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Urban Accessibility of Historical Cities: The Venetian Case Study

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Abstract**—**The preservation of historical Italian heritage, at the urban and architectural scale, has to consider restrictions and requirements connected with conservation issues and usability needs, which are often at odds with historical heritage preservation. Recent decades have been marked by the search for increased accessibility not only of public and private buildings, but to the whole historical city, also for people with disability. Moreover, in the last years the concepts of Smart City and Healthy City seek to improve accessibility both in terms of mobility (independent or assisted) and fruition of goods and services, also for historical cities. The principles of Inclusive Design have introduced new criteria for the improvement of public urban space, between current regulations and best practices. Moreover, they have contributed to transforming "special needs" into an opportunity of social innovation. These considerations find a field of research and analysis in the historical city of Venice, which is at the same time a site of UNESCO world heritage, a mass tourism destination bringing in visitors from all over the world and a city inhabited by an aging population. Due to its conformation, Venetian urban fabric is only partially accessible: about four thousand bridges divide thousands of islands, making it almost impossible to move independently. These urban characteristics and difficulties were the base, in the last 20 years, for several researches, experimentations and solutions with the aim of eliminating architectural barriers, in particular for the usability of bridges. The Venetian Municipality with the EBA Office and some external consultants realized several devices (e.g. the "stepped ramp" and the new accessible ramps for the Venice Marathon) that should determine an innovation for the city, passing from the use of mechanical replicable devices to specific architectural projects in order to guarantee autonomy in use. This paper intends to present the state-of-the-art in bridges accessibility, through an analysis based on Inclusive Design principles and on the current national and regional regulation. The purpose is to evaluate some possible strategies that could improve performances, between limits and possibilities of interventions. The aim of the research is to lay the foundations for the development of a strategic program for the City of Venice that could successfully bring together both conservation and improvement requirements.

Keywords**—**Accessibility and inclusive design, historical heritage preservation, technological and social innovation.

I. Introduction

MUCH of Italy is characterized by historical architectural heritage which has been subject to significant restoration interventions over the years in order to preserve its original functionality or to add new functions, while always safeguarding its historical and cultural value.

In historical refurbishment intervention it is often necessary to intervene ensuring appropriate levels of accessibility, reducing as much as possible the presence of architectural barriers.

Making the country's heritage accessible to people with disabilities, means restoring and adapting urban spaces, while looking for solutions that are able to combine restoration preservation requirements with those of Inclusive Design and regulations that guarantee their correct application; however, it is not always to achieve this aim. This is especially the case in historical cities characterized by strong morphological and typological features that make it difficult to identify appropriate tools and references. This is the case for Venice, where the urban fabric, made up of over a 100 islands connected by more than 400 bridges, prevents the use of standard indications. For these reasons, new solutions have been studied and applied in the historical city, and over the years have transformed Venice into a more liveable and safer place for its citizens and for the tourists who visit every day.

This paper, through an analysis of the major projects, shows some of the choices made by the Venice City Administration with the contribution of many designers and consultants, to make most of this city accessible. Those accessibility solutions have been studied and analyzed in order to understand which could be the best strategies for the future, not only for Venice, but also for other situations where it is not possible to intervene through traditional methods.

II. Accessibility and Heritage

Historic buildings, memory and value of the past, should be protected in their integrity; at the same time, they need to be used for contemporary activities. This principle should be applied to individual artefacts as well as to the whole city. Moreover for architectural structures, unlike art works, usability is a fundamental concept: "an asset isn't a real one if it is not usable" [1]. Conservation and refurbishing can dialogue together by using technical and constructive reversible systems, to preserve the existing structures and to defend the historical value of the heritage. This approach becomes more complex when it is related to the elimination of architectural barriers: this principle is often in conflict with the preservation of an historical asset.

The Venetian reality is a perfect example of this situation. Since the 1987, Venice and its lagoon belong to the list of UNESCO World Heritage Sites for its uniqueness, for the influence it has had on architectural and monumental

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development, for the character of "archaeological" witness, and for the "complete typology of medieval architecture, whose exemplary value goes hand-in-hand with the outstanding character of an urban setting which had to adapt to the special requirements of the site" [2]. For years, attempts were made to make this complex urban tissue accessible, as it is composed of protected elements, recognized as living memories but which have to deal with functional requirements and uses.

