Overcoming the degradation of Arterial Towns: Typo-morphological studies and Technological robustness

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Abstract

Over the last few decades, the part of the world identified as 'developing' has witnessed dramatic increase in urban population, drastic changes to its urban landscapes, and the launch of separate construction markets with limited connection in terms of building procurement modes and labour allocations. Sri Lanka is no exception: the extremely limited opportunities offered by the dwindling economies of small towns in the country's interior have triggered the migration of rural population to Colombo and other major towns, which have in turn produced radical transformations in building morphology, land use patterns and labour market structures.

The small towns located along regional arteries, in particular, are morphing into continuous commercial strips without apparent structure, coordinated land use planning or good performance of its building stock. Such urban growth has come to depend on largely unskilled workers, which does not favour the production nor the industry's ability to meet demand, thereby resulting in operational barriers and the subsequent proliferation of sub-standard building systems and processes in urban areas.

This paper looks at countering the performative failures of arterial towns by developing a two-phase response. Firstly, typo-morphological studies of the urban fabric are proposed to determine the technical and functional behaviour of the existing building stock, and identify the problems and potentials of the emerging building types, forms and constructional responses.

Secondly, a framework for a design theory, which addresses the building challenges posed by urbanization is presented by comprehending and appropriating the organization, skill-base and internal links of various industrial actors and processes that make up the industry, because it is only within this scale that the rationale and the means for action can be found and possibly activated.

Keywords: *Urban development, Arterial towns, Typo-morphology, Technological robustness, Architectural design.*

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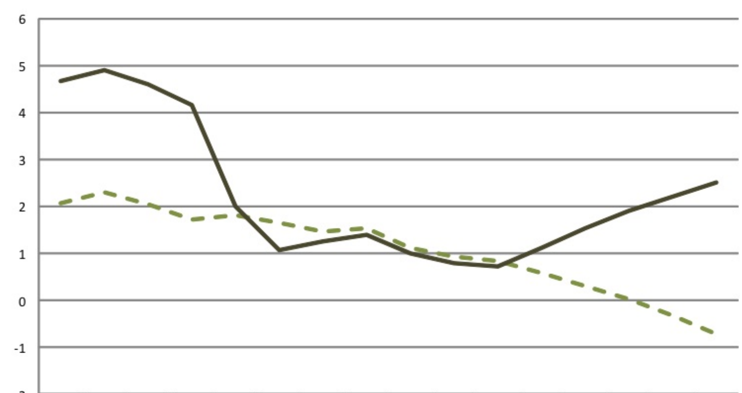
The case of Sri Lanka: Growth of urban agglomerations

Since the midpoint of last century, many so-called ‘developing’ countries in the world – including Sri Lanka - have seen a steady growth of their urban populations and subsequent expansion of the urban building stock. As shown in Figure 1, population growth in Sri Lanka’s urban areas was high during the two decades following the country’s independence in 1948, when Sri Lankan nationals started to move into the urban administrative and commercial spheres previously controlled by colonial rulers. The agriculture- and local industry-focused economic policies of subsequent years (1957-1977) had managed to counterbalance migration pressures for some time, until the open and liberalized economic policies put into effect in the late 1970s gave new and overpowering momentum to urban growth by encouraging investment in cities. By 2030, the annual rate of urban population growth in Sri Lanka is expected to reach 2.5 percent, against negative figures for the rural population.



	1950-1955	1955-1960	1960-1965	1965-1970	1970-1975	1975-1980	1980-1985	1985-1990	1990-1995	1995-2000	2000-2005	2005-2010	2010-2015	2015-2020	2020-2025	2025-2030
Average annual rate of rural change (percent)	2.06	2.29	2.04	1.71	1.8	1.64	1.46	1.53	1.12	0.92	0.84	0.57	0.31	0.02	-0.33	-0.72
Average annual rate of urban change (percent)	4.66	4.89	4.58	4.15	2	1.08	1.27	1.4	1.01	0.81	0.73	1.13	1.54	1.91	2.22	2.5

Fig 1: Average annual rate of urban and rural population change in Sri Lanka: 1950-2030 projections
Source: UN (2004, pp 208-227).

