JCSS

Joint Committee
on Structural Safety

Workshop on Assessment of Existing Structures

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Rehabilitation and seismic upgrading of the Villafranca bridge

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IN SUPREMÆ DIGNITATIS
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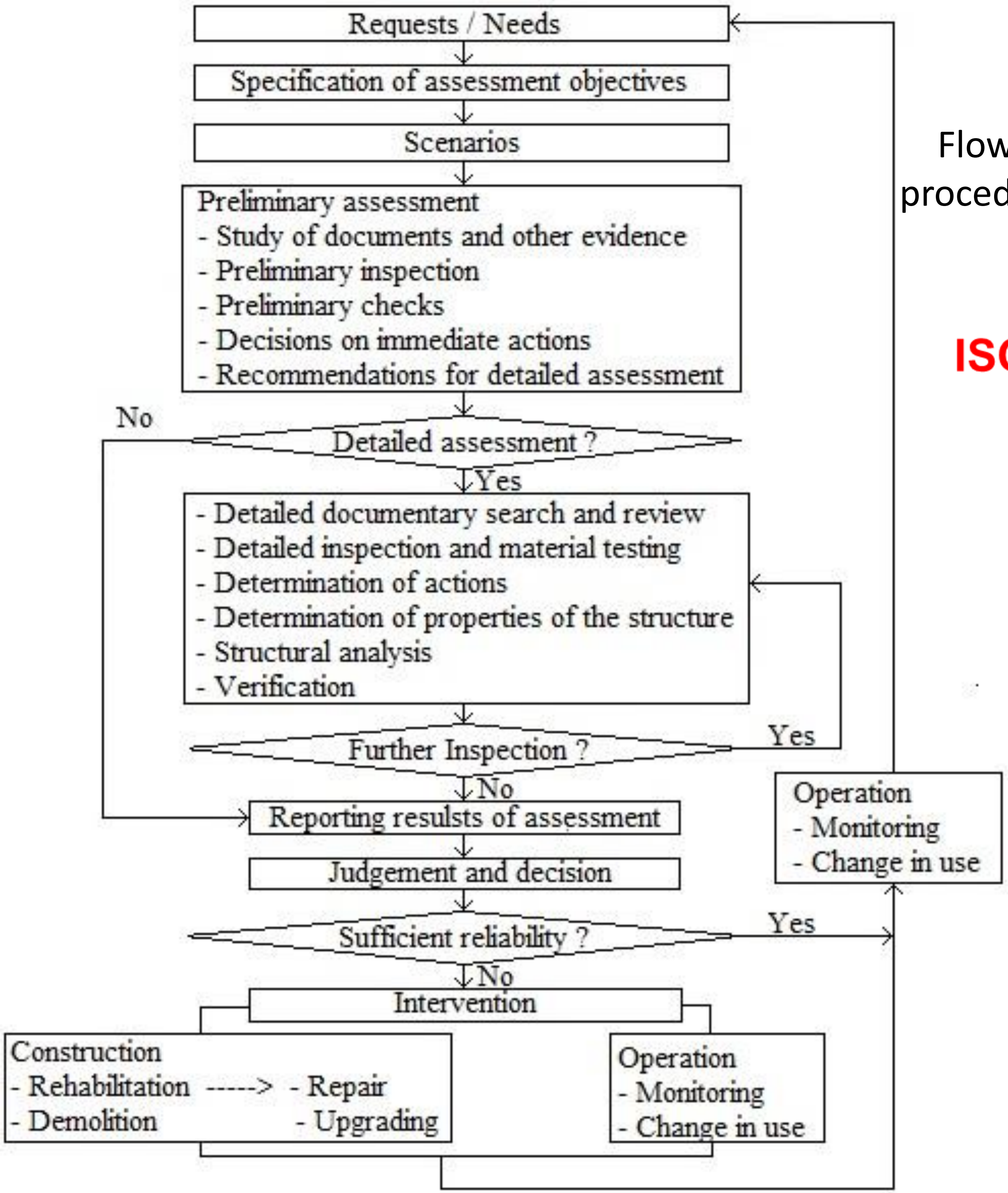
The presentation deals with the rehabilitation and the seismic upgrading of an historical masonry bridge crossing the Magra river between the small towns of Mulazzo and Villafranca in the northern part of Tuscany (I). The bridge was partly destroyed by the 2011 flooding (Croce N. et al. 2018)

