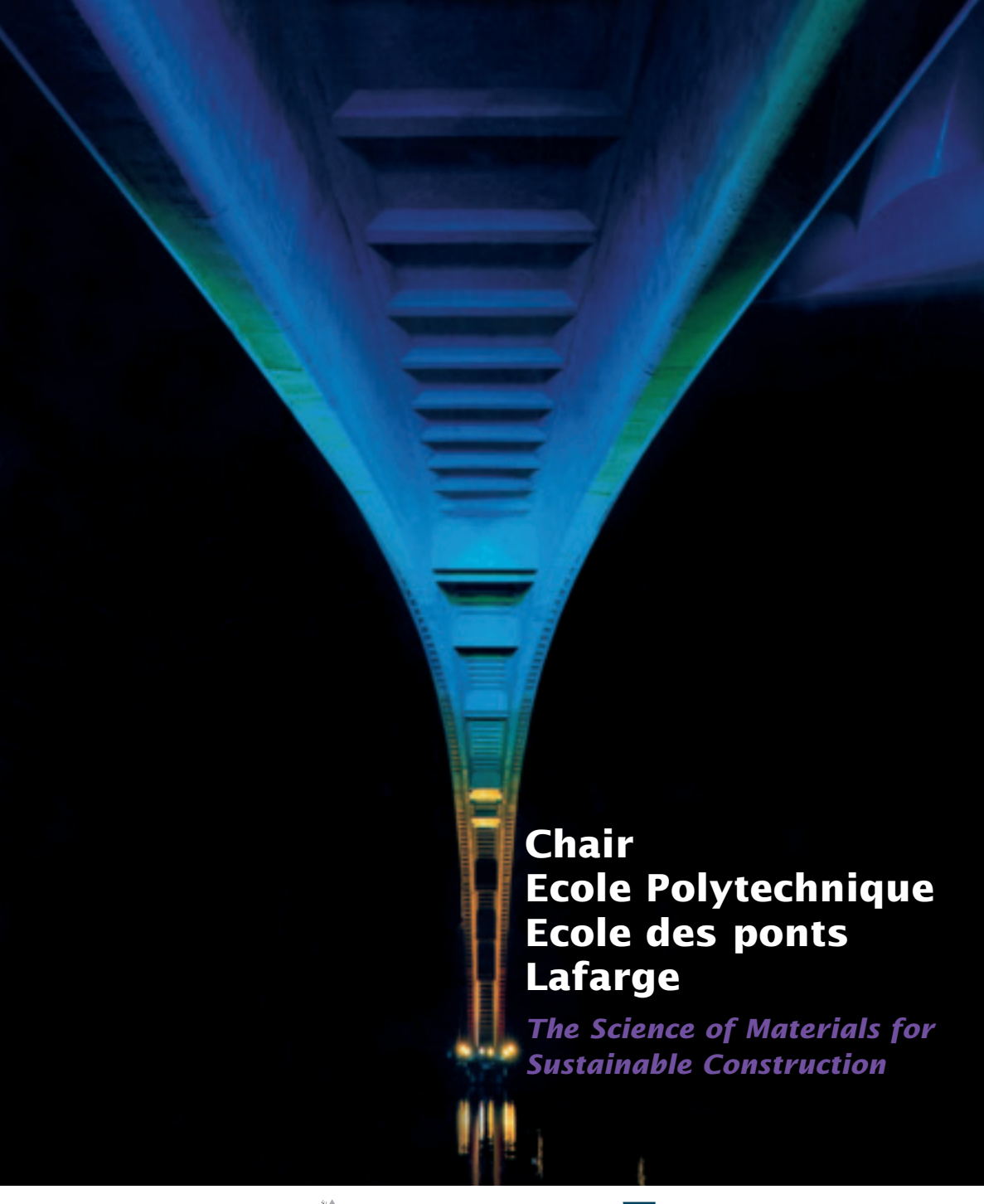


Chair
Ecole Polytechnique
Ecole des ponts
Lafarge

The Science of Materials for Sustainable Construction

ÉCOLE NATIONALE DES PONTS ET CHAUSSÉES

LAFARGE

ÉCOLE POLYTECHNIQUE

The science of building materials opens the way to a large number of new architectural and construction possibilities.