Many actions have been taken on individual buildings but the most important challenge is at the urban scale; bridges represent, for Venice, the main problem for accessibility and usability. This is the most important physical barrier of the city that required a greater effort to improve mobility for residents and tourists with disabilities.

The usability of the historic urban space increases difficulties of movement (independent or assisted) and the simple transport of aids (wheelchairs, trolleys and suitcases, carts to allow the transport of goods). This situation implies a daily contact with architectural barriers.

The whole city of Venice is considered as a monumental and historic context, in accordance with the national legislation (D.Lgs. 42/2004 - *Code for cultural goods and landscape*, as established by Article 10 of the Law 6th July 2002, n. 137). For this reason, architectural barriers cannot be "eliminated", but they must be able to be "overcome".

The diversification of involved issues determines a complex solution, able to respond to heterogeneous needs, ensuring accessibility to the largest number of people possible, according to the principles of Inclusive Design [3].

Finding solutions to bridge accessibility for people with disabilities, in fact, means to introduce Inclusive Design, according to the *British Standards Institute (BS 7000-6:2005),* providing services and products that meet the needs of a wide audience, and then responding to the needs of crowds of people, residents and tourists, and their right to move as much as possible, independently.

III. Mobility Problems in Venice

In the past, waterways navigation was the most widely used way to travel. This traditional means of transportation is potentially accessible. But today, the situation has changed: owning a private boat is not as common as owning a car, furthermore not everyone can get on or off a boat without assistance.

Public transport does not reach all the city areas and the intermittency of the service, caused by high tide, represents a further problem: the reduced height of the intrados of some bridges forces disruption to services along some routes, and the increase of the gangway slope that links the *fondamente* to the piers makes it harder to use this service.

The City of Venice has also introduced an on-call boat service for people with disabilities which, however, does not appear as an independent mobility strategy, and cannot be applied to large numbers. Movements around the city take place on foot in any season, completely exposed to natural weather conditions, which increases mobility problems.

Calli and *campi* have few problems, generated mostly from the traditional flooring realized with *masegni* made of trachyte, which can be bumpy and difficult to traverse, especially by wheelchair. But above all, the real architectural barrier is represented by bridges that allow crossing canals connecting different *insulae* of the city. In order to answer to these needs, the Venetian Municipality has achieved over the last two decades, an urban accessibility policy, according to the requirements of Italian Law, realizing a PEBA (*Plan for the Elimination of Architectural Barriers).*

The PEBA, drawn up in 2004, identified 80 strategic bridges for pedestrian accessibility that needed intervention, and it recognized public water transportation as a means of support for the displacements. Unfortunately, the number of bridges that have been modified with the aim of overcoming architectural barriers is much less than necessary (about 20 in all), even if they are a panorama of specific solutions which can be an important examples for other historical cities [4].

The city's municipal technicians, with the help of external professionals, for example, studied and applied the principle of the "stepped ramp" as a reinterpretation of the *cordonata* (a sloping road with steps), or the temporary ramps built for international sports events, such as the Venice Marathon, in order to allow citizens to continue to use it once the annual event is over.

IV. Bridges: Measures for a Functional Adaptation

There are over 400 bridges in Venice and several modifications have been made over the centuries to improve their usability and security [5]. These changes have concerned formal and technical aspects, such as:

- The increase of the bridge rises (15th century);
- The introduction of parapets, on one or both sides (16th century);
- The replacement of ramps with steps (until the 15th century bridges were crossed also on horse).
- The replacement of wooden elements with stone ones.

Bridges have different conformations, morphological and structural characteristics. For this reason, every project has to be assessed according to the specific context. In Venice, every solution to overcome an architectural barrier is unique, specifically adapted to each different artefact.

