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THE RULES OF CONSTRUCTABILITY

AIM

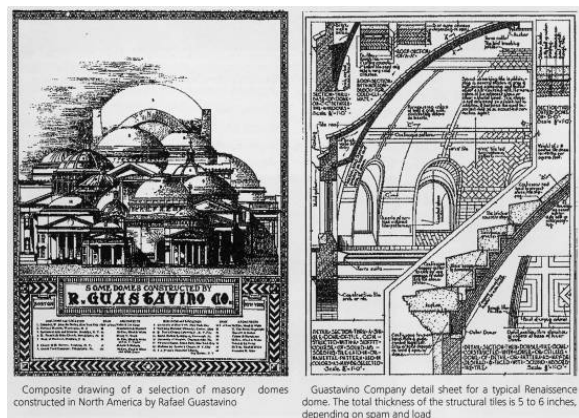
Building construction technology seems to have recognisable rules that differentiate it from other technologies for producing material goods. Construction technology uses a little material, a little energy and a little knowledge to provide specific responses to problems that have arisen at certain times and places. It is important to identify these specific characteristics of construction, and the dynamics of its evolution, as they affect many aspects of current innovations. Many new construction products are launched on the market every day, but few survive. Those that fail probably do not comply with some rules of the art of construction. In addition, it is important to be vigilant for the following reason. The environmental needs of our planet in the next few years may make it essential to incorporate new construction materials comprised of organic matter and recycled goods or even to recover abandoned materials. If these new products do not meet the rules of constructability, we will probably not be able to attain sustainability itself.

METHOD

It is as important to know which questions to formulate as it is to give appropriate answers. On the Architecture Technology, Construction and Urbanism Doctoral Programme, which is taught by the UPC's architecture schools, we study these topics and thus boost students' abilities to observe and analyse the reality.



The Catalan vault or flat brick arch is a construction system that was introduced anonymously (2) in an area of the western Mediterranean coast.



Composite drawing of a selection of masonry domes constructed in North America by Rafael Guastavino

Guastavino Company detail sheet for a typical Renaissance dome. The total thickness of the structural tiles is 5 to 6 inches, depending on span and load

At the beginning of the 20th century, a Catalan architect called R. Guastavino emigrated to the USA, patented the system and industrialised it. However, the technique had fallen into disuse by the 1960s.

01. Why does construction always vary according to time and place?



In time and space, materials, energy and knowledge have been combined in various ways to respond to the problem of human habitability, in the form of buildings. However, habitability is also a problem that evolves as it involves many environmental, individual and social aspects. If habitability varies, the associated construction technique probably has to alter too.

02. Why do many products that are launched on the market never succeed?

Some products last, such as brick.



Some products do not last, despite good intentions. .

It is important to know the technical rules that affect the success and durability of a product and its associated technology. Some new products that are offered with the best of intentions do not survive, whereas other opportunistic and incidental products continue to be used in the sector for a long time.

03. How does a material become a construction product?

Logs of wood were cut to the same length and split longitudinally to create this singular facing.



An example of facing comprised of prefabricated sheets of cast aluminium. This is technically possible, but unusual.

We have constructed buildings from organic materials and from totally synthetic materials, but we still do not know what materials we will use in coming years, given the future availability of resources, the environmental impact and prospects of hybridisation.



Waste sheet glass, piled up to form a load bearing wall.



Construction with bags of sand has clear advantages that have only been explored in emergency situations.

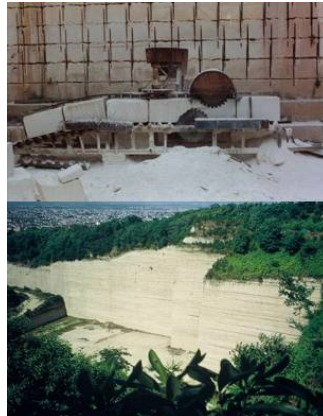


There have been attempts at completely pneumatic constructions, using new translucent materials and integrated installations.

What are the answers to these questions and, by extension, the rules of **constructability**, with respect to the corresponding construction systems that have been developed?