Bertrand Collomb, Chairman of Lafarge

Bringing together the best scientific and industrial talents, in favour of the citizens.

Yannick d'Escatha, Chairman of Ecole Polytechnique

Materials science and construction for the benefit of society.

François Roussely, Chairman of Ecole des ponts

> Mère-Enfant hospital in Nantes, France, made with self placing concrete Agilia®
> Architect : Rémi Butler

Cover page :
> Seonyu footbridge in South Korea
> Made using Ductal® ultra-high performance concrete, the footbridge is 120 meters long with a roadway just 3 centimeters thick
> Architect: Rudy Ricciotti

A WAY TO EXCELLENCE

unmatched in the world, serving a new dynamic

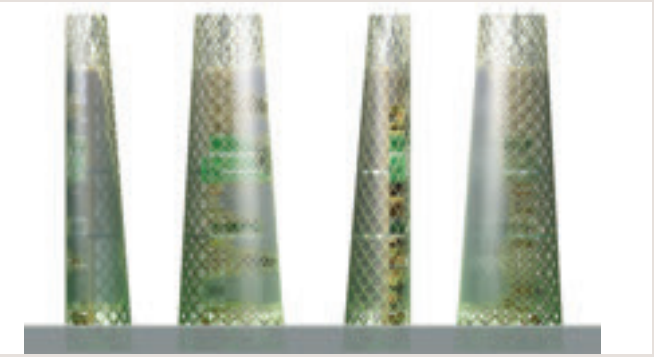
Ecole des ponts and Ecole Polytechnique, in close affiliation with Lafarge, are combining efforts to create an education program that will be unique in the world. As part of an interdisciplinary approach, this will allow for material sciences to be used at the highest level and in a new way in order to achieve sustainable construction.

The Education and Research Chair provides an original combination of the most advanced skills in the areas of physics, mechanics and chemistry, to offer international outstanding training and research in construction materials, to reach sustainable develoment.

The team of professors is supported by the wellknown expertise of the mechanical engineering and physics departments of Ecole Polytechnique, the leading expertise developed by Ecole des ponts in thermodynamics and thermo mechanics in complex continuous environments, and the unique expertise of the Lafarge Research Center. Special contacts will be developed with the greatest international universities working in the sciences and engineering of building materials.

BACKGROUND

The past two years have seen revolutions in numerous aspects of building materials. One of the most remarkable breakthroughs is the emergence of ultra-high performance concrete with properties comparable to steel, a veritable opportunity that opens the way to a large number of new architectural and construction possibilities.



This was made possible by the steady development of a scientific approach that is increasingly demanding and interdisciplinary, merging physicochemistry, mechanical engineering, and advanced tools for observation and digital simulation.

> Hypergreen, a very tall building project for a sustainable world
> Wind bracing grid skin made with ultra high performance concrete Ductal®, that ensures the horizontal stability of the 246-meter high building thus freeing up its central core
> Jacques Ferrier Architects in partnership with Lafarge

At the same time, modern society is confronted with the limits of economic development and unchecked urbanization, indeed the limits of the planet, and must face up to a new set of responsibilities. Consequently, society must explore the new profiles of sustainable development, that is to say, it must meet the needs of present generations without compromising the ability of future generations to meet their own needs. There are a number of new challenges: thermal and acoustic insulation, multifunctional constructions, positive energy buildings, controlled ageing of works and recycling of materials and structures.

