CODES AND SPECIFICATIONS AS APPLIED TO HISTORIC PRESERVATION PROJECTS

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INTRODUCTION

The most difficult task for an engineer is to learn in the process of restoring historic structures, to unlearn the habits of modern engineering that are based on Codes and Standards that look more like cookbooks and distance the engineering mind from understanding behavior and materials in their true nature. Engineering training promotes the systematic study of a problem in order to solve it. Basic science guides the engineer through the understanding of the effects of the surrounding universe in his life. In modern times building codes and lawyers equally affect the potential solution to a problem.

Therefore, in order to restore a building or structure the engineer must truly understand the times, knowledge and construction practices during the original construction, expansions, remodeling, and repair of it. In terms of preserving historic structures, engineers must unlearn the rigidity that modern codes and lawyers impose, and travel through time in order to really understand the context where the building was conceived, designed, and constructed and maintained. Modern education has shortfalls:

1. Code based and regulated
2. Safety issues
3. Lawyers driven
4. High level of specialization
5. Lost of Basic engineering science
6. Obsession with computers

In order to consider Rehabilitation and Restoration as an ART, it needs to acknowledge the need to strengthen, to alter or to add to a historic building to meet continuing or changing uses while retaining the building historic character and

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heritage. To understand the effects of modern codes upon historic structures it is needed to study historic standards that guided the development of structures in Europe and America.

**CODE OF HAMMURABI AND CONSTRUCTION**

The Code of Hammurabi is a well-preserved Babylonian law code, dating to ca. 1700 BC. It is one of the oldest deciphered writings of significant length in the world. The sixth Babylonian king, Hammurabi, enacted the code, and partial copies exist on a human-sized stone stele and various clay tablets. The Code consists of 282 laws, with scaled punishments, adjusting “an eye for an eye, a tooth for a tooth” (*lex talionis*) as graded depending on social status, of slave versus free man.

One nearly complete example of the Code survives today, on a diorite stele in the shape of a huge index finger, 2.25 m or 7.4 ft tall. The Code is inscribed in the Akkadian language, using cuneiform script carved into the stele, today on display in the Louvre, in Paris.

The code has been seen as an early example of a fundamental law regulating a government, a primitive form of what is now known as a constitution. The code is also one of the earliest examples of the idea of presumption of innocence, and it also suggests that both the accused and accuser have the opportunity to provide evidence. The Code’s provisions do not cover important areas of law and commerce. The occasional nature of many provisions suggests that the Code may be better read as a codification of supplementary judicial decisions of the king. Rather than being
a modern legal code or constitution, it may have as its purpose the self-glorification of Hammurabi by memorializing his wisdom and justice. Its copying in subsequent generations indicates that it was used as a model of legal and judicial reasoning.

In terms of Construction, it represents one of the oldest written standards. It is not a prescriptive code but some sort of a performance code, stating basically the punishment for failure in construction. For example:

- If a builder build a house for a man and do not make its construction firm, and the house which he has built collapse and cause the death of the owner of the house, that builder shall be put to death.

- If it cause the death of a son of the owner of the house, they shall put to death a son of that builder.

- If it destroy property, he shall restore whatever it destroyed, and because he did not make the house which he built firm and it collapsed, he shall rebuild the house which collapsed at his own expense.

ROME

Romans were famous for their advanced engineering accomplishments, although some of their own inventions were improvements on older ideas, concepts and inventions. Technology for bringing running water into cities was developed in the east, but transformed by the Romans into a technology inconceivable in Greece. The architecture used in Rome was strongly influenced by Greek and Etruscan sources. Roads and bridges were common at that time, but the Romans improved their design and perfected the construction to the extent that many of their roads are still in use today. Their accomplishments surpassed most other civilizations of their time, and after their time, and many of their structures have withstood the test of time to inspire others, especially during the Renaissance. Moreover, their contributions were described in some detail by authors such as Vitruvius, Frontinus and Pliny the Elder, so there is a printed record of their many inventions and achievements.