[1] Croce, N. et al. (2018) Rehabilitation and seismic upgrading of the masonry arch bridge over the Magra river in Villafranca. Procedia Structural Integrity, 11, pp. 371-378.
doi: 10.1016/j.prostr.2018.11.048



Flowchart summarizing the procedure for the assessemnt of existing structures

ISO 13822, 2003

THE BRIDGE

- Single lane carriageway masonry arch bridge built in1874:
- 8 arches spanning 19 m around each;
- 12 m height intermediate masonry piers on shallow foundations;
- dept of the original pier foundations diminishing from Villafranca toward Mulazzo

The bridge during the erection phase

- In 1874 the course of the river was slightly different; the bridge was on a right bend (velocity of the current higher on Villafranca side (left bank)

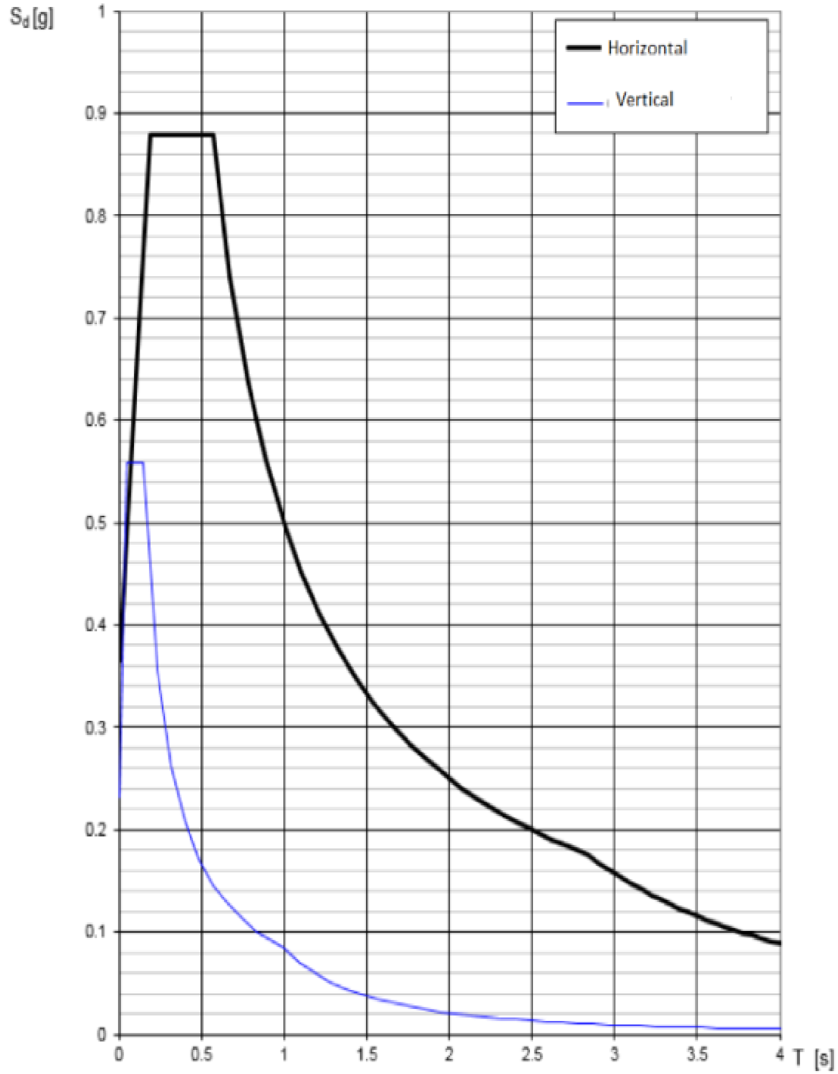
- To carry two lanes, in 1961 carriageway was widened by means of two lateral prestressed concrete beams, hiding the arches and modifying severely the bridge original aspect.