What does not change is the assessment of public space and the historic tissue of the city: in most cases the *calli*, *fondamenta* and *campi* do not have enough space to allow ramps insertion, to reach regulations standards. Therefore, the city has implemented different approaches, which are classified in this paper into five groups depending on the system used: mechanical systems; removable platforms; complementary ramps (stairs and ramps); overlapping ramps; "stepped ramps".

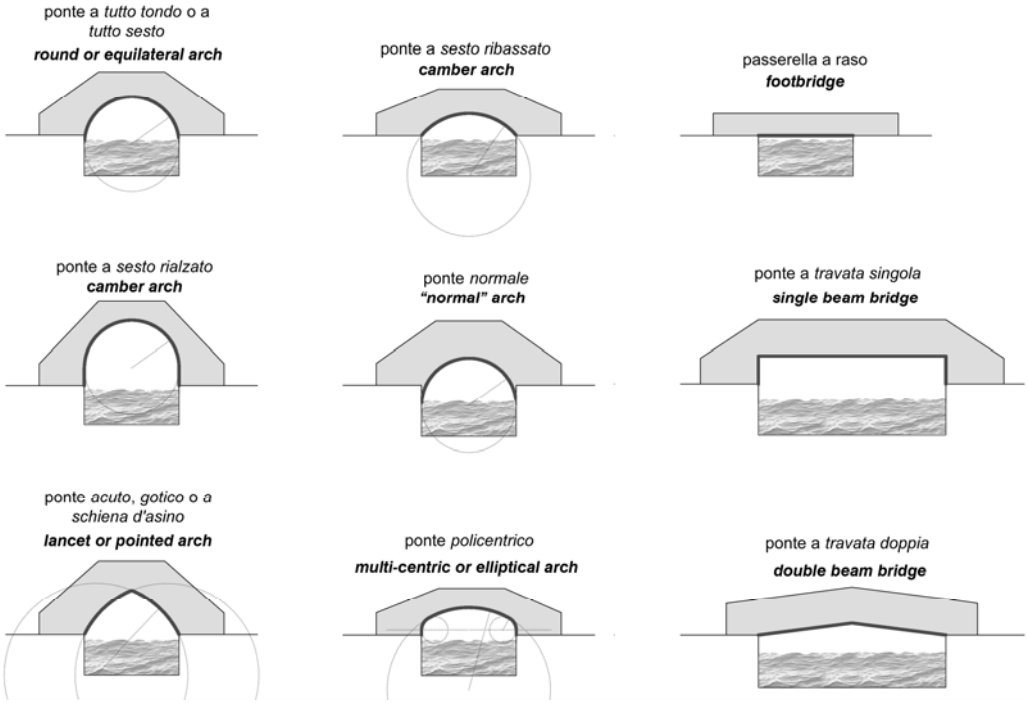

Fig. 1 Venetian bridges typologies: different geometries and structures determine the importance of considering each bridge as peculiar

A. Mechanical Systems

Fig. 2 Mechanical systems: a. An example of stair-lift at the *Ponte de la Saponeta*; b. Elevators at the *Ponte Longo*; c. "ovovia" on the *Ponte della Costituzione*

At the end of the 80s, the Venice Municipality installed 13 stair-lifts; however, their reduced functionality, high maintenance costs - especially after breakdowns and acts of vandalism - and limited autonomy in use, proved the inadequacy of this solution. Every stair-lift was activated by a key that had to be requested from the Municipality prior to use, reducing autonomy and functionality for residents and tourists. In 2009, the city removed these systems.

Today only one stair-lift in Venice is in use, installed for private use by a family with a disabled daughter (at their own expenses), which only through this kind of device, can reach the platform to access the water public transportation.

A second solution concerns the *Ponte Longo* at the *Isola della Giudecca;* where in 2006, two lifts were set on both sides of the bridge. These allowed for overriding the steps and to achieve the flatter section of the bridge, and *vice versa*. The high salinity of the environment and incorrect use of lifts, and excessive loading, resulted in their malfunction and their consequent closure, even if the elevators are still present today.