The buildings and architecture of Ancient Rome were impressive even by modern standards. The Circus Maximus, for example, was large enough to be used as a stadium. The Colosseum also provides an example of Roman architecture at its finest. One of many stadiums built by the Romans, the Colosseum exhibits the arches and curves commonly associated with Roman buildings. The Pantheon in Rome still stands as a church, monument and tomb. As a matter of fact the construction of the Pantheon’s dome was done in roman concrete, using three different types of concrete; normal medium and light weight. The Baths of Diocletian and the Baths of Caracalla are remarkable for their state of preservation, the former still possessing intact domes. Such massive public buildings were copied in numerous provincial capitals and towns across the empire, and the general principles behind their design and construction are described by Vitruvius writing at the turn of millennium in his monumental work De architectura. The technology developed for the baths was especially impressive, especially the widespread use of the hypocaust for one of the
first types of central heating developed anywhere. That invention was used not just in the large public buildings, but spread to domestic buildings such as the many villas which were built across the Empire.

Part of Hypocaust system in Pompeya’s bath house.
Notice the channels within the interior of the wall.

In all modern countries that were part of the Roman Empire, their historic construction was mostly influenced by their method and materials. Basically until the development of iron and steel structures and the commercial use of Portland cement the Construction Materials, methods and techniques did not evolve significantly. As a matter of fact, the roman concrete mix formula that included volcanic sands or artificial additives (pulverized clay tiles and bricks that work as artificial pozzolana) was lost for centuries during the dark ages in Europe.

After the discovery of the American continent, all construction up until the late XIX Century was basically based on Roman Construction techniques.

Although not a code as defined in modern terms, Vitruvius book De Architecture, was a standard guide and specifications of materials and construction. Although lacking some scientific knowledge, Vitruvius power of observation of the behavior of materials is outstanding.

Vitruvius on Bricks
He extensively describes the materials, the proper season and quality control for producing quality bricks.
I shall first treat of bricks, and the earth of which they ought to be made. Gravelly, pebbly, and sandy clay are unfit for that purpose; for if made of either of these sorts of earth, they are not only too ponderous, but walls built of them, when exposed to the rain, moulder away, and are soon decomposed, and the straw, also, with which they are mixed, will not sufficiently bind the earth together, because of its rough quality. They should be made of earth of a red or white chalky, or a strong sandy nature. These sorts of earth are ductile and cohesive, and not being heavy, bricks made of them are more easily handled in carrying up the work.

The proper seasons for brick-making are the spring and autumn, because they then dry more equably. Those made in the summer solstice are defective, because the heat of the sun soon imparts to their external surfaces an appearance of sufficient dryness, whilst the internal parts of them are in a very different state; hence, when thoroughly dry, they shrink and break those parts which were dry in the first instance; and thus broken, their strength is gone. Those are best that have been made at least two years; for in a period less than that they will not dry thoroughly.

There are three sorts of bricks; the first is that which the Greeks call Didoron, being the sort we use; that is, one foot long, and half a foot wide. The two other sorts are used in Grecian buildings; one is called Pentadoron, the other Tetradoron. By the word Doron the Greeks mean a palm, because the word dw=ron signifies a gift which can be borne in the palm of the hand. That sort, therefore, which is five palms each way is called Pentadoron; that of four palms, Tetradoron. The former of these two sorts is used in public buildings, the latter in private.

Vitruvius on Lime

The production of lime as a construction material is an outstanding discovery by mankind. Different civilizations around the globe discovered the process of using lime. Basically is a process of transforming limestone from solid state to a paste and transforming it back to limestone. Vitruvius, without knowing the actual chemical process, understood and describes the process, laying out the best materials and precautions to be taken in the development of lime putty.

Having treated of the different sorts of sand, we proceed to an explanation of the nature of lime, which is burnt either from white stone or flint. That which is of a close and hard texture is better for building walls; as that which is more porous is better for plastering. When slaked for making mortar, if pit sand be used, three parts of sand are mixed with one of lime. If river or sea sand be made use of, two parts of sand are given to one of lime, which will be found a proper proportion. If to river or sea sand, potsherds ground and passed through a sieve, in the proportion of one third part, be added, the mortar will be better for use.

The cause of the mass becoming solid when sand and water are added to the lime, appears to be, that stones, like other bodies, are a compound of elements: those which contain large quantities of air being soft, those which have a great
proportion of water being tough, of earth, hard, of fire, brittle. For stones which, when burnt, would make excellent lime, if pounded and mixed with sand, without burning, would neither bind the work together, nor set hard; but having passed through the kiln, and having lost the property of their former tenacity by the action of intense heat, their adhesiveness being exhausted, the heat being partially retained, when the substance is immersed in water before the heat can be dissipated, it acquires strength by the water rushing into all its pores, effervesces, and at last the heat is excluded.