- In 2005-2010 a severe crack pattern appeared in two arches in Mulazzo side, due to scour of the piers

- Monitoring and inspection programme

- During the 2011 Magra flooding two arches collapsed
- Light traffic was allowed by a Bailey bridges

- Rehabilitation, restoration and seismic upgrading
- (Class IV structure – 200 years reference period)



Theoretical reliability analyses require the knowledge of the relevant statistical properties

mean, COV

of the mechanical properties of the material.

Generally, specific in situ tests can allow to appreciate the mean values, but not the COVs

To evaluate the COV, reference could be made to large databases of test results obtained on similar coeval structures, built in the same region with similar workmanship and material

To assess the pdfs of mechanical properties “blind” cluster analysis could be performed on huge databases of secondary and raw test results.

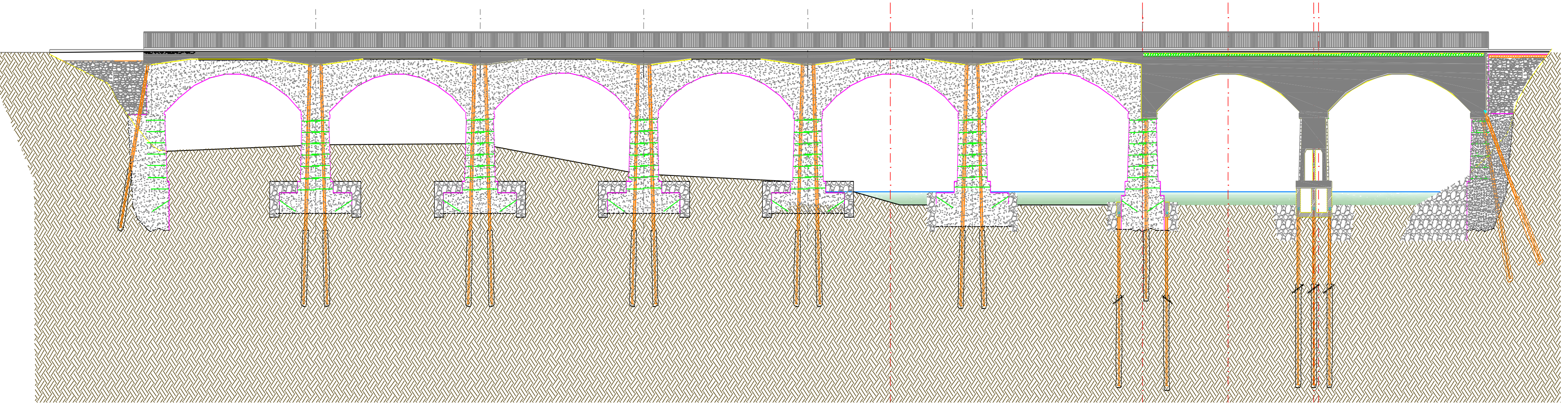
The application of that methodology is illustrated in Croce, P. and al. (2021) for masonry, in Croce, P. and al. (2020) for reinforcing steel and in Croce, P. and al. (2018) for concrete.

Croce, P. and al. (2021) Bayesian Methodology for Probabilistic Description of Mechanical Parameters of Masonry Walls. *ASCE-ASME J. Risk Uncertainty Eng. Syst., Part A: Civ. Eng.* (in press) DOI: 10.1061/AJRUA6.0001110

Croce, P. and al. (2020) Influence of reinforcing steel corrosion on life cycle reliability assessment of existing R.C. buildings. *Buildings* 10 (6): 99. doi: 10.3390/buildings10060099.

