D3.2

WP 3 Validation of products and technologies at laboratory scale

Final Version / 30-10-2018

DEFINITIVE SELECTION OF THE CASE STUDIES

Innovative materials and techniques for the conservation of 20th century concrete-based cultural heritage

H2020-NMBP-2016-2017

Grant Agreement Number: 760858

Project Information

Project Ref No.	760858
Project Title	Innovative materials and techniques for the conservation of 20th century concrete-based cultural heritage
Project Acronym	InnovaConcrete
Funding scheme	RIA
Start date of the project	January 1st, 2018
Duration	36 months
Project Coordinator	María J. Mosquera (UCA)
EC Project Officer	René Martins
Project Website	http://www.innovaconcrete.eu

Deliverable Information

Deliverable n°	3.2
Deliverable title	Definitive selection of the Case Studies
WP no.	3
WP Leader	UCA
Contributing Partners	ICOMOS, DOCOMOMO, LODZ, BeWG, UCA-SSH
Nature	Report
Authors	Gunny Harboe, Kyle Normandin
Contributors	Fernando Espinosa de los Monteros, Maria J. Mosquera, Fernando Merello, Rafael Zarzuela, Luis M. Carrascosa, Manuel Luna, Mª Teresa Blanco, Elena Frias, Juan Queipo de Llano, David López, Mª Isabella Pierigé, Gabriella di Carlo, Lorenzo Fernández-Ordóñez
Reviewers	Maria J. Mosquera, Fernando Merello, Rafael Zarzuela, Luis M. Carrascosa, Manuel Luna, José Mª Rodríguez-Izquierdo
Contractual Deadline	31-10-2018
Delivery date to EC	30-10- 2018

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

Dissemination Level

PU	Public	✓
PP	Restricted to other programme participants (incl. Commission Services)	
RE	Restricted to a group specified by the consortium (incl. Commission Services)	
CO	Confidential, only for the members of the consortium (incl. Commission Services)	

Document Log

Version	Date	Author	Description of Change
Draft	10/26/2018	Normandin/Harboe	Draft
Final	10/30/2018	Mosquera et al.	Final version

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

Table of Contents

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

1 Executive Summary

Twentieth Century historic concrete is at risk from a lack of appreciation and care. Some monuments have been lost and more are in danger. There are two main obectives related to the choice of the case studies in InnovaConcrete project. The first is to serve as the sites where the experimental validation of the conservation products and techniqes developed in the project can be tested in situ. The other is to help promote citizen awareness of 20th Century concrete-based Cultural Heritage. Thus, the case studies have been selected to cover a wide range of societal/economic impacts as well as to represent different environmental conditions and conservation problems.

One of the main objectives of the Work Package 3 is the characterization of concrete samples extracted from different monuments selected as case studies in the project. Five monuments were chosen as case studies, previous to the final submission of the InnovaConcrete proposal. Moreover, a specific task (subtask 3.1.2) focused on complete the case studies selection has been included in this WP. Two additional monuments -the Kaunas Ninth Fort Monument in Kaunas, Lithuania and the Flaminio Stadium in Rome, Italy- has been chosen during the implementation of this task with two targets:

(i) To improve the representative of European climate and environmental conditions.
(ii) To add other significant monuments according to the the information obtained in subtask 3.1.1 entitled "Identification badges of the most significant concrete-based asset of cultural interest".

In addition to the seven monuments selected for technical study, an eighth was selected to carry out a pilot action related to socio-economic analysis and long-term societal spill-over effects of the project. The methodology will be developed and tested in one single monument -Zarzuela Racecourse in Madrid, Spain- as a pilot action, and will be provided to the owners and managers of other monuments to complete the analysis.

Finally, it is important to remark that the eight InnovaConcrete case studies will be employed as a tool for promotion of citizen awareness of 20th Century concrete-based Cultural Heritage.

A description of all eigth sites selected in InnovaConcrete project and the reasons for their selection is included in the following paragraphs.

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

2 Criteria for the Selection of the Case Studies

The definitive selection of the case studies has been the objective of the subtask 3.1.2. This task has been led by ICOMOS with the participation of the following partners: DOCOMOMO, LODZ, BeWG and UCA-SSH.

Five case studies were proposed to be carried out as part of the original proposal submitted for the InnovaConcrete project. Two additional technical case studies have been added since the award of the Project. All the sites taken collectively are intended to cover a complete range of different contexts, according to the following criteria:

1) **Humanities criteria** (symbolism, period of construction, economic and societal importance).
2) **Scientific criteria** (decay processes and environmental conditions).

However, after the award of the Project, two additional case studies were chosen:

(i) In order to improve the representative of European climate and environmental conditions

(ii) In order to more fully represent the range of concrete cultural heritage created in the former socialist countries.

(iii) In order to incorporate other significant landmarks selected in the task 3.1.1.

(iv) In order to include monuments in a poor state of conservation.

3) Broadly, the topic categories that define and guided the selection of the case studies.

The Table 2.1 shows the monuments chosen as technical case studies. As shown in the Table, the selected monuments cover the entire 20th Century, from 1913 (Centennial Hall year of construction) to 1989 (Chillida sculpture construction). In addition, it is remarkable that three different sculptures (war memorial towers, Kaunas and Chillida sculptures) have been selected as case studies because they also represent a significant part of 20th Century Cultural Heritage. Regarding the environment, monuments in very different zones have been chosen, including urban areas with continental climate, coastal areas or even, sub-mountainous areas.

The case studies will be employed as the main tool for the citizen awareness. Thus, they have also been chosen to cover a wide range of societal/economic impacts. The selection includes

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

significant monuments such as the spectacular Centennial Hall building, included in the UNESCO world heritage list, Chillida sculpture with a significant number of visitors per year, Flaminio stadium, a masterwork built by Nervi, one of the most important enginneers in the 20th Century and Kaunas nith fort monument, one representative monument of socialism architecture.