In terms of absolute numbers, however, Colombo-centred Western provinces have taken the brunt of the migration flow. In 1981, for example, the urban extension of Colombo metropolitan area was only 699 km2 in land area – or just 1 percent of the country’s land extent - but had accommodated approximately 1.7 million people, or 11 percent of the island-wide population. By 2001, the population of Colombo had risen up to 2.25 million, making it one of the most densely populated areas in South and East Asia.

Although it is inhabited by several million people today, the city of Colombo was created over 100 years ago for a city population of 35,000; it was first planned as a fortified ‘harbour city’ and then as a ‘garden city’ during the latter part of the British occupation. With the plantation economy (established in 1830), Colombo Harbour became the main economic focus of the city. The fort area was later developed as the Central Business District and linked to the rest of the country through an arterial road system (structured around Old Negombo road to the North, Kandy Road to the North-east, Kesbewa Road to the West, Awissawella Road to the South-west, and Galle Road to the South). With population increase, new suburbs expanded along these arterial roads, leaving previously high residential areas of Colombo occupied by low-income families. Meanwhile, starting in the mid-1950s, available undeveloped inner-city land started undergoing a process of progressive saturation with slums and squatter settlements inhabited by those who had come to the city in search of work with harbour-related enterprises. Government land reservations along infrastructural lines and water retention basins within and around the city (e.g. railway lines, canals and marshes) would be targeted next.

Besides informal settlements, urban population growth has also generated ribbon development along commercial routes. The small towns located along regional arteries, in particular, are morphing into continuous commercial strips without apparent structure, spatial hierarchy and harmonized land use planning (Prematilleke & Senanayake 1999, p 64). The urbanization of these towns - and their subsequent expansion along arterial routes - has resulted in many environmental challenges, especially when low-lying areas and sensitive wetlands are tagged for commercial, industrial and residential uses.

The morphology of arterial towns: Performative failures of urban building stock

One of the major complications of these unplanned arterial commercial developments is the proliferation of substandard buildings embedded with inferior technical, environmental and formal performances. Increasingly, urban buildings are built with little or no regard to local climatic conditions, environmental protection, structural integrity, proper servicing of water and electricity, and the need to respond to the visual and cultural dimensions of the city; not only such buildings are visually repugnant, they are also subjected to perilous technological failures.

Fig 2**:** Contemporary, urban, commercial vernacular
Source: Authors

In developing countries, where the framework of building production is mainly a tacit one, technological system failures occur more due to inadequacies in economy-dependent and culture-inflected applications. A fine example is the use of curtain wall glazing as a wall assembly system for urban commercial buildings; a glass-skinned facade wrapped around an economical concrete skeleton epitomizes the typical commercial building form propagating in urban Sri Lanka (Fig. 2). However, the application of such sophisticated building system, within the cultural and economic limitations of the local building process, has resulted in an error-filled, sub-standard building element, with obvious detriment to the durability of the building stock.

Indeed, the prescription of highly glazed façades is problematic in tropical climatic conditions. Inefficiencies related to solar gain control and subsequent greenhouse effects are high in the tropics where buildings are directly exposed to the sun. The mechanical solutions employed to overcome the subsequent thermal and visual discomfort will result in higher energy costs and an increased ecological footprint for the building.

But this situation is further heightened by the lack of proper application of the system in developing world industrial environments, especially in the low-cost sectors. Glazed curtain walls differ from storefront systems in that they are designed to span multiple floors, and take into consideration thermal expansion and contraction, building sway and movement, water diversion and, of course, thermal efficiency for cost-effective heating and cooling. Crucial to the performance of curtain wall technology is the 'rain-screen principle', which is based on the equilibrium of air pressure between the outside and inside of the 'rain-screen' to prevent water penetration into the building.

In order to achieve such equilibrium, the glass is captured between an inner and an outer gasket in a space called the glazing rebate. The glazing rebate is ventilated to the exterior so that the pressure on the inner and outer sides of the exterior gasket is the same. When the pressure is equal across this gasket, water cannot be drawn through joints or defects in the gasket (Anderson & Gill 1988, p 60). In a proper application of the curtain wall technology, these gaskets come as part of one composite system along with extruded aluminium framing, infill glazing and the sub-framing required to fix the system to the main building structure.