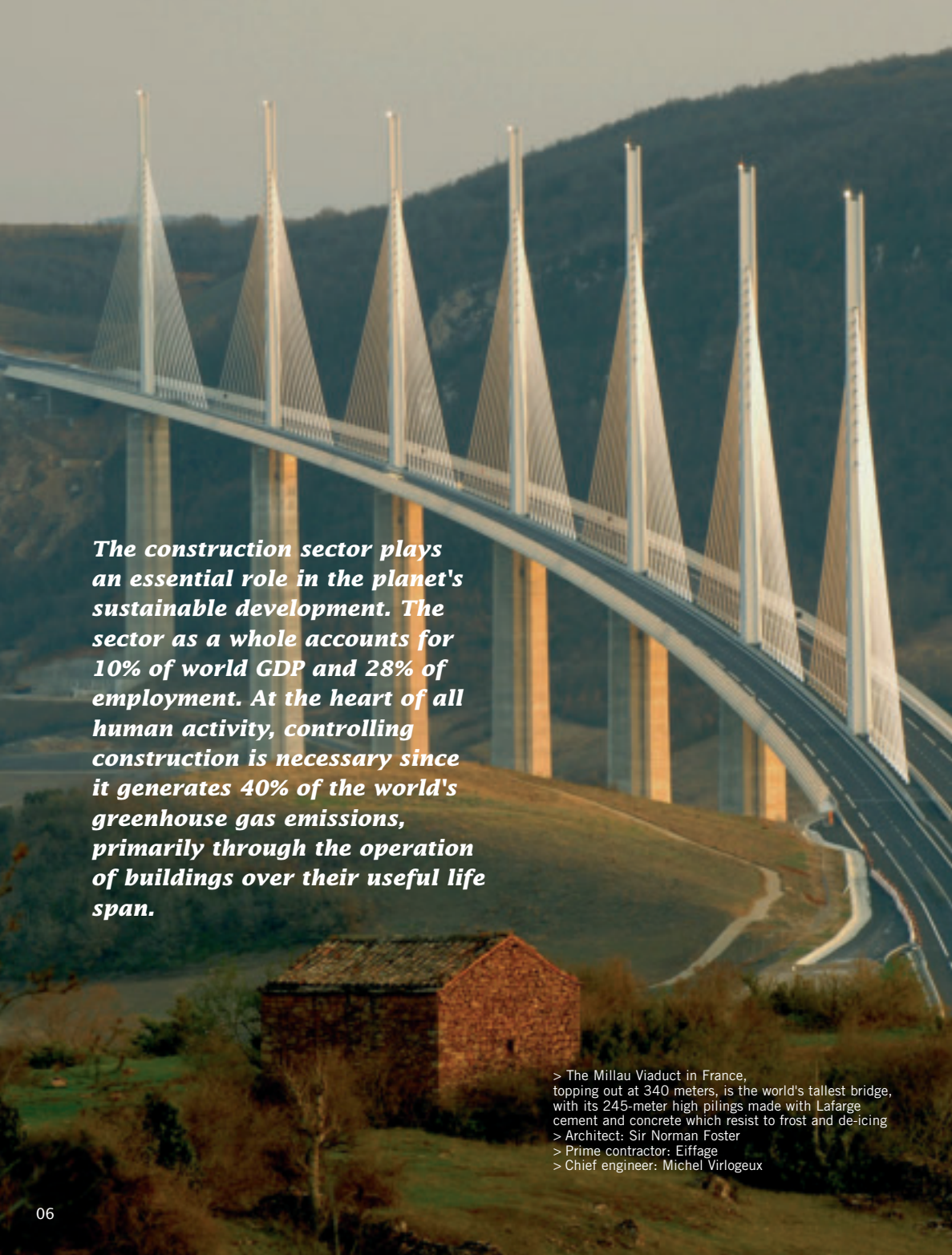
Faced with these opportunities, and with so much at stake, we see only one solution: to link the potential of scientific ideas with the pertinence of complex issues arising from industrial experience.