The third system consists of a particular kind of inclined lift called "ovovia", set to overcome the *Ponte della Costituzione*, the fourth bridge on the Grand Canal designed by S. Calatrava and completed in 2008.

In this case the lack of an accessible design obliged the Municipality to find a mechanical solution after the bridge's construction, which appears as a late element, not included into the original project. The "ovovia", installed in 2013, was a failure and has been out of service since 2015. The failure of the work is due to the travel time considered too long and to the fact that in the summer, the cabin overheats excessively. Moreover, the saline environment compromises the operation and blocks the "ovovia", as it does for the other mechanical devices in the lagoon city.

B. Removable Platforms

On some bridges, characterized by very deep treads and small risers, it was possible to join up steps by inserting small removable platforms, obtaining a ramp with a discontinuous slope. One architectural and functional positive solution is

located on the *Ponte Papadopoli* designed by the architects A. Torsello and A. Buzzacchi.

The intervention, facilitated by a good tread and riser ratio, allowed the development of an architectural solution, made of steel, consisting in a unitary system of inclined modules, parapet hooking and handrails.

Small plastic platforms facilitate the use of the *Ponte de la Paglia*, behind *Piazza San Marco*, and the same system was used for the *Ponte di San Pietro.* These interventions are characterized by a low architectural impact and a high reversibility. As a negative consequence of this reversibility, the plastic modules have been removed several times (as an act of vandalism).

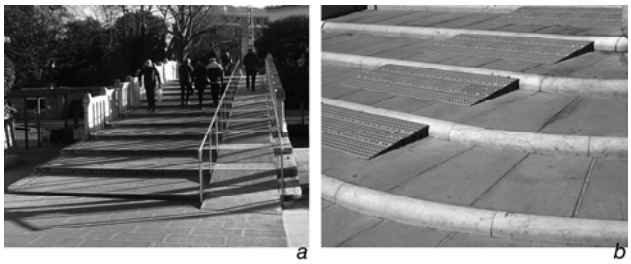

Fig. 3 Removable platforms: a. *Ponte Papadopoli*; b. *Ponte di San Pietro* with small plastic platforms

C. Complementary Ramps: Stairs and Ramps

An alternative solution to overlapping strategies is the predisposition of a ramp integrated with the bridge that can be used as a complementary path. This solution is only applicable in the presence of large spaces, such as very long and wide *calli* or *fondamenta*. In new bridge constructions or in those who have been rebuilt, this strategic solution, according to the principles of the Inclusive Design, includes a double integrated system, including ramp and stairs. Some examples of this strategy are: the *Ponte San Gervasio* at the *Isola della Giudecca*, o *Ponte dei Lavraneri* (between *Giudecca* and *Sacca Fisola*), the *Ponte sul Rio Morto* at the *Isola di Mazzorbo*.

D. Overlapping Ramps

Several bridges have been made accessible by overlapping the original structure with independent ramps, which can also be temporary, such as the ramps used during the Venice Marathon.

The possibility of overlapping ramps to original bridges for a functional rehabilitation of the historical artefact is closely related to existing spatial constraints and heritage protection restrictions. According to Italian legislation (D.M. 236 of 14th June 1989), the ramp should have a maximum gradient of 8%. However, common sense and experience has lead to reducing the slope to 5%, to ensure autonomy of movement and use to a people in wheelchairs.

Several types of ramps were placed in superposition to ancient bridges with a reversible approach.

In some cases, as in the *Ponte del Paludo* designed by architect A. Torsello (2008), the complementary ramp becomes also an opportunity for the introduction of urban furniture systems. The project consists of a simple ramp (8% gradient, with an intermediate floor for its over 10 meters length, and 1.20 meters width) in burnished steel, positioned on the bridge structure and curved on *calle Paludo*, which offers the possibility to place chairs on the *Sant'Elena gardens'* side, and provides a vertical surface for posters on the facade of the Pastor Pavilion, that houses the Biennale library.

Temporary ramps are also those installed for the annual Venice Marathon race held in the city since 1986. Temporary ramps are placed each year for this event on 13 bridges located in the southern part of the city (from *Fondamenta delle Zattere* to the *Riva degli Schiavoni*).

