STUDY AND RESEARCH ON TRANSPORT INFRASTRUCTURES. EXPERIENCES AT THE IUAV UNIVERSITY OF VENICE D.C.A. (Department of Architectural Construction) (Section I)

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ABSTRACT

Nowadays Veneto region is playing a leading role in the heated discussion related to the implementation of new infrastructures connecting, integrating and improving actual network links.

Transport structures are various: railways, roads, ports and airports which aim at a faster, safer and more integrated connection among the trans-European and pan-European corridors of the region. Public and administrative bodies pay great attention to the topic of territorial services. As result, cooperation on mobility infrastructures between IUAV University and public bodies has begun.

In particular, the Department of Architectural Construction of the IUAV University of Venice co-operated with Italian Railway Network as regards to railway structures and networks, and with ANAS and Veneto Strade as for road infrastructures. Other co-operations started with some public bodies and trade associations aiming at a high-standard design and an enhanced management of transport networks.

The performed activities could be divided into: study: courses and "Laboratorio di sintesi finale", which aimed at training architects with infrastructure skills, were carried out; research and design within interdisciplinary groups composed by professors, researchers and Ph. D. students who tackled different topics proposed by the agreements, assessing and checking the real status and planning new scenarios.

Hereafter the most relevant results are described, highlighting that the Architect vision, in synergy with the Engineer, may contribute to the implementation of safe and functional infrastructures with a high standard of quality referring to the territory.

The exhaustive document is divided as follows: railway and road infrastructures.

Keywords: study, research, railway infrastructures

1. PREAMBLE

Nowadays problems related to the relationship between the transport infrastructures, both for single person and for groups, and territory, as the environment they go through, are at the heart of a heated discussion.

It is clear that the economic and territorial development in Europe and, especially, in Italy is strictly connected to its infrastructure equipments, but often the infrastructure - territory relationship leads to problems that are not simple to solve.

Infrastructure plan should not be taken into account only from a mono-functional point of view connected to the flow quantification or to the speed, capacity, fluidity and safety of vehicle traffic, but it has to be considered as an instrument of interaction among single person, society and landscape.

Significant road systems could represent a growth factor for territory and for constituent and governing elements of landscape. Thus it is necessary to operate on the new and pre-existing infrastructures understanding their intrinsic value, so they could be converted into a cultural message and a symbol of local culture linked to the territory identity and its characteristics.

In Veneto, there are relevant and clear problems related to the new infrastructure settling-in because this area, core and node of the road and railway system linking Italy to Europe, is characterised by many widespread buildings influenced by a large network of historic and consolidated infrastructures that are the basis and governing element for the urban, social and economic growth in the whole region.

Because of this particular regional organisation, the implementation of many infrastructures, essential for local and national growth, is very difficult or, at least, the local community has strongly been hostile to it having a great impact and undermining a just weak balance.

The IUAV University and especially the Department of Architectural Construction focused on solving these problems pausing on specific topics and developing, at the same time, a multi-disciplinary approach to their study. Thanks to the cooperation and commitment of different professors, researchers and Ph. D. students, the problems concerning railway and road network infrastructures have been solved, admitting, each time, new technical co-operators of different administrative bodies. The transport system infrastructure is the base for developing the different research fields, above all during this period.

The researches, hereafter described, have been developed from railway network problems, paying great attention to the ongoing transformations, in terms of the integration of the new trans-European Corridor no. 5 and the relationship among territory, landscape and anthropized environment.

1.1 Railway infrastructures

1.1.1 Venice and its railway network system

Agreement: R.F.I. VENICE DEPARTMENT

Re: Referring to the fact that Venice with its islands and lagoon is a unique "natural" landscape, also because it is connected to the mainland by means of a trans-lagoon bridge, the research aims at tackling the serious problem of Venice seclusion in relation to the more and more pressing and modern needs of connection with the region.

