in the exterior walls and as free-standing sculpture in the walkways and courtyards, however, reflected inappropriate previous repairs that required removal and further repair.



Rubble concrete wall with several different exposure levels of the rubble aggregate.

The assessment of the concrete was designed to evaluate existing conditions and distress. Small areas of deteriorated concrete were opened to determine existing conditions, causes of deterioration, and as-built conditions. Core samples were removed for laboratory studies, and extensive archival research was performed at the Yale archives by the project team to understand the original design and construction processes.

The most challenging aspect of the repair program was to match some of the unique aesthetic characteristics such as the warm, buff color, and special texture and finish, of the original concrete. Archival photographs indicated that the design architects had taken a hands-on approach to finishing the concrete in large-scale mock-ups, to achieve the exact finish desired as part of the aesthetic envisioned by Saarinen. Each type of finished surface—large rubble aggregate, mortar parging, or board form finish—required samples, trials, and a high level of craftsmanship to properly match the original concrete. The first challenge was to identify the aggregates, sand, and cement used in the original concrete. A series of field mock-ups was conducted to refine the mix design and protocols for repair.

Close-up of rubble concrete, showing a crack on the right side and various levels of soiling.

The primary objective of the repairs was to use materials and techniques that would be sensitive to the existing façade, meet the specification criteria used in the original construction, and perform well in an exterior environment. An example of these challenges was experienced at the thin jamb sections of concrete at the large vertical windows. In order to achieve these goals, the program included development of sample repair materials and procedures, performance of trial repairs on the building, and then using a high level of craftsmanship to perform repair work on the rest of the building façade.

With guidance provided by the project engineers and architects, the contractor developed trial mixes and repair techniques which were performed on shop samples to determine how to best match the original appearance while providing a durable repair. Next, in-place trial repairs were performed to permit technical and aesthetic evaluation of the completed repairs and an assessment of the scope of work and the contractor's procedures.

The process of investigation, analysis, samples, and trials and mock-ups allowed refinement of installation procedures as the project progressed. The level of craftsmanship was critical in performance of the repair work and was used to achieve a concrete repair that matched the adjacent original concrete in appearance and met the established criteria for good concrete repair practice. A conservation approach was used to guide technical and engineering decisions, resulting in repairs that perform to modern practice standards and are aesthetically successful.

Various concrete mix sample designed to match the original architectural concrete, shown in the foreground. Note the different degrees of buff color in the mixes.

Based on archival documentation reviewed, and as confirmed by field investigation and laboratory petrographic examination, the rubble concrete mix consisted of fine aggregate composed of rock fragments and sand; coarse aggregate consisting of Millstone Point granite; cement; and water. The original specifications and laboratory studies indicated that for the original rubble concrete, the coarse aggregate consisted of granite that is 50 percent buff, 50 percent pink, in color. In terms of size, the large aggregate included 50 percent passing between 8 and 6 inch sieve and 50 percent passing between 6 and 3 inch sieve, with some aggregate also greater than 12 inches in diameter.

The original specifications also required that the concrete meet a compressive strength requirement of 5,000 psi for grout, and for 3,000 psi for the rubble concrete. The compressive strength test method required 2 inch by 2 inch by 2 inch cubes for the grout, and 18 inch by 36 inch cylinders for the rubble concrete. Note that the very large size of the rubble aggregate required that large cylinders rather than cubes be used for this testing. In addition, the specification required air entrainment of 3 to 5 percent.

After the field investigation, the original existing and repair materials were analyzed to determine material components, composition, and causes of deterioration. Laboratory studies of the concrete included petrographic evaluation following ASTM C 856, Standard Practice for Petrographic Examination of Hardened Concrete, and tests to determine air content, water-cement ratio, cement content, general aggregate identification, carbonation depth, and chloride content. Petrographic evaluation was performed to provide a general identification of components and aggregates of original concrete. This information was used to develop a mix design for the repair concrete.

CONSERVATION APPROACH AND REPAIR METHODOLOGY

The goal of the project was to repair the concrete on both the exterior and interior of the buildings, using materials and techniques that would match the existing façade as closely as possible and that would perform well over time. The repair design needed to match the unique characteristics of the original construction—both rubble and board form concrete—that are key to the unique aesthetic of the buildings, and also provide a similar board-form concrete for new construction incorporated as part of the building expansion.