However, the operational barriers of low-cost and low-skilled construction settings in developing countries often result in the partial application of the technology, theoretically and/or practically. On many projects, sizing and installation of framing members and glazing are performed at the job-site, and often have the glazing span between the floors like storefront systems because of the additional cost and engineering knowledge required to develop more complex sub-framing mechanisms to hang the glazing curtain externally. Attempts to do so without proper procedures or investment can lead to failure chains.

Another problem is the use of sub-standard materials. Exposed glazing seals and gaskets, for example, need to be built well in order to minimize water penetration through joints. Yet, in hot tropical sun, sub-standard sealants tend to melt and expose the wall to air and water infiltration through gaskets, loosening of glazing at mullions, and destabilization at the fixing of mullions to the super-structure – especially where the glazing spans between floors and the direct connection between superstructure and mullions are stabilized by sealants. While air and water infiltration through a curtain wall is acceptable within limits, heavy penetration can lead to substantial heat losses and affect cooling costs. Generally, removal and replacement of perimeter sealants require meticulous surface preparation and proper detailing, skills that are scarcely available on conventional construction sites.

Joints, in fact, prove to be most problematic in curtain wall glazing, especially when integrating other building systems into the wall (e.g. operable windows, or vents and louvers to areas where mechanical equipment inside the building requires ventilation or fresh air to operate). Attempts to insert mechanical air conditioning units through curtain wall glazing with disastrous outcomes are common occurrences in urban Sri Lanka. Within typical construction sites, it is rare to come across the skill and precision required to implement such a task. Moreover, it is not only the skills, but also the technical specialist knowledge that can be found lacking. For example, fire stopping at the gap between the floor and the curtain wall is essential to slow the passage of fire and combustion gases between floors. In general, spandrel areas must have non-combustible insulation at the interior face of the curtain wall. Some building codes even require the mullion to be wrapped in heat-retarding insulation near the ceiling to prevent the mullions from melting and spreading the fire to the floor above.[139] Yet, such practices are ignored in large parts in the low-cost building sectors, where building codes are rarely given due consideration in light of the operational thresholds they entail.

The idea of Typo-morphology: The background, definitions and derivations

In order to understand such socio-technical predicaments, situations and patterns of the contemporary commercial building production, this study has referred to the notion of 'typo-morphology'. In general, the term 'typo-morphological study' signifies an assessment of a physical landscape focusing on the cultural and technical production of its built forms and building types. As discussed earlier in this paper, the process of urbanization defines the built forms as well as social patterns, economical structures and technological dimensions of the existing urban agglomerations. Even though a cultivated debate is simmering within the academia and practice on the ideas of urbanism, urban planning, and the patterns of urban settlements, there is a visible gap on the study of contemporary commercial building forms, especially in the context of the linear expansion of arterial towns in the developing world. Given the continuous physical and technical degradation of such urban agglomerations, it is indeed puzzling that no proper studies have been done on these situations.

Understanding the dynamic transformation of commercial building forms in arterial towns however, requires a change of intellectual attitude and academic interpretation. In most of the contemporary situations, professionals and academics identify, interpret and create the image of the developing-world city as one that is dominated by west-centered global forces and process-blind imitation of the alien urban paradigms. In countries like Sri Lanka, however, the urban built fabric has inevitably become a by-product of the bottom-up, vernacular building tradition based on the availability of material and labour, and the popular know-how of construction applications. In such a cultural and technical context, the key questions that become central to a broader investigation on the arterial building fabric would be: (1) what are the formal conditions that this form of vernacular produces in our towns, (2) what are the types of building elements appropriated in such application of popular building practices, (3) what are the types of relationships it creates between the street, building, and the construction systems, and (4) what are the technical, functional and cultural repercussions of such an informal building process.

In a very concise interpretation, the concept of typo-morphology explains the physical and spatial structure of cities; it is the study of urban form derived from studies of typical spaces and structures. Such studies can be referred to as being both typological and morphological at the same time, because they describe urban form (morphology) based on a detailed classification of buildings and open spaces by type (Typology).

