TU1406
COST ACTION

WG2 and WG3 WORKSHOP

Bridge performance goals and quality control plans

PERFORMANCE GOAL ASSESSMENT FOR EXISTING BRIDGES SUBJECT TO PIER LOCAL SCOUR

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INTRODUCTION

- In European roadway and railway networks, many multi-span unreinforced arch bridges were built in the last centuries.
- Piers are often characterized by shallow foundations placed in the river bed, which can be subject to hydrodynamic turbulences in case of river floods and can lead to localized scour phenomena.

INTRODUCTION

- The lack of adequate monitoring can cause over time scour-induced settlements able to involve bridge structural failure.
- The structural behaviour of existing masonry bridges through the failure analysis of a finite element model case study is investigated.

1901

2011 (retrieved online at www.lametino.it)

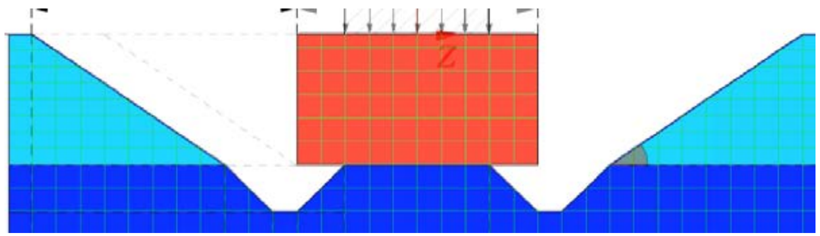
AIM OF THE WORK

- Numerically simulating the evolution of the structural behaviour and finding a relationship with the local scour profile at the base of pier foundations.

P.I.?

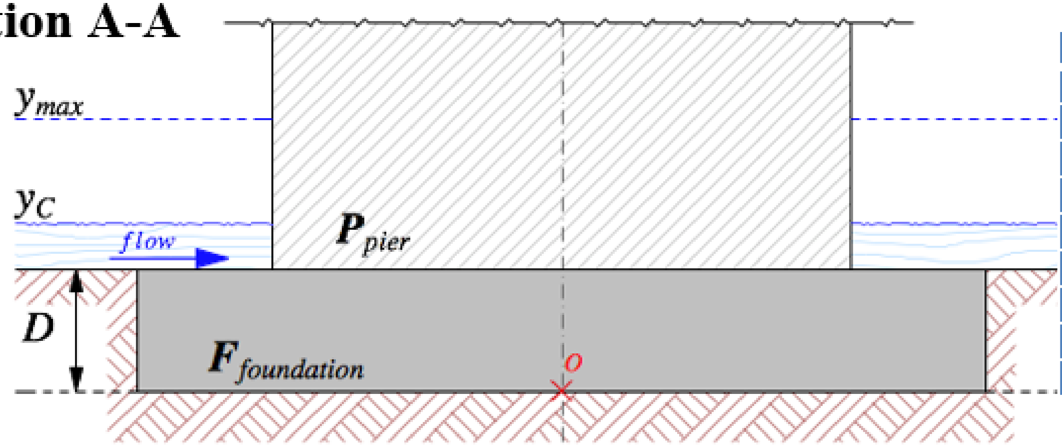
P.G.?

Il momento della caduta del ponte della foce(1834), avvenuta il 22 agosto 1965. Da archivio foto di Ballinari R., Verbania.