10. The most appropriate shape and size for a construction product

View of a quarry in Menorca

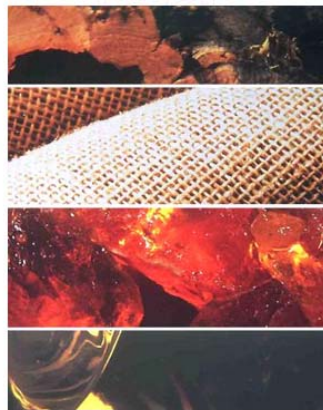
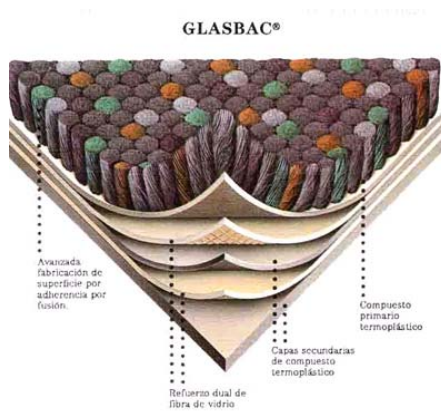


Stone has played an active role in the construction sector for many years, probably because it is available in all possible shapes and sizes.

One of things that characterises construction is that any material can appear in practically any shape and size.

View of a quarry in Naples

11. A construction product must be dimensionally stable



Textiles are one of the most technical construction materials, but they have always been difficult to incorporate into the construction sector due to their lack of dimensional stability: they must be tightened or attached to a stable support structure to ensure that this quality is maintained.

12. A construction product must be safe and ergonomic when it is installed



Large problems are resolved with large tools, such as borers.

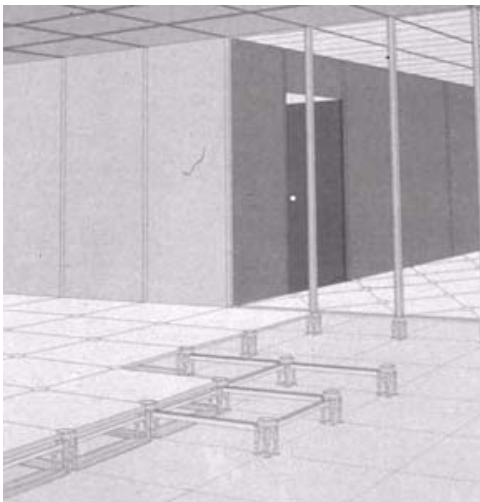


Manual skills still play an important role in construction: hand tools are increasingly sophisticated, and act as an extension of hands.



Amorphous materials continue to be an attractive alternative because they can be suspended where they are needed.

13. The dimensions of a construction product must be easy to coordinate



Construction is an open market. Any product may reach a construction site and come into contact with another unknown product. The first problem that arises between different products is that of dimensional coordination. Cutting, generating trimmings, filling in joints, levelling, etc. are common activities in construction and are likely to remain so in the future. In the same construction site, we can find components such as windows and the irregular blocks used in foundations.

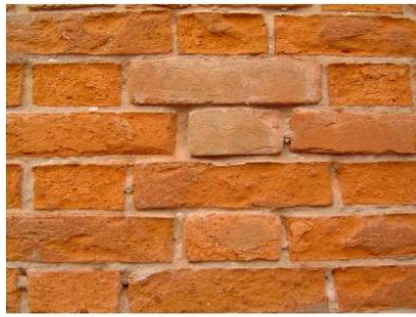
14. A construction product must be versatile



The construction sector uses highly specialised products alongside extremely versatile products. As this business sector is fragmented in time and space, versatile materials tend to be successful. The advantage of such products is that they give fast results, even though they may not be as good technically. Commodities in the sector, such as bricks, paint, steel or cement, are available everywhere.

Silicon sealants are always found on construction sites.

15. Construction products must be compoundable



Units of construction products must be able to be added to other units of the same product to form bigger construction elements.

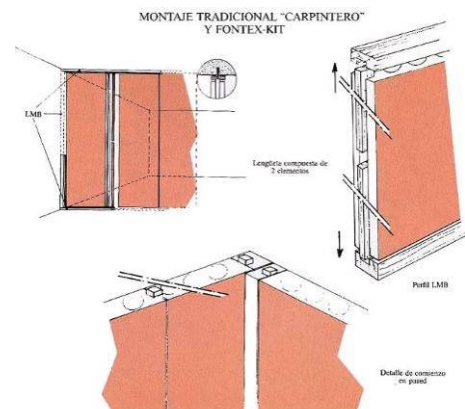
This characteristic led to the emergence of modular and prefabricated buildings.

