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Pre-industrial construction techniques, using industrial materials, in Greek urban vernacular architecture: the peculiar heritage of a transitional period (from 19th to 20th century)

Nicos Bobolos, Eleni Theotokatou

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Pre-industrial construction techniques, using industrial materials, in Greek urban vernacular architecture: the peculiar heritage of a transitional period (from 19th to 20th century)

Nicos Bobolos, *Department of Interior Architecture*, University of West Attica, Egaleo, Greece
nbobolos@uniwa.gr

Eleni Theotokatou, *Department of Interior Architecture*, University of West Attica, Egaleo, Greece
etheotokatou@uniwa.gr

Abstract. In late 19th century Greece, newly introduced industrial materials are found to be used in small-scale vernacular constructions, following a quasi-autonomous path, detached from respective construction technologies of the time. This detachment can be understood in practical, financial and cultural terms, as well as in terms of symbolic order. In this context, this paper analyses a series of construction details in several cases of urban vernacular architecture, that make use of industrial materials that usually substitute traditional ones, in order to classify them and understand their contribution to the transition from traditional construction materials and techniques to an industrialized construction world. The analysis follows a comparative study, including field, relevant literature and personal archives research, photographs, graphic representations and descriptions, in order to make a contribution to the study of these peculiar architectural heritage samples.

Keywords: Vernacular architecture, 19th century architecture, Industrial, preindustrial construction, Modern Greece architecture history.

1. Introduction

From the end of the 18th century, along with the rapid industrial development, the building industry entered a period of innovation, with an increasing variety of new industrial building materials - i.e. wrought iron, cast iron, steel and later, Portland cement and structural steel bars to produce reinforced concrete - entering the markets and gradually replacing natural building materials (mainly stone and wood).

In countries subjacent to the first waves of industrialisation, in an environment of rapid urbanisation, the construction material industry responded to the demand for large scale constructions, requiring innovative technologies to be implemented massively, safely and at a low cost. New materials were developed during an excessive industrial growth resulting from scientific progress and the consequent development of new construction technologies, refined by pioneering architects and engineers as J.-G. Soufflot and J.-B. Rondelet (Panthéon of Paris), H. Labrouste (National Library of France, Sainte Geneviève Library), E.-E. Viollet-le-Duc (Castle of Pregny project etc.) [ ], J. Paxton (Crystal Palace) [ ], G. Eiffel [ ], J. Bogardus (New York cast-iron factory) [ ], F. Coignet and F. Hennebique (reinforced concrete) [ ]. Nowadays, this category of historic structures and the variety of construction methods related to them have been recognised and analysed in depth, promoting as well several protection and reuse technologies and techniques, as proven by the richness of relevant literature [ ].

However, the transition to the new era was accomplished as new building materials and construction technologies were spread to the periphery of industrial growth, regulated by local socio-economic conditions. In late 19th century Greece, new industrial building materials are often used just to replace pre-industrial materials, following traditional construction methods, instead of being a part of a newly introduced innovative building technology. Such examples are more than frequent in heritage buildings built after 1880, yet they are not adequately studied.

The objective of this paper is to highlight and analyse the case of these peculiar architectural heritage samples and underline the need for the creation of a historic and technical record about this part of Greek architectural construction history. Collecting and organizing relevant knowledge could facilitate the protection and reuse of such constructions.

Regarding the method followed, this study is comprised of (a) an in-depth relevant literature review, including urban history, building architectural techniques, technology and materials construction records and history and relevant Greek legislation, (b) a comparative field survey, by taking notes, photos and creating sketches of constructions' details, and (c) the survey and retrieval of relevant information from our personal and professional archives. Making use of the above, we developed a study plan that directly addressed our research goals.

2. Analysis

2.1 Innovative construction technologies, new materials and vernacular architectural production

In late 19th century Greece, innovative technologies and new industrial building materials were implemented in two ways: (i) Through high quality and costly constructions (mostly large-scale buildings and luxury residences), elaborated by architects and engineers, that made use of new materials and applied innovative construction technologies [ ] and (ii) In small-scale mainly residential constructions.