Over the years these ramps were greatly appreciated by the inhabitants and remained in use for a longer period, a temporary solution received with disappointment by the *Superintendence of Architectural, Natural, Historic, Artistic and Ethno-Anthropological Heritages in Venice and its Lagoon* (a peripheral organ of the Ministry of Cultural Heritage, Activities and Tourism), whose aim is to preserve and return to the bridges' original conformation. Currently, there is an ongoing redesign of the system always directed to a provisional application, but with the aim to provide a better functionality and a greater architectural quality.

Fig. 4 Overlapping ramps: a. *Ponte Paludo*; b. Temporary ramps for the Venice Marathon

E. Stepped Ramps

The stepped ramp is a solution developed in Venice. It describes a ramp with "a step that, in order to reach a certain height difference uses an extended and sloping tread, as well as a small step suitably shaped" [6].

The first applications date back to the 1987, in the *Ponte delle Guglie* and the *San Felice* one. In the *Ponte delle Guglie,* the step has a curved chamfer to allow wheelchairs and trolleys to overcome it, and an important slope of the tread. In this case there are 60 centimetre treads with a slope of 8% and rises chamfered with a curved 4.5 centimetres Istria stone element. In the *Ponte San Felice*, the 70 centimetre tread has a slope of 11.5% and 8.5 centimetre rise made with a chamfered stone block.

Basically, the "stepped ramp" incorporates the concepts of the *cordonata* or sloping road, by better defining the slope and tread ratio and height of the rise. With this system it is possible to reduce the length of the ramp in comparison to a simple ramp (8% or 5% slopes), that in a city like Venice, is not always possible to place near bridges.

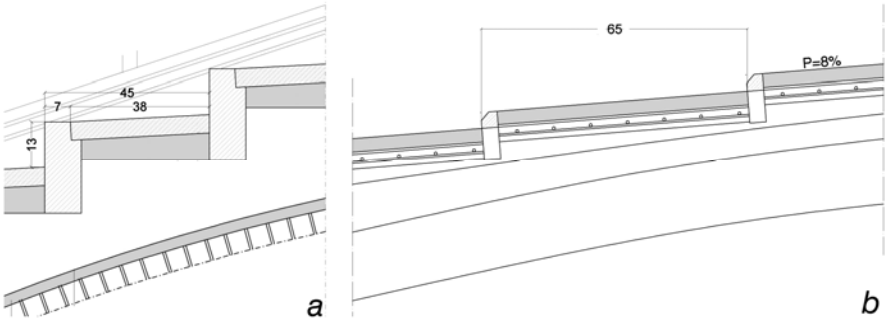

Fig. 5 Differences between the traditional step (a. *Ponte San Felice*) and the "Stepped ramp" (b. *Ponte delle Cappuccine* in *Isola di Burano*)