> Typo-morphology is an unusual approach to the urban form. First, it considers all scales of the built landscape, from the small room or garden to large urbanized area. Second, it characterizes urban form as a dynamic and continously changing entity immersed in a dialectic relationship with its produces and inhabitants…….. typo-morphology offers a working definition of

[139]. International Conference of Building Officials (ICBO), 2007, ***2007 California Building Code, Title 24, Part 2***, pp 153-161

> space and building types, and serves as a rich launching ground for studying the nature of building design, its relationship to the city, and to the society in which it takes place.
>
> Moudon, 2007: 257

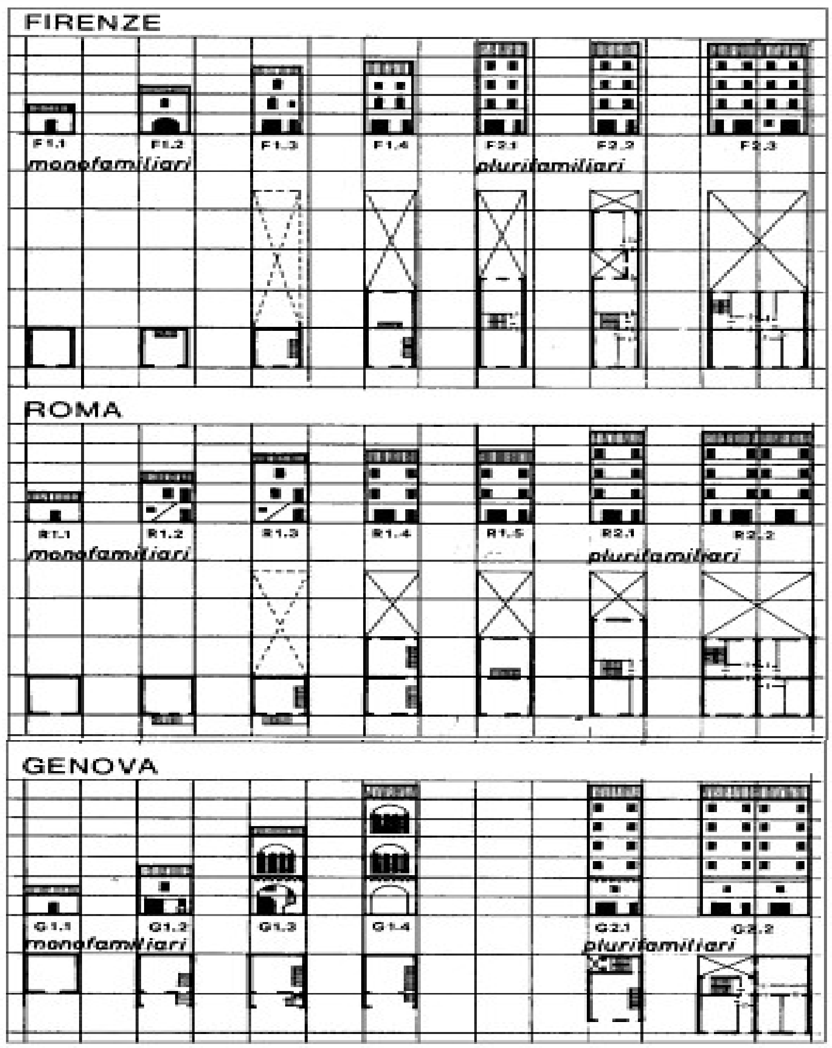


Fig 3: Reconstruction of the diachronic transformation of basic building types in Florence, Rome and Genova
Source: Caniggia and Maffei (2001)

According to Larice and Macdonald (2007), typo-morphological study is a systematical analysis of urban fabric where the subsequent typo-morphological information can be used as the basis for the design of new built forms. Since all types of built forms are fundamentally linked with social practices and process, the study of typo-morphology of the built environment enables us to understand, evaluate and reorganize social practices related to the built form. Moreover, in typo-morphological studies, the reading of the landscape does not simply comprise of classifying different elements of the built form by type; it also comprise of reforming the transformation of these types over time. For example, Fig 3 depicts a typo-morphological study by Caniggia and Maffei (2001), where the gradual transformation of basic building types in the Italian cities of Florence, Rome and Genova is identified, analyzed and classified.

