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Preservation of the Venetian Bridges

Conservation des ponts de Venise

Erhaltung der Brücken Venedigs

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SUMMARY

The paper deals with a research investigation started with the aim of assessing the present state of the Venetian bridges, providing at the same time historical and structural information. The research is divided into three main steps: historical investigation through bibliographical and recorded sources; listing of bridges by type and location; graphical and photographic filing of public bridges, classified by their district.

RÉSUMÉ

Cette recherche a pour but d'étudier la situation actuelle des ponts de Venise, en fournissant des renseignements concernant l'histoire et la structure des ouvrages d'art. La recherche est partagée en trois parties: enquête historique avec renseignements bibliographiques et d'archive; liste des ponts selon modèle de construction et lieu; archive graphique et photographique des ponts publics, classés selon leur arrondissement.

ZUSAMMENFASSUNG

Es handelt sich um ein Forschungsprojekt mit dem Ziel, den aktuellen Zustand der Brücken Venedigs zu untersuchen, damit aber auch gleichzeitig geschichtliche und konstruktive Informationen über diese Brücken zu erhalten. Die Forschungsarbeit wird in drei wichtige Gruppen unterteilt: Historische Untersuchung mittels bibliographischer und archivarischer Quellen; Katalogisierung der Brücken nach Ort und Bauart; Graphische und photographische Bestandsaufnahme der öffentlichen Brücken, unterteilt nach ihrer Lage in den verschiedenen Stadtteilen.

1. INTRODUCTION

In Venice continuity of pathways is ensured by 343 bridges. Big bridges and small bridges, mainly the work of unknown masters. In recent years, the urgency to restore many of these structures has led to the discussion on how to ensure their future conservation on the whole.

Venetian bridges have many peculiarities, due to the following reasons: the characteristics of the venetian environment, which often led to foundations on unstable ground; the instability of the soil, liable in the centuries to a slow but continuous lowering; structures are often built in already saturated urban site; salient humidity combined with chemical action of salt; mechanical action of water in the canals, worsened by the constant increase in wave motion due to the modern means of transportation.

Early venetian bridges were built in wood, erected on flat piles, low arched and with no steps so that they could be ridden by horses. In the 16th century the town began to thoroughly modify its appearance and the obsolete wooden bridges gave way to the more lasting arched brick bridges. Notwithstanding iron structures, greatly fashionable in the last century, brick bridges represent at present the majority (263). Most of them are in an evident state of physical degrade and lacking adequate and up-to-date census of their real condition. Recent visual inspections showed up a distressing situation, in which the bridges – that still bear on their structural body many pipe-lines (gas, electricity, telephone ...) – present diffused cracks, tiring out of haunches, worn out ties, micro-organisms and saline efflorescences which cause detachment of plaster (Figs 1-3).

At the Istituto Universitario di Architettura di Venezia a research has been undertaken, with the aim to illustrate the present state of the town bridges. The investigation was carried out in three phases: a) historical investigation; b) listing of bridges; c) annotated graphic and photographic filing. The work is still in progress, in collaboration with the venetian municipality, within a general restoration programme.

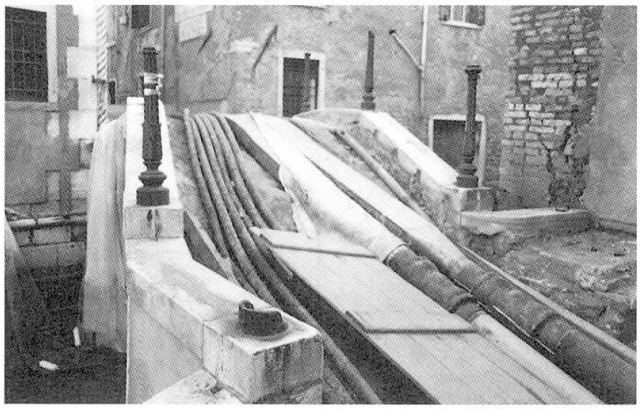

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Fig. 1 Services on a bridge.
Fig. 2 Detachment of plaster.
Fig. 3 Saline efflorescence.