- Hence, limestone, previous to its burning, is much heavier than it is after having passed through the kiln: for, though equal in bulk, it is known, by the abstraction of the moisture it previously contained, to lose one-third of its weight by the process. The pores of limestone, being thus opened, it more easily takes up the sand mixed with it, and adheres thereto; and hence, in drying, binds the stones together, by which sound work is obtained.

**FRANCE: NAPOLEONIC CODE (1804)**

In 1800, Napoléon I appointed a commission of four persons to undertake the task of compiling the Napoleonic Code. Their efforts, along with those of J. J. Cambacérès, were instrumental in the preparation of the final draft. The Napoleonic Code assimilated the private law of France, which was the law governing transactions and relationships between individuals. The Code, which is regarded by some commentators as the first modern counterpart to ROMAN LAW, is currently in effect in France in an amended form.

For Latin América and Spain the big heritage in construction is the establishment of the term of responsibility for a constructed project.

- **If there is a loss in serviceability in a constructed project within 10 years of its completion because of a foundation failure or from poor workmanship, the contractor and architect will be sent to prison**

The term architect in modern application of the law applies to engineers, and the word contractor applies to sub contractors as well. In the United States the modern term is normally associated to three years.

**SPAIN: ARTE DE ALBAÑILERIA, DON JUAN DE VILLANUEVA, 1827**

This book is the culmination of the outstanding career of a great Architect; all the construction techniques of the late XVIII and early XIX Centuries are collected as a guide. He was well known for his design of the Prado Museum and Façades of the Kings Palace in Madrid, Spain. After retiring, he thought it was necessary to publish a book to instruct young craftsmen the Art of Masonry Construction. It was not noble enough for such a famous architect to speak about such mundane works and the original version was published under another name. The book can be downloaded at no cost from the Biblioteca Nacional de España or Spanish National Library on
the Web at http://www.bne.es/es/Inicio/index.html. For engineers and architects through America and Spain it represents the techniques and specifications of tools, materials and methods of construction. It contains beautiful drawings to illustrate the reader.

Images of Arte de Albañileria drawings specifying construction methods and tools.
UNITED STATES OF AMERICA: MODERN CODES AND GUIDES

Thought the United States several Codes developed over the years. There are City Codes, County Codes and State Codes. Some of them were regional until the year 2000 when a unified Code was publish as the product of the merge of several Codes mandated by the US Congress. The Code was named International Building Code, and it is a family of Codes to be discussed later.

In terms of historic preservation there were two main influence in the development of historic patrimony, the British construction on the East Coast and the Spanish construction pushed from Mexico to the north west and in the State of Florida region.

General building codes has not enforce direct guidance to professionals, rather they express allowance for not enforcing modern provisions. As examples:

UNIFORM BUILDING CODE: Chapter 34 of the UBC (1997)

- *Historic Buildings. Repairs, alterations and additions necessary for the preservation, restoration, rehabilitation or continued use of a building or structure may be made without conformance to all of the requirements of this code when authorized by the building official provided.*

- *The building or structure has been designated by official action of the legally constituted authority of this jurisdiction as having special historical or architectural significance.*

- *Any unsafe conditions as described in this code are corrected. The restored building or structure will be no more hazardous based on life safety, fire safety and sanitation than the existing building.*

- *The UBC also has an entire Uniform Code for Building Conservation, which can be officially adopted or, more often, referenced by the code official.*

INTERNATIONAL BUILDING CODE: Chapter 34 of the IBC (2000)

- *Historic Buildings. The provisions of this code relating to the construction, repair, alteration, addition, restoration, and movement of structures, and changes of occupancy shall not be mandatory for historic buildings where such buildings are judged by the building official to not constitute a distinct life safety hazard.*

Particular and special codes has been developed over the years in addition to the General Building codes. The State of California has developed a great Code that is very relevant and important for earthquake prone areas with historic buildings. It can be downloaded free at: http://www.dgs.ca.gov/dsa/AboutUs/shbsb/shbsb_health_safety.aspx .
2010 California Historical Building Code
California Code of Regulations, Title 24, Part 8

The California State Historical Building Code (CHBC) is intended to save California’s architectural heritage by recognizing the unique construction issues inherent in maintaining and adaptively reusing historic buildings. The CHBC provides alternative building regulations for permitting repairs, alterations and additions necessary for the preservation, rehabilitation, relocation, related construction, change of use, or continued use of a “qualified historical building or structure.”

