Emmanuel Tzakakis

Construction in the New Era

School of Architecture
Aristotle University of Thessaloniki
Greece

Introduction

The means and the methodologies of construction are changing systematically. Due in large part to the results of applied research that continuously advance the technology available, these changes are also the product of the new possibilities opened up by information technology and the tools it provides.

Together with these changes come changes in the means and methodologies of engineering studies. The computer has evolved from a means of presentation to a means of project design and of support for project production, and has at the same time become a tool for architectural research.

The teaching of construction has to adapt to this evolution, if not anticipate it. The minimum that is required of construction teaching is that it follow the changes and adapt to them. A more attentive examination of the matter, however, taking into account the fact of the inevitable time lag between graduation and professional employment, points to the necessity of anticipating developments.

In order to test this position we will be describing the following points.

- The classical structure of the construction curriculum.
- The basic factors that lead to changes in the subject matter and the components of construction teaching that change.
- Our proposals for a new structure.
- The basic effects of these changes on the teaching of construction.

Construction as it is classically taught

Given that the teaching of construction traditionally follows the order of order of building construction, its content is naturally adapted to that pattern. Thus we have the familiar series of component units within the overall subject of construction, as listed below.

- Introduction (standards, directives, regulations, standardisation)
- Foundations (soil, excavation, foundations, waterproofing)
- Skeleton (concrete, steel, masonry, wood)
- Floors, balconies
- Stairs (design, geometry, construction, ramps)
- Masonry (heavy, light, cladding, painting)
- Floors (sub-floor, surface, false floors, floating floors)
- False ceilings (suspension, finishing, systems)
- Joints (kinds, construction)
- Roofs (sloping, flat, chimneys)
- Openings (doors, windows, façades)

Although changes, both cumulative and of weight, are beginning to be apparent in the contemporary literature, most textbooks remain heavily influenced by the classical approach to the subject. What are particularly interesting are certain differences of approach that attempt to follow what is happening in contemporary architecture more closely, proving that the classical way of teaching construction is not enough.

The basic factors driving these changes

The constant increase in the requirements for building protection
The components of building physics (heat, damp, fire, sound, light, energy, climate) were assembled into an autonomous branch with a considerable entity in, primarily, the 1970s, after the first energy crisis. What had up to then been a largely empirical approach to the elements of building physics in the teaching of construction, as in matters of damp-proofing and sun protection, was replaced by a contemporary scientific approach that was initially (and to a considerable degree still is) handled as ex post facto measures of protection.

However, the growing importance of environmental planning, for society and for the economy, in conjunction with the increasing integration of elements of building physics into building design (forms of buildings, spatial layouts, construction materials), led to the incorporation of building physics into construction (and into other aspects of design). This incorporation was not cumulative but substantive, and so definitively altered the classical way of building.

The incorporation of these aspects of construction into construction teaching is obvious in the content of the most recent books on the subject. At the same time, and this is something that is becoming more obvious every day we are also seeing the shell as a more complex entity in the building. The shell is acquiring a particularly important role, since it must meet many critical but conflicting requirements of the building. The conjunction of digital technologies for handling the functions of the shell and the continually increasing importance of energy as a component element make designing the shell even more complex, from the initial conception to the final resolution.

The constantly growing number of products used in building construction
The significant reduction in the amount of work done on the construction site and the corresponding increase in the use of industrially prepared building materials are a well-established reality. The construction site on which basic materials were processed and turned into a building has become a construction site on which a building is put together from ready-made elements.

Although some on-site jobs still preserve the old image of the construction site, with the exception of the skeleton almost all the remaining elements are now ready-made building components: that is, they are factory-made rather than being produced on the site. Even the skeleton (in Greece almost exclusively of reinforced concrete) is factory-prepared (ready-mixed concrete and iron bars) and transported to the site for assembly. With the increased use of metal skeletons (almost all industrial buildings), the construction site is losing the last vestiges of its traditional appearance.

Quality control in engineering projects and the standardisation of quality
Today, every single element that goes into the making of a building is described in a standard. The description of each component element, and the concomitant description of the means of testing to determine conformity with the standard, constitute the basis for the quality control of building construction and the creation of a framework for fair competition in the field.