2. VENETIAN ENVIRONMENT AND BUILDING PROCEDURE

The area on which Venice is built was a lagoon region with a lot of silt, sand banks, marshes, meandering canals, with neither potable water, freestone, lumber, nor wood for domestic use. The low bearing capacity of the ground soil, and the difficulty in finding building materials, added to high environmental wilderness, affected perhaps more than anywhere else the way in which the town was built and renewed, from the single element to the whole urban configuration. This has led to an architecture which exhibits a strict correlation between statical behaviour and functional and distributive organization, together with high interdependence between building materials and formal style.

The soil is made of non homogeneous strata of silt, clay and sand. In particular, under a more or less recent sediment of soft sitly clay, 1 to 6 m thick, one can find either a 2 to 4 m layer of compact clay named "caranto" or alternate layers of medium silty clay with dense sand.

The common building procedure provides a stone foundation 2 to 3 m below sea level based on a simple or double layer of timber joists, the so called "madieri" placed directly on "caranto", whenever possible, or conversely on elder, elm, oak or larch piles 2 or 3 m long.The soil strata loaded this way, slowly consolidate, due to partial expulsion of interstitial water present among soil particles, this implies the progressive improvement of their loading capacities but also a great reduction in volume and therefore a subsidence directly proportional to put loads. To insure regular subsidence of the structure, various kinds of pile, slab and raft foundations were used for the same built unit.

In rebuilding, which was most frequent for bridges, whenever possible old under-sea foundations of demolished buildings were used, regardless of distribution and regularity of shape, having the advantage of being founded on already consolidated ground soil.

The statical behaviour of venetian buildings is based on disconnections and continuities, which allow the highest degree of relative movement among the various components, while assuring stability on the whole structure.

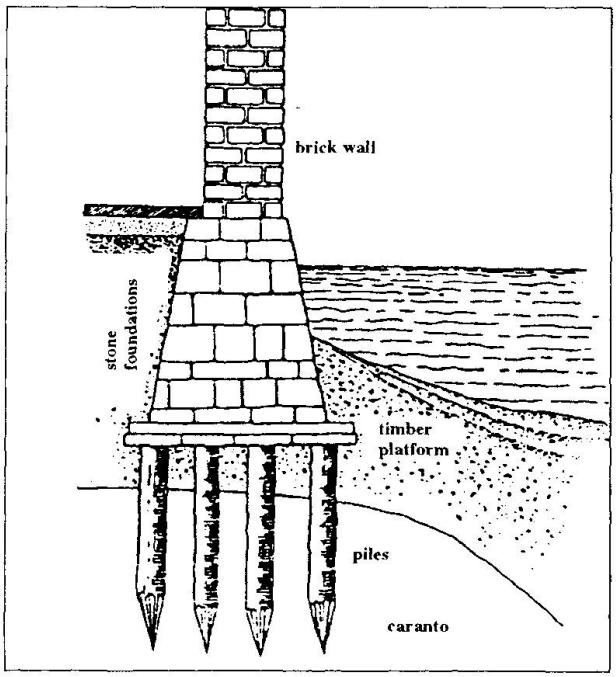

Fig. 4. Venetian building procedure.

Bridges play a very delicate role in this equilibrium, due to the need to match their own statical requirements with those of the buildings joined to them.

3. HISTORICAL INVESTIGATION

Historical investigation is carried out through the analysis of the urban site and of the street system, following a chronological order, based on the historical town maps by Jacopo De' Barbari, Ludovico Ughi, Bernardo and Gaetano Combatti and on maps and papers registered in the venetian archives.

Stone bridges, which date back to the 12th century, were very few, and wooden bridges – being built on piles which rotted easily

owing to dampness – required frequent maintenance and were soon replaced by arched brick bridges. In times past, they were constantly maintained in good state by the owners and by the government of the Serenissima Repubblica, as stated by innumerable decrees, provisions and warnings. The pathologies once suffered by these structures are not much different from the present ones, the essential difference being that while, formerly, a suitable restoration followed shortly the damage, nowadays a fair knowledge of the bridge condition simply does not exist.

