Introduction

In the field of construction and particularly in civil engineering, organic materials are essentially perceived as *bonding additives*. Whether we are talking about bitumens for road surfacing, polymers for formulating products for repair and structural gluing or admixtures for a more compact concrete, all these products are intended for realizations where we want to ensure the cohesion of granular groups.

This is in fact the primary role assigned to this class of materials, but we must not forget that there are other fields where *plastic materials* have been developed successfully, particularly sealing, environmental protection and engineering geology in general. Here, we enter into the field of manufactured products where the term "organic material" takes on its fullest meaning. We may also note in passing that industrial wood, the discovery of which is of course not recent, but whose industrial development is changing rapidly, falls under this second category.

The presentation of organic materials used in civil engineering therefore compels us to study these two aspects in depth. As such, we will deal with these in the first few chapters, but we will not place our main focus on them, as our study is based on a physico-chemical approach, as suggested by the subtitle of this book. This point calls for a few explanations.

In a construction project, the designer expects from the materials that he intends to use a set of properties, in particular:

– mechanical properties, such as a certain compressive strength for the realization of a load-bearing unit, bending strength and therefore tensile strength for a structure that must present a certain flexibility, resistance to impact or other types of aggressions;

– physical properties, if necessary, with respect to water or gas-tightness; sound insulation, for instance;

– aesthetic or more generally sensorial properties, in order to better meet the aspirations of the project owner and future owners;

– practical properties, as regards their handling or their use in general.

All this is part of the art of the engineer and the architect, but also implies requirements in terms of the minimal durability of all the above properties as well as in terms of the waste management at the end-of-life of the materials used.

These two aspects deserve particular attention insofar as they are today as important as the requirements in terms of mechanical strength. Man in the 21st century must know that he is not building for eternity and that his project must take into account the service life that he requires from the builder. It follows logically that he is compelled to comply with, willy-nilly, health and environmental requirements imposed on him to preserve the living environment of the community.

The durability of a material structure brings into play the nature of the materials that constitute it, the manner in which they are arranged with respect to each other, the manner in which they are assembled, and their potential evolution within the structure, without forgetting the conditions under which they are placed. We thus enter the physico-chemical field: the evolution of a material under static or dynamic stress depends on its structure and its composition. The knowledge of these data and the laws that govern them is fundamental for anyone interested in the durability of structures and buildings. In some cases, this can even be a decisive criterion in the choice of materials.

We must therefore never neglect the physico-chemical aspect in all the operations that involve materials. Even in cases where it might not seem useful to us, it is a precaution that can prove invaluable in responding efficiently in the event of an unfortunate development.

Conversely, it would be stupid to think that the chemical analysis of a material, however meticulous, can suffice to inform the user of its capacity to meet a given need. We must remember that a material is never perfectly homogeneous. A specimen is representative only from a sample that is macroscopically homogenous and correctly fractioned or that is limited to a given geometric area. The role often reserved for analysis (in its widest sense, i.e., without forgetting the physical state, texture, etc.) is therefore relative: when two samples are subjected to similar physico-chemical analyses, we can affirm that the materials that represent them have a good chance of having the same behavior in service. This evidently calls into question the representativeness of the sampling, as we have just explained, but also the degree of sophistication of the analysis itself. Besides, this very simple reasoning is used in the certification procedures of some products.

Lastly, we must mention that all organic materials are not polymers. We will see that bitumens are not polymers and that wood is a complex system in which polymers play a role, but is not a polymer in itself. However, the basic knowledge that will be presented about pure polymers will be useful to better understand these two complex materials.

The book is therefore structured as below:

– Chapter 1, *Organic Polymers*, is devoted to a general presentation of these physico-chemical entities, from the macromolecular structure of the pure material to the properties of formulated or manufactured products and their durability; the concepts developed here will help us understand all organic materials which are strictly speaking always mixtures.

– Chapters 2 and 3, *Organic Binders*, are devoted to the "bonding additive" aspect of organic materials mentioned above. They contain three developments on *bitumens and road construction* (Chapter 2), products for repairing and protecting concrete and paints (anti-corrosion, on concrete and for road marking) – *materials for the maintenance of heritage and safety* (Chapter 3).

– Chapter 4, *Manufactured Products,* deals primarily with sealing products and systems, the concept of material becoming less clear-cut when there are several elements to perform the required function, then with geosynthetics in general, with geotextiles and geomembranes, with materials and systems for the realization of light fills, tank structures, with devices for supporting works of art, with warning devices for buried networks, etc.