On the other hand, buildings such as the Arseniusz Romanowicz Station and war memorial towers which are hardly recognised as Cultural Heritage by citizens has also been chosen as InnovaConcrete case studies.

Specifically, the Arseniusz Romanowicz station is a typical example of reinforced concrete thin-shell structures, one of the important achievements of the post-war modernist movement, being a clear symbol of socialism architecture. It has been chosen in InnovaConcrete, togheter to Kaunas monument, with two objectives:

(i) To promote citizen awareness for the of structures built in socialism period.
(ii) To promote new tourism activities related to this architecture in east-European countries.

Thin-shell structures were built in many train stations in communist countries (i.e. Poland, Powisle and Ochota Warsaw Train Stations; Latvia, Dubulti Station, Riga; Romania, Predeal Station, Predeal; Ukraine, MetrostationDnipro, Kiev).

The Angel commemorating the fallen War Memorial Tower and the other war memorial tower in Abruzzo (Italy) have been chosen as case studies in InnovaConcrete for their symbolic value for European citizens. The war memorials were built across Europe in different periods of the 20th Century, especially after the First and Second World Wars. As an example, in Italy the total number of War Memorials is about 12,000. They represent important territorial social reference points, constituting a significant component of European individual and collective identity. They have been chosen in InnovaConcrete with three objectives:

(i) To foster a feeling of unity in European citizens from their common history.
(ii) To promote citizen awareness of about 60 years of peace, democracy and solidarity in our continent from the European Economic Community (Treaty of Rome).
(iii) To promote new tourism activities related to these symbolic monuments in Europe.

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

Finally, for example, the Torroja Building has been chosen as a representative model of interdisciplinary collaboration between architecture and engineering during the 20th Century.

Monument	Location	Date	Environment	Main Decay	Social/Economic Impact
Centennial Hall	Wroclaw Poland	1913	Urban area Continental climate	Chemical	UNESCO world Heritage site. Nº Visitors: 600,000 per year.
War Memorial Towers	Abruzzo Italy	1922 1950	Sub-mountain area Continental climate	Physical	Significant territorial social reference points. Important component of individual and collective identity.
Eduardo Torroja Institute	Madrid Spain	1953	Urban area Mediterranean/continental climate	Biological	Model of interdisciplinary collaboration between architecture and engineering. Several annual visits are organized for professional associations and students.
Flaminio Stadium	Rome Italy	1958	Urban area Mediterranean climate	Physical Biological	Masterwork by one of the most important enginneers in the 20th Century. Advanced state of decay.
Śródmieście Raylway Station	Warsaw Poland	1962	Urban area Continental climate	Chemical	Important part of the urban landscape. Not considered as Cultural Heritage by citizens
Kaunas IX Fort Monument	Kaunas Lithuania	1976	Urban area Continental climate	Physical	A representative example of Socialism architecture
Elogio Horizonte Sculpture	Gijón Spain	1989	Coastal area Atlantic climate	Chemical	Symbol of the city and the most visited monument Nº Visitors: 300,000 per year

Table 2.1. The monuments selected as case studies in InnovaConcrete.

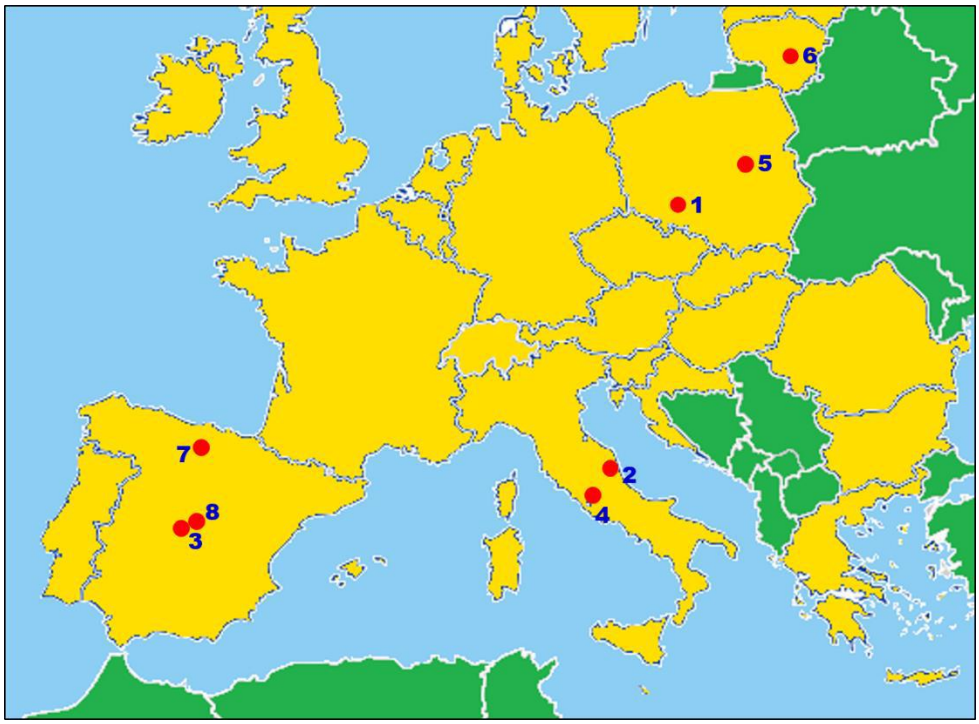

Figure 2.1. Geographical location of the cases of study. (1) Centennial Hall, (2) War Memorial Towers, (3) Eduardo Torroja Institure, (4) Flaminio Stadium, (5) Śródmieście Raylway Station, (6) Kaunas IX Fort Monument, (7) Elogio del Horizonte, (8) Zarzuela Racecourse.

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

In addition to the seven monuments selected for technical study and to raise awareness of the heritage value of the concrete architecture, an eighth was selected to carry out a pilot action related to socio-economic analysis and long-term societal spill-over effects of the project.