Venice Department has proposed the study of infrastructure nodes also linked to the request of new solutions:

- connection between Mestre Station and the New High Speed – High Capacity Railway Line
- potential connection with Marco Polo Airport of Tessera.

Agreement development:

- By means of exhaustive information, analytic and training activities and the establishment of Environmental Planning Courses (January 2002, January 2003), and of a "Laboratorio di sintesi finale" (September 2002, September 2003), we focused on the students' awareness on problems linked to the building, management and maintenance of railway networks and their related structures.
  - study and research purposes could be divided as follows:
    - railway network system: urban context, train movement, traffic capacity, safety and signalling systems, locomotion mechanics, general characteristics for design, building, use and maintenance of railway line, railway yard;
    - station: planning hypothesis of new buildings, restyling of existing sites for implementing the underground line stops or the long-path stations;
    - architectural requalification of civil engineering structures; railway, superstructure, modern stations, bridges, the history of great stations by means of competitions, patterns and prototypes of stations of Italy and worldwide.
- Intervention hypothesis and typologies through the report of:
  - Writing exams on:
    - Safety in railway yards
    - Accessibility to Venice, transport of persons and goods from and to the lagoon
    - Creation and development of the historic railway networks of Veneto region (the building of Valsugana line)
    - The Corridor no. 5 and the transit of the High Capacity/High Speed Line in Mestre area
    - Requalification of the so called "*Linea dei Bivi*"

    We requested to students some proposals developed in compliance with the norms of Public Works and a preliminary Study of feasibility.
  - Graduation thesis on:

- Mestre node, reinterpreted with a series of different planning proposals: on the one hand the implementation of an interchange node between the High Speed - High Capacity network and the local railway and underground line, to be placed in a new centre at Gazzera (west of Mestre); on the other hand the design from a functional requalification point of view of Mestre station and its related area;

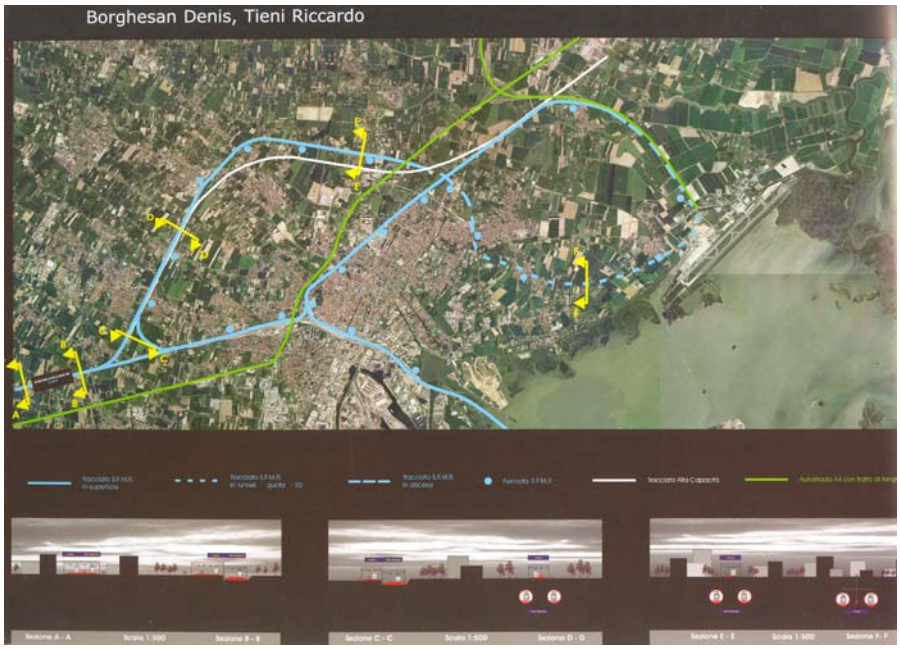

Figure 1 Connection Hypothesis with SFMR layout between Mestre and Marco Polo airport of Tessera (Borghesan, Tieni)

