The spatial conception of major public works has undergone a profound modification due to social, technological, and functional reasons, from the Beaux-Arts system at the beginning of the 20th century to the total success of the Modern Movement in the post war. These aspects have been well documented. While being an evident characteristic of this evolution, the role played by the materials used has been subject to less scrutiny.

The subject of this paper is the dependence on materials, as seen in the construction of two major higher education buildings in the Lisbon area: the Instituto Superior Técnico, in the city of Lisbon, designed by Porfírio Pardal Monteiro from 1926 to 1936 and the College of Education in Setúbal, designed by Álvaro Siza Vieira between 1986 and 1995. While having similar educational uses, the spatial distribution is very much influenced by the availability, transportation opportunities and skilled workers, know-how as regards to a set of chosen materials. These were stone and masonry in the construction of the IST, built in the eve of reinforced concrete’s period. This last material is used, but in a subdued way and hidden from view. In the case of the Setúbal’s College, it is the dominating structural material, while iron beams play in this building a similar role to RC in the Lisbon complex. A comparative analysis looks for similarities and differences in the conception process as regards the constructional constraints that a selection of materials imposes from the outset.

From local to global, an evolution is made evident with these buildings. The first one was designed in an historical period of political and economic closure, and had to depend on the ‘products’ of the land at a regional level. The second one was designed in the period of opening up to the outside world, following the fall of the Salazar-Caetano regime and immediately after the country’s integration in the EU. The radius of availability of materials has multiplied manifold.

The dependence on material will be analysed with recourse to the architects’ drawings and texts and to archival documentation.

INTRODUCTION

Detecting the constructive rationale of two major 20th century projects for educational facilities is the proposed aim of this paper. Considering a limited number of buildings may serve as an exploratory means of perusing into the nature of design processes and shedding light into the apparently disconnected historical magma of facts, expectations, and practices. The criteria of function for the selection is the result of the interpretation of this particular program —new higher educational premises— as prone to a enhanced unfolding aptitude as to the architectural creative processes of the time and also due to its variety of spatial requirements. Education for all is a desideratum glowingly aimed at by European states in the 19th and 20th centuries. Since the modern university
was contrived in Berlin in 1810, higher education buildings and campuses have become the quintessential building program of modernity. Although they were not entirely industrial-age new programs like railway stations, higher education buildings had a distinct and enlarged role to play in societal development. They also had to find a representational place in the urban fabric and establish a foundational image for the modern refounded state from the 19th century to the globalisation era. They secured national funds and, at the later stage of European reunion, international funds. They spurred a particular effort from the architects towards precise functional definition and novel representational values. From the public and especially from their sponsors, each was the object of great expectations.

Although both buildings are singular enterprises and hardly referred to by their authors as first studies in a later developed sequence, they are subject to three conditions that relate them closely to this endeavour. First, they participate in the same general tendency of the modern movement to design its buildings always as prototypes, as E. Ford signalled in his detailing’s study of that period (1990). Secondly, they belong to this particular typology —the campus or the set of higher education buildings— that has been rightly exposed as a laboratory ground for modernity and even societal ideal form. Finally, they represent the first opportunity for both authors to address the issue of an educational building —and think afresh about the role of architecture in the cognitive process and emotional experience of a school for late teenagers and young adults. An inaugural propensity is present. While it is manifest that the optimisation of program deals with functional and spatial definitions, its correspondence in the constructional agenda may be sought and assessed. Which materials were chosen and how were they connected? Were these materials and relationships established as a kind of statement of a preferred building system, an exploration of new technologies or simply a means of putting together space in a specific way?

Constructional concepts for 20th century architecture

The categorising of tectonic/atectonic proposed by K. Frampton for the analysis of building deeds provides a conceptual base for a study of any project. P. M. Barata carried out the report of Siza’s first 20 years work using these concepts (1997). Frampton himself considered extensively the Portuguese architect’s work from that perspective (1997, 1998 and 1999).