The value of sustainably protected built heritage goes beyond the simply economic. To quantify the socioeconomic gains and analyze the long-term societal spillover effects of the project we are using an innovative methodology (Ecosystem Services Approach). The methodology will be developed and tested in one single monument (Zarzuela Racecourse, see Figure 2.1) as a pilot action, and will be provided to the owners and managers of other monuments to complete the analysis.

This monument has been selected because it is a key piece of architecture and engineering of the twentieth century, which also represents a leisure and restoration offer of great tradition in Madrid. This allows us to analyze at the same time the public's perception of the monument, its potential to generate "ecosystems" services (provisioning, regulating, cultural and supporting services) and its use for tourism.

3 Case Studies

As previously described, the selection of the case studies was intended to provide a range of building types, ages, regional environments, and states of conservation. In addition, the selections include significant monuments such as the Centennial Hall and Chillida sculptures with a significant number of visitors per year, and buildings such as the Warsaw Rail Station and war memorial towers which are not readily recognised as Cultural Heritage by citizens. Specific information about the 8 case studies is included in the following paragraphs:

3.1 CENTENNIAL HALL

Location: Wrocław

Construction period: 1911 – 1913

Author: Max Berg

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

Site Description

Centennial Hall was designed by Max Berg, an architect and constructor. The structure was erected between 1911 and 1913, and its interiors held Centennial Exhibition to commemorate 100th anniversary of Napoleon's defeat at Leipzig. The facility was erected in the grounds of Szczytnicki Park, in the place of a former horse racecourse. Centennial Hall was built with the use of reinforced concrete technology. The dome of the Hall spans 65 m, the building is 42 m high and it can hold 10 000 people. The main hall is surrounded by the corridors. Multi-purpose space, untypical structure, unique and spacious location represent just a few of its advangates. Centennial Hall complex currently is one of the most desired venues among domestic and foreign organizers of exhibitions, conferences, cultural, sport and congress event. In 2006 Centennial Hall became a part of UNESCO World Heritage List.

The cupola modeled on the Festhalle Frankfurt was made of reinforced concrete, and with an inner diameter of 69 m (226 ft) and 42 m (138 ft) high it was the largest building of its kind at the time of construction. The symmetrical quatrefoil shape with a large circular central space seats 7,000 persons. The dome itself is 23 m (75 ft) high, made of in steel and glass. The Jahrhunderthalle became a key reference for the development of reinforced concrete structures in the 20th century.

Historical sources indicate that when the Centennial Hall was being erected, concrete making facilities and aggregate producing mills were installed on the building site. In places highly exposed to load, crushed-stone aggregate made from Strzegom granite of the highest quality was used. Special cement, produced in the Silesia Cement Plant in Opole, was used to make the concrete.

Author

Max Berg (1870 – 1947) graduated from Technical University in Charlottenburg (Berlin) in 1893. After the studies he worked in Frankfurt am Main as a building inspector. In 1898 he passed the second state examination and became a government architect (assessor). In 1899 Berg briefly worked for the Szczecin Building Administration. He then worked as a construction inspector at the city administration in Frankfurt am Main, during which he met the ideas of urban planning Camillo Sittes.

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

From 1909 until 1925 he was elected city councilor for building construction in Wrocław's City Council. Max Berg designed many buildings in Wrocław, such as Centennial Hall, the public baths, the hydroelectric power stations, the modernist chapel, etc. Due to numerous conflicts with the city council, Max Berg resigned from the SPD and retired on January 30, 1925 from office. That year, Max Berg moved to Berlin, gave up his architectural career and dedicated the rest of his life to the study of Christian mysticism. Despite the scandal over his departure, Berg maintained his reputation in Wroclaw, where he participated as a judge in architecture competitions. During the World War II he moved to Baden Baden until his death in 1947.

Reasons for Selection

InnovaConcrete has chosen The Centennial Hall as an outstanding example of early Modernism and the innovative use of reinforced concrete structures in the building industry. Centennial Hall is listed as a UNESCO World Heritage site. UNESCO described this monument as "a landmark in the history of reinforced concrete architecture".

Figure 3.1. Centennial Hall. (a) General view, (b) sampling on the monument, and (c) Max Berg.

Wroclaw is characterized by a moderate transition climate with visible ocean influences. The characteristic feature of such a climate are the frequent changes in weather associated with the movement of barricades, the influx of moist polar air or less dry continental air. This climate conditions is other reason for the monument choice. Due to this wheathering conditions, the surface of concrete was cracked in many places, with numerous damages and losses. Thus, it was subjected to complex conservation/repair works.

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

3.2 WAR MEMORIAL TOWERS

Location: Torricella Peligna, Abruzzo, Italy

Construction period: 1922, 1950

Author: N. Lucci – Walter Sibona

Site Descripction

Torricella Peligna is a small Town in the province of Chieti in the Abruzzo region – Italy, located at about 1000 metres above the sea level.

During the Second World War, this town was included in the "Gustav Line" area, a defensive line that divided Italy in two parts by using the natural obstacles aimed to delay the advance of Alliance force.

After the great slaughter of innocents, the citizens of Torricella Peligna built two monuments – The Angel and The Tower – in order to commemorate and not to forget the fallen of both the World Wars.

THE ANGEL

The monument named "the Angel" is impressive and majestic and it was dedicated to the fallen of the First World War. This War Memorial is located at the centre of the Remembrance park, on the top of a hill close to the the Historic Town. The monument at the central and highest position acts as the organizing element of the park, with majestic and imposing dimensions.

Standing on steps in travertine with a quadrangular base with four littori bundles at the corners and surmounted by an obelisk, it recalls the names of the heroes of Torricella during the Wars.

The Angel sculpture in concrete is placed against the obelisk at the frontal side, looking towards the town.

The figure, with female features in classical style, has hair that is worn tied back from the face and a wreath of laurel leaves. A strong sense of power is associated to the kindness of the winged figure, represented while is writing in a golden book the names of the fallen and at the same time is squashing with hers left foot a big eagle, a symbol of the the Hapsburg empire, which in the meantime is struggling to get free.

