Fighting fires.
Jean-Far Eustache de Saint-Far's contribution to the debate on fireproof constructions in France at the end of the eighteenth century

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Introduction

In the second half of the eighteenth century, in particular during the last decades of the Old Regime, Paris became a vital centre of innovative experimentations on materials and techniques able to improve the fire resistance of buildings. The capital of the Kingdom was affected by daily fires which jeopardized its cultural and architectural heritage. At the same time, due to the scarce availability of wood, a material widely used in French buildings, alternative construction techniques were required. As testified by the success of the treatise published by the Count d'Espie (1708-1792) in 1754 [1], the theme of fireproof constructions and the research of materials capable of replacing wood, appeared of great concern. In the following decades, experiences and experimentations aimed at reducing the risk of fire spread multiplied. Architects, inventors and artisans contributed actively to the development of new materials and systems that would replace traditional timber floor framing as well as wooden vaults and domes.

In this cultural context the figure of the artist-engineer Jean Far Eustache de Saint-Far (1746-1828) [2] is to be considered. As outlined by Prof. Antoine Picon, Saint-Far belonged to the first generations of artists-engineers who studied at the *École des Ponts et Chaussées* in Paris, representing the last offshoot of a professional category with a solid humanistic formation and a strong practical experience. Saint-Far was a versatile technician, engaged on many professional fronts: as well as being an engineer of the *Corps des Ponts et Chaussées* and architect of hospitals, he was also interested in constructive strategies to improve fire resistance of buildings as testified by his rich journalistic production published in the Journal *des bâtiments civils et des* arts. In fact, in 1785 he developed a lightweight and fireproof construction system for vaults and domes using hollow clay pots, reinterpreting a Roman-Byzantine technique and transforming what was once an ancient "technical object" into an artistic one with aesthetic and cultural traits too. His invention was positively evaluated by the Academies of Architecture and Science in Paris as well as by the *Bureau de consultation des Arts et Métiers*, inaugurating a season of interesting experimentations often associated with wrought iron.

In the light of these considerations, the paper deepens Saint-Far's contribution to the debate on fireproof constructions in France at the end of the eighteenth century. The study reconstructs the genesis of his inventions through the critical reading of documents preserved in the Parisian archives (*Archives Nationales* and *Archives du Musée des Arts et Métiers*) providing a small advancement in the history of fire engineering in France [3]. Moreover, the proposed subject fits within the current literature on the figures of architects-engineers-artisans and

on the role of the technical invention in the Age of Enlightenment [4]: both are themes of interest for Architecture but also for human and social sciences.

The debate on fireproof construction in Paris in the second half of the 18th century

An interesting paper published last year by Prof. David Garrioch highlighted the reasons why Paris did not experience devastating fires at urban scale in the seventeenth and in the eighteenth century, unlike London and other European cities [5]. The combination of interconnected factors saved Paris from the destruction of large parts of its urban fabric, allowing fires to be confined to individual buildings. Specifically, the use of relatively fire-resistant building materials, such as limestone, brick and gypsum (besides hardwood, of course) together with the absence in the city centre of industries representing a high fire risk, were some of the reasons which contributed to protect the French capital city from burning [6]. In addition, Paris had regulations and controls which, apparently, were more stringent than in London. In such way, Paris managed to prevent the countless isolated fires that struck its architectural heritage from spreading to large parts of the city.

Despite a favourably privileged situation compared to London, the issue of fire prevention accompanied the reflections of French scholars and technicians throughout the Age of Enlightenment. The challenge was not how to limit the extent of fires in the city but how to prevent the destruction of important public buildings. The seventeenth and the eighteenth centuries, in fact, were characterized by fires which, although isolated, damaged important edifices and works such as the *Palais de Justice* (1618), the *Petit Pont* (1718), the *Chambre des Comptes* (1744), the *Hôtel-Dieu* (1737 and 1772) and the *Opéra* (1763 and 1781).