- Link Connection system in Venice, assessing problems related to the particular relationship of the lagoon city with its territory and the difficult introduction of new transport networks in the city (people-mover);
- Railway link between Tessera airport and the urban system of Venice mainland or the lagoon area, assessing different connection hypothesis both through the lengthening and implementation of current underground railway lines of the territory and through a trans-lagoon line integration (maglev);
- Padua and Treviso stations, their urban system and transformations related to the new railway networks in the metropolitan area (SFMR, Regional Metropolitan Railway System) and above all the essential links with High Capacity – High Speed lines;

- Integration works and accessory structures such as railway underpasses and overpasses: as an example, the viaduct of Mestre Padua through which passes the line coming from Treviso, or the settling-in of tunnels and new railway lines;
- Impact analysis referred to the noise and environment problems; the crucial relationship between railway network and the city such as Trento;
- Layout for new medium and little stations with a new approach; Multi-purpose and interchange centres.

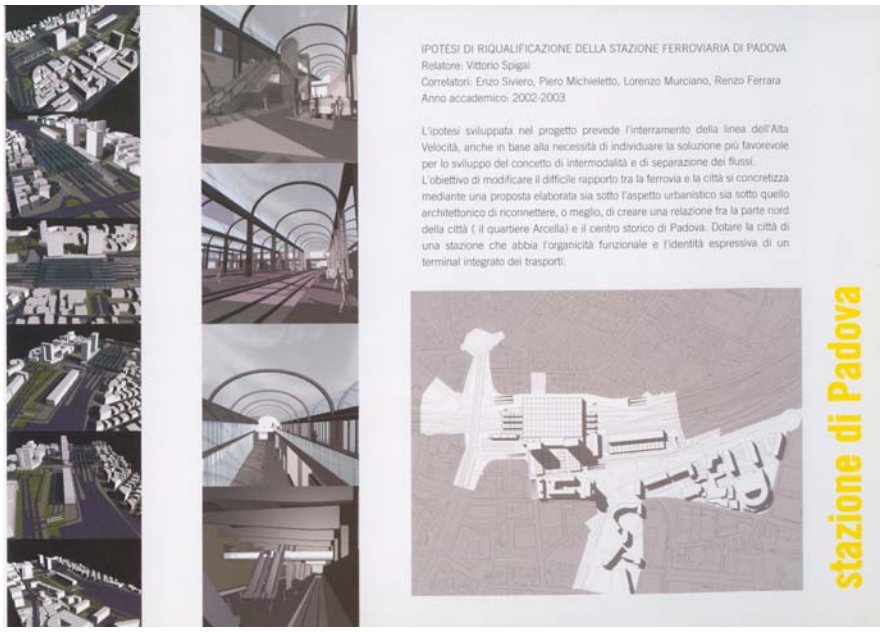

Figure 2 Requalification proposal of Padua station (Pasqualato)

- Agreement products:
  - Articles published on Transport and Culture journal (Trasporti e Cultura);
  - Presentation of the results achieved by graduation thesis during the meeting "Transports – a multidisciplinary pathway" to which some principal research professors took part in, Verona 11 December 2003;
  - Trade fair stand at Padua "Binaria – Asphaltica" ("Rails – Roads") in December 2004;
  - Presentation of the exhibition during the meeting "Metropolitane e Tramvie" (Undergrounds and Tramways), 10 December 2004;
  - Catalogue titled "Eticittà e Mobilità" (Ethicity and Mobility) presented at the trade fair Rails, Padua December 2004;

- Meeting organised at the IUAV University of Venice in March 2005 on the railway structure and yard safety.