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

The monument is a work of N. Lucci from Pennadomo, built in 1922, the inauguration was in the same year with the participation of political and other relevant personalities as well as common citizens.

The celebration was a moment of popular aggregation and still today the monument recalls the sacrifice of local people during the World Wars.

After a few years, the monument was damaged by a hurricane and then was also bombarded during the Second War World.

A reconstruction intervention was carried out in the early 50s, involving the local administration committees to remember always the horrors of Wars and the human sacrifice.

THE TOWER

The Tower is located at the highest point of the town, a position chosen with great symbolic significance, because different buildings that were present in this square were completely destroyed during the War due to the violent bombing.

The Tower War Memorial was designed in the 1950 by Walter Sibona to commemorate the 120 civilian victims who fell during the Second World War. In the original project, the monument was initially six metres taller than the current one.

For the construction of this monument, a city committee was formed to raise funds, as for the Angel monument. The poor possibilities prevented the construction of the monument in all its high and it was be built six meters lower than the original project.

The Tower is about 20 meters high, its base is in chiselled stone, surrounded by an iron railing worked with depictions of the coat of arms of the village of Torricella Peligna. The monument is entirely of concrete and has the shape of a truncated pyramid with a square base.

The shape of this War Memorial is particularly original because it is similar to a lighthouse in its form. It has a highly symbolic meaning, because like the lighthouse, that illuminates during the night, with its light reminds the strage of the innocent and those who lost their lives in battle.

The interior is bordered by a series of walkable floor connected by stairs, which allow you to climb to the top, from where you can dominate the surrounding landscape in all its beauty.

Built and inaugurated in 1961, with great political interest and citizen aggregation.

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

Authors

Both monuments, were created by artists from the Abruzzo region. Respectively, the Angel and the Tower were designed by the local artist N. Lucci in 1922, and by the local architect Walter Sibona in 1950.

Reasons for the Selection

The Angel and the Tower were selected for their symbolic value for European citizens. They are typical of the thousands of war memorials built all over Europe after the First and Second World Wars. They were selected to foster a feeling of European unity and common history; to promote citizen awareness of 60 years of peace, democracy and unity through the creation of the EU, and to promote touristic activities related to symbolic monuments in Europe. Moreover, they are hardly considered as a Cultural Heritage for citizens. Thus, it becomes an interesting case to analyse the measurements proposed in InnovaConcrete to increase citizen's awareness around historic concrete.

Owing to their location in a mountains climate, both monuments have different characteristics and conservation problems, one structurally similar to a building and the other to a statue in the round, and their different position contributed to the different state of conservation. Specifically, the Tower monument presents different decay phenomena, including: cracking and disintegration, strong corrosion of the iron reinforcement, and detachment of splinters of material. The Angel statue provides an example of an structure with different states of deterioration and constituent materials, always in concrete but with different types of constituents, due to the numerous interventions of restoration over the years.

Figure 3.2. War Memorial Towers. (a) The Angel, (b) The Tower, and (c) sampling on the monument.

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

3.3 EDUARDO TORROJA INSTITUTE

Location: Madrid, Spain

Construction period: 1953

Author: Eduardo Torroja

Site Description

In order to improve the construction techniques Eduardo Torroja founded, with a renowned group of architects and engineers, the company ICON (research in construction). From this organization the Technical Institute of Construction was born in 1934 (now Eduardo Torroja Institute for Construction Sciences), the first private sector organisation created in Spain to steer, further and publish research on construction and related areas to foster progress, promoting the use of concrete and cement, unthinkable structures in those days.

In 1951 they decided to construct their own building with workshops for the creation of models and equipment, with facilities to test these models (even on life-sized), equipped with study and training rooms, general services, a library; as well as a pilot plant for manufacturing cements and for semi-industrial scale testings of this product. These spaces were designed to innovate and to detect problems for the cement and concrete industry of those days.

The research was developed in two closely related fields: on the one hand, the theoretical study of problems and, on the other, trials and the experience to solve them. In the first case, the subject is the man; in the second, the machine. This challenge required two different typologies with two different scales: laboratory-scale of human-scale type, and testing facilities, on a much larger scale.

For this purpose, a modern-functional style building, designed by the architects G. Echegaray and M. Barbero, is conceived. Singular shaped concrete elements, precast concrete pieces and other structural reinforced concrete models were tested and used.

In order to systematically organize the works, simplify the monitoring and economize the specialized labour, constructive systems for this Institute were tested. For this purpose, concrete elements were preferably used, especially precast concrete pieces according to units of 1.60 m, in order to standardise the construction method.

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

On the other hand, iconic and singular elements, some of them in reinforced concrete, were used to contrast with the systematic precast construction.

Author

Eduardo Torroja Miret (1899-1961) was one of the most prominent international proponents of the history of progress attained in civil construction and architecture in the golden decades of Modernism. He played a major role in the scientific and technical revolution that preluded the brisk development of reinforced and pre-stressed concrete in the first half of the twentieth century and the concomitant evolution in the construction industry, structural typologies and the new aesthetics championed by Modernism. He was internationally acclaimed not only for his innovative works, but also for his many-faceted professional activity: designer, scientist, researcher, manager and teacher.

He is the author of iconic works such as the Thermal Power Plant of the University of Madrid (1932, National Prize of Architecture in 1932), the market of Algeciras (1933, declared cultural heritage by the Junta de Andalucía in 2001, best example of the Modern Movement in the region), Frontón Recoletos in Madrid (1935, disappeared) or the Zarzuela Racecourse in Madrid (1931, declared a Spanish historic- artistic monument in 1980).

Reasons for the Selection

The Eduardo Torroja Institute has been selected as a significant 20th century building, which will be used as a case study to validate the performance of the solutions proposed. This institute, since its creation, constitutes a landmark of industrial and research architecture in concrete, both nationally and internationally, and was a model of interdisciplinary collaboration between architecture, engineering and other disciplines related to construction.