The CHBC defines a “qualified historical building or structure” as “any structure or property, collection of structures, and their associated sites deemed of importance to the history, architecture, or culture of an area by an appropriate local or state governmental jurisdiction. This shall include structures on existing or future national, state or local historical registers or official inventories, such as the National Register of Historic Places, State Historical Landmarks, State Points of Historical Interest, and city or county registers or inventories of historical or architecturally significant sites, places, historic districts, or landmarks. This shall also include places, locations, or sites identified on these historical registers or official inventories and deemed of importance to the history, architecture, or culture of an area by an appropriate local or state governmental jurisdiction.”

The CHBC’s standards and regulations are intended to facilitate the rehabilitation or change of occupancy so as to preserve their original or restored elements and features, to encourage energy conservation and a cost effective approach to preservation, and to provide for reasonable safety from fire, seismic forces or other hazards for occupants and users of such buildings, structures and properties and to provide reasonable availability and usability by the physically disabled.

Chapter 8-7 is called Structural Regulations, and it requires enforcing agencies to accept any reasonably equivalent alternatives to the regular code when dealing with qualified historical buildings or properties. It requires knowledgeable professionals to evaluate the structure:

8-703.1 Scope. When a structure or portion of a structure is to be evaluated for structural capacity under the CHBC, it shall be surveyed for structural conditions by an architect or engineer knowledgeable in historical structures. The survey shall evaluate deterioration or signs of distress. The survey shall determine the details of the structural framing and the system for resistance of gravity and lateral loads. Details, reinforcement and anchorage of structural systems and veneers shall be determined and documented where these members are relied on for seismic resistance.

This is very important because, unfortunately, I have seen many historic structures damaged by professionals with no knowledge in historic preservation. Although due to space limitations we can not review the entire documents there are two other sections I wish to comment, seismic risk and what the North Americans call archaic materials.

8-706.2.1 All structural materials or members that do not comply with detailing...
and proportioning requirements of the regular code shall be evaluated for potential seismic performance and the consequence of noncompliance. All members which might fail and lead to possible collapse, or threaten life safety, when subjected to seismic demands in excess of those prescribed in Section 8-706.1, shall be judged unacceptable, and appropriate structural strengthening shall be developed. Anchorages for veneers and decorative ornamentation shall be included in this evaluation.

The Code is liberal enough to allow engineers to explore alternatives to structural solutions which would work best in order preserve the patrimony, yet it cautions the designer to guarantee life safety.

8-801.3 Scope. Any construction type or material that is, or was, part of the historical fabric of a structure is covered by this chapter. Archaic materials and methods of construction present in a historical structure may remain or be reinstalled or be installed with new materials of the same class to match existing conditions.

Modern structural engineers are normally terrified by lawyers to use older materials due to the lack of code protection. With this section it protects the usage of other than modern materials and the chapter give guidance on types of testing’s to be performed.

INTERNATIONAL EXISTING BUILDING CODE (2009)

The International Existing Building Code (IEBC) is a powerful tool to encourage building rehabilitation and the restoration of historic properties. It provides a choice of three code methods that can address the majority of code challenges faced with historic structures. Although the structure and approach of this rehabilitation code differ from traditional codes written for new construction, it has been written through a consensus process and widely tested. There is an excellent publication by the National Trust for Historic Preservation, the May/June 2007 issue, entitled Model public policies, which can be downloaded for free at: http://www.preservationnation.org.

DEFINITION: Historic Building (IEBC Definition): Any building or structure that is listed in the State or National Register of Historic Places; designated as a historic property under local or state designation law or survey; certified as a contributing resource within a National Register listed or locally designated historic district; or with an opinion or certification that the property is eligible to be listed in the National or State Register of Historic Places either individually or as a contributing building to a historic district by the State Historic Preservation Officer or the Keeper of the National Register of Historic Places.