EC Directive 89/106, which is a synthesis of hundreds of technical texts, promotes the creation of the conditions that will permit any interested party to learn the specifications of all construction materials products. Apart from the basic principle of establishing rules for fair competition in all dealings, the Directive fixes certain basic requirements with regard to mechanical strength and stability, fire protection, sanitation, health and the environment, safety during use, noise protection, energy saving and conservation of heat.

For its implementation the Directive provides for the operation of declared inspection bodies, the procedure for the obtainment of the CE symbol, certification of conformity and assurance fees. These changes mark a new drastic shift of content that creates new issues that require an important position in the new construction curriculum.

New materials, new forms

Since the days when the subject of construction materials existed as a separate field, independent of the teaching of construction, the introduction of new building materials has always caused a change in the content of construction teaching. The huge quantity of new materials as such, especially in the cladding and insulation sector, and the enormous changes brought about by certain materials that have developed into building systems (dry construction and construction glass among others) make it impossible to incorporate them, and the concomitant increase in course material, into the programme. In addition, in current practice engineers are more and more frequently working with chemists, biologists and physicists to explore the possibility of creating new materials to satisfy the specific demands of the project or altering the characteristics of familiar materials to meet other technical specifications aimed at securing a specific aesthetic result or specific environmental behaviour needs. At the same time, as we all know, a large part of the architectural avant-garde is experimenting with and creating forms that do not follow the "rules of art and science", forms that emerge from the utilisation of the possibilities of special computer programmes. In conjunction with the issue of energy-sensitive buildings, or buildings that use contemporary materials and new construction methods, the quest for these new forms is based on experimenting with materials and how they can yield the new architectural forms.

The increase in the importance and size of building installations

Contemporary building technology has readdressed and incorporates – in new forms, given their direct operational value – knowledge that had long been dissociated from the content of construction, such as for example the networks of installations, naively accepting that these could be incorporated into the plans for the building at a later date. The increase in the number and complexity of these networks (electricity, water, drains, ventilation, air conditioning, gas, heating, Internet, communications, sound and image, sensors, remote controls, security systems, etc.) and the complexity of the specifications for each one of them makes it essential that networks be addressed today creatively and as an integral and fundamental part of the design and construction of the building.

In addition, many installations have acquired dimensions that impose special technical solutions for the passage and service of their networks, something that was virtually unknown just a few years ago. Even in a simple building, the old approach of containing networks within the plasterwork is no longer enough. Finally, both the basic building installation control systems and the additional installations demanders by the users depending on their specific needs are promoting the systematic use of computers to control the various functions, which are bound to increase systematically in number and kind in the years to come.

The increase in the requirements of basic studies

Contemporary project requirements demand more of the basic studies. They need to incorporate more elements, they require input from more different specialists, they demand greater precision of application, there are more specifications that have to be met. In order to satisfy all these requirements engineers have at their disposal new design tools and new sources of information.

Plans in digital form have made the collaboration between engineers both closer and more efficient. The existing software allows fuller control of the validity of the plans. It also allows plans to be altered faster and at less cost, which paves the way for plans and studies to cover more aspects and for projects in the planning stage to be vetted with advanced evaluation and presentation tools.

At the same time plans have become a more flexible component of the project, open to alterations by more specialised engineers, so as to incorporate more expertise and experience. This in turn requires greater superintendence of the progress of the work of other engineers, which is to be used in the project, and a minimum level of security expertise to allow them to communicate with one another.

The consequence is the creation of a new layer of content in construction, in conjunction with the shrinking of older once important aspects, the shifting of the responsibility for the construction of many elements of the project to industry, the new and constantly changing requirements demanded of projects and studies, the need to monitor changes in the work of other engineers, the exploit to the maximum the new materials available and to explore more thoroughly the new relations between drawing board and construction site.

The entities of the new science of construction

The above exposé allows us to formulate the view that a number of new entities have appeared in construction. These have nothing to do with the order of construction but with the problems the architect has to address in designing the project and the matters that arise and have to be solved along the way. Thus not only does the role of each element in the whole of which it is a part become more comprehensible, but the dynamic relation between synthesis and construction becomes clearer, as does the artificial distinction between them, product of the formal classificatory approach typical of classic construction teaching.

The shell of the building

The energy crises of the past few decades have heightened the importance not only of heat insulation but also of other aspects of building design and construction, such as lighting, sun exposure, microclimate and in general all the positive and negative factors that contribute to their energy efficiency. At the same time, new requirements, until recently unknown, such as the demand for sound insulation, have further complicated the matter.