The building is protected by the city of Madrid, due to its singular concrete structure, model of the 20th century architecture. Additionally, this work appears in DOCOMOMO database, in order to achieve the recognition as part of the 20th century culture and the heritage protection and conservation.

The location of the Torroja building in Madrid, a citiy with a high level of polutions, will permit to evaluate the effect of acid rain and other decay mechanisms produced by pollution in a concrete building.

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

Specifically, three architectonic elements of the construction were chosen for their study taken into account their singularity and their conservation state:

(i) The precast mortar Windows frames, which show show multiple cracks, material loss and biological colonization.

(ii) The seven-shaped pergola, constructed in reinforced concrete. Decay is observed in support, ending and corner zones, where also significant cracks are visible.

(iii) Elephant trunk shaped shell, constructed in reinforced concrete. Biological colonization is observed in many areas of the slab, but also rust stains showing corrosion of steel bars is present.

These elements, in contrast with several others (coal tank and chimney, lemniscata-shaped pergola, etc.) have not been previously repaired and the behaviour of the impregnation new treatments applied in their in-situ validation can be compared with the traditional coatings materials used in the already repaired elements.

Figure 3.3. Eduardo Torroja Institute. (a) General view, (b) sampling on the monument, and (c) Eduardo Torroja.

3.4 FLAMINIO STADIUM

Location: Roma, Italy

Construction period: 1958

Authors: Pier Lugi Nervi / Antonio Nervi

The Site

The Flaminio Stadium was designed by Pier Luigi Nervi and his son the architect Antonio Nerviin the late 1950s as a key element for the 1960 Summer Olympics to be held in Rome, Italy.

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

It was intended primarily to accomodate football matches and could host up to 50,000 spectators. The structure also contained four gymnasiums, a pool, a bar, changing rooms and a first aid station.

The stadium was designed using state of the art construction methods. Concrete was employed in different ways and in original forms: in situ castings for the large structural frames, prefabricated elements for the grandstands, undulating slabs of ferrocement realised on site in specially designed formwork for the canopies. The project demonstrates how Nervi was already focused on the phase of construction while still designing, convinced that obeying the laws of statics was a guarantee in its own right of the proper aesthetic result.

The stadium has been abandoned for years and is currenty in an advanced state of deterioration. This poor state of conservation can be attributed to several causes that includes poorly executed previous interventions that failed to respect the important values of the original structure and general deterioration due to the age and lack of maintenance of the building and all its systems.

Author

The engineer Pier Luigi Nervi (1891-1979) was one of greatest structural engineers of the 20th Century. He was both a designer and a builder in the traditional way.

Pier Luigi Nervi was born in Sondrio and attended the Civil Engineering School of Bologna from which he graduated in 1913. After graduating he joined the Society for Concrete Construction and, during World War I from 1915 to 1918, he served in the Corps of Engineering of the Italian Army. From 1961 to 1962 he was the Norton professor at Harvard University. Nervi began practicing civil engineering after 1923. His projects in the 1930s included several airplane hangars that were important for his development as an engineer. During the 1940s he developed ideas for reinforced concrete which helped in the rebuilding of many buildings and factories throughout Western Europe, and even designed and created a boat hull that was made of reinforced concrete as a promotion for the Italian government.

He was very concerned about how his structures were made and how the materials were used. His work contributed greatly to the image of modernity through the creative use of new technologies to create new and exciting architecture. He was particularly intereseted in innvoations in utilization of precast elements and the use of thin-shell structures.

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

Reasons for the Selection

In this Stadium, Pier Luigi Nervi, who is unanimously recognised as the most ingenious Italian engineer of his time and a pioneer of the study and use of reinforced concrete, used concrete in different ways. Some structural elements were obtained by in situ castings, the grandstands were made of prefabricated elements and the canopies were realized by producing on site undulating slabs of ferrocement.

The Stadium is currently affected by serious degradation, which is mainly due to improper interventions that modified the original structure and to the lack of appropriate conservation actions that have amplified the effect of degrading processes due to atmospheric aggressive pollutants, water infiltration and biological decay. Damages to the structure are clearly detected, such widespread cracks, spalling and detachment of concrete.

This case study will be employed to alert about the poor state of conservation of some 20th century monuments and thus, it is important to draw attention to its condition and encourage its preservation and conservation.

Figure 3.4. Flaminio Stadium. (a) General view, (b) sampling on the monument, and (c) Pier Luigi Nervi.

3.5 ŚRÓDMIEŚCIE WKD STATION PAVILION

Location: Warsaw, Poland

Construction period: 1962

Author: Arseniusz Romanowicz

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

Site Description

Warsaw railway station system

The railway stations in Warsaw were designed by architects Arseniusz Romanowicz and Piotr Szymaniak in 1954-1955 as a part of the Warsaw Cross-City Line for the regional trains. Nevertheless, the works did not start until 1962. Such a long break was caused mostly by political reasons. Finally, the buildings were completed in 1963. Śródmieście WKD Station, together with four other stations: Central Station, Ochota, Powiśle, and Stadium. creates a unique architectural development, that carefully renovated is still in use and perfectly serves its function.

Each of the station buildings was given a different form, which was a direct result of structural systems applied. Architect and engineers decided that they would search for a construction system which would suit the station's functional needs. They have chosen the structures of reinforced concrete thin-shells. All the station buildings are designed according to one scheme. Each pavilion consists of relatively small waiting room and ticket office set in one open space. Fully glazed curtain walls provided interior with daylight. Buildings are covered with reinforced concrete thin-shell roof of different shapes.

The diverse, dynamic forms of the stations were supposed to differ from the static urban development. Architects wanted them to become landmarks. At the same time they were perceived as a display of capabilities of modern architecture in communist Poland.

Śródmieście WKD pavillion

Besides Śródmieście WKD Station not being the more important one of the five stations in terms of operation, it is the one that best matches the purposes of the InnovaConcrete scope and its history is directly linked to the other four structures.