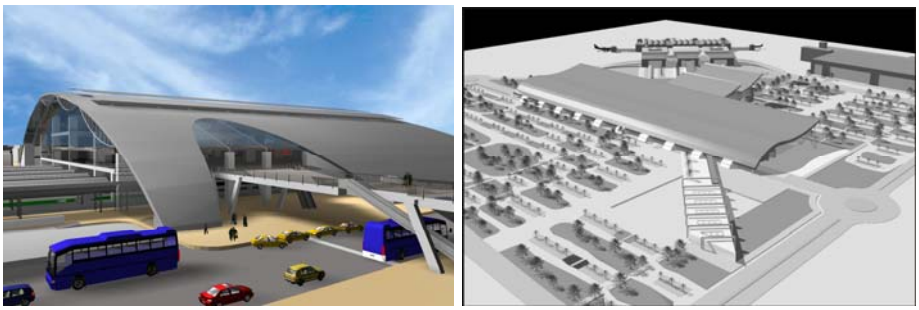

Figure 3 A proposal for Mestre station (Berno, Borgo) and for the connection with Marco Polo airport of Tessera (Borghesan, Tieni)

1.1.2 Solution of problems related to territorial integration of the new underpass planned by HS/HC Venice-Trieste project from Ronchi to Trieste route, replacing the metal truss crossing viale Miramare in Trieste.

Agreement: R.F.I. TRIESTE DEPARTMENT

Re: Commissioning group requested to the Department of Architectural Construction a technological study, which aimed to imprve the relationship between the underpass and the environment context, working together with the Department of Architectonic and Urban Projects of the Architectural Faculty of Trieste.

A report with an assessment of the relationship among the new underpass, its environment context and existing structures, and a second document studying the structure and proposing a feasibility study were required.

Thus the research purpose was:

- An impact assessment about the underpass integration in connection with its location, reporting and explaining the relationship with urban context in which the structure is placed in terms of: volumetry, shape, style, material choice and colour.
- Definition of site and its subsequent landscape quality, according to the following criteria: nature, history, culture and specificity aspects.
- Structure integration in connection with the coexistence, in harmony or contrast, of different building typologies and surrounding environments. An in-depth study on structure visibility from various points of view such as: surrounding roads, more or less distant panoramic sites or particular areas accessible to people. Particular attention is paid to structures placed near important natural, historic, and artistic landscapes.
- The strict relationship with the involved Bodies and the exhaustive assessment of the technical – building aspects led to a non-stop check of the hypothesis proposed together with potential alternative solutions.

Agreement development:

This ongoing research and the activities carried out up till now could be divided into two phases.

Phase 1: Preliminary contextualization and assessments.

- Information and analytical activities aiming at identifying and studying intervention problems:
  - Definition of guidelines related to the analysis of technical-functional, architectonic, environmental solutions in compliance with the current norm criteria.
    - Territorial setting: identification of the intervention area.
    - Intervention reason: identification of the road network problem as well as the main reasons leading to the project.
    - Identification of program frame of reference: identification of rules and obligations reported within the landscape, territory and urban plans as well as of the general and interested zone (related to the intervention area).
    - Identification of project frame of reference: description of the chosen project solution; description of potential project alternatives; identification of alternative sites in order to carry out the project;
    - Identification of environment frame of reference: environment description (flora, fauna, soil exploitation, anthropic phenomena, landscape major historical resources)
    - Identification of the assessment criteria: definition of the assessment criteria referring to the structure – environment relationship and the implementation of an analysis pattern.
    - Identification of the structure – territory interferences: identification of interference or conflict situations between the project intervention and the surrounding environment, especially referring to a building or operating phase reporting potential measures of environment offset and the potential intervention of mitigation.
  - Finding data resulting from the typological setting report, the study on technical-architectonic feasibility, the preliminary study on the territory impact, the preliminary study on hydraulic feed, the structural design and the preliminary study on characterisation.
  - Comparative analysis of data: comparison among the characteristics of the different solutions checking the increase or decrease of potential effects on landscape and on the symbolic features in compliance/contrast with the typology of surrounding structures.
- Results from the first phase:
  - The first project hypothesis: it is expected a widening of railway line at the side of "sea", which will lead to an interaction with the port area aiming at the division in two of Viale Miramare in its crossing with the railway overpass. It is preferably maintained the formal continuity with the existing bridge representing the main example for the most of railway bridges. This should be carefully assessed also in connection with the

symbolic value of the overpass being the main entrance of the city, as a gateway.