The concept of the tectonic, derived from Gottfried Semper’s uncompleted architectural theory of 1860–63, naturally ignores the one material that would dominate the building industry in large parts of Europe. Steel-reinforced concrete had already been invented but had a long way to go before it became used with confidence in architecture. The singling out of four main categories of substances —textiles, ceramics, carpentry and ‘stereometry’ or masonry— was conceived when the constructive system which lasted for centuries was still in full vigour but was at the eve of formidable transformations and accelerations for change, in technology, building industry and architectural desiderata. It is disconcerting that a theory that exerted such profound influence should make it so difficult to study the combination of different materials, due precisely to the innovative character and composite nature of the artificial newcomer. It either assumes the role of a tectonic light frame material or its exact opposite, the heavy compressed ‘stereometry’. Focussing on the articulation between materials and on the differentiation between supportive and supported elements provides a starting point through which to appreciate and compare different architectures.

L. Quaroni proposed a less complex classification as a didactic scheme (1995). He distinguished three types of building systems in relation with the structure: continuous homogeneous, discontinuous homogeneous and discontinuous dishomogeneous. According to Von Meiss in another theoretical treaty (1990), form and technique are related in five categories, ranging from glorification of technique, to technique as an image, to falsification of technique, to technique subjected and to technique tamed. I. Paricio (1997) opposes two contrasting modes of construction —isotropia vs. anisotropia— and surveys means of resolving the problems of internal and external corners and side façades. He focuses in the extremes of the building, the al canto problems —where the compositive order changes direction. When relating closure and structural elements, he proposes three types of solution’s concepts— the formal, the explicit and the radical. E. Ford (1990), in
his study on the details of the modern movement and its predecessors, differentiates between the monolithic and the layered construction and further differentiates the analogous and literal treatment of the surfaces.

These different conceptualisations offer a prodigality of frameworks for an inquiry into constructional rationales of a modern period. As the subject is not prone to an indisputable determination, these concepts can be best be used as a setting for the observation of the selected cases. After Perret alleged that there is no such thing as a detail in architecture, Gregotti states that architectural articulation is made visible by detail (1996). Frascari stresses the importance of the joint: in the detail resides the place of innovation: it is always a joint, always a discontinuity of material (1996).

Raw materials, structural systems and material joints are therefore the key points for an inquiry into the architectural rationales regarding construction.

The Architects

The two cases presented here are united by function and authors' prominence. The function is new buildings for a school of higher education. Both were designed by architects who are leading professionals in the Portuguese context and in their respective time: Pardal Monteiro (1897–1957) and Siza Vieira (born in 1933). Furthermore, Siza Vieira gained the international recognition that Monteiro never achieved, in spite of the fact that his work was published in influential professional periodicals such as L'Architettura d'Aujourd'hui.

Porfírio Pardal Monteiro was one of the first Portuguese architects to use a modernistic language, and one of the few who consistently did so throughout his career. However, his was a not a homogeneously inspired production. When compared with contemporaneous architects, he is known for the rationalistic expression he gave his numerous projects, most of which were de facto built: maritime stations, churches and seminaries, middle class housing blocks, hotels, and above all, public institutions and government buildings. He enjoyed the reputation of having a fairly well organised architectural office, and employed a few of the soon to be independent architects in the Lisbon scene. His text on the architects of the reconstruction of Lisbon following the 1755's earthquake acknowledge his inclination towards regular, repetitive procedures and an esprit de système. Although his first designs exhibit a richness of materials and detail —such as the CGD’s banking institution in Oporto or the Av. 5 de Outubro’s villa in Lisbon, he later evolved to a dry, stringent monumental architecture.

