5.10.1. INFRASTRUCTURE

The management of research, development and innovation in infrastructure activity is coordinated by the Dragados departments and by the Hochtief companies.

Following the objectives set by the parent companies, at the end of 2019 the infrastructure companies of the ACS Group had 56 ongoing projects. For the development of this R+D+i activity in 2019, an investment of 22.1 million euro has been made.

NEXPLORE (HOCHTIEF AND ACS)

HOCHTIEF is working with ACS and the Group’s operating companies to actively promote digitization in its core activities through the Nexplore company, which was created in 2018. Nexplore is currently working with innovation centers located in Essen, Frankfurt/Darmstadt, Madrid, Minneapolis, Sydney and Hong Kong, as well as leading universities (collaboration agreements have been signed in 2019 with Massachusetts Institute of Technology (MIT), Polytechnic University of Madrid and Darmstadt Technical University, among others) and computer consulting firms. The aim is to exploit the opportunities that digitization offers for business, such as through artificial intelligence, virtual reality, the Internet of Things and Industry 4.0.

Through the products and processes developed by Nexplore, HOCHTIEF has the goal of increasing efficiency, quality and improving project control, providing immediate benefits to our employees, customers and Group partners.

Example of a project carried out by Nexplore:

IMPROVEMENT OF THE INFORMATION SYSTEM IN CONSTRUCTION PROCESSES

The technologies that communicate with each other independently via the Internet (Internet of Things (IoT)) allow data to be processed automatically. To allow multiple construction-related data to be measured continuously, HOCHTIEF Innovation Management is working with Nexplore and the employees of the Technical Competence Center, HOCHTIEF Engineering, and HOCHTIEF ViCon for sensor integration to improve efficiency in the construction process. Sensor data is transferred to a digital platform and through a system developed by Nexplore, the data from the different sensors is translated and integrated, sending it to a common platform, generating additional information that facilitates decision making, especially in critical situations in construction processes.

The Internet of Things applications not only provide project managers with a very helpful information base during construction processes, but can be used for predictive maintenance with the help of artificial intelligence systems in the later stages.
The MADAME R+D project: Development and validation of Highly Durable Materials for Application in Maritime Structures and Barriers (Materiales de Alta Durabilidad para su Aplicación en estructuras Marítimas y Espaldones) vulnerable to climate change was approved in the 2017 CHALLENGES-COLLABORATION (RETOS-COLABORACIÓN 2017) tender within the scientific-technical priority I: Climate change, line (vii) adaptation to climate change in critical infrastructures. This initiative was co-financed by the Ministry of Science and Innovation within the National Plan for Scientific Research, Development and Technological Innovation. The project, which will be completed in 2021, is coordinated by DRAGADOS, with the participation of DRACE INFRASTRUCTURE, Galaicontrol, CTC Technological Center and the Fundación Agustín de Betancourt (Ports and Coasts Laboratory, Polytechnic University of Madrid).

The overall objective of the project is the development of a new concept of barriers for vertical seawalls that combines the use of new construction materials, optimal structural design and construction processes for obtaining elements of high structural integrity and durability against environmental agents. Likewise, the development of a robust instrumentation system for monitoring the structural and functional performance of barriers throughout their useful life is also considered. Both developments will increase the resilience of port infrastructures against the effects of climate change.

The use of alternative materials to adapt the barriers to structural and environmental conditions of both in-service barriers and new barriers is being analyzed. To this end, the project includes the design of a new barrier that allows the use of these new materials. These new designs should serve to improve the performance and especially the long-term durability of the barriers. In addition, construction processes are introduced as one more variable to be taken into account in risk analysis, which will allow the selection of optimal solutions from a global point of view.

As a novelty, the project uses the Marine Corrosion Test Site El Bocal, which belongs to the CTC Technological Center located in Santander, as a new study methodology for the analysis of the durability of concrete structures subjected to demanding conditions of waves, tide, currents and wind. This facility allows installation and recording over a period of several months of the degradation processes of concrete cores subjected to the real marine environments affecting port structures. The results obtained will be applicable in the calibration of numerical degradation models. Likewise, they can be compared with the results of accelerated physical trials.