The building materials industry is a key player in development: concrete is the most heavily consumed product worldwide after water. It can be found in all infrastructure projects, which are essential for the economic and social development of local communities. Through its use in projects such as homes, roads, schools, hospitals, and water supply infrastructure, it serves mankind's legitimate need for housing, healthcare, education and mobility.

World leader in building materials, Lafarge has been committed to a deliberate strategy of sustainable development for many years. Initially, its actions focused mainly on the impact of its industrial activities. Yet aware of its responsibilities and the enormous challenges facing the construction industry for the future of the planet, Lafarge now takes into account the impact of its products over the course of their life cycle, from their initial manufacture to their end-of-life recycling. The Group is seeking to promote construction techniques that respect man and his environment, as much by advocating construction sites that are better integrated, more efficient, faster and safer, as in choosing materials and systems that can reduce the overall ecological footprint of buildings and facilitate their rehabilitation.

At the heart of this sustainable development strategy, and created in partnership with two of the most prestigious engineering schools in these disciplines, the Teaching and Research Chair will endeavor to propose solutions for society's legitimate expectations, without compromising the environmental equilibrium of the planet.

In addition to concrete-based materials, the Chair aims to develop the scientific foundations necessary for an approach to materials that are complex, multi-scaled and non-crystalline, and for the optimization of their application, their functional properties and durability.



The construction sector plays an essential role in the planet's sustainable development. The sector as a whole accounts for 10% of world GDP and 28% of employment. At the heart of all human activity, controlling construction is necessary since it generates 40% of the world's greenhouse gas emissions, primarily through the operation of buildings over their useful life span.

> The Millau Viaduct in France,
topping out at 340 meters, is the world's tallest bridge, with its 245-meter high pilings made with Lafarge cement and concrete which resist to frost and de-icing
> Architect: Sir Norman Foster
> Prime contractor: Eiffage
> Chief engineer: Michel Virlogeux

INTERDISCIPLINARY APPROACH

The Chair's goal

To become a world center of excellence in the science of building materials for sustainable development.

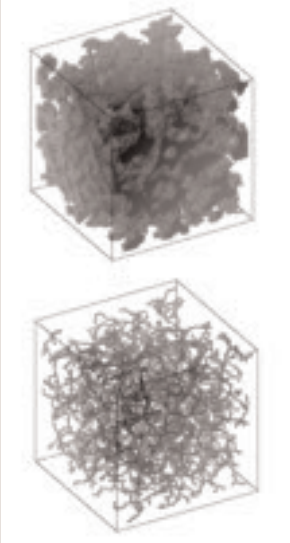
To develop a training at master's level, as part of the Ecole Polytechnique and the Ecole des ponts's training program.

To develop and federate an interdisciplinary approach, based on the preparation of thesis within the CIFRE agreements or the obtention of scholarships to prepare PhD. Financial helps for accomodation are available for students.

Recruitment level > Engineering school or Bachelor degree
Launch > September 2006

Chair academic directors

~ Patrick Le Tallec, Ecole Polytechnique (1)
~ Olivier Coussy, Ecole des ponts (2)
~ Paul Acker, Lafarge (3)



> 3D reconstruction of the topological skeleton (bottom) characterizing a granular porous mineral (top).
P. Levitz, Ecole Polytechnique

(1)
~ Professor of the Universities
~ Ph.D., Doctor of Sciences
~ Former engineer of Ecole des ponts
~ Professor of Ecole Polytechnique
~ Vice-President of the mechanical engineering department of Ecole Polytechnique
(2)
~ Director of research in the Ministry of infrastructure
~ Director of the Navier Institute
~ Ph.D., Doctor of Physical Sciences
~ Civil engineer of Ponts et Chaussées
(3)
~ Director of the "Structured materials" Pole in LCR (Lafarge - Central Research Laboratory)
~ Doctor of Ecole des ponts, hdr
~ Former Director of research in the central laboratory of les ponts in precast concrete
~ Bachelor of Ecole Centrale

