SERVICE TUNNELS AS AN ELEMENT FOR THE REGENERATION OF HISTORIC CENTRES: THE CASE OF PAMPLONA

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Abstract

Linked to the enormous growth and modernization of cities, especially since the late nineteenth century, a need has arisen for new networks of urban services destined primarily to distribute electricity, gas and telecommunications. These networks have been sharing the underground section of the city with other services such as sewer and water systems that have traditionally occupied this space.

There are many cities that, despite their high initial cost compared to the traditional burial system, have opted for the construction of service tunnels understanding these to be one of the best alternatives for new urban developments. This is somehow justified in the improvement of services aimed to make preventive, predictive and corrective maintenance faster and cheaper.

Taking this one step further, the city of Pamplona has decided to use these kinds of service tunnels in conjunction with the redevelopment and pedestrianization of its historic center. This facility has a space reserved for a future pneumatic collection system for solid urban waste. This is a pioneer urban regeneration project that, with over 4 kilometers of service tunnels implemented over the time, has allowed the combination of the history of its medieval old town with the modernity of 21st century urbanism.

Keywords: Service tunnel, utilidor, service networks, urban regeneration, historic quarter, urban science.

1. Introduction

Urbanization projects are committed to specifying and materializing those determinations previously defined at a conceptual level by means of urban planning figures. Within these projects defining the building of the city, a very important portion is occupied by those whose objective it is to provide it with infrastructure and services.

Traditionally, these services have been relayed underground as is the case of drains or water supply pipes, whose origins go back to Roman times. With the increase in population in the cities and technological advances, some new urban service typologies appeared at the end of the 19th century such as electricity, gas or telephony. Some of these networks based on extensive cabling went on to indiscriminately occupy part of the façades of the buildings.

The growing level of exigency on the part of the cities’ inhabitants has risen up to our times, and has gone hand-in-hand with an increase in service networks as a means of improving the quality of life.

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During the last two decades the installation of aerial wiring has been prohibited. At the same time, a great effort is being made by city councils to remove most of this wiring from the fronts of buildings in their cities.

A generalized burial of these services has meant that the large cities have their underground sections occupied by numerous pipes, many of them out of use, which cross it with no coordination and not programmed, and this is in spite of the efforts of rationalization and planning made by public administrations, and by the private companies themselves who supply these services to the inhabitants. As a result of this conduct, we can rightly talk about “the chaotic situation in which the pipage of the public services buried under our streets is to be found” [Acebillo, 1989].

In 1867, Ildefonso Cerdá in his work on the reform and enlargement of Barcelona, already warns about these circumstances and asks the administration to take measures to remedy this chaos. He indicates the need for coordination in urban facilities and for preventing an almost everyday perturbation in urban highways due to the installation and maintenance of the different pipelines [Cerdá, 1867].

The effectiveness of infrastructure projects therefore depends on their integrated character and their polyvalence, i.e. they must serve for something beyond a specific function. That is why it is necessary to arrange and rationalize the use of the underground section of large cities, basically in those areas of the city expanding towards their periphery. Here the problem is easier to solve, correcting the current anarchical and non programmed location of service pipelines, which, very often, are set up one behind the other in the same street to serve the same citizen, offering him/her first water, then light and last gas. This leads to the belief in the convenience of using spaces or common service tunnels through which the pipes or conduits of the different services can run.

2. Historical evolution of service tunnels.

Service tunnels (also called service corridors, service gallaries, utility corridors, utilidors, multipurpose galleries or technical galleries) can be defined as being a transitable structure, usually underground and linear, isolated or inserted in a network of similar structures, which contain the conduits of public (or private) services and which permit the servicing, maintenance, repair, renewal or enlargement of the service with no necessity of carrying out any excavation.

The history of the service tunnels started with the famous “greatest” sewer of the city of Rome ordered to be constructed by the Etruscan king Tarquin the Elder in the 7th century BC, and which would be subsequently enlarged. This was not exclusively a drainage system as it was also used for supplying water to the city for which there were blocks of stones inside it to hold up the pipes used for this purpose. This fact makes it the first known service tunnel.