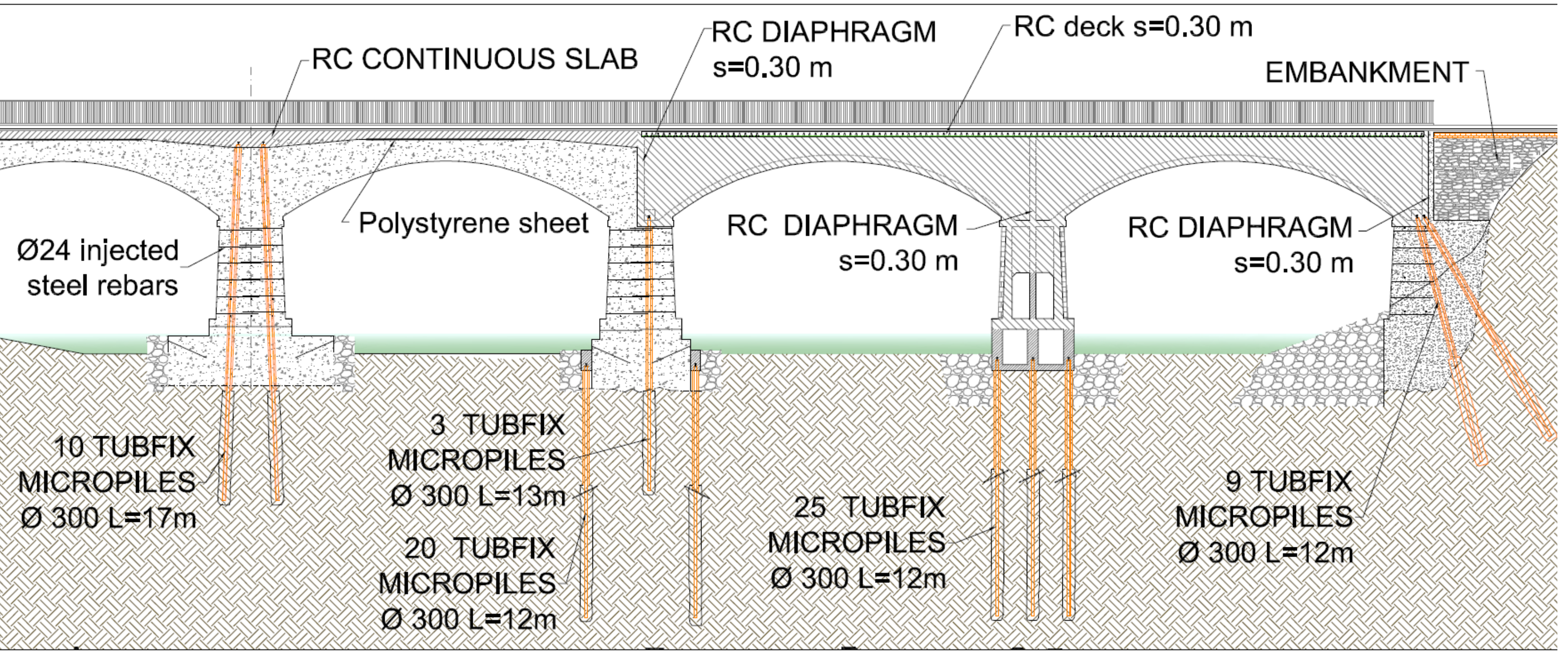
Croce, P, and al. (2018) Evaluation of statistical parameters of concrete strength from secondary experimental test data. *Constr. Build. Mater.* 163 343–359. doi: 10.1016/j.conbuildmat.2017.11.001.