The construction of historic buildings was made possible by the technique of adding small elements to each other.

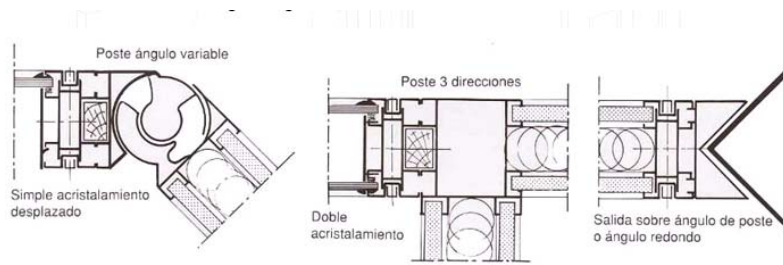
20. THE MOST SUITABLE JOINTS FOR A CONSTRUCTION PRODUCT

When a new product is developed for the construction market, its viability is largely dependent on whether it involves a system of joints that are secure and easy to make and tighten.

Chipboard panels have an independent system of end joints that have replaced traditional wood joints.



21. The joints formed with a construction product must remain rigid

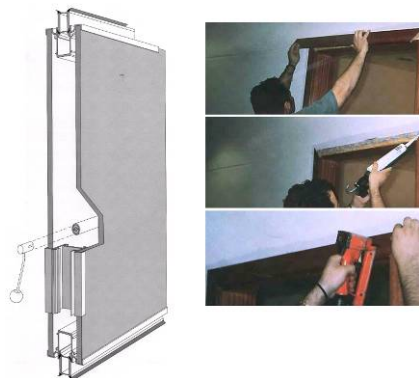


Permanent buildings must be particularly rigid. Resistance is relatively easy to attain, but the requirement of rigidity is more difficult to meet.



In some cases, the rigidity is only partial, as in the images shown here: an inner partition, a reinforced concrete pillar or a drain.

22. A construction product must be easy to install



Most new construction systems are based on joints formed by very simple activities (impact, a quarter turn, securing, etc.)

Moveable partitions are fixed to the ground with a quarter-turn lever. Carpenters now use pneumatic staplers instead of nails.

23. The installation of a construction product should not be highly dependent on environmental conditions



Construction systems are greatly affected by the environmental conditions at the time of their installation: rain, wind, sun, dust, etc. The most sophisticated systems can only be used in the workshop or inside buildings.

Whilst the foundations are laid and the infrastructure is put in place, the environmental conditions are extreme. This affects the construction techniques that can be used.

24. Construction products must be ready for immediate use



Immediacy is a key factor in the current times. Products that need time to dry or grip once they have been assembled are considered inferior to solutions that can be used immediately, almost without running-in.

Modular carpets have had significant commercial success as their joints are rapidly ready for use. This speed is highly valued in interior construction.

25. A construction product must be installed in a similar way to existing products



Each product is associated with a particular technology and environment. When a product's installation involves innovative or improved processes, many teams of labourers have to acquire new habits or change their existing ones. This is easier to achieve if the new proposal is similar to existing systems.

Construction workers have a great ability to adapt, as techniques that are commonly used in construction processes are frequently similar.

26. The product should be installed with tools that are universal, light and inexpensive



The characteristics of tools have a major impact on the dissemination of technology. For example, the cost, transportability and universality of laser levels has led to an increase in their use, which is not the case of polymer welding on building sites.

The increased popularity of ceramic tiling has led to more use of cutting tools and serrated plastering trowels.

27. A high level of specialisation should not be required to install the product



Building construction has always required a lot of labour and resisted early processes of industrialisation. Consequently, labourers may have a low initial level of specialisation. Any new technique should take this into account.

The construction sector still uses manual installation techniques. This fact is not fully understood outside of the sector.

28. The installation of the product must be reliable



To date, construction has been characterised as having a high level of reliability. Nevertheless, there are large amounts of each product and, as a result, anomalies will always occur. However, the severity of these anomalies rarely leads to a building being put out of service.