4. TYPOLOGICAL STUDY

4.1 The plans

The bridges issued from the "calli" (pathways) and the "calli" are the spontaneous offspring of buildings, regardless of future need of their connection, as both the structure and the shape of many bridges prove. The aim of linking the buildings without altering them has given birth to some utterly unexpected forms: there are twisted bridges that link up "calli" that are not one in front of the other; drawbridges like the one of the Arsenale, which had to leave ships pass; private bridges to enter houses and palaces. Moreover, we can have bridges linking two opposite "fondamente" (pathways running along a canal) or two sides of the same "fondamenta" interrupted by a canal, which can defined as *regular*, while others are more or less *irregular*, or even "storti" (twisted) as they are named both in the official and popular toponymy. The latter are side bent over the canal or skew to the canal axis because they have to link up two streets leading to the water but not facing each other. Their shape is defined by pre-existing structures, with the scope to meet the needs of contiguous houses.

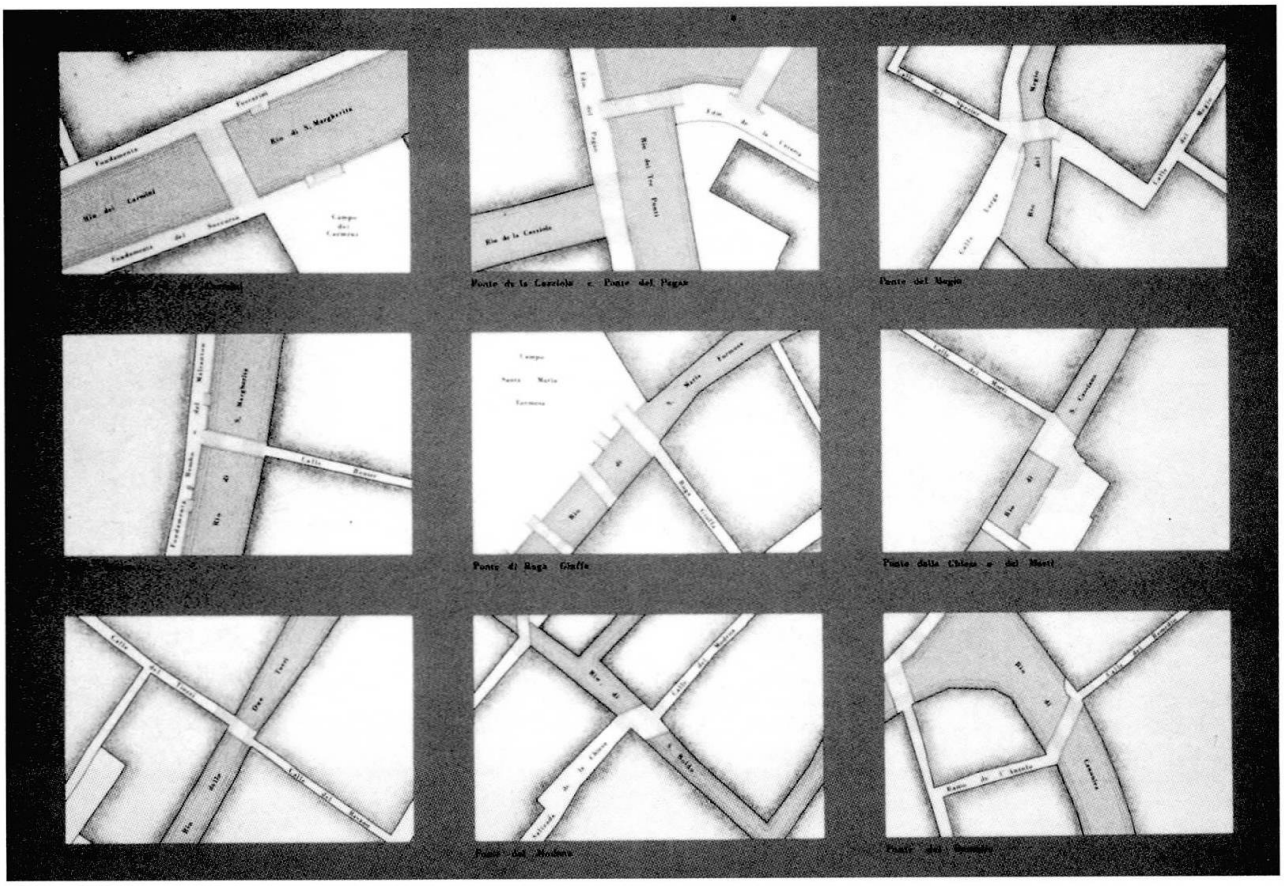

Fig. 5 Example of plan typologies of venetian bridges.

These bridges have ramps branching out in several directions, widening tops to allow the opening of entrances of houses and shops; little pensile paths are not rare: four, five or even twenty metres long, they were thrown to enter houses which otherwise could be reached only by water.

Some bridges are double, *i.e.* they cross with separate arches, which can be parallel or perpendicular to one another, the same canal or two different canals, sharing one or even both ramps. Although each bridge has its peculiar shape, some standardization has been studied based on the type of connection they allow: between "fondamenta" and "fondamenta"; between "calle" and "fondamenta"; between "calle" and "calle", as shown in fig. 5.

4.2 The arch

Our study classifies nine different arch typologies (see Fig. 6 and Tab. 1).

The arch of a bridge has to be high enough to let the boats, loaded with goods, pass; with the exception of the three-arched bridge, called ponte Tre Archi on Cannaregio canal, and the mid-arched one at S. Maria del Giglio, all venetian bridges have only one arch, to meet the needs of water traffic. Bridges crossing very narrow canals often have a round arch; in two cases they have an ogive or gothic arch, a shape not easily found in bridge construction.

The half-elliptic and the double girder bridge appear only once (ponte della Feltrina and ponte dell'Arsenale). The arch shape is related to the canal width: in the narrowest canals the use of round, parabolic or ogive arches is preferred, while in the widest canals the depressed arch is more usual (Tab. 1).