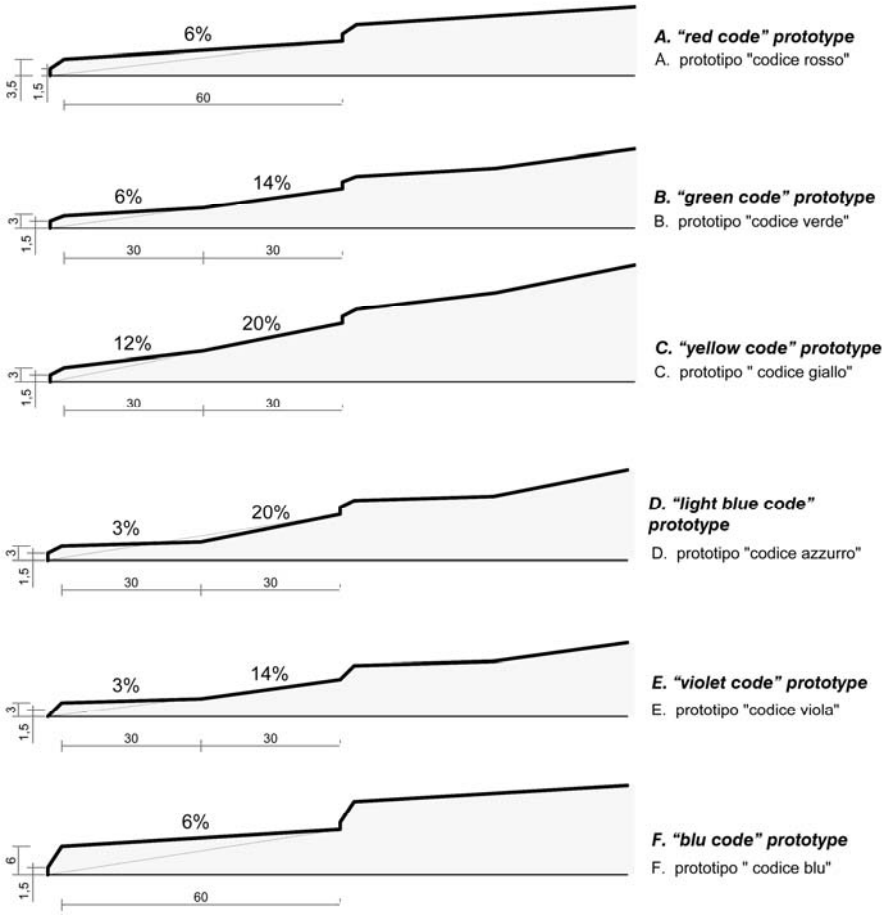

Fig. 6 Prototypes of "stepped ramp", elaboration from the Venice Municipality study [6]

The main limitation of the stepped ramp is that this system does not allow the same autonomy of use as a ramp with a slope of 8% and people on manual wheelchairs need help.

The *D.P.R. 236/1989, Art.12 "Updates and changes"* gives to a Standing Committee, established by the Ministry of Public Works and Social Affairs with the Ministry of the Treasury, the assignment of solving problems related to the application of the decree, also providing an opening up to changes (*Art. 12, Paragraph 2*): "Local authorities, academic institutions, individual professionals may propose alternative technical solutions to the Standing Committee which, in the case of recognized suitability, may use them to update this decree".

The study conducted by the Office for the Elimination of Architectural Barriers (EBA) of the City of Venice between 2008 and 2010 was aimed to evaluate new slopes to apply for a better stepped ramp solution [7].

The study led to the development of a prototype consisting of a telescopic metal base and the application of different types of ramps with various slopes and compositions. The six different ramps were composed of shaped metal slabs, each ones included:

- a single 60 centimetre tread or a double 30 plus 30 centimetre treads with a gradient from 3% to 20%;

- a suitably shaped 7 centimetre step, with 3/3.5 centimetre heights, depending on the prototype.

For the verification phase of the best solution, the Municipality invited professionals and stakeholders to work together, also taking into account the different types of disabilities (physical or sensory), and the use of different manual or electrical aids. The tests, carried out in 2009, showed the preference of people with physical disabilities for the more advantageous type, consisting of a 30 plus 30 centimetre double step with a slope of 6% and 14%, provided of a triangular string-course section of 3 centimetres high and 7 centimetres long, identified as the "stepped ramp". In this way, the recognized best profile is also a tool for an "equivalent accessibility" (as proclaimed by *D.M. 509* of March 2nd, 2010) [8], allowing to obtain a length reduction of 40.43% compared to a simple ramp with a gradient of 8%.

Today, only 11 bridges are equipped with this system, which is made up of different materials (stone, wood, plastics and concrete steps) [9].

Even if this system solves the length problem, it is not always the best solution in terms of usability. In the case of *Ponte di Ognissanti*, the City intervened with a stepped ramp, which constituted a double module and different slopes. The usability in this case has proved to be problematic for the able-bodied: several slip and falls have occurred due to the material of the floor and the reduction of each double slope. The stepped ramp in the *Ponte San Felice* is not used by people with manual wheelchairs because of the excessive slope, and in *Ponte San Pietro*, small platforms were added to the stepped ramp because the lift was too high. Even with these modifications, wheelchair-users do not to use the ramp because it is too steep, preferring to use stairs with a helper. Therefore, even if the stepped ramp solution obviously offers advantages in terms of length, it does not seem to solve entirely the design questions of correct dimensional ergonomics in order to become a common reference for designers and to be applied in specific situations.