However, in Greece, a small and poor country of European semi-periphery where steel products were imported until the 1930's [ ], large-scale constructions were rare as not of primary demand. Moreover, the lack of housing development policy kept housing construction as a small-scale and private activity, in line with the small scale of the vast majority of urban land properties [ ].

This applied even in Athens that, although lacking remarkable industrial growth, was to become the country's dominant urban centre. As the capital of the new state, its population grew rapidly, creating a high demand for new constructions and attracting a significant number of builders, masters of traditional techniques mainly from the Aegean islands [ ]. New building materials were imported and were disposed in Athens as well as in other urban centres with adequate transport access. Athens was subjected to a rapid urbanization, with the land divided in small properties, distributed to the lower middle strata and actively involving building craftsmen to its development, as entrepreneurs [ ]. Furthermore, according to the vague legal framework applied from 1828 to 1923, no structural study was required in order for a building permit to be issued, concerning common housing projects [ ], while several buildings were constructed without any permit at all.

In this respect, the majority of small-scale residential buildings, up to the 1920's (and further), could be classified as of vernacular architecture. According to J.M.F. Pardo "Vernacular architecture can be defined as a type of regional construction influenced by geography, available materials, climate, traditions and culture that is produced by non-experts through knowledge transmitted and enriched from one generation to the next" [ ]. Moreover, for both the international charters for the protection of architectural heritage [,] the concept of "vernacular architecture" broadens to include, where appropriate, any kind of widespread, everyday "architecture without architects" expressing local conditions, resources and cultures [ ].

It is in this context, from late 19th century, that new building materials [ ] were often used as substitutes for traditional ones of the pre-industrial era, according to traditional construction methods. New materials were embedded into vernacular constructions empirically, without prior theoretical knowledge and as such, did not fulfil their specifications. Consequently, such structures belong to a particular typology and have their own pathology, in need to be recognised and documented.

2.2 Objective, cultural and symbolic influences on vernacular architecture's choices

Luxury residential and large-scale/multi-storey special buildings, where new construction technologies were applied and new materials were used, as well as relevant technical publications [ ] were providing examples and information about construction innovation to vernacular architecture builders. However, an examination of new building technologies from late 19th to the first decades of 20th century [ ] does not reveal any notable influence on vernacular architecture construction methods, other than the occasional use of new materials. E.g. there are no cases of substitution for complicated timber structures' with wrought iron or steel ones, like metal truss structure roofs, to replace timber ones, or metal frame walls, with brick infill, to replace traditional timber frame walls, with stone or brick infill.

Practical and financial issues [ ] may be important reasons for this: the use of new materials could improve the structure's strength, decrease on-site works, while maintaining traditional construction procedures [ ]; besides, imported, wrought iron and steel structural elements [,] were hardly affordable, so their use - especially in vernacular constructions - was as limited as their budgets.

Besides, the conventional use of new materials did not produce a new architectural language in Greece [ ] - or elsewhere [ ]. Historicism as the dominant spectrum of architectural languages, until early 20th century, remained well established as a major influence on architectural design, even in common and vernacular structures, leading architects and builders to hide new materials behind traditional material coatings or appropriately shape them in order to imitate historic architectural forms [ ]. In fact, the way new materials were embedded in vernacular architecture construction was perfectly in line with historicism and did not actually affect construction procedures. Building activity stayed attuned to neoclassicism, dominant in Greece [ ] at that time, which later evolved to a "neoclassical eclecticism".

2.3 Vernacular building techniques by industrial materials: a typology record

In this context, from late 19th century and on and mainly in urban vernacular Greek architecture, several new materials replaced traditional ones (see tables 1, 2).

Prefabricated cast-iron balcony railings and cantilever corbels became popular thanks to their rich sculptural patterns and widely replaced hand-made wrought iron elements and their modest geometrical form. Since 1870, local production of such parts [ ] made possible their wide application, by making them affordable. As A. Sowa states [ ], cast-iron parts promoted the popularisation of neoclassicism.