In summary, ‘typo-morphology’ – as specific to this study – is a concept that brings together the studies of ‘typology’ and ‘morphology’ to elaborate a research position that looks at the types and meanings of built forms emanating in Sri Lankan arterial towns. While the focus of the study is essentially about the different social, technical and cultural forms of buildings (morphology), such analysis cannot be divorced from the classification into types (typology) as the diversity of types has resulted in a diversity of forms. While this description of the term ‘typo-morphology’ gives us a basic understanding of its concept, different authors have interpreted it in different ways depending on the context within which they have evaluated it. In order to establish a specific methodology of analysis, this study sought to impinge on Gianfranco Caniggia’s definition of the term ‘Typo-morphology’. Due to the space limitations of this paper, a broader explanation of that particular selection is unable to carry out here. However, following description of Caniggia’s definition will convey the necessary reasons why it has been preferred over the others.

In particular, the key reason for this study to impinge on Caniggia’s definition is its different scales of analysis; it is a simple definition of the term, which allows us to look at different urban grains – i.e., from the city to street, street to buildings, buildings to systems, and systems to elements, etc. Since the purpose of the study was to identify and classify different cultural and functional responses of contemporary commercial vernacular*,* such a scaled analysis from city to building elements was required to isolate different types of building conditions, situations and responses.

According to Caniggia’s position, the form of the city is established by seven interrelated “built objects” namely, the region, the city, the group of building, the building, elements, structures and systems. These seven objects - at seven different scales - relate to each other to define the form of the city. Moreover he believes that the establishment of typologies is the basis for understanding the making and the design of the city and its architecture (Moudon, 2007, pg.259).

Typo-morphological studies of Sri Lankan arterial towns: The methodology and outcome

In order to identify the existing conditions of the contemporary building practices in arterial commercial developments, a methodology is derived based on the notion of typo-morphology and the subsequent study of building forms, types and technical responses. This selected methodology looks at the physical organization of building forms and technical systems with respect to the reciprocal relationships between the street, the building and the building systems/elements. Hence, Cannigia’s first three scales of typo-morphological analysis – namely, region, city, and group of buildings - are omitted from this analysis due to word limitations as well as their irrelevance to the broader objectives of this paper. More specifically, the key objective of this paper is to develop a framework to investigate how commercial buildings in Sri Lankan arterial towns response to specific functional, environmental and technical situations of their production, as opposed to exploring semantic meanings of how they reflect the conditions of their larger physical region. Therefore, the outcome of this paper is limited to identifying different types of responses in the way in which urban commercial buildings react to the technical and functional thresholds between: (1) street vs. building form, (2) building form vs. building structure, and (3) building structure vs. building systems/elements.

As ideal-typical case studies for the research, three arterial commercial towns with varying scales of geographical and administrative relevance have been selected as follows: (1) Kegalle (Fig. 4) - a tertiary level town and a provincial secondary, which is also a large scale commercial strip located along Colombo-Kandy trunk road, (2) Pilimathalawa (Fig 5) - an average scale commercial strip along Colombo-Kandy trunk road, and (3) Madawala (Fig 6) - a small scale commercial strip located outside of – but in close proximity to - the arterial connection between Kandy and Matale.

Accordingly, the specific scales of the case-study selection refer to following logic: (1) a provincial secondary located along the arterial road connecting a provincial capital with the primate city, (2) a typical, average town located along the arterial road connecting a provincial capital with the primate city, and (3) a small town located outside of the arterial roads connecting provincial capitals with either the primate city or a provincial secondary. From each of the above three towns, five buildings were selected randomly to form a sample of 15 buildings for the case-study exploration; the chosen building typology is low/medium rise (1 to 4 storey), commercially-used building structures with a minimum of 4m street frontage.

Fig 4: A segment of Kegalle ribbon development
Source: Authors

Fig 5: A segment of Pilimathalawa ribbon development
Source: Authors

Fig 6: A segment of Madawala ribbon development
Source: Authors

The subsequent case study analysis has resulted in the following classification of typological patterns.