- Rationale of the interventions



- Recovering the original aspect

- Details of the strengthening intervention



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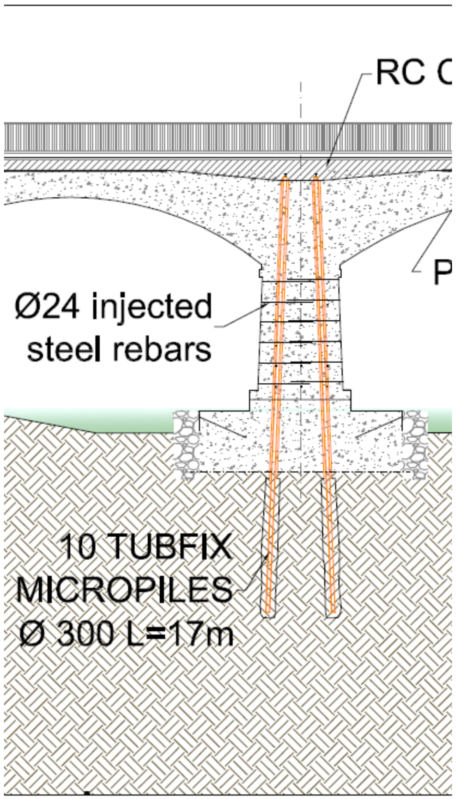
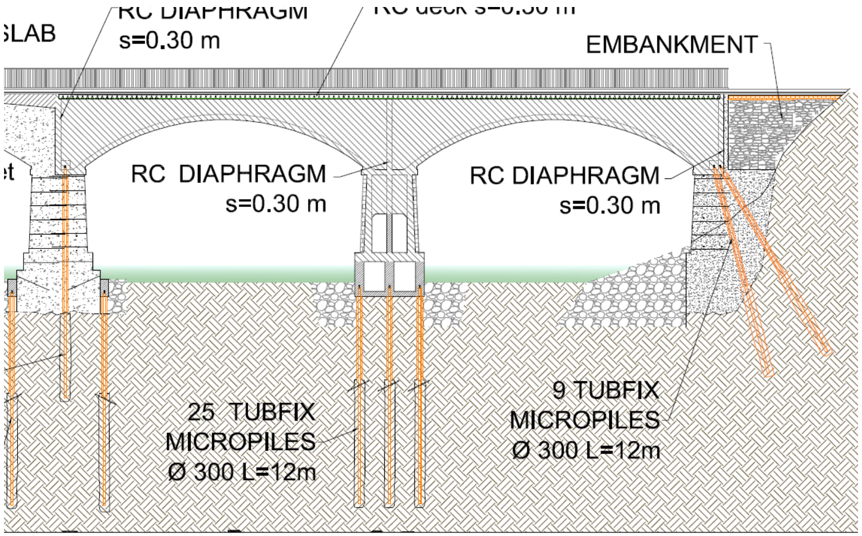
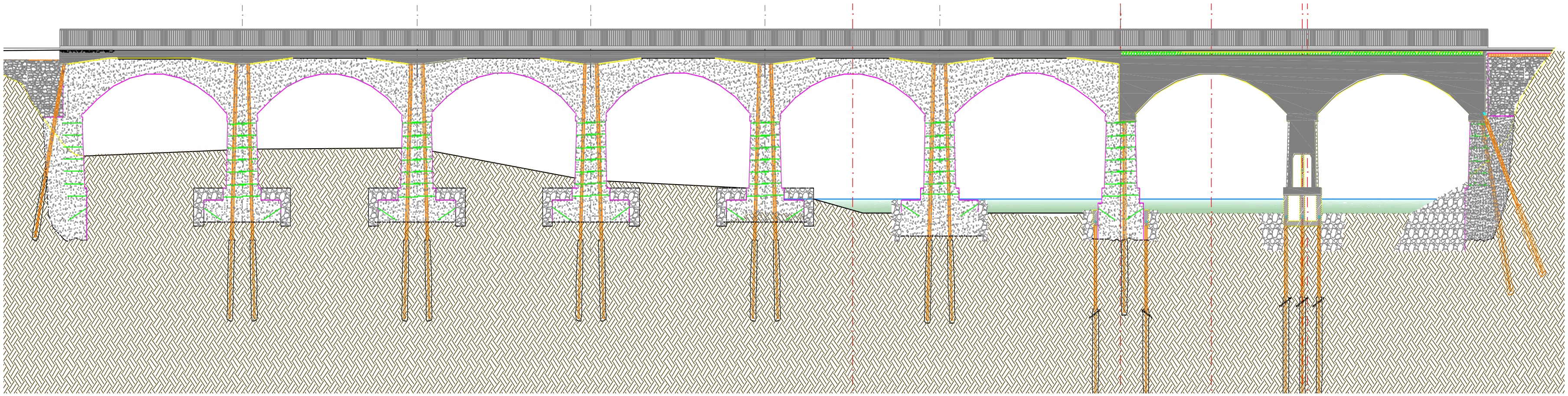