Álvaro Siza Vieira is known in the international scene since the 60’s, initially mainly from Portuguese, Spanish and Italian architectural publications. He has claimed another level of freedom—which translates into an iconographic catalogue that borrows further and further into the whole world and also into a prodigiously expanded temporal scale. Figure 1.
M. Cunha Matos

FUNCTIONAL DEFINITIONS

Monteiro’s ‘Instituto Superior Técnico’ (IST) became the new site for the existing school of engineering of the capital city and its planning and building process lasted from 1926 to 1941. Classes started in the newly completed pavilions in 1936. Siza’s Teacher’s Training College in Setúbal (ESE) was designed and built between 1986 and 1995. In both cases, a collection of similar rooms, with quasi equivalent requirements in light incidence, air renovation, sound insulation, gross area, volume, etc., combines with a collection of atypical rooms programmed for very definite functions – the large lecture hall, the laboratories, the workshops, the administrative and the management sectors, the sports hall, the housing units for keepers or guests. Circulation and social areas allowing for the functioning of the premises constitute a more flexible requisite.

The plots being quite generous in both cases excluded the need to occupy them intensely. The spreading out of the various parts of the buildings is analogous. It is therefore possible to look into the functional vs. the constructional constraints without the interference of limitations in substructure area.

The making-up of the design brief was very diverse in the two cases. In the ESE, the long experience in higher education facilities by the Ministry of Education provided a relatively straightforward mechanism for defining the quantitative and organisational contents of the program. In the case of IST, however, the absence of recent precedents in the country led the architect to perceive the functional requirements’ study almost as a work by itself. He went for a long journey abroad, visiting the major engineering schools in Europe. The only evidence of an internal survey and dialogue is a notification to attend signed in 26 August 1927 by the all-important recently empowered director of the school, Duarte Pacheco: professors and other faculty members were asked to draft reports for the project’s program. Another letter addressed to the Ministry of Foreign Affairs asked for assistance from our embassies abroad to obtain plans and other data from ‘modern’ engineering schools. The whole process of programming and building was removed from the everyday knowledge of even the school’s faculty, as can be deduced by the reading of the record of proceedings. Nevertheless, an innovative brief was proposed, of large laboratories and lecture halls, of an indoor swimming pool and sports ground, of spacious classrooms and workshops and generous circulation areas. Carefully designing the equipment went so far as to incorporate the entire furniture in the design and production, which took place in the actual school workshops.

Taken in a comprehensive meaning, functional definition also entails the sign value. The symbolic purpose in Lisbon’s IST was twofold. In filigree, to express and reveal the engineers’ rise to power in a society dominated by Law School alumni. And to give impetus to a planned urban expansion to the Northeast of town, assuring an important part of the role of Lisbon as capital city on a colonial scale. Figure 2.

In the ESE, democracy is at work. Political turmoil was still very intense in the aftermath of the 25th April 1974. The industrial crisis of the Setúbal peninsula provided a developmental role for the new school. Highly determined patrons in the school administration were able to secure the commission from their chosen architect and to obtain the funds which were necessary to respect the project’s level of finishes.

CONSTRUCTIONAL CONSTRAINTS

The availability of materials, their mode of transportation, the level of craftsmanship, the type of contract are all factors impinging on the selection of a set of materials and building system.
Materials and building system

The building system in the IST is a compromise between load-bearing walls and concrete floors. Stone, brick and rubble masonry are used in the walls and reinforced concrete is used in beams, in a number of pillars and in floors. These are made in solid concrete slabs, either simple or combined with beams. The masonry is covered with stucco on exterior and plaster in interior. Figure 3.

Another important material is stone. It is employed in the limestone base of the buildings, in which case it is disposed in alternating layers and wedge-shaped voussoirs over the windows; as marble floor mosaics in circulation areas; as marble and Algarve’s and Estremadura’s brecha veneers in the revetment of the grand hall, Grand Salon and stairs; Figure 3; and in smaller applications such as window sills. Ceramic is used in the coloured tiles lining the floors of the basement floors. Iron is used in the door and window-frames and their gratings, in the structure of the suspended glass ceiling covering the great hall, in the gates and railings surmounting the exterior walls; and in the open-air lamp-posts. Steel is used in the railings protecting staircases and galleries, and in the door handles and other fixtures. Cork is used in the floors of some major spaces, designed as a mosaic. Wood is used in classroom floors; in the handrails and banisters of staircases of non-central pavilions; and in the smaller windows-frames in the lower floors. Plaster is also used in the uniformly painted decorations in the façades.