Poured resins, with their close links to science, have tentatively entered the construction sector under a scientific guise. They left the laboratory to enter a little known sector, and are now used in domestic settings.

30. NATURE OF THE MATERIAL



Despite our ability to transform materials or to create hybrids, many of the positive and negative characteristics of products are still due to the nature of the raw materials.

The characteristics of wood and glass can be found in all derived products.



31. The constituent material must be chemically and physically stable



Regardless of their origin, construction materials are subject to the physical and chemical action of the atmosphere. This includes both natural processes, pollution due to the use of various materials, and damage caused by contact with different materials.

32. Products must not be too dense



The density of construction products determines many of their properties. In general, this has led to a preference for denser products. However, in terms of the installation of products and their combined use, less dense products are more appropriate and better received (lower cost and environmental impact, and easier to handle).

33. The material that constitutes the product must be abundant, recyclable or renewable



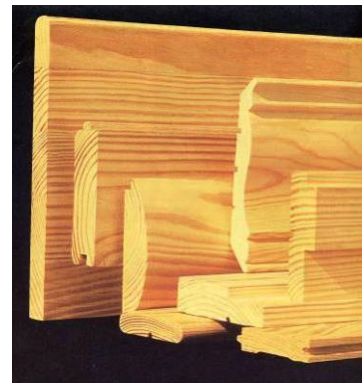
The availability of raw materials has been a limiting factor for all civilisations. Now there is a new situation: many raw materials are left unused in clients' houses or are thrown away. What should be done about this?

34. The quality of products should be constant, certifiable and easy to assess



Since the start of the construction industry, one of the challenges has been to ensure constant quality. This requirement has limited the use of organic materials and other traditional techniques.

In the future, a balance will have to be found between regularity and sustainability.



40. DEVELOPMENT OF CONSTRUCTION SYSTEMS



A product has no value unless it leads to a construction system that meets requirements. For thousands of years, animal hides have been used by nomadic tribes to cover their homes.

This technical solution is not used today, as no appropriate construction system has been developed for hides in the modern age. Many construction proposals use polymers to imitate the results produced with hides.

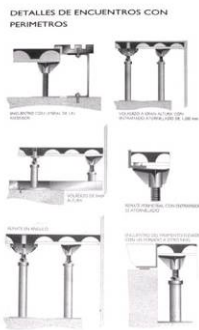
41. The product must offer solutions that can be adapted to each case and standardised

76/600 (46) 15+46+15	122/600 (70) 2x13+70+2x13	154/600 (46+46) 2x13+46+46+2x13	378/600 (90+90) 3x13+90+90+3x13
arena 40	arena 60	2 x arena 40	5 x arena 60
41,6 dBA	53,4 dBA	61,2 dBA	77,8 dBA

The use of a product in a building forms part of complex construction systems that are adapted to the requirements of each situation.

One of the strengths of laminated plasterboard construction systems is that hundreds of solutions with different features can be obtained using a combination of different boards and sections, which can be adapted to the requirements of each case.

42. The construction system must provide solutions for interior and exterior edges



All construction systems have a similar ability to provide solutions to common problems. However, they clearly differ from each other in the way that they resolve edges, both in interiors (openings, conduits, etc.) and exteriors (harmony with the rest of the building).

There is a wide range of different raised floor systems, but very few satisfactorily resolve all of the possible incidences.

50. THE RESULTING CONSTRUCTION SYSTEM MUST BE CLEARLY COMPETITIVE



In a market segment, one product does not replace another overnight. Competition between products may last for decades, as the level of competitiveness is very high and a competitive advantage is not always enough to justify a replacement.

One example is systems for cables. Despite their clear advantages, in 40 years they have not been able to completely replace the practice of cutting channels into walls of buildings.

51. The products that make up a construction system must come in a range of sizes

When a construction system is developed on the basis of a product, this material must be available in a range of sizes, so that it can be adapted to requirements in each case. Major twentieth century construction developments have been based on I beams, the diameters of copper conduits or the thickness of laminated glass.