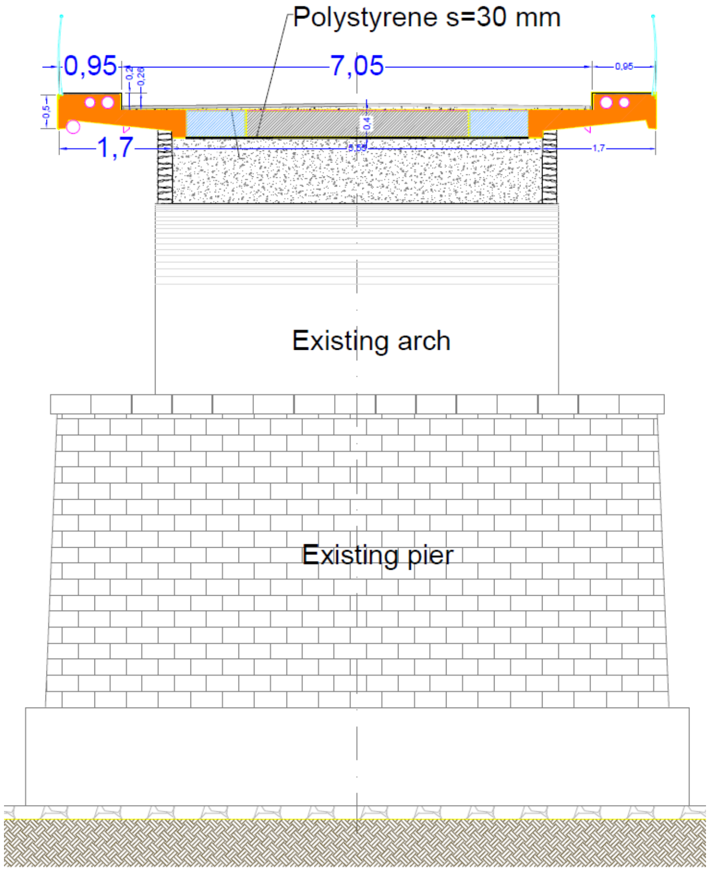
- Erection of the new concrete arches

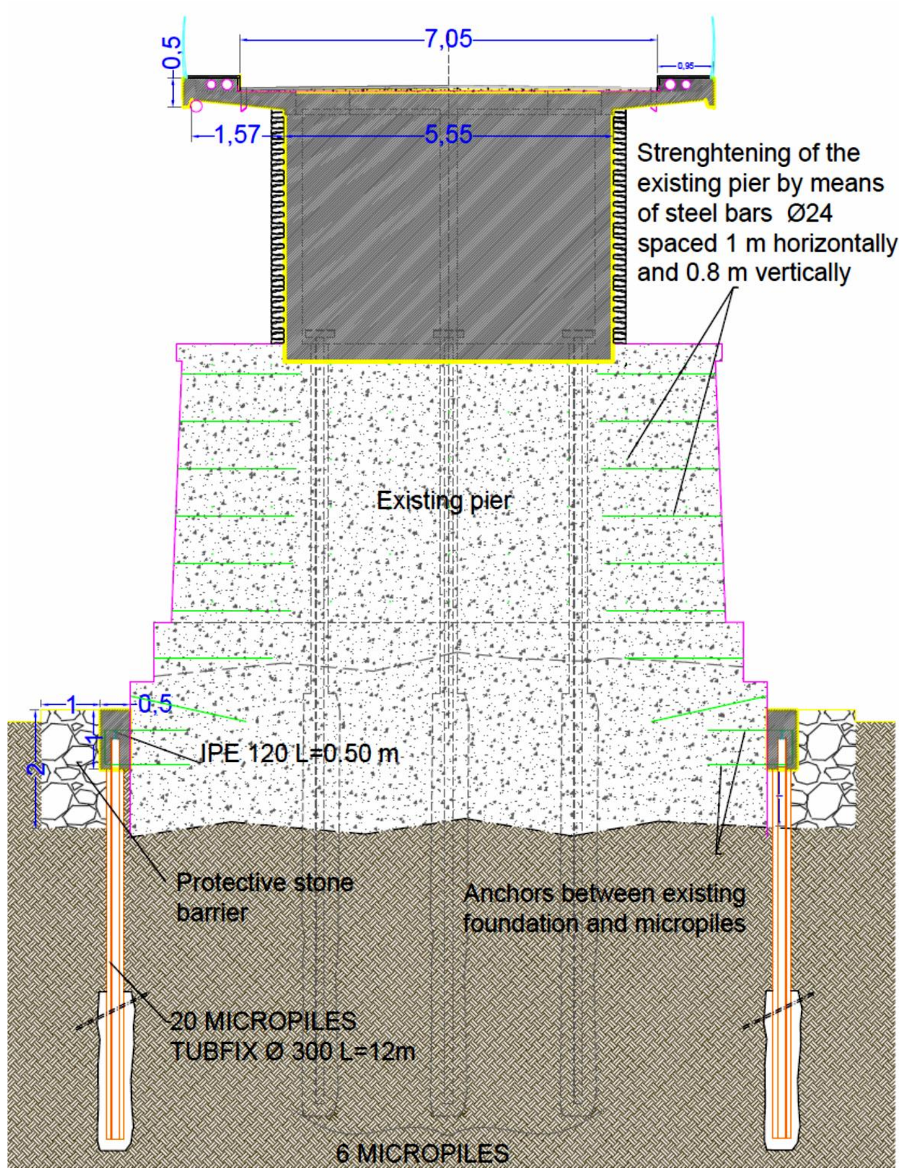


- The rc continuous slab



- Strenghtening of existing piers





- Phase 1: strengthening of the external body of existing piers (steel bars ϕ24, spaced 0.8 m vertically and 1.0 m horizontally, duly injected) and foundations of the existing piers (external micropiles connected to the existing foundations and protected from scour by means of stone barrier (light traffic permitted);

- Phase 2: erection of foundation and body of the new concrete pier (light traffic permitted on the bridge);

- Phase 3: setup of alternative routes to mitigate the effects of the closure of the bridge;
- Phase 4: dismantling of prefabricated beams in c.a.p. put in place in 1961 to widen the carriageway and restoration of the external surfaces
- Phase 5: disassembly of the Bailey bridge;
- Phase 6: erection of the two new spans in c.a. cast in place (Fig. 19);
- Phase 7: strengthening of the remaining part of the bridge (6 arches);
- Phase 8: erection of the new r.c. concrete deck slab (Fig. 19);
- Phase 9: finishes.

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Conclusions

The rehabilitation, strengthening and seismic upgrading of the Villafranca bridge on Magra river, aimed not only to repair the collapsed arches, but also to widen the carriageway, fulfilling at the same time severe requirements in terms of static and seismic performances.

Now, the bridge is able to withstand traffic loads and seismic actions foreseen for new bridges. seismic actions with return period of 1898 years have been adopted, considering a soil Category E and a refence PGA on soil Category A of 0.309 g.

The interventions have been conceived in order to preserve as much as possible the historical and cultural value of the bridge, adopting were possible reversible solutions, like for the new concrete deck, and recovering the original aspect of the bridge, anyhow not hiding the unavoidable additions, linked with the reconstruction of the collapsed parts.

Open issues and further developments

In assessing the reliability of existing structures, the following aspects should be carefully considered also in view of future developments:

probabilistic parameters of relevant mechanical properties, in particular COVs are often uncertain;

Hidden unsafety versus hidden safety: the structure is existing, so it can be better known compared with a new one, but, at the same time, some (unsafe) modifications can be present, which is nor documented neither easily seen.

Unusual strengthening methods, which are not directly considered in Codes, are often adopted

Thank you for your attention

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