These were in part the reasons that led the Count d'Espie to publish in 1754 his treatise on the construction of tile vaults and of a new fire-resistant vaulted roof, the so-called *Comble Briqueté* [7]. Its aim, clearly stated in the text, was to find a method that would make incombustible the French warehouses and arsenals, used for war purposes. According to his research, he found the answer in the use of bricks. Following his example, some years later the architect-engineer Léonard Racle (1736-1791) planned and built in the region of *Auvergne-Rhône-Alpes* (Pont-le-Vaux) a fire-resistant house without wood, entirely in bricks [8]. Incidentally, the need to find alternatives to wood did not stop here. In fact, we must not forget the experimentations of the royal architect Jacques-Germain Soufflot (1713-1780) which proposed the use of wrought iron in many of his projects. For example, in the stair hall leading to the *Grande Galerie* of the Louvre Museum in Paris, he designed a roof framed entirely in wrought iron which, in addition to being a daring technical experiment, was fireproof too [9].

The fire which struck the *Opéra* of Paris in 1781 was the occasion for a renewed reflection on the theme. In the same year the architect Nicolas Le Camus de Mézières (1721-1789) published a *mémoire* suggesting a new method to render the overall theatre incombustible [10]. He started by denouncing the countless fires that hit the city and proposed to eliminate one of the cause by avoiding the employ of wood in each part of construction. For the masonry and the vaults he proposed the use of limestone and brick respectively. In contrast, the ceilings, the bridges, the doors and the loges were planned using iron combined with brick, limestone and gypsum. Lastly, he suggested to replace the wallpaper and the curtain, highly flammable, with copper plates. A fire-resistant construction, which, albeit expensive, would have been more resilient than a wooden one. The following year, the master carpenter and entrepreneur Jean Pierre Ango (1739-1815) together with the master locksmith Pérard de Montreuil, presented the plans and the model of an incombustible performance hall [11]. As well as Le Camus de Méziéres, they considered the iron as a potential and valid substitute for large wooden carpentry.

Moreover, in addition to the problems related to fires, the increasing price of wood between the eighteenth and the nineteenth century, caused by the scarcity of raw material and its massive use in all area of construction, should also be taken into account [12]. In fact, the need to reserve wood supplies for the French Navy led Jean Far Eustache de Saint-Far to propose his invention in 1785.

The contribution of the artist-engineer Jean Far Eustache de Saint-Far

Jean Far Eustache de Saint-Far, to whom the re-invention of hollow clay pots (*briques* or *poteries creuses*) is attributed, was born in Paris on 11th March 1746. Considering his career path, which we will not dwell on entirely in this paper, he was a particularly versatile scientist-artist able to deal with issues related both to the urban scale (i.e. the plan for the city of Mayence, nowadays Mainz in Germany), and to the architectural one (in 1782 he was awarded of the title of architect of hospitals).

In June 1764, at the age of 18, he was received as a student at the *École des Ponts et Chaussées* where he was soon noticed by the director Jean-Rodolphe Perronet (1708-1794), who involved him in the construction site of the Bridge of Neuilly. The young engineer, in fact, in 1772 became Sous *ingénieur de la Généralité* of Paris and, thanks to Perronet, realized some of the drawings of the bridge published between 1782 and 1789 [13].

In the 1770s, he took also part to the construction of the harbours in Honfleur and Cherbourg, developing his competences as a designer of works at urban scale. The involvement of young engineers in State work allowed, on one hand, to provide for the constant shortage of personnel and, on the other hand, to train the new generations of technicians in the field [14]. Thanks to these assignments, Saint-Far gained the trust of Daniel Charles Trudaine (1703-1769), the promoter of the *école*, who encouraged him to study the French and the Italian hydraulic works [15].

Hence, in 1775 Saint-Far travelled to France by analysing many channels among which the seventeenth century Loing channel, the Briare (1642) and the Orleans channel (1692). The following year he went to Italy where he focused on the hydraulic channels near Bologna and Vicenza as well as on the ancient water mains in Rome. Unfortunately, no drawings or descriptions of this journey have been found [16].

The trip was certainly a source of inspiration, considering that in 1778, on his return from Italy, he replicated, in the atelier of the Windsor brothers, some Arabesque decoration of Italian inspiration on wallpaper, as proof of his creative talent. As a matter of fact, this short journey was particularly useful to Saint-Far not only for studying the Italian hydraulic system but also for acquiring knowledge on both ancient construction techniques and new particular inventions of the time. We know, in fact, thanks to an Italian journal, the *Memoria per le belle Arti*, that Saint-Far came in contact with the Italian architect Leonardo Massimiliano de Vegni (1731-1801), and that he was interested in his technique to produce bas-reliefs and others works, through a process known as *plastica dei tartari* [17].