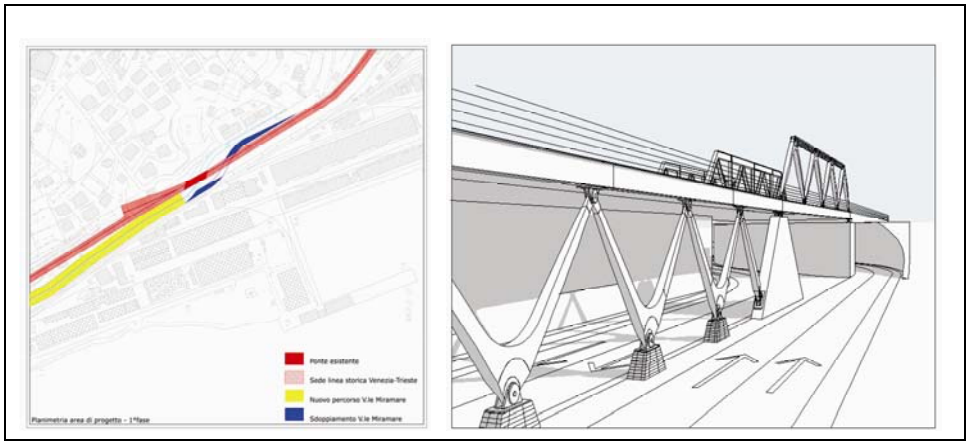

Figure 4 The first hypothesis of project

Phase 2: Assessment of the project hypothesis.

- Occurred problems. Referring to the site problems and the structure composition, we pay great attention to the different types of interferences, especially:
  - Building interferences: check the conflict aspects during the structure implementation such as potential temporary effects related to noises and air pollution in yard areas.
  - Interferences related to the permanence in the area: the whole project intervention represents a functional adaptation aiming at the reorganization of road network system and the improvement of the area accessibility to the involved urban centres. Thus, the intervention value will be directly proportional to a particular area.
  - Use interferences: as the project objective is the implementation of the technical-normative conditions in order that people and goods can safely pass below the overpass, thanks to this plan, along Via Miramare the traffic flow capacity increases. Nevertheless, we should check if this intervention, due to its setting as regards the road network and urban centres, could increase traffic build-up and consequently lead to a growth in pollutant agent quantity.

- The second project hypothesis. A new project hypothesis has been proposed characterised by the introduction of a tunnel, which aims at linking the two different parts of the city and the consequently requalification of the involved areas. The hypothesis starting point was the analysis of occurred and assessed problems related to the presence, near the intervention site, of

structures with a relevant historic and artistic importance. Researches on this hypothesis are currently being carried out.

Figure 5 real status and integration of the second project hypothesis

1.1.3 Structural analysis - bridges

Agreement: R.F.I VENICE DEPARTMENT

Re: To the Department of Architectural Construction, Venice requested the performance of a Structural Analysis program related to some structures (bridges) by means of a mathematical model. This agreement refers especially to theoretical – statistical surveys, paying great attention to four significant structures: the brickwork bridge so-called "Vecchio" (Old) in Venice, the metal truss bridge with two bays in order to pass through Brenta river in direction Milan – Venice, the brickwork three arches bridge on Tesina river in direction Milan – Venice and finally the brickwork bridge with a 24-meter arcade and two underpasses called "*Gobba*" (Bump) in direction Venice – Udine.

Agreement development:

The typological and constructive diversity of structures, whose analysis was requested, leads to the implementation of different study groups.