INNOVATIVE SCIENTIFIC AND ENGINEERING TRAINING

TO ADDRESS THE MAJOR TECHNICAL AND SOCIAL CHALLENGES OF SUSTAINABLE CONSTRUCTION

> Lafarge - Central Research Laboratory (LCR) in l'Isle d'Abeau, France

The Chair offers students a high-level education, one that proposes the latest scientific knowledge, the acquisition of technical know-how, a mastery of methodologies and industrial tools, as well an understanding not only of the challenges of sustainable construction, but also the economic constraints of the business world.

Training is organized as six modules that represent the fundamental scientific disciplines.

Students will study industrial applications based on industrial and social issues that have generated major scientific advances in recent years.

Classes will be taught primarily by the professors of Ecole des ponts and Ecole Polytechnique, but also by the engineers and researchers of the Lafarge Group and by guest professors and researchers from international universities. The six modules are described below.

The specific classes of the Chair are

~ *Economics, sustainable development and management of the CO_2 emissions market*

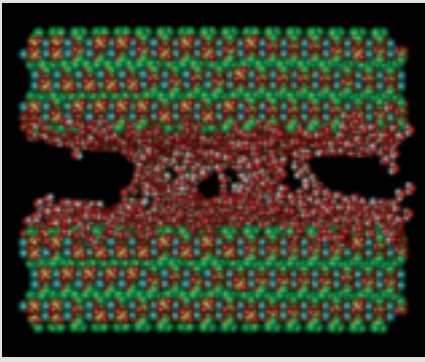
Presentation of the economic, environmental and social stakes associated with the manufacture and application of building materials. Analysis of the life cycle of concrete. Market for CO_2 emissions trading.

~ *Physicomechanical characteristics of porous environments*

Building materials are porous matter subject to various physical phenomena: hydric transport, sorption, crystallization, internal reactions, thermo-hydro-mechanical coupling. This module aims to understand these different phenomena in a unique environment, and to experiment them in the laboratory.

~ *Physicochemistry of building materials*

Physicochemical mechanisms that are triggered during hydration of hydraulic binders, and their interaction with the environment. Study of key drivers to modify these mechanisms.



> Microstructure of gypsum
P. Jouana, University of Montpellier

~ *Rheophysics and soft matter*

Study of the rheophysical behavior of viscous pastes and mixtures. Applications to the formulation of materials in order to facilitate their use under all conditions, reducing their environmental impact, and improving the quality and aesthetics of the final structure.

~ *Digital simulation and methods for changing scale*

Presentation of different approaches and digital methods to better understand the multi-scaled nature of building materials, from the smallest nanometer to the full size of the structure..

~ *Disordinate structures and physical tools*

Presentation of the most recent results in the observation and physical characterization of the microstructure of materials.

RESEARCH

Research will be organized in projects lasting several years (master internship in research labs, thesis, contracts) that address major issues with strong industrial applications and substantial scientific content.

> Rion-Antirion Bridge, linking Peloponnesus with mainland Greece
> Wind stability and earthquake resistance of the structure
> Architect : Gefyra

Example of research themes include

~ ***Environmental behavior of plaster***

The challenge is to guarantee the durability of plasterboard's mechanical performance in environments with variable humidity.

~ ***Deferred behavior of concrete***

The challenge is to predict the long-term behavior of major structures (bridges, nuclear power plants, etc…)

~ ***Reaction of concrete to freezing***

The challenge is to develop types of concrete that are more resistant to freezing damage, especially in countries like Canada and the United States.

~ ***Analysis of CO_2 emissions generated during the life cycle of concrete***

The challenge is to develop a life cycle that limits the CO_2 balance of concrete.