The ESE is built using reinforced concrete extensively in walls, columns, floors and roof slabs. Figure 5. It takes the place masonry had in the IST. Stone is used in veneers around columns in wainscots and in floor surfaces. Iron is used in door and window-frames and various railings. Wood is used in panelling areas and in interior doors and fittings. Figure 6. Cork is used for the floor in most of the rooms.

Type of contract

The IST’s director, the electrotechnic engineer Duarte Pacheco, personally managed the works.
Transportation of materials

The ease of transport depends on the relative location in the city. The IST was built in an urban fringe, soon to be a booming middle-class residential quarter. It had various public transports, but the site itself was farmland. The beginning of the work coincided with a dramatic financial crisis of the Portuguese State that would eventually lead to the dictatorship of Salazar. We can infer the difficulty of procuring the necessary vehicles for the earth movements from the correspondence sent from the school in 1927. In a letter, director Pacheco asks the Minister of Commerce and Communications to lend the school a digging machine belonging to CP, the railway-lines company. In fact, an important railway-line ran near the future school and soon plans were made to implant one of the main railway stations just outside the school grounds, with a purpose-built branch-line. Pacheco also wrote the Leixões’s port authority asking for 20 to 30 wagons for the levelling of the ground, also as a lease; he insisted three times until supposedly he got what he wanted. The difficulty and expense of earth disposal led to replacing the maximum volume in site and promoted the solution of the site surface treatment in platforms, grandiosely leading to the central pavilion, the compositional climax. Figure 7. Earth, the first building material, set thus the tone: economy was the aim. Portuguese materials were given preference.

The ESE was located outside Setúbal in an almost totally rural setting at the time; but it had roads that could be negotiated by heavy-goods vehicles.

Availability of materials

Using RC in parts of the IST buildings leads to the conclusion that sufficient know-how and workers' skill was available to use this building system. It was the shortage of iron in the market and economic reasons that led to the masonry alternative. Monteiro endorses the decision by declaring in 1934 that masonry construction really costs very little. A well-known story tells how Pacheco built his school using the samples he asked from various furnishers. However implausible this story, he certainly summoned officially all the firms of ceramics listed in

In 27 November 1929, the first stone for the central pavilion was laid down. The earth movements and excavation had begun in July 1927. The architect was commissioned the project in November 1928. The work was finally completed in all its exterior arrangements in 1941, two years before Pacheco's untimely death. A remarkable amount of more than a hundred suppliers were registered.

In the ESE, the traditional procedure of contracting a building company was adopted. Young civil engineers were in charge of the work in the building site.
Functional definitions and constructional constraints

The imposing façade of the Central Pavilion (IST). Original elevation by Porfírio Pardal Monteiro

Figure 7

the Lisbon’s Commercial Directory in September 1927, well before actual building began; later perhaps he ceased to render account of his doings to his colleagues. The scarcity of resources was also likely eased, due to the loans extended to the IST by the banking institution Caixa Geral dos Depósitos and to the financial operations that made possible the urbanisation and plot selling of the rest of the original farms by the school.

In the ESE, the disappearance of political and economic frontiers inaugurated a European-sized market. New materials were arriving every day to the country. It was one of the first pedagogic buildings to be thermally isolated in a PVC composite in all the exterior surfaces. The novelty of this new market was still not completely assimilated. Ten years of instability and economic difficulties had set a pattern for the building industry. Efforts were mainly made in controlling quality in the finishes throughout the school, not into the experimentation of new materials. The set of materials was limited and familiar to the architect.