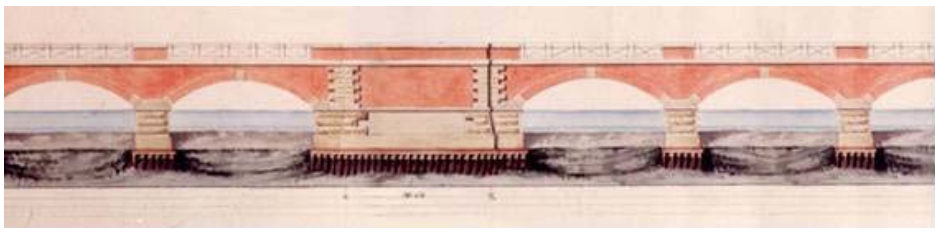

Figure 6 prospectus of bridge designed by Andrea Noale, Archives of Italian Railways, Venice.

The railway brickwork bridge of Venice. Due to the particular bridge features, the study has been divided into different phases:

- Phase 1: an in-depth study on the historic setting of the Venice – mainland linking network and on the origin of such link has been performed.
- Phase 2: search for the authentic cartography and study on structure geometric relations.
- Phase 3: collection of information about the technologies used for the bridge construction and about the utilized materials. In this section, we have also analysed the camber systems for the arch construction.
- Phase 4: structural analysis. During this phase, different historic and structural aspects have been carefully studied.
  - Study of historic handbook documents for the check of arch structures
  - Assessments of theories related to the railway bridge structural design finding within the historic handbook documents
  - Structural analysis of the Translagoon bridge instability
    - Check the arch stability and the instability occurrence. Therefore, the bridge reliability has been experimentally assessed.
    - Checks and assessments of some piers for which non-destructive testing has been carried out and its effects on the structure of train transit have been evaluated.

Figure 7 metal truss bridge on Brenta river

Metal truss bridge on Brenta river – km 234.886 of Milan – Venice line. Study and assessments on this structure have been performed in order to understand the reaction to an increase in railway traffic as well as its speeding up.

It is expected that the analysis has:

- a phase of theoretical study on the structural response of the bridge by means of the creation of simulation models in connection with the geometric and mechanical characteristics of its actual structure. So a numerical model has been developed thanks to a program for the creation of the bridge elements. This model is based on documents related to the 1947 project as well as the strengthening intervention dated 1997. The particular mechanical feature of the material, due to the lack of guidelines as for 1947 project, has especially referred to materials pursuant the norm of that period. As regards the strengthening intervention, some explicit constitutive guidelines have been reported.
- A structural analysis, in compliance with the current norm, which has identified the most interested elements, such as the bridge beams, has been developed.
- Potential degradation phenomena have been expected but, due to the problems in finding documents and carrying out checks on materials and junctions, some hypothesis on the bridge preservation have been developed:
  - potential corrosion of bridge metal parts and following effect on its maximum tension and whole structure;
  - potential damage of junctions between bridle and lower beam and the following effect on its maximum tension and whole structure.
- Some assessments as for the structure horizontal alignment:
  - the bridge obliqueness effect on stress diagrams in comparison with the same parallel structure;
  - effect of lozenge plank covering braces on stress features in comparison with the same cross braced structure;

Brickwork bridges: Gobba bridge and bridge on Tesina stream

Study was developed as follows:

Phase 1: General assessments on railway brickwork bridges

- Preliminary analysis on the current brickwork bridge status has been deepened evaluating the plank covering features. The instruments for static and bridge structure checks have been identified underlining problems linked to the checking of bridges with one or more arches.
- Constitutive and checking elements have been identified up to delineate which checks on the brickwork bridge plank covering, piers and spans have to be carried out.
- The necessary interventions for bridge structure adaptation have been recognized drawing up some guidelines for brickwork railway bridges adaptation. Adaptation criteria have been found by means of composite bracing.

Phase 2: These assessments have been used in order to check Gobba bridge and bridge on Tesina stream, for which we have made:

- assessments on loads and overloads in compliance with reference norms and following enforcement
- assessments on external actions stressing the structure: loads of estimate
- adaptation proposals.