Wrought iron or steel beams used in the construction of roof, floor and cantilever (balcony) slabs, replaced timber beams. In some cases, railway tracks were used instead of structural beams. That application is another example of pure empirical/experimental construction processes in Greek vernacular architecture. Flooring remained traditional, using timber planks mainly on interior floors, or slate stone slabs mainly on rooftop slabs and balconies. In stone or brick masonry, wrought iron or steel beams, were also frequently used as lintels, bridging wall openings, replacing timber lintels or in order to straighten slightly arched openings. Transversal bridging, between metal lintels, was achieved with slate slabs or solid bricks. In a similar way, timber bond beams in bearing walls were replaced with steel.

During 1920's, two new construction materials were increasingly spreading: reinforced concrete and lime-cement mortar, for stone or brick wall construction and their coating. Reinforced concrete, a technology rather than a material, was primarily used replacing (a) floor and roof slabs supported by stone or brick walls and (b) cantilevers (balconies). A rather rare application of concrete is in the construction of a horizontal slab of densely arranged concrete beams, lightly reinforced, casted between rows of common clay bricks (~20cm long), that are eventually integrated in the slab.

In cantilevers' construction, marble or metal corbels and marble/timber/metal sheet slabs were replaced by reinforced concrete elements (two or more corbels embedded/anchored in the bearing wall, supporting a reinforced concrete slab). Concrete balcony corbels' formation often followed neoclassical or eclecticist style. A rural version of similar reinforced concrete cantilevers appeared after WWII, when the timber balconies of thousands of houses of Greek villages had to be reconstructed after being burned due to occupation forces retaliations.

From the 1930's and onwards, engineers and architects became increasingly involved in the production of the urban built environment, through multi-storey apartment building construction, using reinforced concrete. However, construction remained small-scale, as it was generally carried out on the same small properties [ ], construction crews remained small-scale craftsmen groups in labour-intensive enterprises, more or less retaining traditional construction techniques, with the exception of the transition to reinforced concrete load-bearing technology.

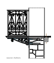
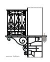
The prevalence of "artificiel" coating (chipped cement plaster) in multi-storey apartment buildings is another example of the condition discussed. "Artificiel" is about a cement-based mortar, worked out with a traditional technique of stone craftsmanship, in order to reproduce the texture of chipped stone in buildings' façades. It was initially used to imitate the roughness of uncoated stone wall surfaces in late historicist building façades, but was gradually established as the standard façades' treatment for multi-storey residential buildings and survived for as long as traditional stone craftsmen still worked for the building industry (until 1970's).

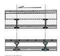
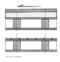
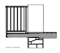
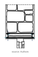
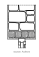
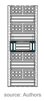
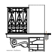
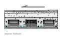
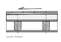
Table 1: Traditional construction techniques that use new materials from late 19th to mid-20th century and their correspondence with the traditional ones they replaced.

	Period (estimation)	Construction type	Construction with new materials	Relevant traditional construction
Cast iron parts	1890's-1910's	Cantilevers (open balconies)	Cantilevers supported by cast iron corbels (support beams) with ornaments. Bridging (flooring) with one-piece thin marble slabs, timber planks or sheet metal.	Cantilevers supported by wrought iron corbels (support beams). Bridging (flooring) with timber planks.