Skilled workers

In the IST, providing jobs to the maximum number of workers was the welfare policy put into action, well before the New York’s crash and subsequent Depression. A battalion of unemployed workers was given a low-paid job. At its peak, there were 700 workers on site simultaneously.

Yet, some excellent craftsmanship can be found in the buildings: mainly the stereotomy of the ashlars, the metallic fittings and the ceramic floors. The architect had a particular relationship to stonework. The extraction, carving and setting of limestone and marble had been a family business since 1888. It was located in Pero Pinheiro, Sintra —approximately 40 km from the capital— where Monteiro lived as a child.

In the ESE, the period of building corresponded to a reversal of the emigration direction, from outward to inward bound. The mass emigration of the skilled workers, at its peak by the middle and end of the 60’s, had ceased. From 1975 onwards, the country integrated a significant population of ex-colonials and of African-born Portuguese descendants (the ‘retornados’). A steady flow of African emigrants from the ex-colonies began. A building site’s view was likewise altered: an incongruent mix between old skilled workers and small subcontracted firms with newly arrived emigrants who didn’t speak the language. The strict modulation of the project and the complete gridiron drawn stamped across all the architectural drawings might be related to the potentially confusing situation that building sites were beginning to exhibit and to the proliferation of subcontracting. The project is subject to a strict three-dimensional geometry.
AN ARCHITECTURAL INTERPRETATION

Modes of detailing

Although it is an avant-garde set of building, the IST keeps much traditional detailing in the profusion of cornices, pilasters, mouldings and reveals; and in the design de per se of the main non-pedagogic rooms, where ceilings are treated as a unifier of space. Figure 8. Heavy plastered geometries are suspended in wood structures, in a clear continuity to the 18th and 19th centuries elaborately stuccoed ceilings. Unity is also sought in the modern classrooms, where apparent RC beams are duplicated as false beams so as to compose a symmetrical pattern in the ceilings. Figure 9.

Every marble wainscot is trimmed. But the heavy architrave supported by the marble veneered pillars in the grand hall and Grand Salon are devoid of any transitional tropes: the capital is suggested by the slight glide upwards of the front veneer. Figure 10.

Modern detailing is overtly used in the entire metallic door and window-frames and in the treatment of the exterior surfaces. Arts Deco is a conspicuous influence in formal motives, colour selection and combination of materials; above all, in the delectation of veneered stone in diverse types of patterns, colour and marbles combinations. Mies van der Rohe’s 1929 Pavilion had fostered the precious materials appeal. The 30’s would see a proliferation of marble veneers facing the housing building facades in Lisbon, mainly through the production of architect Cassiano Branco. In some cases, heavily veined marbles in black and white patterns or other strong colours were used. It was a time for the discovery of the abstract play of veins in stone. In the IST, veneered wainscot in circulation areas and enclaves created by the main staircases and water distribution fountains are also reminiscent of Loos.

Very few working drawings have survived, although a family-owned architectural agency has
maintained the archive in order. In the remaining plans and sections, neither infrastructure networks or structural elements are indicated. Figure 11. The absence of detailing drawings is not so surprising for, as Edward Ford states, when craftsmanship died, detailing was born. And this was still a highly ‘crafted’ architecture, notwithstanding its modernistic simplification and abstract character. Beside a reduction of the door and window-frames, only hewn stone is drafted one by one in the elevation drawings. Figure 12.

In ESE, a limited number of materials, encompassing the preferences for the white stuccoed volumes, sustain a logic of lightness and evanescent materiality. Few clues are given as to the passage of AC ducts or other networks. Suspended plastered ceilings creating their own designs hide away the technical ducts. No beams are apparent. Columns always support strictly flat planes, even if they are tilted or covering an exterior area. Steel I beams are used in some large spaces, but they are covered up too by the ‘neutralising skin’ of white plaster. Even the exterior thermal insulation helps to maintain the neo-modernistic formal aspect.