Service tunnels were not used again until after the second half of the 19th century, when Napoleon III commissioned Baron Haussmann, Prefect of the Seine Department and a great admirer of Roman civilization, with the urban reform of the city of Paris. With the help of Belgrand, Director of Engineering of the Waters and Sewers of Paris, he designed a real service tunnel, which took up the underground section of the public highways. These ovoid-shaped sewers had the function of ensuring the immediate evacuation of waste water and rain and the capacity to receive public service water distribution pipes, hooked up on the vaults of the sewers or placed on their racks.

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Haussmann, who could be considered as being the pioneer of collection systems of urban facilities, already wrote in his memoirs then that the objective pursued was the integration of urban facilities in order to obtain their good arrangement, exploitation and maintenance.

In the same era, the city of London was provided with a similar drainage network. However, it was a long time before the building of other service tunnels was undertaken. With the exception of some isolated cases like that of Washington University in Seattle (1910), Moscow (1920) or Tokyo (1926), few service tunnels were built before 1950.

From that moment on, this system spread as a rationalizing element of urban subsurfaces to a large number of cities. In some cases it was linked to other systems for the use of the roadway underground for transport or other types of constructions.

The first notable case in Spain goes back to 1924 with the Project of a service tunnel for pipelines under the ground in Madrid. Later, in 1929, on the occasion of the Universal Exhibition, some underground stretches in Barcelona were built to supply water and electricity to the fountains of Montjuic, although the most important advance was undoubtedly produced by the Special Plan for Service Tunnels developed at the time of the Olympic Games in Barcelona in 1992 [Cano and Canto 1998].
3. Advantages of service tunnels.

In view of the results of a multitude of comparative studies on the employment of service tunnels compared to the traditional burial system, it should be noted that, apart from the higher financial cost of the first installation of the service tunnel, the latter contributes a long list of advantages with regard to its usefulness and sustainability, which fundamentally become obvious throughout its useful life.

It is possible to distinguish between the advantages concerning the networks themselves and those which affect the space in which they are located.

3.1. Advantages relative to the networks:

- Permanent accessibility to the networks, which permits their maintenance, a continuous control, and the immediate repair of possible system failures, with no need to carry out any demolition work in the roadway.

- Structured organization of the networks in a reduced volume. Possibility of superimposition of networks, which acts on space economy and rationalization in the use of the underground section.

- Concentration of the majority of networks in an enclosure which is shut off and located geometric- and geographically. This prevents the digging of large trenches and the possibility of damaging other networks when it is necessary to locate a breakdown.

- Possibility of disposing of precise, complete and safe databases of the networks, a basic element for the Geographic Information Systems (GIS).

- Reduction in work times and repairs, and, consequently, in labour costs. The maintenance work done inside it is not affected by weather conditions.

- Improvement in network security: almost total elimination of risks of damage to networks caused by excavations or other work localized in their proximity. The objective of any network is to ensure supplies.

- Control and coordination of the interventions of the concessionnaires and their representatives and inspectors.

- Easiness of maintenance and access, with the frequency desired by each supervisor, with no risks to other networks; control of the state and quality of the networks.

- Possibility of substitution of stretches of networks and flexibility for their progressive implementation according to the needs appearing in the cities without having to act in the road and, therefore, not disturbing the surroundings or other networks.

3.2. Advantages relative to ground use and sustainability:

- Rationalization of the use of the ground due to the need to concentrate the networks.

- Possibility of reserving spaces at the sides of the service tunnels for the incorporation of vegetation into the urbanizations or other services.

- Diminution of the deterioration of the urbanization with the openings in roads and pavements on the public highway being notably reduced. The need for road patching is avoided.

- Possibility of elimination of networks which are no longer used.
- Quality of life and convenience for citizens who see how the number of roadworks is considerably reduced, thus eliminating problems both for users of the public highway (pedestrians and car-drivers) and the inhabitants (access to dwellings and commercial premises).

The service tunnel is, therefore, an efficient means for reducing the number and importance of works on the public highway, for structuring the underground space, and for improving the useful life of the networks. Thus, they should be perceived by all the agents implicated and the service companies as being one of the best instruments in matters of urban convenience, of coordination and of security in the networks.

4. The service tunnel in the reurbanization of the Old Quarter of Pamplona

4.1. Historical evolution.

Although the city's origins go back to Roman antiquity (74 BC), the Old Quarter of Pamplona contains an urban stretch which proceeds, to a large extent, from medieval times and which, throughout the centuries, has survived with slight variations in its boundaries. In 1423 King Carlos III promulgated the Privilege of the Union, by which the city was unified. Up to then it had been conformed by three independent nuclei, the Navarrería, the Burgo de San Cernin, and the Población de San Nicolás, with their own administrations. As from the Privilege of the Union, the road layout was completed, fundamentally using for this the trenches and "no man's land" which separated the old quarters.