A total of 24 examples have been manufactured, 20 of which have been installed at the MCTS El Bocal at different heights: submerged and in tidal, splash and marine air areas. The other four have been placed in the facilities of the Spanish Institute of Oceanography, near the test site, to analyze performance in structures near the coastline, but without being subjected directly to the action of the sea.

The samples will be removed after an 18-month exposure and analyzed in a laboratory to determine their performance. This information will optimize the concrete design to adapt it to the required durability as well as to the new design of the barrier planned for the project.
Building Information Modeling (BIM) is the digital tool of the future for project execution. The design and construction of projects using BIM is what customers in many countries currently demand. The methodology is based on actively connecting all the people involved in a project using 3D computer models that can be detailed with additional information, such as deadlines, costs and use.

Based on this model, project participants can also calculate carbon footprint and potential savings.

HOCHTIEF recognized this potential from the outset and founded HOCHTIEF ViCon GmbH, which specializes in these methods. The goal is for HOCHTIEF ViCon to be the overall BIM expert at HOCHTIEF, offering courses in this area for both own employees and a course provider for other companies, as well as a consultant and advisor specializing in BIM for projects undertaken by public administration or private companies. Additionally, BIM is already used in many of HOCHTIEF’s companies.

Thus, in 2019, the total number of projects carried out using BIM increased to 2,560 projects (compared to 2,300 in 2018) and the number of employees trained in this area is 3,375 (1,179 in 2018), to meet the needs of customers, offer sustainable products and services and thus improve their market position.

### NUMBER OF EMPLOYEES PROVIDED WITH BIM OR SIMILAR TRAINING IN 2019

<table>
<thead>
<tr>
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<th>TOTAL HOCHTIEF</th>
<th>HOCHTIEF AMERICAS</th>
<th>HOCHTIEF ASIA PACIFIC</th>
<th>HOCHTIEF EUROPE</th>
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<tbody>
<tr>
<td>EMPLOYEES</td>
<td>3,375</td>
<td>450</td>
<td>2,165</td>
<td>760</td>
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Free translation from the original in Spanish. In the event of discrepancy, the Spanish-language version prevails.
E-TESTING PROJECT (GEOCISA)

Since November 10, 2017, GEOCISA has worked, with the collaboration of the International Center for Numerical Methods for Engineering (CIMNE) of the Polytechnic University of Catalonia (UPC) on the E-TESTING project, which is a numerical-experimental tool for determining the integrity status of structures, especially aimed at railway bridges.

The methodology that the tool follows for establishing the structural health study consists of:

- Detailed study of the structure. It includes the collection of the existing information, that is, all types of plans, measures and primary inspection in the field to verify their conservation status and adjust the plans to reality. Preparation of a preliminary model of the structure.

- Adjusting the Model. The preliminary model is refined with real information, from on-site trials, in which the structure is implemented comprehensively to acquire the maximum information from it. These consist, among others, of a static and dynamic load test.

The static part consists of placing known overloads (locomotives, gang cars, etc.) for a certain time to verify their elastic performance and to compare the actual deformation produced, with the theoretical one from the model.

The dynamic part consists of passing several times over the structure at different speeds to achieve parameters such as frequencies of the main modes of vibration, impact coefficient or dynamic amplification and damping.

The adjustment of the model continues at a later stage, and is fed by the permanent instrumentation of the structure. What is ultimately intended is to find out the actual response of the structure to the environmental and operational effects (temperature, humidity, wind speed, loads, etc.). In this way, any abnormalities detected, where an abnormality is understood to be any event that cannot be correlated with the effects mentioned above, would be a candidate to be regarded as a deterioration.

- The sensors that are permanently available in the structures are essentially accelerometers and temperature and humidity sensors. These sensors are wireless and self-sufficient in terms of power, as they have solar panels. The signal from all of them is received by a router with Internet access, which is also powered by a solar panel. The router sends the data to the cabinet for treatment and analysis. This system is fully scalable for better adaptability.

Test structures are currently being monitored. The result of the project will provide both monitoring of information and the software tools required to assess structural health and to track it over the long term, both routinely and at specific times after the occurrence of unique events.