(1) Street vs. Building

The relationship between the street and the building is a key factor in making the building part of its immediate physical and social context. On the one hand, the entrance of the building has a considerable ability to furnish a strong physical presence and a visual message at the street level. On the other hand, the threshold between the street and the building must be resolved well in order to facilitate proper physical and social use of the building. The study has identified three typological patterns of the way this threshold between street and building is resolved in the selected commercial arterial strips.

(a) No demarcation (Building as an extension of the street)
In this situation, the activities of the building are extended to the street. User can identify the building's function by observing the extended activities than what is communicated through the building structure, systems or elements. Often these buildings have aggressively encroached the pedestrian movement paths, while failing to build a strong physical and formal presence at street level.

(b) Third space
Some buildings have established a 'third space' at the entrance as a strategy of physically separating the street and the building. Activity wise, this 'third space' relates neither to the building not to the street, and has its own functional and social meanings. In most occasions, these spaces have dominated the building at street level, and contributed to establishing proper physical and social use before entering into the building; different strategies have been used to define this third space, such as introducing level changes, raised platforms and demarcating the space by unique paving strategies, allocation of specific functional uses between the street and the building, and erecting canopy structures to volumetrically define the space, etc.

(c) Infill structure
The third typology identified under this segment concerns with erecting an image-enhancing structure between the building and the street as a way of making the building visible long before reaching it. Accordingly, the main objective of these in-between structures has been to construct a formal image for the commercial activities that are housed inside the building proper. While few of these structures have positively merged with the street elevation, most remain as isolated objects, competing with each other and contributing to the unwanted visual clutter of the street. There have also been situations where this infill structure acts as an additional environmental protector for the building.

(2) Building vs. Structure

The relationship between the building and its structural system is also a key factor, which determines the form of the building as well as its eventual technical performance. There is certainly a visual dimension in the selection of the structural system for a building, although it is first and foremost determined by other socio-economic factors such as the spending capacity, available know-how and workmanship skills, expected speed of construction and the functional program of the building. This study has identified four key typological patterns governing the choice of structural systems in contemporary commercial vernacular.

(a) Monolithic structures
These are uniform - or homogeneous – structures, often built by using load-bearing structural walls following a traditional, ground-up building strategy. The whole building works as a

monolithic structure in terms of its structural performance and the subsequent load-transferring functions. The key limitation of such structures is mainly due to restrictions in building height, as the structural loading is determined by the strength of ground floor walls; also, the process of incremental building is restricted and there is little flexibility in material choice.

(b) Layered structures
In this construction approach, building systems are introduced to the structure as vertical layers as opposed to the horizontal ground-up building strategy of monolithic constructions. These buildings use a structural skeleton as the load-bearing component (often, a concrete beam-column frame) and rest of the buildings systems (such as infill brick walls, window mullions, glass facades, steel façade claddings, advertising panels, etc.) are introduced to the building as non-load bearing vertical layers. Layered buildings enjoy a great variety of material choice for their non-load bearing, external environmental skin.

(c) Transformed structures
These situations occur when existing buildings are transformed into new uses, forms and aesthetic configurations. In this process of transformation, buildings could end up having more than one structural system; monolithic buildings, for example, can be seen extended and transformed into layered buildings without demolishing the original structural components. Such buildings can also be identified as hybrid buildings. Generally, performance errors are high in such interventions, as the task of combining the old with the new requires advanced levels of technical and formal skills.

(d) Historical structures
Arterial commercial towns also contain buildings that are older than at least 50 years but still remain without transformations to their building form, structure or facade. Most of these buildings now contain new uses; hence, problems can be seen in adopting the old layouts into new spatial configurations. In some cases, considerable work has been done for the internal spatial layout, but the external form remains mostly untouched except for the introduction of advertising panels, security doors and shading canopies, etc. From a formal point of view, most historic buildings are seen as physically-isolated and visually-contradictory structures amidst the ever-changing commercial character of the adjoining built fabric.