Additionally, the study of the ancient roman monuments gave him the inspiration, ten years later, in 1785, to reinterpret and reinvent the ancient roman-byzantine construction technique in hollow clay pots. In a document preserved in the archive of the *Musée des Arts et Métiers* of Paris, the artist-engineer explained the origin of his invention. He wrote that, after his stay in Italy, he had put this idea aside until a specimen of hollow clay pot from Rome was donated to the Academy of Architecture by a French scholar [18]. It was in this occasion that he realised the opportunity to transform this object into a constructive process with a great potential. Specifically, the

hollow clay pots would have made it feasible to build lightweight and fire-resistant structures as well as to reserve good quality wood (the so-called *bois de brin*) for the Navy, whose shortage forced the French to import it from abroad. Saint-Far highlighted the innovative nature of his invention and pointed out the difference between his practical approach in reading the ancient monuments and that of many others travellers interested mainly in the formal aspects of architecture. In his letter he implied that he studied in depth buildings in ruin without any decoration which, for this reason, were not of interest to other artists. Unfortunately, he does not specify which buildings and therefore his architectural references are unknown.

Hence, in 1785 Saint-Far presented a dissertation dedicated to the use of hollow clay pots for the construction of vaults and slabs at the Royal Academy of Architecture and at the Royal Academy of Science [19]. The author declared that the idea of building vaults using this construction system derived from the examples found in ancient Roman and Byzantine buildings and that despite its great potential, this construction system was ignored and no longer used in Italy [20]. The first essay was submitted during the session of the Royal Academy of Architecture in Paris on 9th May 1785 and evaluated by a commission composed of Michel-Barthélemy Hazon (1722-1822), Antoine-François Peyre (1739-1823), Charles-Axel Guillaumot (1730-1807) and Étienne-Louis Boullée (1728-1799).

In the following days, the architects of the commission went to Mr Gobelet's laboratory, a trusted master-tiler involved in many Parisian construction sites, who was the material executer of the Saint-Far's innovative ideas. In order to allow a correct evaluation of the system by the commission, he made three prototypes of vaults made up of hollow clay pots of different shapes and sizes, subjecting them to weather conditions and variable loads. Moreover, he placed metal tie rods on the extrados so as to contain the thrust generated by the vaults on the vertical partitions and to limit the swelling of the gypsum. The Commission showed great enthusiasm for the innovative construction technique, highlighting the possibility of using it instead of wooden systems. The numerous advantages related to the lightness and non-combustibility of the material were appreciated too. Furthermore, it was recommended the use of top quality lime mortar instead of gypsum, whose poor resistance to weathering and the tendency to swell during the drying phase represented vulnerability factors difficult to control. The technicians finished the report praising the construction system and considering it susceptible to possible variations depending on the location and the type of construction to be carried out.

The same memory was evaluated a few months later, on the occasion of the assembly of the 6th September 1785 also by the Royal Academy of Sciences in Paris and by a commission composed of Louis-Claude Cadet (1731-1799), Antoine François de Fourcroy (1755-1809) and Charles Augustin de Coulomb (1736-1806). In particular, the latter proposed to Saint-Far to carry out load tests to verify the behaviour of the vaulted systems and to evaluate their actual resistance and reliability. The result of the experiments was positive and the academics approved the construction system whose success, nevertheless, appeared to be closely related to the level of quality of the hollow clay pots used. Finally, they pointed out that it was essential to carefully design and calculate these vaulted systems, assessing the pressure and the consequent thickness at each point of the construction [21]. Although they could not examine in detail all the prototypes presented by Saint-Far due to lack of time, the members, on the basis of the experiments conducted, considered the construction system worthy of approval as a valid and economical alternative to the expensive wooden carpentry.