The Śródmieście railway station building's roof is designed as a hyperbolic paraboloid. The shape was a result of the search for a roof shape, that would allow to cover both- pavilion and asymmetrically placed stairs leading to the platforms.

The station was designed for commuter and regional traffic, complementary to the Central Station, operating long-haul domestic and international connections. The station (platforms,

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

ticket office etc.) is beneath the level of the street. The only part which is visible from the ground level is the reinforced concrete thin-shell canopy, which covers the stairs leading to the platform.

Originally, stairs on both ends of the platform were covered with reinforced concrete canopies, but only one of the two structures has survived to our times. The western structure was removed in the early 1990s to make room for the Swede Centre office building.

Author

Architect Arseniusz Romanowicz (1910-2008) graduated from the Faculty of Architecture at Warsaw University of Technology in 1938. At the university he met Piotr Szymaniak (1911-1967), who became his lifetime associate. Together, they took part in numerous architectural competitions and designed many buildings in Warsaw.

From 1938-1939 he was an employee in architectural office working on the project of Warsaw Central Station During the occupation, he was employed in the German Ostbahndirekzion, where he dealt with the adaptation and finishing up of the Central Station, which was destroyed during the Warsaw Uprising burnt in 1939. This project secured the victory in the SARP competition no. 135, landing Romanowicz and Szymaniak the employment in 1951 in the Railway Design Office. Although railway sations dominates in Romanowicz's work, not all of his works are associated with it, as demonstrated by his completion of numerous competitions, such as the design of the mosque in Warsaw (1935), the Yacht Club in Gdynia (1937) or the design of the Polish pavilion for the World Exhibition in New York (1938).

Reasons for the Selection

Avant-garde modernist constructions were typical for the architecture after 1956 in communist Poland as well as other Eastern and Central European countries. Reinforced concrete thin-shell structures were perceived as a definite proof of technological development of socialist countries. Due to their avant-garde forms which seemed to deny the gravity, they became landmarks in many cities in Central and Eastern Europe. They were not only functional and aesthetically sophisticated, but at the same time they were the symbols of ambitious aspirations of the developing countries.

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

It is worth highlighting that these new designs implied new construction techniques, from particular formworks, to the difficulty of placing the reinforcement and vibrating the concrete, what resulted in constructions that were more an experimental than industrialized activity.

Moreover, the monument presents decay problems that want to be addressed with the products that are being developed as part of the project.

Finally, its location allows assessing different climate and boundary conditions, which enables testing the performance of the products under development in different environments. Particularly, Warsaw involves a polluted environment that can present acid rain, which can activate particular decay processes not present in other locations.

Regarding one of the most important targets of InnovaConcrete "citizens awareness about concrete Cultural Heritage", the structure represents that not only monuments and buildings of great magnitude are worth heritage recognition, but that simplicity and design needs also to be considered. The fact that the canopy next by was demolished in the 90's, enhances the importance of this structure and the lack of awareness within the society, point that wants to be addressed as one of the main goals of the project.

Figure 3.5. Śródmieście WKD Station Pavilion. (a) General view, (b) sampling on the monument, and (c) Arseniusz Romanowicz.

3.6 KAUNAS IX FORT MONUMENT

Location:	Kaunas, Lithuania
Construction period:	1976-1984
Authors:	Adolfo Vytauto Vieliaus & Gediminas Baravykas (Architects)
	Alfonsas Vincentas Ambraziūnas (Sculptor)

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

Site Description

The site consists of several buildings: old structure of the fort, memorial, museum, and administrative building.

OLD FORT

Ninth Fort of Kaunas was built in 1902-1913, as a part of the Kaunas fortress. The general plan of the whole Kaunas fortress complex was done by military officials of Russian army. The project of Ninth Fort was done in 1897 by engineer Konstantin Velička. At that time, the project of the Ninth Fort was innovative as all fortification rooms were concrete. The thickness of ceiling reached 1.5-2 m, and different parts of the fort had safe connections via underground galleries. The fort had electricity and forced air ventilation system in tactical purpose rooms.

In 1914, when the World War I started, the Ninth Fort remained practically undamaged during battles, and at the end of the summer of 1915, when Russian troops retreated, the fort and the whole fortress were occupied by the German army. In 1922-1924, the fort was transformed into a prison for heavy duty, and from 1941 to 1944 it was turned into a mass massacre place.

In the Ninth Fort, people were massively murdered from October 1941 to August 1944, when the Red Army of the Soviet Union occupied Lithuania. The October of 1941 was exceptional in the scope of mass murder: on October 4, 1,845 Jews and on October 29 – 9,200 Jews were killed. Before this, never in history such a large number of people in one day were killed in Lithuania. During mass murders, not only men, but also women, children, and old people were shot. In addition to locals, people from other European countries were imprisoned and killed in Kaunas Ninth Fort: Austria, Poland, France, the Soviet Union, and Germany. On the basis of provisional data, around 50,000 people were killed in the Ninth Fort during the Second World War.

NEW MUSEUM AND MONUMENT

The Fort museum was founded in 1958 after the reconstruction and restoration of the old fort. In 1975 the fort was restored again. In 1976-1984, the museum was substantially expanded in the territory with construction of a memorial complex (sculptor Alfonsas Ambraziūnas, architects Vytautas Vielius, Gediminas Baravykas, constructor Andrius Gavelis). This monument has been chosen as case study in InnovaConcrete.

At that time the press presented the complex as an impetuous and ideologically important monument: "the entire memorial ensemble must speak about the struggle, the victory and the

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

suffering of the people, those who died in the struggle for liberation." The monument reflects the Soviet tradition of spectacular monuments. Architects of the memorial have been able to visit places of similar nature in Volgograd, Brest, Yerevan and other.