Trial mixes and repair techniques were evaluated to determine how to best match the original appearance while providing a durable repair. The implementation of repairs at trial locations permitted technical and aesthetic evaluation of the completed repairs, and an assessment of the scope of work and the contractor's procedures. Information gathered in the first two phases was utilized in refining requirements for the project.

As part of the trial repair process, repair materials were identified, trial mixes developed, and repair procedures and techniques evaluated. The contractor performed patch repair samples, from preparation through finishing, various techniques to select repair materials and finishing techniques to match the existing concrete. In addition, a protection system was selected to protect the concrete against moisture penetration. Mock-ups were then constructed at selected locations using the repair materials and techniques identified through trials. The mock-ups were evaluated and procedures refined to meet as-built conditions. Repair work was then performed at remaining portions of the facade.

Variations in appearance were a part of the aesthetic, with different colors, shapes, and sizes of aggregate providing a highly textured and colorful surface for the rubble concrete walls. The board form concrete reflects the texture of the wood forms, with lift lines visible. Craftsmanship was essential to the success of the repairs, and quality control was ensured by the extensive trial repair and mock-up program. Achieving variations in the finish is always a challenge, when the contractor may be accustomed to the goal of a final consistent appearance.

Surface preparation is one of the most important components of any concrete repair. Surface preparation typically includes removal of loose and unsound concrete at spalls or failed previous patches; sawcutting the perimeter edges of the repair area to a depth of one inch and approximately one inch beyond visible corrosion of the embedded steel; chipping of concrete within the patch area to a minimum of 3/4 inch deeper than the reinforcing steel; sandblasting and air blasting of the patch area to clean away laitance, dirt, and other debris from the exposed concrete; and cleaning, preparation, and priming and coating of exposed steel with a rust-inhibiting coating; followed by installation of the new patch material.

The procedure for placement and finishing involved installing formwork at repair areas to match existing profile of adjacent concrete; testing the concrete for conformance to specifications; placing the concrete into forms using internal and external vibration techniques; curing for approximately 24 hours, followed by removal of the forms and exposure of the aggregate at the exterior surface of the new concrete with a combination of low-pressure water and hand brushing to resemble the original concrete finish adjacent to the repair area; and curing the repair concrete.

A particular challenge in the repairs at Morse and Stiles Colleges was implementation of patches adjacent to window frames. Because of the complex configuration of the building footprint, the interface at some windows was less than a 30 degree angle. The highly textured rubble concrete created a highly uneven surface to be repaired, and the location of the window frame was another constraint on preparation and patch installation. Once the repair mix was confirmed through samples and trials, preparation at repair locations was completed; exposed steel cleaned, primed, and painted with a rust-inhibitive coating system; and new concrete installed and cured. A clear, penetrating silane-based sealer was applied to new concrete to enhance its moisture resistance.

CONCLUSION

The project team approach for the conservation and repair of the rubble and board-formed concrete at Morse and Stiles Colleges with an understanding of the higher standards required for repair work for historic concrete and the additional time needed for assessment, trials, and mock-ups. At Morse and Stiles Colleges, this approach was understood by the entire project team—owner, design architect, consultants, and contractors—leading to an efficient work process and a collegial context most appropriate to the University itself.

The process of historical research, coupled with thorough investigation, laboratory analysis, trial samples, mock-ups, and full-scale repairs allowed for refinement of the repair design, maintaining of installation procedures, and implementation of quality control measures as the project progressed. This process allowed for a conservation based-approach to be used that could guide technical and engineering decisions, resulting in repairs that conformed to modem practice standards and that are aesthetically successful.

Rubble concrete wall with board form concrete in the foreground. Also note the decorative sculpture.

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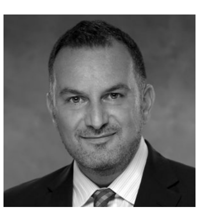

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MISSION

Docomomo US is dedicated to the preservation of modern architecture, landscape and design. Through advocacy, education and documentation, we provide leadership and knowledge by demonstrating the importance of modern design principles including the social context, technical merits, aesthetics and settings of these important pieces of American history.

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