The first attempts to organize and give some order to urban life materialized in the first edicts of the city dating from 1570. It was from the 18th century onwards and in the context of the Enlightenment when a methodical improvement plan was initiated, which was particularly reflected in the infrastructures. These, as from 1767, were focused on setting up a sanitation and drainage network in the city, the supply of water and the paving of the streets. For all these works the municipal engineers had to be assessed at Court and they carried them out in Pamplona following instructions from Madrid.

The sanitation network was conceived by means of a series of sewers which flowed into the river. The first to be built was that of the Calle Mayor to continue its distribution throughout the city until being completed in 1772. These sewers were of a rectangular shape and had a vaulted ceiling. They measured six feet in height up to the beginning of the arch and were three feet in width.

Another undertaking in those years was that of bringing water to the city from Subiza. This propitiated the intervention of national craftsmen like Ventura Rodríguez, who designed the aqueduct of Noáin, and Luis Paret, who designed a series of fountains with the aim of supplying water to the city. In 1895 the new water supply from Arteta was inaugurated.

The modernization of the urban infrastructures was completed with the paving of the streets in 1768, carried out depending on the area with tiles or stones from the quarries of Ezcaba. In 1849, the 18th century pavement was mostly replaced. In the late 20th century one part of the streets of the Old Quarter of the city was paved and the other asphalted.

With respect to the illumination, in 1799 the first public lighting by oil was installed, which was renewed in 1839 and changed to gas in 1861. The electric wiring work did not begin until 1924 [Orbe, 1994].
The last important effort to conserve the Old Quarter of the city was mentioned in the Plan of Local Reforms of 1887. For almost one century the actions in the Old Quarter were centred on typical works to maintain the public highway, which did not stop its deterioration whereas the city was developing, with the building of new districts, outside what had been its walled enclosure.

### 4.2. Reurbanization project.

It was not until the end of the 20th century when it was firmly decided to give a new impetus to the Old Quarter of Pamplona, with the guidelines of the actions being defined. The Old Quarter stopped being considered as a pedestrian area and it was opted to undertake the integrated reurbanization of its streets with the transformation of its roadway into a single platform, as a result of the elimination of the different slopes existing until then between the road and the pavement. Pedestrianization was understood as being one of the priority actions for the rehabilitation and regeneration of the area, and this moment would be taken advantage of to resolve the deficit of infrastructures and services. The works began in 1996 following the project drawn up two years before by the architect Fernando Redón.

After analyzing various alternatives, among which was the possible use of the ancient medieval sewer as a service tunnel, like what had been done in Paris, it was decided to replace it with a real service tunnel into which all, or almost all, of the pipelines existing at that moment fitted, and which, in the near future, permitted the integration of the pneumatic solid waste collection network.

The first stage of the work was undertaken between 1996 and 2007, that of the streets of the Población de San Nicolás being executed in several phases, with an approximate linear development of three kilometres. In 2001, the works corresponding to the Burgo de la Navarrería began, and these are expected to be finished in the middle of 2009. From that moment, the works of the third of the Burgos, that of San Cernin, will begin.

The action started from some needs and very special problems. The underground section of the streets was occupied by the old sewer constructed in the 18th century in charge of the collection of waste water. This old sewer took up the centre of the roadway and on both sides were the rest of the networks which, as new technological advances began to emerge, started overlapping each other.
Having analyzed the area to be intervened, the proposal presented in the reurbanization project had to take into account the following considerations:

- The high degree of obsolescence of the existing infrastructure networks, except that corresponding to natural gas, recently executed. Some stretches of electricity and telephony networks still remained on façades.

- Narrow sections of the street with a breadth of below six metres in some spaces.

- Great archaeological potential of the subsurface as the medieval city was built over the ancient Roman one.

- Deficient or inexistent foundations of some buildings as many of them were situated on lands of filler. This is a road network formed by blocks with a great density of terraced houses with passages which are very long and narrow, and proceed from medieval land plot divisions.