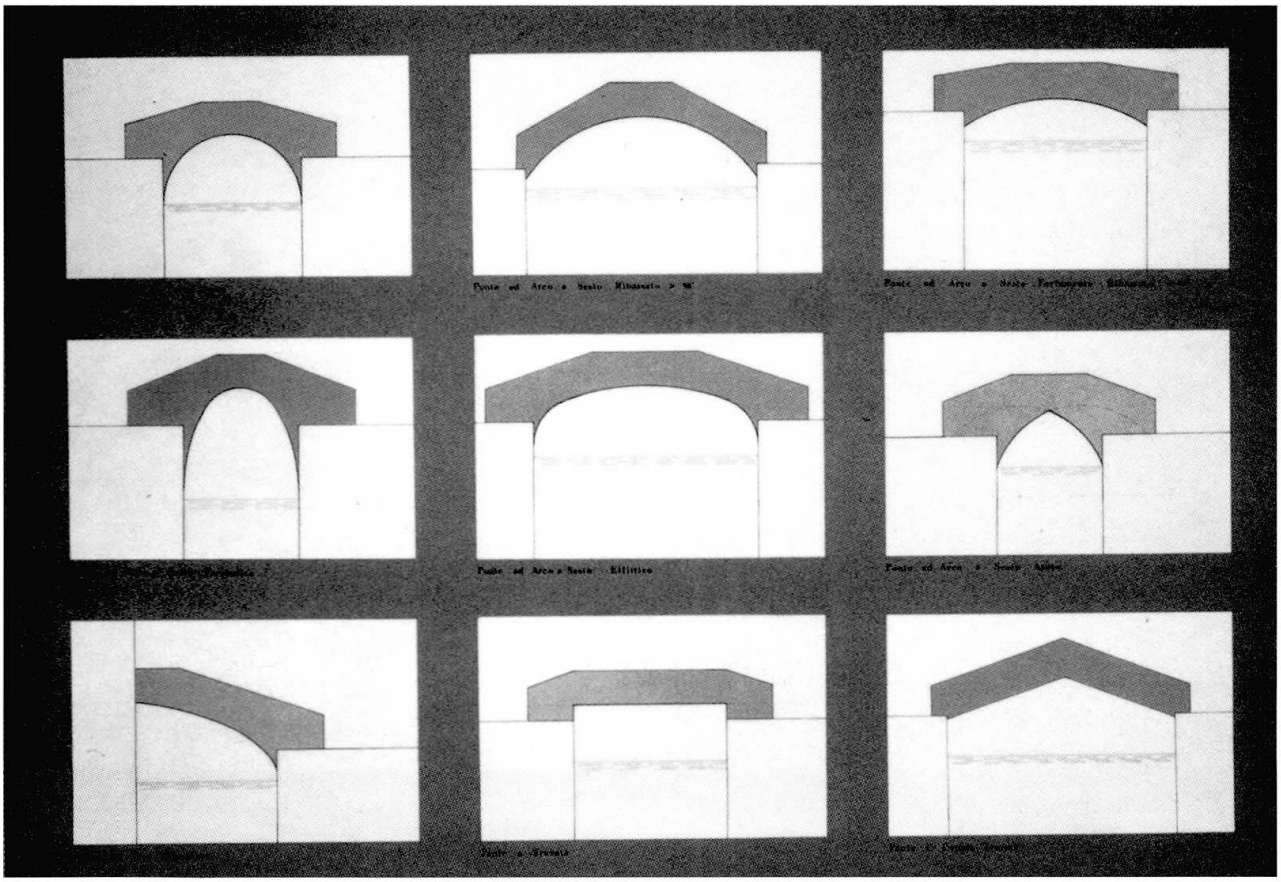

Fig. 6 Schematization of the nine arch typologies of venetian bridges.

Table 1 Venetian bridges arch typologies.

Arch typology	*Quantity*
1. depressed	156
2. very depressed	55
3. elliptic	36
4. parabolic	9
5. round	37
6. ogive	2
7. half arch	1
8. girder	46
9. double girder	1
Total	343

The elliptic arch appears mostly in 19th century rebuilding, when Giuseppe Salvadori was chief engineer at the Municipal Technical Office – *i.e.* the rebuilding in 1827 of the ponte Donà, with elliptic vault, at Fondamente Nuove –.

In the *very* depressed arch category there are bridges with peripheral arch angle less than 90°; bridges with an angle over 90° are instead simply depressed.

The bridges with girder arch are made of wood and of iron, not of masonry, with the exception of the ponte Santa Sofia at Cannaregio.

5. THE FILING SYSTEM

Our bridge filing system gives quick information on quantity, type of structure and location. To this purpose we have made use of several instruments, namely: six maps (one for each "sestiere", as venetian districts are called) (1:2000 scale), synthetical and analytical tables.