(3) Structure vs. Systems and Elements

The systems and elements of a commercial building define the overall visual image of the building, while contributing to build positive or negative relationships with the street and its commercial landscape. But more importantly, building systems and elements have a crucial role in maintaining proper technical and environmental performance of the building. In particular, the jointing of building systems with the primary structure (and each other) - and the subsequent material selection for individual systems and joints - play a key role in upholding the expected visual and technical performance of the building. This study has identified three typological patterns governing the selection and jointing of building systems/elements in commercial buildings.

(a) Symbolic purpose

These are the situations where systems and elements have been incorporated to buildings to decipher a symbolic message of their commercial function. Two types of such interventions can be identified in commercial towns. The first type consists of mere add-ins, where symbolic building systems/elements are joined to buildings as external attachments; these elements do not have any significant technical function other than to express and emphasize the intended commercial image of the building. There are less technical problems in jointing these elements to the building because the primary structure remains unchanged, although environmental errors can be seen where the external elements are fixed to the main building. The second type relates to situations where the whole building stimulates a symbolic gesture. In such interventions, building systems are designed to assimilate a symbolic effect, in addition to their general use in the building as technical, structural and environmental supports.

(b) Functional purpose

This typology of building systems and elements is used in buildings to primarily fulfill a functional aspect as opposed to a symbolic purpose. There are very little external/symbolic attachments in these buildings, and the building systems and elements perform only their intended structural and functional uses. For example, the structural system is only used to transfer building loads, the door systems are applied to let people in and out, the window systems are there to bring light into the building, etc. While these systems generally satisfy their functional purpose, they often tend to fail from an environmental and aesthetic standpoint. In other words, this is a one-dimensional, function-specific approach pursued for organizing building systems with limited economic and intellectual possibilities.

(c) Environmental purpose

This signifies the use of building systems to primarily act as an environmental barrier to protect the interior against direct sun, rain and other external elements. As explained earlier in this paper, a high majority of commercial buildings in arterial strips have not responded adequately to the local climatic conditions; the most of performative errors in such buildings emanate as an outcome of not giving adequate thought to resolving the subsequent environmental joints. For example, not using proper and durable silicon joints have resulted in water seeping through external window mullions and wall systems; glass facades in general work negatively in tropical climate due to high solar gain and subsequent green house effect; roof gutters and flashing are not properly sealed, thereby allowing water to leak between the roof system and wall system; the fixing of frameless glass to concrete structures have not considered different expansion rates between concrete and glass.

Evaluating the preliminary outcome: In search of technological robustness

Examining the aforementioned typo-morphological classification of commercial building production reveals that the contemporary building delivery process is conditioned by both positive and negative attributes. On the one hand, the performative problems of the building stock are not only expanding but also threatening to infuse long-term environmental costs, visual pollution and building failure, while struggling to build up a positive image to the user; most of the symbolic elements attached to commercial buildings are garish, competitive and confusing to the user, and have ended up being mere face-lifting structures of transformative and layered skins. On the other hand, positive responses in terms of spatial uses and technical resolutions can also be seen in the commercial strips subjected to this study. It is important to acknowledge both problems and potentials of these vernacular building responses in order to develop a bottom-up, design theory, which in turn may help us to overcome the current technical and formal predicaments of arterial towns. Following table attempts to list some of such problems and potentials identified in this study.

Table 8: Some problems and potentials of cotemporary commercial vernacular

Problems	Potentials
1. Transformed / layered structures have failed to respond to the local climatic conditions	1. The building process follows a speedy construction phase on site
2. Infill structures formally compete with each other; there is no spatial hierarchy, formal relationship or technical clarity of the extended facades.	2. High flexibility in material choice, especially in the layered type of buildings.
3. Extended functions at the ground floor build a negative relationship with the street	3. Ability to be built with available materials and local building know-how; not dependent on high craftsmanship
4. The purpose of the building do not often match with the built structure; poor visual dimension of the streetscape is a by product of illogically and incrementally developed structures	4. Positive spatial responses such as the 'third space' between the building and the street
5. Low or high symbolism has failed to build a positive relationship with the building as well as with the street	5. Some buildings have a capacity to work with building errors, without subjecting to building failure
6. Services are poorly carried out, often obstructing the front facade	6. Incremental way of building
7. Environmental joints are poorly conceived; lack of construction and workmanship skills are evident through out the selected arterial towns	7. Innovative resolution of technical and environmental joints