- The need to incorporate future networks. Although the possibility of leaving some conduits empty for new electricity or communication pipes is simple, other infrastructures such as the pneumatic collection of garbage need much wider reserve spaces.

As a definitive solution for the renewal of networks, it was opted to execute a prefabricated service tunnel of reinforced concrete with an internal transitable space 2.00 m wide x 2.75 m high, built in modules 1.25 m long with a wall thickness and floor of 15 cm and ceiling of 20 cm.

**Figure 4. Section of street type in Old Quarter of Pamplona**

**4.3. Construction process for building an underground service tunnel.**

The first task to be performed in this type of work consists of the executing of a provisional installation on each building front of the different services (electricity, telephony, water supply, gas, etc.) with the aim of ensuring supplies for the users while the works affecting the underground section are being carried out.
The excavation and placing of the prefabricated boxes is done at 6 metre stretches with the aid of a hydraulic shoring-up machine with mobile vertical plates, which guarantees the safety of the workers and of the nearby buildings. Once the box is in place on a gravel-cement floor and ballast bed, the provisional connecting up of the drainage pipes to dwellings is made. The perforations in the side walls of the prefabricated boxes for the pipes are established and carried out prior to the boxes being put in place. Once the pipes have been laid, filling is begun, at the same time as raising the shoring panels, of the shaft walls with gravel-cement.

Then, outside, the rain water and gas networks are set up, continuing with the execution of the subbase and surface paving with tiles and calcarenite stones. Simultaneously to the paving, the rest of the networks are implemented inside the service tunnel.

Inside the service tunnel there are:

- Side rails to secure a transitable bar grating walkway and support racks for water and drainage pipes and the plastic trays to house the cables of other networks. Under this walkway, a space of 65 cm in height is left for the installation of the piping for the pneumatic waste collection. This installation is formed by a steel tube 500 mm in diameter and signal and data cabling, as well as the load breaking function valves and corresponding inspection windows.
- PVC sanitation pipes (one on each side) from Ø 315 to 500 mm in diameter, to collect the connections from the buildings, at the moment unitary and in the future fecal, as and when the buildings are rehabilitated and their waters are separated. In this way, the pipes do not run along the floor and the transitability of the service tunnel is ensured.

- Galvanized helical-welded water distribution tubing from Ø 150 or 200 mm. For each non rehabilitated building at least 2 pipes of 2" were set up, one to connect the existing pipeline and another in the outlet tube of pipes in its entrance hall as described next:

- PVC trays to hold service cabling and connections, 1 of 400 mm in width on each side for electricity network, 1 of 400 mm each side for telephony, one 100 mm wide for safety, and one 100 mm for lighting and utility tunnel services, 1 of 200 mm for lighting, with 1 reserve tray of 200 mm.

- Outlet of pipes for services in each entrance hall with PVC tubing of Ø 250 mm, where the following two-walled corrugated polyethylene pipes [see Figure 7] are housed: 2 Ø 90 mm for electricity network, 2 Ø 63 mm for telephony, 1 Ø 63 mm reserve and 1 Ø 90 mm for the water supply, which makes a sheath for the future entrance hall pipeline. The PVC Ø 250 mm tubing ends up in the entrance hall, where a multisevice chest is made so that, in the future, when the rehabilitation has been carried out, all the services are connected in this chest.

- Outlets for pipes at each point of the public lighting and possible points of telephone box installation, Christmas lighting, traffic control systems and others.

- Cabling and typical service tunnel facilities like: Normal and emergency lighting, smoke and gas detection, volumetric detection of intruders, televigilance cameras and fire extinguishers every 50 m and close to entrances.

- Inalterable plastic signs with names of streets in the intersections, numbers of entrances with name of street and identifiers of any pipe outlet. Painted numbering of all the modules with 3 letters (street) and 3 digits.

- Openings and ventilation vents every 50 m and large openings for materials, with nodular cast iron covers on a level with the pavement.

- The service tunnel has a drain at all its low points, connected together with a drainage system to a rain water collector, or, siphonically, to a unitary collector, or else by pumping the water towards one of the outlets.

Figure 7. Outlets of pipes to dwelling entrance halls and final photo of reurbanized street.
5. Main problems for its implementation.

The design and construction of the service tunnel of the Old Quarter of Pamplona met with a series of difficulties which can be classified as follows:

1. **Technical difficulties at the moment of its design**, insofar as it was aimed to elaborate networks, habitually set up over the whole roadway surface without bothering about the existence of other networks, cohabit in a limited space.