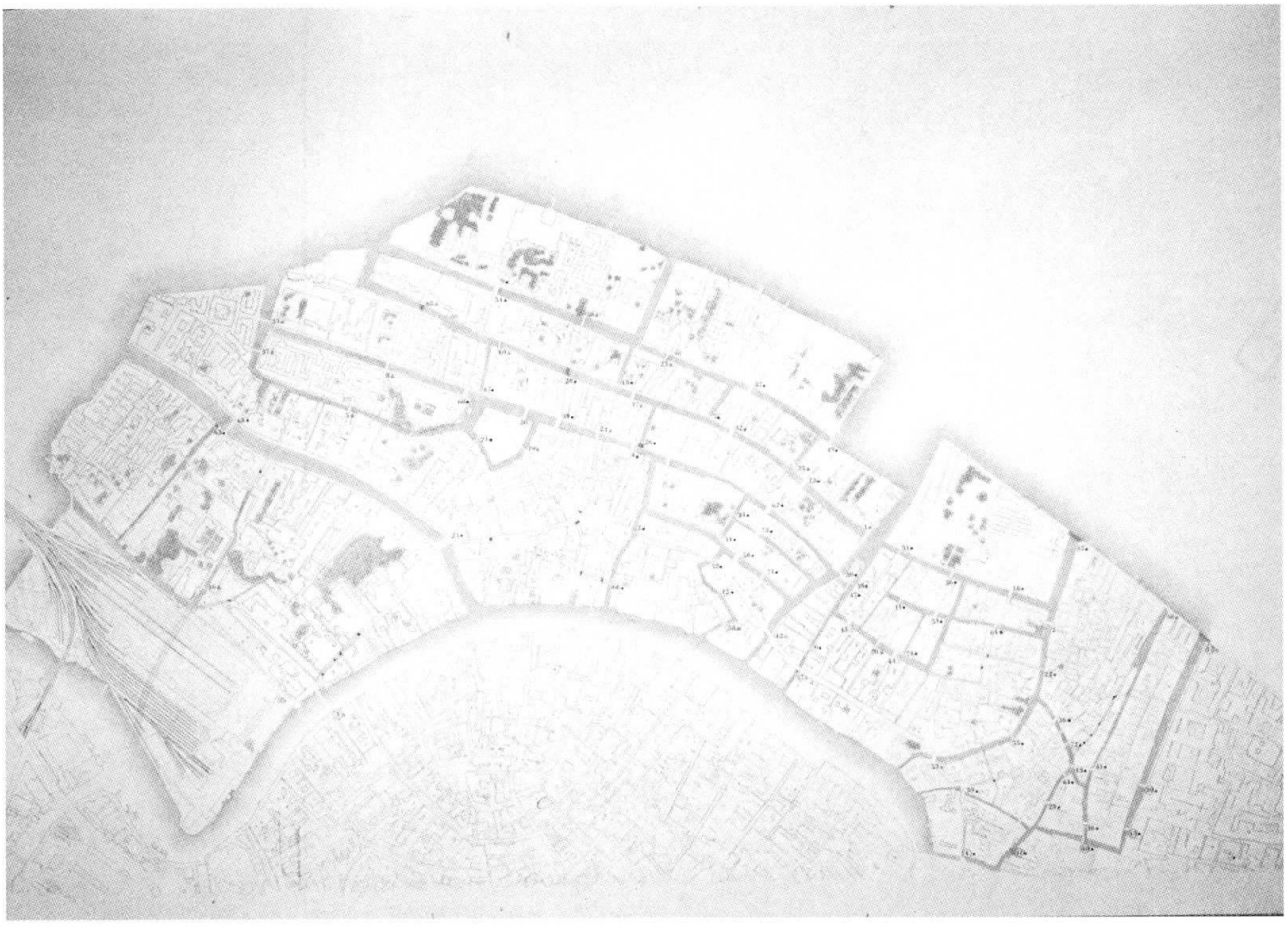

Fig. 7 Example of district map.

5.1 District maps (1:2000 scale)

The analysis develops through six district maps which clearly locate all the bridges pertaining to the "sestiere". A number is assigned to each bridge, circled if the bridge connects two different "sestieri". With this number every bridge will be referred to, both in synthetical and in analytical tables. The symbol and the colour next to the number indicate the building material and the type of arch, respectively (Fig. 7).

5.2 Synthesis tables

Synthesis tables report various information: number, name, canal, place, arch type, skew backs, on each bridge of the district. Beside the progressive numbering and the bridge name we indicate the canal crossed (except for the "cavana" bridges, which do not cross a canal but link two "fondamenta") and the most important nearby sites; technical data on bridge structure, *i.e.* its building material, type of arch and skew backs, are also reported.