Above summary suggests that the technical and formal problems of commercial arterial developments can be largely attributed to the industrial uncertainty caused by the lack of intellectual and financial resources, as well as the break down in local knowledge transferring platforms; this situation has resulted in the propensity for increasing building failures in the urban building stock. When referring to the ability of industrial actors and organizations to counteract building failures in the UK, Steven Groak states:

> Phenomena such as building failures may be construed as symptoms of technological change, where organizations are not able fully to cope with the turbulent environment in which they must operate, that is, the organizations do not have adequate strategies for reducing the effects of uncertainty upon them
>
> Groak, 1990: 165

Since building failures occur when a reliable good practice becomes less reliable, or less robust technologically, stability must thus be introduced. For Groak, the way to industrial and technological stability passes through normative action in the form of explicit, prescriptive instructions that create barriers to operational mistakes (Groak 1992, p 169).

However, any idea of '*robustness*' relevant to building production in the developing world has to incorporate caveats and consider fundamental deviations from the path indicated above.

On the one hand, there is a concrete danger that professional withdrawal into segmented niches of activity end up reinforcing *technological barriers* between spheres of production, thus obliterating any capacity for technology transfer as well as connections in training, know-how and career development paths. On the other hand, building production activity in the developing world is by-and-large a tacit knowledge-led process characterized by informal links and mechanisms: in the assembly of the workforce, in the dissemination and acquisition of knowledge, and in the (little) respect displayed for explicit regulatory frameworks.

This dual factor suggests that introducing restrictions and qualifications in the technological environment of construction in the developing world may have calamitous consequences for the industry. On the contrary, developing countries may need a technological framework conceived to provide operational stability to the industry within broad enough boundaries, while responding to pressing building demands yet without increasing formal complexity. The existence of a broad-based, non-exclusive and tacit knowledge-receptive structure would allow all workforce – that is professional, industrial, formal and informal labour – to travel across construction markets and contribute to the activities within.

This, however, can only be done if the operational limits established by the technical, cultural, and economic frameworks of building can be extended to make wider and scalable technological options available for any given project. In practical terms, such an objective translates into the definition of technical options that can tolerate changes in the economic variables of projects on the one hand, and manage the intricacies of buildings' cultural and technical attributes on the other. This double ability is what this paper considers as appropriate 'technological robustness' (Pathiraja & Tombesi, 2008).

Conclusion

With reference to the growth of London in the 1800s, Clarke states that it was the building production process and labour divisions that determined how and when housing and other buildings were placed, built and consumed (Clarke, 1992). There is no reason why such intellectual position cannot be applied to the highly urbanizing economies of today, while keeping in mind the characters of their production networks and labour markets; to address the consequences of urbanization from a built environment perspective, it is important to understand patterns of social behaviour as well as changes in the technological environment and the building labour process. It becomes also necessary to understand how these changes transform social relations within building production and the subsequent efficiency of the building delivery process, both quantitatively and qualitatively.

Hence, countering the 'urban development' goals pertaining to the construction- and performance-specific conditions discussed here will require a two-phase response.
Firstly, typo-morphological studies of the existing urban fabric must be carried out in order to determine the technical and functional behaviour of its building stock. Such study will reveal that, despite the apparent monotony, sameness and uniformity, there can still be a kind of indigenousness in the physical forms of urban commercial strips; more importantly, lessons can be learnt from the emerging commercial vernacular building types, forms and constructional responses.

Secondly, a design theory addressing the building challenges posed by urbanization must be developed by comprehending and appropriating the organization, skill-base and internal links of various industrial actors and processes that make up the industry, because it is only within this scale that the rationale and the means for action can be found and possibly activated. In order to avoid the technical and cultural failing of the urban building stock, the development of this design theory must be based on the idea of 'technical robustness': a technological framework that can tolerate different economic variables of building projects on the one hand, and the complexities of buildings' cultural and technical attributes on the other.

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