   A current gap in the technical regulations is, together with financial aspects, one of the reasons why urbanists have real doubts about undertaking the development of service tunnels.

   In addition, the time devoted to service tunnel projects is much greater, due to their complexity and need for coordination, than that given to the execution of the same infrastructures by burying them.

   In the case occupying us here, the great archaeological potential of the subsurface due to the medieval city having been built over the ancient Roman one should also be mentioned. This in many cases obliges the space occupied by the new service tunnel to be exclusively that corresponding to the one left by the old sewer. Thus, the possibility of coming across important archaeological findings presents an uncertainty which can only be clarified in the execution phase of the works.

   In view of the risks of leaks and explosions that could be generated by the installation of gas, it was decided to bury this pipeline in the proximity of the service tunnel. It was opted for this solution compared to others which tended to limit the risks of the propagation of gas inside the service tunnel (covered conduits, appropriate ventilation, leak detectors, etc.).

   In order to prevent any flooding risk, wells with pumping systems were installed at the lowest points of the service tunnel.

**Logistic and technical difficulties at the moment of building** the service tunnel, when it is necessary to replace the old buried networks since the cuts in the services have to be managed and administrated, coordinating them with the actual execution of the work. Prior to the work, the networks have to be provisionally diverted and, while the works are carried out, fixed to the façades of the dwellings.

   In the case of Pamplona, during the execution of the works, an intense and permanent archaeological monitoring is done throughout the earth movement phases, and, as a function of the findings, the need to adjust the project is evaluated.

   However, the most complicated moment of the building corresponds to the excavation of the shaft in which the prefabricated concrete module is placed. The underground section, as commented above, has a poor carrying capacity as it is made up of an important amount of filler materials corresponding to the superimposition of strata from previous historic settlements.

   The scant section of the streets with breadths in some spaces of below six metres, complicates the carrying out of the works which have to permit access to dwellings and commercial premises at all times.

   With the aim of being able to work in safety, the use of a hydraulic shoring machine was demanded to guarantee maximum safety both for the workmen and for the buildings located nearby. This machinery also facilitated access to dwellings and commercial premises.
Administrative, legal and associative difficulties when it is attempted to establish a management model for the service tunnel, and, above all, to make the occupiers participate in the investment and operating costs. The legal difficulties can turn out to be a real hindrance to the development of service tunnels, in the sense that the concessionnaires do not exactly know the extent of their rights. Similarly, watch should be kept that the incorporation of new networks does not cause detriment to the efficacy created by the subterranean service tunnel system itself.

Financial difficulties: the initial investment is much larger than that required for a classic buried solution. It is an investment in advance which has to be approached collectively. Associative negotiations are often complex: it is indeed difficult to convince all the associates of the interest of the service tunnels project and that they should, therefore, participate in its financing. In the case in hand, the participation of the different companies was resolved in such a way that each of them contributed with a percentage depending on the space to be occupied that was assigned to them.

6. Conclusions.

In this document, the multiple advantages from the installation of service tunnels have been listed. Most of the actions carried out up to now have been linked to the development of important enlargements of cities and to new urbanistic developments. However, in view of the work being done in the city of Pamplona, it has been demonstrated that service tunnels can become a useful element for the regeneration of historic quarters.

The use of underground service tunnels in the reurbanization of old quarters brings with it a series of additional advantages to those enumerated for the generic service tunnels employed in the new urbanistic developments:

- It is possible to build service tunnels in the historic centres of cities. Bidding for this integrated model of services guarantees the handing down to future generations of some urban facilities which provide a high degree of life quality.

- The use of rigid concrete boxes, together with the materials contributed for the filling of excavated shafts (gravel-cement in the case of Pamplona) in a certain way helps to improve the foundations on which the buildings stand. Likewise, the elimination of leaks of waste water from the old sewers or from obsolete supply networks prevents the possible wetting of materials which might lead to some foundations being worn away.

- Safety in the execution of works, both for people and buildings, due to the shoring systems employed, as well as resulting from it not being necessary to carry out excavations to make future repairs in the networks.

- Possibility of incorporating into very narrow streets all the services which it would be impossible to place there with a horizontal development complying with the minimum distances of safety indicated by the supply companies.
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