In these three chapters, which illustrate the development of organic materials in the field of civil engineering, we will encounter unresolved issues and new notions that require a particular study. Besides, any physico-chemical approach is accompanied by methods for characterizing the matter that is the object of our study. The chemist would like to know on what he is working to be able to reason efficiently, which justifies the organization of the following two chapters.

– Chapter 5, *Gluing and Composite Materials: Concrete Admixtures*, seeks to study in depth two aspects of the role of bonding additives of organic materials. First, we will discuss gluing already mentioned regarding organic binders and particularly the adhesiveness of bitumens. This will lead us logically to a quick overview of organic-matrix composite materials, which have appeared relatively recently in civil engineering. Second, we will present concrete admixtures and related products that can be considered as third degree materials insofar as they do not intervene directly as first degree materials – manufactured products – or second degree materials – binders – but are indispensable to realizing high performance products and structures and are the prototypes for the materials of tomorrow.

– Chapter 6, *Physico-Chemical Characterization of Organic Materials Used in Construction*, is a summary of the methods most commonly used in civil engineering laboratories to characterize these materials.

– Chapter 7 concludes the book by enlarging the reader's field of vision, primarily by coming out of the physico-chemical approach that has been our vantage point so far, thanks to the contribution of external personalities – engineers, researchers, architects, physicians – who have given us their *prospective reflections* on the theme of *organic materials, civil engineering and sustainable development.*

The first question dealt with is economic in nature: what is the importance of organic materials in civil engineering when compared to other classes of materials?

Michel de Longcamp, building and public works delegate of the *Société ATOFINA* and President of the Commission of the *Bâtiment du syndicat des producteurs de matières plastiques* (SPMP), gives us precise insights to elucidate the discussion.

We have seen that bitumen, an organic material in its own right, is not part of polymers.

Bernard Lombardi, director of the *Groupement professionnel des bitumes* (GPB), completes the above point in the field of road construction and opens new avenues for reflection on the evolution of this atypical material.

Separating the field of civil engineering from building could seem artificial to the reader familiar with the complementary nature these fields of activity.

Robert Copé, Assistant Director of Research and Development at the *Centre scientifique et technique du bâtiment* (CSTB), seeks not to deal with the vast subject of the place of organic materials in building, but to highlight the main trends in this field, particularly those where significant progress has been made or should be made to meet the expectations of clients.

After these technico-economic perspectives, it seemed important to us to make a leap forward into the future with the viewpoint of a scientific researcher. For this, we have had two contributions, one on method and the other on the design of new materials.

Regarding method, **Michel Frémond,** European Coordinator of the Laboratoire Lagrange and **Olivier Maisonneuve,** Director of the Mechanics and Civil Engineering Laboratory of the University of Montpellier, affirm the importance of the physico-chemical approach for a mechanical engineer in the study of damage phenomena.

Henri Van Damme, Director of the Structural and Macromolecular Physico-chemistry Laboratory at the *Ecole supérieure de physique et chimie industrielles* of Paris (ESPCI), gives a glimpse into the birth of new structures at the nanoscopic level thanks to the use of organic molecules in cement matrices. Mineral-organic complementarity paves a new way here and prefigures a line of materials of the future.

But the act of building will not be really complete if we do not consider the link between technique and society's viewpoint on the realized construction, from its gestation to its delivery. For this, three players are indispensable: the architect of course, but also the environmentalist and the physician.

Michel Paulin, Professor at the *Ecole nationale supérieure d'architecture de Lyon* (ENSAL) and at the *Grands Ateliers de l'Isle d'Abeau*, brings to us the architect's perspective and illustrates the omnipresence, often ignored by the public, of organic materials in our everyday environment. He insists on the need to enhance their image in the collective unconscious through an in-depth action that is a challenge for both producers and clients.

Among the obstacles identified above, we can note that organic materials are still a source of concern for the defenders of the environment and health. In an effort to sort the real problems from those that are born out of fantasies, we have asked two specialists to give us their insights.

Yves Perrodin, Director of the Environmental Science Laboratory of the *Ecole nationale des travaux publics de l'état* (ENTPE), observing that the evaluation of the environmental impact of organic materials used in the field of construction is still in its initial stages, proposes a methodology applicable to these materials, based on his experience gained with the other types of materials.

Guy Auburtin, epidemiologist, Director of the *Institut d'hygiène industrielle et de l'environnement* (Cnam – IHIE – Ouest), insists particularly on the necessity for all players to develop studies on the risks specific to these materials, for the health of workers involved in construction as well as that of residents and users.

These last two contributions open the horizon for new research. Henceforth, the study of materials will no longer be the business of the technicians of physics and chemistry, but must also take into account the contributions of biologists and physicians. Consequently, these specialists must also play a role in the general approach. This is a long-term effort.