5.3 Analytical tables

These tables (Fig. 8) allow the visualisation of each structure thanks to the graphical support given by a planimetric frame (Atlas of Venice), a plan and a front view (1:200 scale), and a picture. Each file includes some notations to allow exact identification of the bridge and gives information on place, canal, date of construction (if available), structure (arch typology and building material) and details such as coats of arms, inscriptions, sculptural decorations.

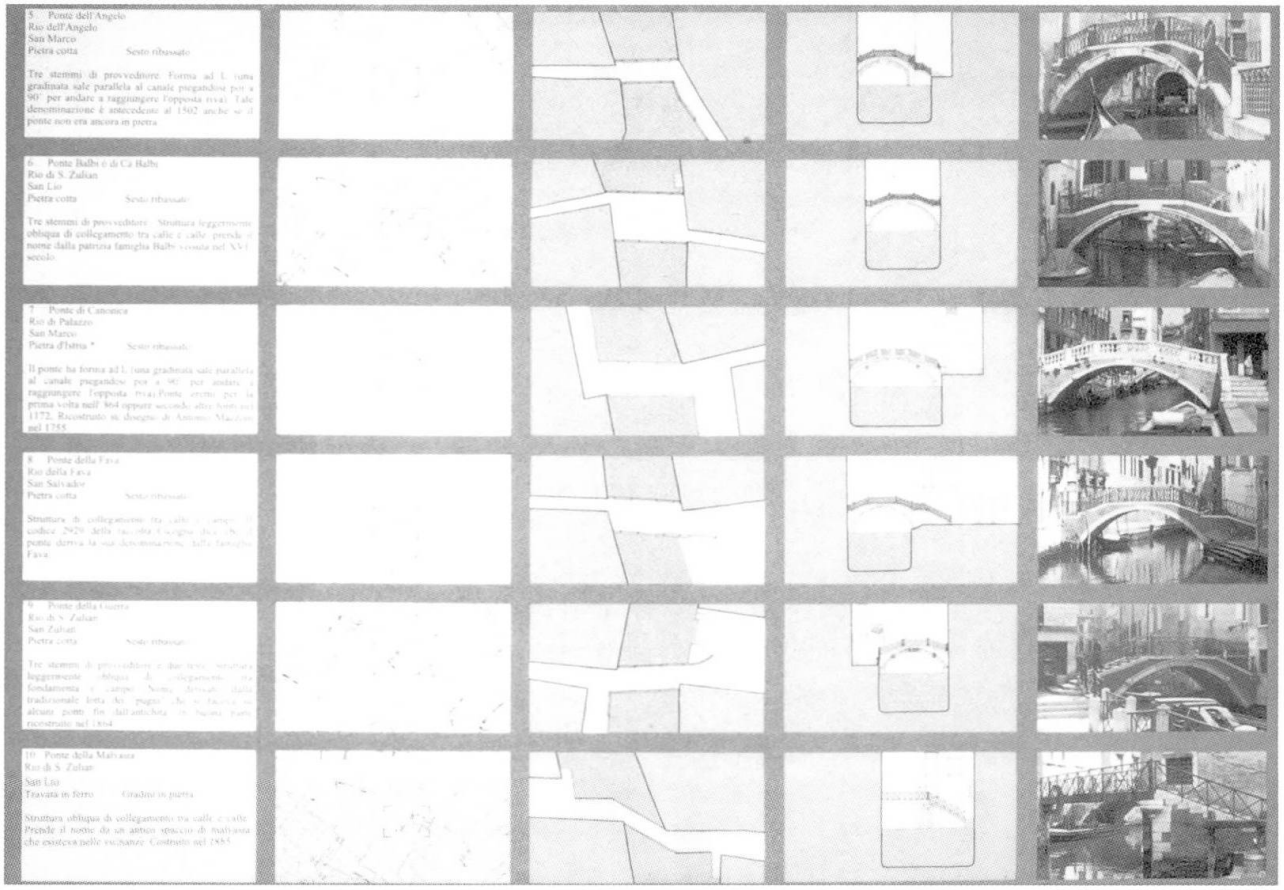

Fig. 8 Example of analytical table.

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