Even if stone is no longer used as a bearing material but as a veneer, a hint of pleasure is perceptible in the choice of its setting, in the detailing of its geometry, in the rhythm of its quasi-imperceptible joints. Figure 13. Frampton alludes to the very corporeal metaphor of a ‘breath’ (1997). These details invite to follow and decipher them, eventually to find their hidden logic, eventually to be caught in a game, an amused sort of contemplation. Loos is rightly cited in the revetment game of the later works of Siza, but the use of that revetment as a means of creating a translucent space is also related to Terragni’s Casa del Fascio.

Expressions

The IST is a grand essay in Monteiro’s career: his subsequent projects would transport the institutional gravity, even heaviness that is so evident in the way he found of settling these buildings on the ground.
The work occurred when a tide of law and order values was overwhelming the country. The earthen, telluric bearing wall stands firmly against instability and menace.

The ESE, contrarily, gives a sense of openness, transparency and accessibility. The revealing of structure in the shape of slender columns joyfully designed in different ways and pointing in different directions only reinforce the optimism, the promise of happiness that the it carries. In a sense, the whole light organism is an aerial frame. It is true that it is made up of pure, abstract volumes. But in the roofs these volumes turn imperceptibly into planes and perform a plastic display: they get curved, they zigzag. Figure 14. And so do they get slanted and twisted and fragmented near the ground. In some places, volumes disappear and turn completely into planes, which gain movement and drag nearby elements into their motion.

**Concluding Remarks**

These projects show the artistic personalities of their creators but also reflect the material conditions, the self-confidence and the expectations of a country in very different phases of its history.
The first project is situated in the last period where the system of sustaining walls could still be seen as a trivial answer to a problem of construction. The ESE project is worked out in a period where RC porticated construction is overly dominant in the country and has acquired the status of 'traditional' constructive system. The break that this building proposes is understated, for it neither aggressively exposes alternative modes of building—which in fact it uses—nor does it even suggest that the issue of building technology has in any way a leading role in the process of its design. Quite the opposite: in strictly technical terms, the ESE building seems to push the RC almost to its limits—in the use of its plastic capacity, projecting negatives and positives, holes and tropes, thin sheets of a material that curves and bends and folds and retreats its beams into itself. Like Mies in his European phase, it is rather the sculptural relationship of the column to the horizontal or vertical bare plane that seems to be the point and not the systematics of any building process. Figure 15. The fact that RC is used throughout the building, in walls, floors, columns and roofs and not in a porticated pattern is concealed by the evidence of columns, pillars, elements of repetition and rhythm.

Space shaping and form giving appear as the desiderata in this instance. The constructional means assume a subdued position in the creative process. Reference to precedents and to the exposition of alternatives dealing with the relationship between structure and closure—namely, the '4 ways' drawn by Le Corbusier—can be found in the project.

The case of the IST is a paradox—being largely constructed through a time-honoured technique and with the same materials used centuries ago and offering an image of absolute modernity. It is moreover a vivid demonstration of the capacity of architecture to transcend the limitations of a given time.

In both these major works of educational and research facilities, the exploration of a formal and spatial agenda is at the foreground; perhaps even the symbolic role they are expected to perform is more important in the process of their design than
constructional consistency. The constraints of place and time weighed heavily in the selection of materials and building process. But what was sought was more important than how it was done; and perceptible unity and consistency there was, as well as firmitas. Architecture does not dispense with logic, but makes do with fragmentary logics.

NOTES

1. Ref. for example the inaugural issue of *Astragalo* (1994).
2. Ref. the Urbanism and Housing Congress held in 1944 in Madrid, Lisbon and Seville, P. P. Monteiro (1945).
3. For an analysis of these two buildings, of their architectural materials and strategies, ref. M. C. Matos (1994) for the IST design and ref. M. C. Matos (1995) for the ESE design.
4. Considering the ideal standards of their own time.

REFERENCE LIST