Table 2.1.16. Profiles L16

Perfil	Aluminio	Acero	Plástico	Aluminio	Acero	Plástico	Aluminio	Acero	Plástico	Aluminio	Acero	Plástico	Aluminio	Acero	Plástico	Aluminio	Acero	Plástico
L16.01	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
L16.02	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
L16.03	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
L16.04	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
L16.05	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
L16.06	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
L16.07	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
L16.08	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
L16.09	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
L16.10	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
L16.11	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
L16.12	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
L16.13	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
L16.14	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
L16.15	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
L16.16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
L16.17	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
L16.18	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
L16.19	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
L16.20	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16

The range of metal sections was one of the first to be standardised worldwide, to provide the market with a product that is mass produced using a specific procedure, as required by the large, stable market.

52. The best products tend to incorporate tasks that had to be carried out separately in the past or they eliminate the need for these tasks



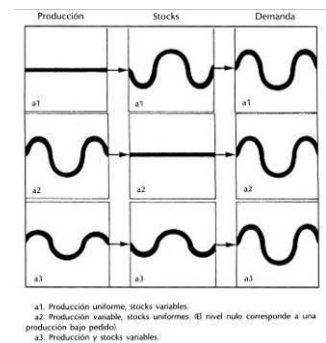
Composites are one of the most representative products of the twentieth century. The industrial capacity to laminate various flat materials to obtain one panel that has the same properties all over has become an extremely important resource. Whenever a construction process involves the successive aggregation of flat products by different labourers, there is an opportunity for generating a composite.

Many examples of composite products are found in roofing, which involves structural requirements, as well as a need for impermeability and insulation.

53. The success of a product depends to a great extent on its distribution chain

Most texts on the industrialisation of construction stress the difficulties that the construction sector has in adapting to cycles of manufacture, distribution and consumption. The most rigid techniques should also be used in other sectors, to compensate for fluctuations in construction. The techniques that have the most flexible production, distribution and construction stages are most likely to persist.

It is fairly common to find new products that take advantage of synergies in the production, distribution and consumption of other products, in order to survive fluctuations in construction.



54. There must be a balance between labour and capitalisation



In the past, the construction sector was not capital intensive, which enabled the indiscriminate entry of many companies that use a high amount of labour. Gradually, some capital-intense techniques are being introduced.

Cement that is produced in a central plant is one of the few capital-intensive techniques that is widely used.

55. The best products are those that can easily incorporate other products



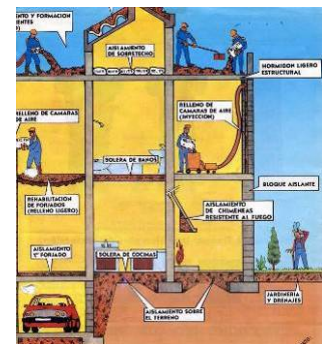
Suspended ceiling solutions have a great capacity to house other systems, such as air conditioning, lights, safety features and speaker installations. These elements must be accessible.

Installations with cables needed to be correctly inserted into construction systems.

56. A good product must be able to absorb its own and other tolerances

From a technical perspective, construction is a melting pot of many technologies applied by various groups with different precision. Thus, a great effort must be invested in improving the geometry of an element, so that the next group of labourers can work easily on top of it.

Expanded perlite is a construction product that does not have very solid features in itself. However, it has an extraordinary capacity to regularise existing geometry, whether it is used dry or in agglomerates.



CONCLUSIONS

- Most technicians work with materials and techniques that they are familiar and confident with, but they have probably never asked themselves why they do not use different methods.
- Construction techniques seem to have been distributed around the world in the same way as other norms of consumption: societies in the developed world impose their practices on less developed countries, due to the technical dependence that arises. We do not consider whether these techniques are the most appropriate, in other words, whether they would be successful without the pressure from the developed world.
- Diversity in construction represents a kind of heritage that should not be lost in these times of globalisation. The future challenges that construction techniques will have to tackle are not yet clear. All the construction techniques that we know of have been capable of expanding and persisting, which proves their utility.
- Construction is closely related to the civilisation that supports it and is therefore difficult to “transplant”.
- Should diversity in construction be allowed to continue? Is a change of focus required? Or should construction be regulated with CE marking and technical suitability documents, etc.?
- Construction is noticeably opportunistic in its time and place.
- Construction is highly diverse, varied and constantly moves towards greater complexity.
- Construction behaves like an ecosystem in constant controlled disequilibrium.

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