The controversial fortune of the construction technique in hollow clay pots at the end of the eighteenth century

The construction technique was soon successfully tested in the Parisian buildings of the time [22]. It being understood that Saint-Far was not the only one who experimented with such a construction system: we know that in the same years the architects Jacques-Guillaume Legrand (1753-1807), Jacques Molinos (1743-1831) [23] and Jean-Jacques Lequeu (1757-1826) [24] had a similar idea and that some experiments had been carried out on the construction site of the *Palais Bourbon* in the mid-eighteenth century [25]. Nevertheless, he was the one who mostly contributed to the dissemination of the technique, thanks both to the dissertations presented to the Academies and to his articles published in the magazines of the time.

As stated by Saint-Far himself, he used the system in all the constructions joining the *Hôtel-Dieu* on the site of the *Petit Châtelet* where he worked as an engineer in the 1780s [26]. Moreover, the technique was employed in the vault of the archives in the *Palais de Justice* by the architect Jacques-Denis Antoine (1733-1801), in the Royal Palace, in the roof of the *Salon Carré* in the Louvre Museum (together with an iron structure) and for the roofing of the barrack in the *Grande Écurie* in Versailles. According to Saint-Far, the hollow clay pots were also used in many private houses in Paris and in *Île-de-France*, especially in Versailles and Rambouillet [27]. Anyway, the building that established the international success of the technique was the performance hall of the *Comédie Française* planned by the architect Victor Louis (1731-1800) in the 1780s.

Despite the great success of the construction system, Saint-Far did not seem to be entirely satisfied with it, considering that just a few years later, in 1802, he wrote an article explaining the reasons why hollow clay pots had not yet become commonly used [28].On the occasion of a letter written to the editor of the magazine on possible methods to reduce the use of wood in civil construction, he highlighted how this system was still particularly expensive in the case of small spans. Furthermore, many carpenters and master builders did not employ it due to their unfamiliarity with the technique and some architects denied the real potential of the system [29]. This was the case of Jean-Baptiste Rondelet (1743-1829) which, in his *Traité théorique et pratique de l'art de bâtir*, in the paragraph dedicated to the *voûtes en poteries creuses*, denounced the excessive cost of the material and warned about the real convenience of the construction technique [30]. Clearly, the opinion of such a distinguished exponent of the French architectural world had to partially influence its diffusion and use. Rondelet also rejected the idea of building the new dome of the *Halle au Blé* in Paris in hollow clay pots, as some architects proposed after the fire occurred in 1802 [31], considering it unsuitable for covering large rooms [32].

Simultaneously, in the same years, in order to increase the knowledge of the construction system, Saint-Far wrote a letter to the *Bureau de Consultation des Arts et Métiers*, which, considering the value of the invention and the expenses incurred for the experiments, decided to grant him a prize and an honourable mention [33]. Taking this into account, it is evident how this theme was topical in the cultural debate of the period.

Saint-Far did not limit himself to the proposition of a single construction system. He was convinced of the need to reserve good quality wood for the Navy and was aware that the French construction world was not yet fully prepared to abandon its use. For these reasons, he explored ways of improving the strength of wood, as set out in an article published in 1802 [34]. On that occasion, he took in consideration a system invented in 1781 by an engineer known as Migneron and verified its success through various inspections of the architectures in which the technique had been used twenty years earlier. The method involved the chemical treatment of the wood not only to increase its resistance but also to facilitate its curvature and purify it from the sap, the main cause of the

deterioration. In this way, it would have been possible to use newly felled wood in construction and replace the resistant oak wood with other less valuable and less expensive ones. Furthermore, in his opinion, the removal of sap from the wood would have made it non-flammable, thus increasing its fire resistance [35].

Conclusions

It is clear from what has been exposed that Jean Far Eustache de Saint-Far was a figure of great creativity and innovation. His assiduous and active participation in the cultural debate of the time and his commitment to even very different fields (a triple role as architect, engineer and inventor) testify and confirm his multiple and versatile inclinations. Moreover, in the nineteenth century, the technique in hollow clay pots knew a great diffusion facilitated and supported by the passage from the artisanal production to the semi-industrial one [36]. It was certainly a highly innovative system which, due to its fireproof characteristics, was also widely used in the rest of Europe, starting with the United Kingdom in the late eighteenth century [37]. This subject, however, given its complexity, deserves a separate and additional dissertation.

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