The complexity lies in the fact that all the above, and other related matters connected with security and specifications, have been quantified (and the results are therefore verified) and must, despite the fact that they require conflicting measures, be resolved simultaneously upon the shell of the building, which has for this reason come to constitute a new entity.

The need to recognise the shell as an entity is intensified by the fact that it constitutes an important element in the form of the building, the external expression of its architecture. Architects have thus acquired a "new" design object, in the sense that it cannot be designed simply in terms of heat or at most heat and sound insulation. New forms of shells that reflect these issues are being described internationally in numerous contemporary examples of works by cutting-edge architects.

The situation is becoming more complex, since the resolution of basically conflicting requirements upon the shell cannot be done by simply adding successive layers of material or constructions, because the requirements are not only mutually conflicting in their method of handling but also imply different time frames. A simple example is that of insolation, as gain or loss depending on the season and in some seasons depending on the time of day and the orientation. More complex examples are the multiple requirements and the many technical solutions available in contemporary glazing, with regard to heat insulation (heat loss) and insolation (heat gain).

Interior finishing

With the recognition of the shell as a new entity, with its own special requirements, that covers the whole spectrum of Building Physics, comes the counterbalancing recognition of the other important entity, that of the interior space. Given that the relations with the outside world have already been resolved by the shell, the architecture of the interior space has to do with handling the arrangement of the interior and designing rooms with other problems such as fire safety, artificial lighting, sound-proofing and acoustics, and also with other materials and products, suitable for interior use. This entity is the interior expression of the architecture of the building, and comes into contact with even more specialised aspects of interior finishing, such as decoration, furnishing, equipment and of course the health and comfort of the occupants.

Interior design determines all the elements that interface with the occupants on a daily basis. At the same time the architectural elements that shape the arrangement of the interior spaces are now all industrial products. The use of components of known and controlled properties shields both the occupants from risks they are not (and have no reason to be) aware of and the engineers from liability in the case that a product causes a functional or health problem.

This creates a new reality in the designing of interior spaces, at once more complex and more demanding. It also demands more of the architect, if within a more demanding environment he is to be able to retain his capacity to design more than standard forms and solutions without having to resort to extremely high-cost options. This was always the problem, of course, but the environment used to be less complex.

The bearing structure
If the shell and the interior space are pre-eminently the domain of the architect, who must retain control of them by increasing his involvement with increasingly complex scientific matters (as the author believes), both the bearing structure and the building installations necessarily involve other engineers.

Despite the fact that the architect is the head of the team of engineers and other experts who play a role in the design of a building, it is the civil engineer who is responsible for the static sufficiency of the bearing structure and who therefore basically builds it.

The inability of the architect to control the form and dimensions of the bearing structure (or his indifference) results in buildings where the bearing structure is incompatible with the architectural design. This incompatibility becomes more complicated when there are specific requirements to be met (e.g. the existing anti-earthquake legislation) that increase the dimensions of the various elements of the bearing structure.

By contrast, the integral incorporation of the bearing structure into the architectural design (which presupposes its initial design by the architect) is not only a basic element for the architectural plans themselves but a basic necessity for anyone who wants to follow the trends that call for a single design incorporating both bearing structure and shell or bearing structure outside the shell.

Reasons for changes in teaching

The proposal for a new approach to construction is not intended to establish this or another arrangement of subjects or entities. The object is to stress the need for a new way of looking at construction and incorporating it into plans and projects.

The effects of the new reality on the production of engineering works are immense, and they impact on many sectors of social and economic life, beyond the narrow framework of the several specific aspects.

The influence of the long-term attempt to achieve European harmonisation on these matters is quite significant, especially through the redefinition of technical content, the introduction of minimal specifications for all the elements of a building and for the structure as a whole, the division of requirements into safety, properties and performance specifications, the organisation of a control framework with European standards and control mechanisms.

There are many reasons why the teaching of construction ought to follow these changes, but primarily because it must

- Adapt immediately to the new subject matter
- Promote a shift in the centre of gravity of interest towards new questions.
- Promote a better perception of the project and its organisation.
- Support compatibility between the project and (all) the requirements.
- Exploit the new design and communication tools that exist
- Prepare the architect for changes that are on the way (10-year horizon).

That will be its contribution to the evolution of architecture.