The first competition project was prepared in 1966. Sculptor A. Ambraziūnas has prepared this project together with architect V.Vielius. In the second round of the competition (1968), architect Gediminas Baravykas became involved in this project. And only after the third (1969) and the fourth round (1970), the final project was approved and proposed to be implemented. The official opening of the memorial ensemble took place in June 15th 1984. In 1985 the USSR State Prize was awarded to the sculptor A. Ambraziūnas and architect V. Vielius and G. Baravykas for the Kaunas IX Fort Memorial Complex. The monument has been chosen as case studie in InnovaConcrete.

Authors

Alfonsas Vincentas Ambraziūnas

Alfonsas Vincentas Ambraziūnas was born in 1933. Valmantiškių village, Kaunas county. 1952 graduated from Wilkie High School. 1961 - Vilnius State Institute of Fine Arts. Studied the sculpture with Professor J. Mikėnas. His works are centered in the fields of monumental, decorative, memorial and small sculptural plastics, creating portrait compositions.

Since 1959 A.V. Ambraziūnas's works were exhibited in many exhibitions organized in Lithuania, as well as in Latvia, Estonia, Russia, Canada, Germany, Denmark, Finland, Poland, Italy, Austria.

A.V. Ambraziūnas worked for a long time in the section of sculpture and in the board of artists' union. Monumental Art Council (under the Ministry of Culture, Deputy Chairperson).

Baravkirkas Gediminas

Baravkirkas Gediminas (1940-1995), was a Lithuanian architect. In 1964 he graduated from the LSSR Art Institute. Since 1964 worked at the Urban Design Institute (head of the group, project chief architect, chief architect of the institute). 1987-95 taught at the Vilnius Academy of Fine Arts; Associate Professor (1992). 1990-94 Chief Architect of Vilnius. Some of his projects include: the former Helios film theater (1977), the 2 nd Chamber of the Lithuanian University of Educational Sciences (1978), the Blessed Church of Jurgis Matulaitis (1989) and architectural

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

parts of sculptural monuments such as S. Nėries in Vilnius (1974) and The Ninth Fort Memorial Complex in Kaunas.

Reasons for the Selection

The memorial monument chosen as case study for this project is directly linked with the Fortress history. Besides being located just by the defensive structure and with in the Complex plot, the contest organizers were looking for a memorial structure that would speak about the struggle, the victory and the suffering of the people who lived and participated in the liberation.

Alfonsas Ambraziūnas sculpture, reflects the Soviet tradition of spectacular monuments. Due to the motive that it represents, together with its majesty, time, materials and construction techniques used, is considered a magnificant example of concrete design belonging to the soviet era that nowadays lacks of the citizens recognition as 20th century cultural heritage.

Moreover, the monument presents decay problems (e.g. spalling, biological growth, calcareous crusts, cracks and delamination) that want to be addressed with the products that are being developed as part of the project.

Finally, its location allows assessing the effects of the northern climate, which has particular impacts on concrete through freeze thaw actions climate, enabling testing the performance of the products under development in different environments.

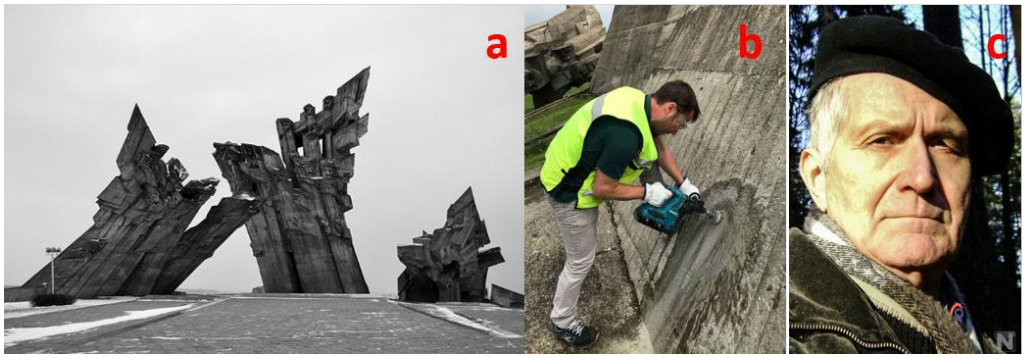

Figure 3.6. Kauna Ninth Fort Monument. (a) General view, (b) sampling on the monument, and (c) Alfonsas Vincentas Ambraziūnas.

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

3.7 ELOGIO DEL HORIZONTE

Location: Gijón, Spain

Construction period: 1989

Author: Eduardo Chillida

Site Description

The monumental work was built opposite the sea, in Santa Catalina hill, as a point for encounter scanning the horizon which for the artist symbolized "the homeland of all men". It brings together Chillida's preoccupations about scale, the relationship between nature, space and the void. It is an open work, an accessible space turned into a place to invite one to look, to contemplate infinity by delving into the unknown. The problem of size was crucial in his work. Each work acquires specific properties according to its dimension and is determined by its relational properties. El Elogio del Horizonte (In Praise of the Horizon) puts the beholder in direct relationship with the work and the cosmos.

This sculpture was one of the most ambitious project of Chillida and entailed a complex elaboration. For its construction, the artist chose a novel material in his work (concrete) because it allowed to significantly increase the scale of his works. The dimensions of this sculpture are: 12.5 m wide, 15.5 m long, 10.0 m high and 1.4 m thick. In order to get a different texture, the artist aged the concrete surface with hydrochloric acid, an unconvenctional method that is often ill-advised in construction.

Author

Eduardo Chillida was born on the 10th January 1924 in San Sebastian. In 1943 he went to Madrid to study Architecture, but in 1947 he decided to give up his university studies to go to the Círculo de Bellas Artes [Fine Arts Circle] to take up drawing. The following year, he went off to Paris where he took up sculpture and exhibited a work at the Salon de Mayo. In 1951, after his marriage to Pilar Belzunce the previous year, he set himself up in Hernani where he discovered iron and produced Ilarik, his first work in this material. Three years later he had his first solo exhibition in Madrid at the Galería Clan and started doing public art works when he fitted the doors to the Basilica of Aranzazu. In 1958 he received the International Award for Sculpture at the 29th Venice Biennale, a door for receiving many other awards throughout

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

his life, from the Biennale prize to the Kandinsky prize in 1960, from the Wilhelm Lehmbruck in 1966 to the German Kaissering in 1985, from the Prince of Asturias in 1987 to the Imperial Award of Japan in 1991. His work is present in over 20 museums worldwide and exhibitions have been held in different cities like Berlin, London or New York.The year 2000 saw the official opening of the Chillida-Leku Museum, where most of his work is located today in an ongoing dialogue with nature.