One significant addition to the latest version is the Prescriptive Compliance method and some technical provisions related to structural conditions, accessibility, and fire protection. The IEBC follows the conceptual framework established in HUD (US Department of Housing and Urban Development). The code expand on the stepped approach to building rehabilitation, referred to as the 25/50 percent rule,
which had existed in previous documents. The 25/50 percent rule refers to project cost thresholds that are used in traditional rehab codes to determine the extent of required code compliance. In general, the rule establishes the following:

1. If the proposed rehab work costs 50 percent or more of the building’s value or replacement cost, developers have to bring the entire building up to current code standards for new construction.

2. If project costs fall between 25 and 50 percent of the building’s value or replacement cost, only the parts of the building undergoing renovation have to be brought to code.

3. For proposed rehab projects that cost less than 25 percent of the building’s value or replacement cost, local officials and contractors can negotiate standards for compliance.

The proportional codes provide special consideration to relocated buildings and additions and have four important differences from previous rehabilitation codes:

1. **Thresholds for Required Work.** The IEBC replaces the three-step 25/50 percent system with a sliding scale of requirements in five work classifications, categorized as a function of the scope of work intended by the applicant.

2. **Work Areas and Supplemental Requirements.** The concept of work area is another means to limit the required work so that most rehabilitation projects need not meet new construction standards. At the lower levels of work classification, Repair and Alteration Level 1, requirements generally are limited to the work area defined by the scope of repairs intended by the applicant. For more intensive projects classified as Alteration Level 2 or 3, additional work may be required outside of the work area.

3. **Change of Occupancy.** Earlier codes required projects involving a change of occupancy to meet new construction standards. The proportional codes evaluate Changes of Occupancy according to the change of hazard level presented by the old and new occupancies relative to three Categories: Means of Egress, Building Heights and Areas, and Exposure of Exterior Walls. The most stringent requirements are imposed on occupancy changes where there is a hazard increase.

4. **Historic Building Provisions.** Provisions that serve as exceptions or provide alternate approaches for qualified historic buildings are included. In some situations these require approval by the code official.

**Advantages of the IEBC**

As a tool to encourage building rehabilitation, the IEBC provides many advantages:

1. **Predictability.** Technical provisions for historic and existing buildings were historically vague in building codes written for new construction. Because the three code paths included in the IEBC address most rehabilitation issues, the design professional can solve many common historic building issues without
involving the code official.

2. **Encourages Reinvestment.** Statistical evidence documents the contributions proportional codes have made to urban revitalization. The reuse of downtown buildings, in particular upper floors, is a critical component of efforts to encourage economic development of the nation’s older cities.

3. **Safety.** Rehabilitated buildings are safer than vacant and unimproved buildings. Vacant buildings are most susceptible to arson, a leading source of fire start in the U.S. Fires are also most likely to occur in poorly maintained buildings that lack basic safety improvements including upgrades to electrical systems and heating appliances.

4. **Tax Revenue.** Rehabilitated buildings increase public revenue by generating increased property and sales taxes. Even the rehabilitation of buildings owned by nonprofit entities can generate sales taxes through expenditures of visitors and employees.

5. **Smart Growth and Sustainability.** Community and regional planning trends focus on growth with minimal environmental impact, opportunities to reuse existing infrastructure, and the deceleration of urban and suburban sprawl. All of these goals rely on the technical and economic feasibility of building reuse.

### EXAMPLE SPECIFICATIONS

Owners, in particular Government projects, require modern specifications to formally instruct repair and construction techniques to contractors. Over the years we have developed many specifications for repair of wood, development of lime putty, etc. On the following section we present portions of specifications that are been used for preservation projects. The wood repair is included because we strongly believe that preserving the use of the original wood section is better for preservation purposes, than substituting the segment with a similar modern wood. The repair process adds modern material to the wood section, but preserves and restore the use of the historic material. The Slaked slime is included because in many places in America it is a lost art. The scientific approach to proportioning the amount of water provides a lime putty that can be use in 30 days.

**Wood Repair Execution (Based on the use of Liquid Wood and Wood Epox by Arbatron)**

1. Drill 1/4” or 3/16” holes in affected wood to receive epoxy consolidate will leak out from behind. When on a vertical surface, angle the holes so epoxy will not leak back out. Dam any surface cracks with oil clay so that epoxy will not leak.