	1890's-1910's	Balcony railings	Cast iron railings or mixed construction railings, including cast iron railing parts (posts, ornaments) and wrought iron parts.	Wrought iron railings forming decorative patterns.
Steel parts	1890's-1920's	Floor slabs	Floor slabs supported by railway track beams or "I" shape steel beams. Bridging with schist stone pavement slabs. Flooring with cement tiles.	Floor slabs supported by timber beams. Bridging (flooring) with timber planks (one or two crossed layers).
	1890's-1920's	Rooftop slabs	Rooftop slabs supported by railway track beams or "I" shape steel beams. Bridging with schist stone pavement slabs. Final cover with thick earth layer and stone slabs or cement tiles.	Rooftop slabs supported by timber beams. Bridging (flooring) with planks or schist stone pavement slabs. Final cover with thick earth layer and stone pavement slabs or clay.
	1900's-1920's	Cantilevers (open or enclosed balconies)	Cantilever supported by railway track beams, or "I" shape steel beams, as extensions of internal floor structure. Bridging with schist stone pavement slabs. Flooring with cement tiles.	Cantilever supported by timber beams as extensions of internal floor structure. Bridging (flooring) with timber planks.
	1900's-1930's	Lintels in wall openings	Lintels of "I" shape steel beams in the wall sides, bridged with schist pavement slabs or bricks.	Arched lintels in stone walls. Lintel horizontal levelling with mortar or timber lintels. Horizontal straight lintels made with timber beams in the wall sides, bridged with schist pavement slabs or timber planks.
	1900's-1930's	Bond beams in bearing walls	"I" shape steel bond beams in bearing walls' both sides, bridged with schist pavement slabs or bricks.	Bond beams in the in the bearing walls, made by schist pavement slabs, or bricks, or timber beams in the wall sides, bridged with timber sticks.
Reinforced concrete	1920's-1950's	Cantilevers (open balconies)	Cantilevers supported by reinforced concrete corbels (support beams) fixed in the bearing walls of the building. Bridging (flooring) with concrete slab, often as extension to the interior slab (where exists).	Cantilevers supported by marble or stone corbels (support beams) fixed in the bearing walls. Bridging (flooring) with one-piece thick marble slab.
	1920's-1930's	Rooftop or floor slabs	Slabs constructed of a dense arrangement of thin reinforced concrete beams, bridged with transversely placed perforated bricks.	Rooftop slabs supported by timber beams. Bridging (flooring) with planks or schist stone pavement slabs.
Cement plaster	1930's-1980's	Building façades	Façades design with "*artificiel*" (chipped cement plaster) that imitates the texture of chipped stone.	Chipped stone bearing walls' façades.

Table 2: Graphic and photographic representation of Traditional construction techniques that use new materials from late 19th - mid-20th century and their correspondence with the traditional structures they replaced.

	Period	**Constr. type**	**Construction with new materials**		**Relevant traditional construction**	
Cast iron parts	1890's-1910's	Cantilevers (balconies)				

	1890's-1910's	Balcony railings				
Steel parts	1890's-1920's	Floor and rooftop slabs				
	1900's-1920's	Cantilevers (open or enclosed balconies)				
	1900's-1930's	Lintels in wall openings				
	1900's-1930's	Bond beams in bearing walls				
Reinforced concrete	1920's-1950's	Cantilevers (open balconies)				
	1920's-1930's	Rooftop or floor slabs				

3. Conclusions and discussion

In late 19th century in Greece, the spread of new industrial building materials was largely due to their use in vernacular architecture, replacing traditional pre-industrial ones, rather than being properly introduced along with new construction technologies. In this context, prefabricated cast-iron balcony railings and cantilever corbels replaced wrought iron elements, steel beams replaced timber beams in roof, floor and cantilever slab construction, as well as lintels in wall openings and masonry bond beams. A bit later, reinforced concrete floor and roof slabs replaced cantilevers' corbels and slabs and chipped cement plaster appeared in façades.

This study, identifying, analysing and classifying a number of relevant construction details of this peculiar architectural heritage, attempts to promote the need for further recognition and research, in order for (a) the creation of a historic and technical record about this path in Greek architectural history and, eventually, (b) to contribute to the accumulation of relevant knowledge that could encourage the protection and reuse of such constructions.

Research concerning this particular category of architectural constructions deserves to be enhanced and broadly extended into issues of recognition, description, pathology and intervention methods, in order to support positive and scientifically correct interventions [ ].

This study could also promote a discussion about today's building production socio-economic and cultural aspects in Greece, as well as in countries developing in a similar context. Factors such as urban land fragmentation into small scale properties and interdependent small scale, work-intensive craftsmanship, construction system do not favour innovation, but tend to remain attached to traditional construction procedures: e.g. there is always an aspect of reluctance on behalf of many craftsmen, who resist innovations, as they are considered unreliable, especially when there is a lack of know-how. Apparently, a rationalised reconciliation of traditional and scientific knowledge in every aspect of buildings whether it is about construction, conservation, restoration, rehabilitation, reuse, is necessary, in order to obtain sustainable ways to produce and treat the build environment.

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