Eduardo Chillida died on 19 August 2002 in San Sebastian before seeing the completion of his great dream, the Tindaya project, a public work right in the heart of the mountains.

Reasons for Selection

The site was selected because it is a scuptural work that is a symbol of the city with a high significance and over 300,000 visitors a year.

In addition, it is situated in a very aggressive climatic enviornment on the edge of the sea. Thus, the sculpture is a clear example of monument decayed by saline mist. Some of the consequences of the environments and the acid treatment, previously described, consists of a carbonation front around 10 mm deep. In addition, the presence of significant chloride penetration (around 20 mm) has been demonstrated. Its presence has promoted a significant corrosion in some parts of the monument.

Figure 3.7. Elogio del Horizonte. (a) General view, (b) sampling on the monument, and (c) Eduardo Chillida.

3.8 ZARZUELA RACECOURSE

Location:	Madrid, Spain
Construction period:	1934-1941
Authors:	Carlos Arniches & Martín Domínguez (architects)
	Eduardo Torroja Miret (engineer)

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

Site Description

The new racecourse in Madrid, that would replace the existing one in "Paseo de la Castellana" to facilitate the street extension, was located in "Monte del Pardo" (a National Park). The proposal was distinguished by taking advantage of the natural beauty of the site and the existing unevenness (in favor of aesthetic effects, visibility, circulations and amenity), and by achieving the unity of the architectural complex (through retaining walls and arcades, which serve as a connection between buildings). In the final solution, the vernacular is not renounced but with a formal refinement.

The winning solution of the 9 submitted proposals was awarded to the design of C. Arniches, M. Domínguez and E. Torroja for their original structural idea for grandstands and roof. The structure is based on transverse reinforced concrete frames spaced every 5 m, joined by curved sheets protruding out the frames of the portal to form the cover of the large betting room. The central frames are rigidly joined to provide stability; the rest is joined to this central mass by a simple tie beam, which allows a free expansion of the whole.The roofs are reinforced concrete sheets with hyperboloid shape of variable thickness, between 65 cm in the pillar area and 6 cm at the edges. Their structural system consists of a 5 m wide V-section module with curved edges, supported on a single central pillar and jutting about 13 m one of its ends balanced on its back part by steel tie beams.

Authors

Carlos Arniches Moltó (1895-1958) and **Martín Domínguez Esteban** (1897-1970) were Spanish architects and intellectuals of the "Generación del 25", forerunners of the Modern Movement. They started working with Secundino Zuazo, in whose studio they contacted as partners and friends until the exile of Martín Domínguez in 1936. In the work of Carlos Arniches, simplicity and adaptation to the needs of the client are combined with the modern interpretation of the vernacular architecture, what he himself called "razonabilismo" (reasonableness). Aligned to other modern contemporaries, such as Pikionis, Kozma or Lino, he laid the foundations of Spanish Expressionism. Martín Domínguez was attracted by the ideas of Le Corbusier, presenting in his works the logical rationalism of Adolf Loos and the main priority for society and environment of Tony Garnier. With a technical, progressive and scientific personality, culture and tradition had an important role to play in modernity but far from academic rules.

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

After his exile, he worked in Cuba and the United States, being professor at Cornell University and member of The American Institute of Architects.

Reasons for selection

In addition to the seven monuments selected for in-situ validation (and to raise awareness of the heritage value of the concrete architecture), an eighth was selected to carry out a pilot action related to socio-economic analysis and long-term societal spill-over effects of the project.

This monument has been selected because it is a key piece of architecture and engineering of the twentieth century, which also represents a leisure and restoration offer of great tradition in Madrid. This allows us to analyze at the same time the public's perception of the monument, its potential to generate "ecosystems" services (provisioning, regulating, cultural and supporting services) and its use for tourism.

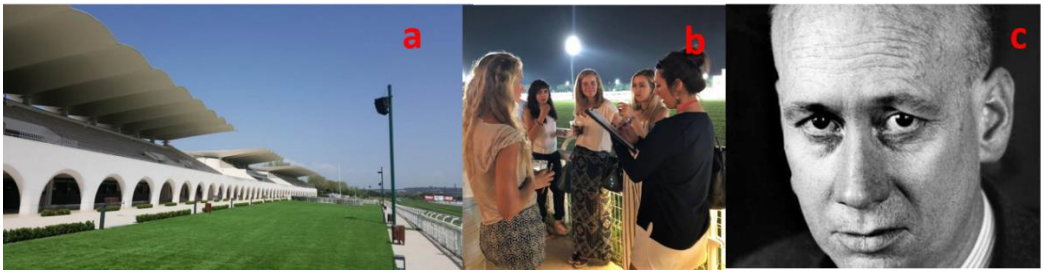

Figure 3.8. Zarzuela Racerhorse. (a) General view, (b) Survey on site by using ecosystem approach, and (c) Eduardo Torroja.

4 References

[1] http://www.icomos-isc20c.org

[2] http://socialistmodernism.com/

[3] http://whc.unesco.org/en/list/1165

[4] http://www.stadioflaminio.org/index.php?lg=en#home

[5] https://culturacientifica.com/2016/08/26/elogio-del-horizonte-chillida-encuentro-ciencia-arte/

[6] https://www.ietcc.csic.es/

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858

[7] http://www.9fortomuziejus.lt/

[8] http://www.docomomoiberico.com/

[9] http://www.cehopu.cedex.es/

[10] http://212.145.146.10/biblioteca/fondos/ingra2014/index.htm#inm.F3.83

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nº 760858