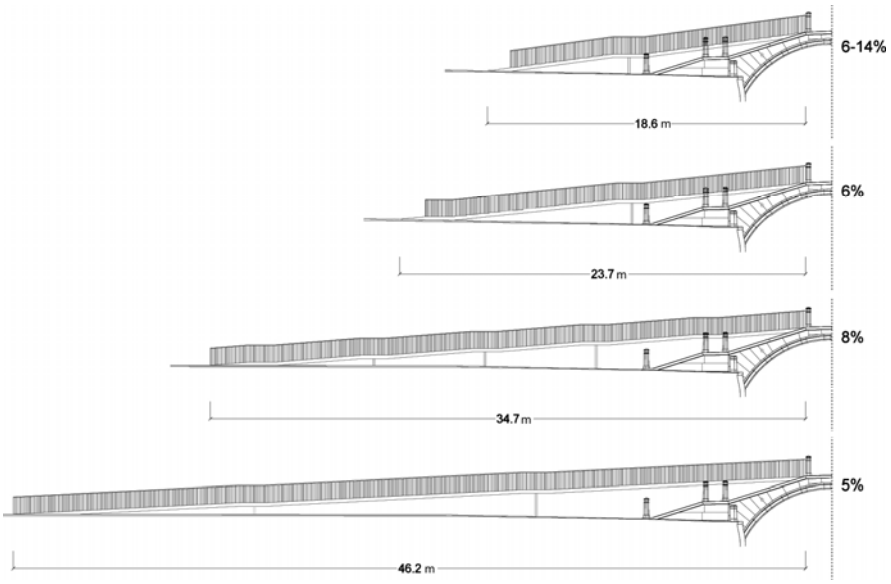

Fig. 7 Length reduction with the use of "stepped ramp" instead of simple ramp with different slopes

V. Conclusion

The specificity of Venice is at the basis of different intervention strategies: not only design project solutions, but also orientation tools such as maps with alternative ways to reach different areas since the city offers a different path to reach the same place, avoiding or using inaccessible bridges.

The Municipality in Venice has undertaken considerable works in order to find the most appropriate solutions with the aim of resolve the issues of user autonomy and usability.

Several experimentations over the years demonstrated that there cannot be a "unique" solution, but a series of possible solutions to be adopted as appropriate.

The analysed experiences set the framework of the state-of-the-art on accessibly and usability for a historical city that, more than others, shows all its frailty in the research of a balance among conservation issues, functional requirements and standards and regulation adaption.

The analysis conducted demonstrates that the specificity of the context requires considering each bridge as unique, with its own history linked to each particular environmental context.

Analytic studies are the first step for a deeper and instrument-based research that will investigate, in particular, the real efficacy of the stepped ramp, in order to adopt it for a more functional slope and height ratio.

Certainly, this solution is the most advantageous (above all for dimensional reasons), even if there are some negative aspects (such as the limited autonomy in use) that could be reduced. Mechanical systems have been abandoned for their inefficiency, deficiencies in consideration to Inclusive Design Principles and difficulties in use. On the other hand, reversibility, light construction techniques and solutions for

the length reduction, represent a future interesting scenario for public administrations, superintendence and, by extension, designers.

The overlapping strategy, evaluating a more appropriate architectural definition for the Venetian cultural and landscape environment is the aim of this adaptation, in order to preserve historical artefacts in the perspective of "equivalent solutions" for the complex urban fabric such as those of historical cities.

The changing ergonomics require specific solutions to be actuated for each architectural artefact, doubling by overlapping or duplicating the way of climbing Venetian bridges, answering to appropriate geometry and dimensions for each case study.

Venice, in its particular conformation and context, is an abacus of diverse and complex solutions. It is a reference for the research of the highest level of accessibility and usability in those contexts in which functionality must be related to conservation.

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