2. Following manufacturer’s instructions, mix a small amount of the consolidant components, the resin and the hardener, together in an applicator bottle. Stir the mixture thoroughly by hand with a thin stick for 4 minutes or with a bent coat hanger chucked into a drill for 2 minutes.

3. Carefully squirt the consolidant into the pre-drilled holes. The aim is to
completely saturate the wood. Move from hole to hole refilling until the wood can hold no more. More than one application may be needed.

4. If severed pieces need to be re-attached, glue them in place with a mixture of consolidant and filler (saw dust or wood chips).

5. After the consolidant has cured, the voids in the surface can be filled with epoxy filler. If the voids are large, filler can be applied in succession, 1” of depth at a time. This cuts down on the possibility of problems associated with heat build-up.

6. Mixing of the two part epoxy filler is similar to the consolidant. When mixed, the filler has the consistency of a glazing compound and can be worked with a putty knife. The surface of the filler should be built up slightly above of the wood surface to allow for planning and sanding smooth after it has cured.

7. After the filler has cured, the surface can be smoothed. A wood preservative can be applied to surrounding wood surfaces and the whole surface should be primed and painted properly.

SLAKED LIME

1. It can be produced on site by slaking and soaking the quicklime as specified in Part 3 of the specs.

2. It can be bought pre-mix from a certified manufacturer.

3. When converted to paste as lime putty it must conform to ASTM C5.

4. When used for pigmented finish coat, it should be mix and stored for five weeks prior to mixing with sand and applying to walls.

5. The quicklime will be slaked only using the fusion method.

6. It can not be produced using open trenches.

7. It must be stored a minimum of 30 days.

8. It must be kept free of impurities, foreign particles and direct sunlight.

9. The quicklime should be crushed in an open impermeable tray to a dust like particle size. Then it shall be sieve to remove uncrushed particles. It will be set out in layers alternating the quicklime with sand in accordance with the specified proportions. Water will be added to produce an uniform putty.

10. For determining the proper amount of water for the slaked lime pour excess water in a container where a piece of quicklime is inserted. Both the water and the quicklime portion should be weighted prior to the mixing process. After the quicklime is converted into slaked lime, remove the excess water from the paste and weight it. From the difference in weight of water the amount of required water is determined.
LIME AND RUBBLE MIX WALLS

1. Lime and rubble mix will be used for the construction of new walls, filling of voids in existing walls, columns and arches.

2. Sand, clay dust, crushed limestone and slaked lime shall be mixed according to specified proportions.

3. Coarse sand shall be used.

4. Wall construction shall be limited to 1.0 m. height per week.

5. Wall shall be allowed to cure a minimum of 30 days before applying superimposed loads.

6. Walls shall be burlap three days after pouring the mix. Plastic can be used but it should be tented to avoid direct contact with the wall.

ROMAN PLASTER

1. Roman plaster shall be used for the finishing of the interior of the historic cistern and the walls above roof level.

2. Sand, crushed brick and slaked lime shall be mixed according to specified proportions.

3. Fine sand shall be used.

4. Surface must be damped prior to applying the finish coat.
5. Apply diluted mix with a brush prior to applying the finish coat to the historic or new wall.

6. Maximum thickness shall be 1 cm.

7. Walls shall be burlap three days after applying the finish coat. Plastic can be used but it should be tented to avoid direct contact with the wall.

CONCLUSION

The protection, preservation and continued viable use of historic resources demands of us the application of today’s technology to yesterday’s construction materials and methodology, recognizing and utilizing the strengths inherent in archaic materials and methodologies which have permitted them to withstand the test of time.

Building on this foundation, and supplementing it with the best in seismic resistance technology, we are committed to incorporate a reasonable level of seismic resistance in the least intrusive manner. It is rationally indefensible to misuse the Codes in order to fund, at a lower level than its non-historic peers, the earthquake repair of a structure identified as an historic resource. And it is a misreading of the Codes to interpret it as a license to merely “paint the cracks” of historic buildings.

The commitment is to the preservation of these resources, by implementing, on a case-by-case basis, the solution which best fulfills the unquestionably long term goal that word implies.

References

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