…

In the context of a partnership with Lafarge, I study the mechanical properties of cement at the nanometric level (10^{-9}), which is to say, the infinitely small. It is a particularly interesting scientific approach, because it reveals previously unknown, yet universal, properties. Like the human genome project, and the gene therapy that has developed from its decoding, this research will make it possible to design extremely high performance materials and to prolong their useful life. Concretely, I test materials in partnership with researchers from Lafarge. In my view, Lafarge is the only construction group that has mastered a nanometric approach to materials.

Franz-Josef Ulm, Associate Professor of civil and environmental engineering, Massachusetts Institute of Technology (MIT), United States

INTERNATIONAL SCOPE

The Chair works in close collaboration with international experts in sciences and building materials engineering.

~ ***Conferences with international professors, including >***

Pr. R. James Kirkpatrick, University of Illinois, Urbana-Champaign

Pr. Paulo Monteiro, Berkeley

Pr. Leo Pel, Delft

Pr. George Scherer, Princeton

Pr. Franz-Josef Ulm, MIT

~ ***International student exchange programs***

~ ***Organization of international internships***

~ ***Organization of conferences and seminars***

~ ***An active policy of publishing in international reviews***

PRESENTATION

Ecole Polytechnique

Ecole Polytechnique is the most prestigious and one of the oldest engineering University in France. Its mission is to educate men and women with a strong scientific background, who will take key positions in the government, the military, research and the private sector in France and other countries.

Each year, Ecole Polytechnique trains nearly 2,000 students through its engineering curriculum. Instruction is based on very high-level multidisciplinary scientific education with a strong focus on applied knowledge in the corporate world.

> Cinema SF in Bangkok, Thailand
> Use of plaster-boards with high acoustic isolation properties
> Architect: Wichai Khaemajitpishit "760i architects"

The school is also host to 400 doctoral candidates who conduct their work in its 21 research laboratories.

Lastly, Ecole Polytechnique has tapped its educational and research potential and its partnerships with academic institutions and industry to create 19 multi-disciplinary master's programs for research or professional development purpose. Through these programs, Ecole Polytechnique has expanded its international academic reach and developed its relationships with the professional world.

Ecole des ponts

Created in 1747 and traditionally known for its engineering curriculum, Ecole des ponts has become an international educational and research institution attended each year by nearly 1,300 French and foreign students and 7,000 interns enrolled in continuing education programs.
The school's mission is to promote and disseminate knowledge to benefit

the nation, Europe and the world in several ways >

~ it offers master's and doctoral programs to engineers and specialists with high-level scientific, technical and managerial skills, imparting the knowledge they need to hold high responsibility positions in a variety of sectors, including civil engineering, urban planning, construction, transportation, the environment, industry and services;

~ it conducts research leading to new discoveries while contributing to innovation;

~ it makes this new knowledge available to companies and to the government;

~ it promotes critical thinking, scientific and technical creativity, professionalism and good citizenship.

Lafarge

Created in 1833, Lafarge is the world leader in building materials and holds leading positions in each of its business lines. It is No. 1 worldwide in Cement and Roofing, No. 2 in Aggregates and Concrete and No. 3 in Plaster. With 77,000 employees in 75 countries, the Group is present around the globe. Its operations generated sales of EUR14.4 billion in 2004.

Lafarge is active in business lines that rely heavily on the engineering professions and the Group employs 4,000 engineers. Research and innovation are of major importance for the Group, as they are a source of growth and enhanced competitiveness in an industry such as ours.

Over the past ten years, Lafarge has rolled out key innovations, particularly in concrete (Agilia®, Ductal®). It has also developed major process innovations with solutions designed to reduce energy consumption and pollution.

The Lafarge research center in Isle d'Abeau is staffed by over 500 researchers of different nationalities and works in partnership with the world's largest universities and engineering schools.

Lafarge

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> Palais de Justice, Pontoise, France, Façade made with self-placing concrete Agilia®
> Architect : Henri Edouard Ciriani
> Prime contractor: GTM Bâtiment, Carillon BTP

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