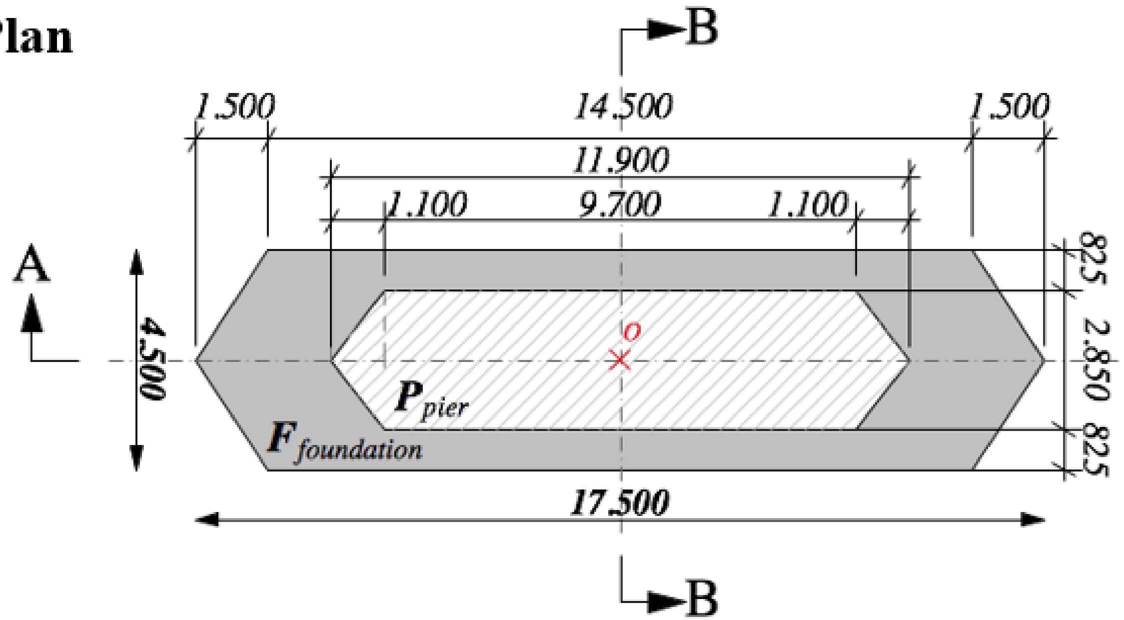
FOUNDATION GEOMETRIC CONFIGURATION

Section A-A

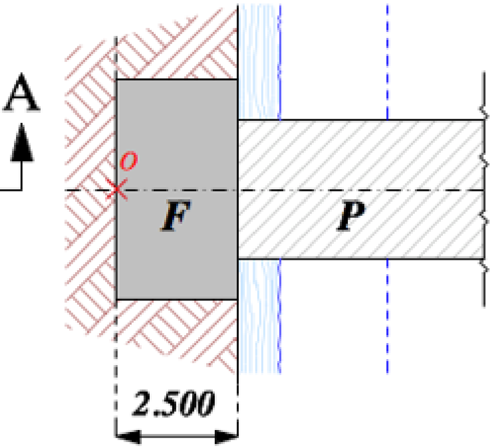


Parameter	Soil	Foundation
Specific weight	γ_S = 18 KN/m^3	γ_F = 20 KN/m^3
Saturated unit weight	γ'_S = 8 KN/m^3	-
Elastic modulus	E = 50 MPa	E = 20000 MPa
Poisson’s coefficient	n = 0.25	n = 0.20
Finite element	Plate Quad8	Plate Quad8
Constitutive law	Elastic-Plastic	Elastic
Material model	Mohr-Coulomb	von Mises
Friction angle	φ' = 35°	-
Cohesion	c = 0.001 MPa	-

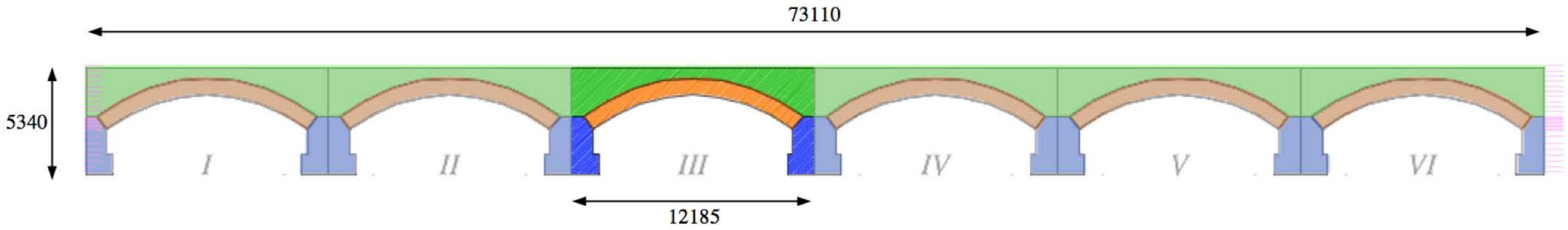
Plan



Section B-B

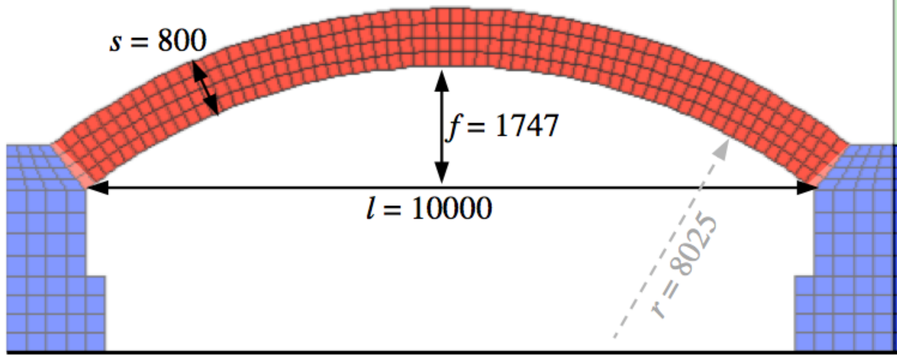


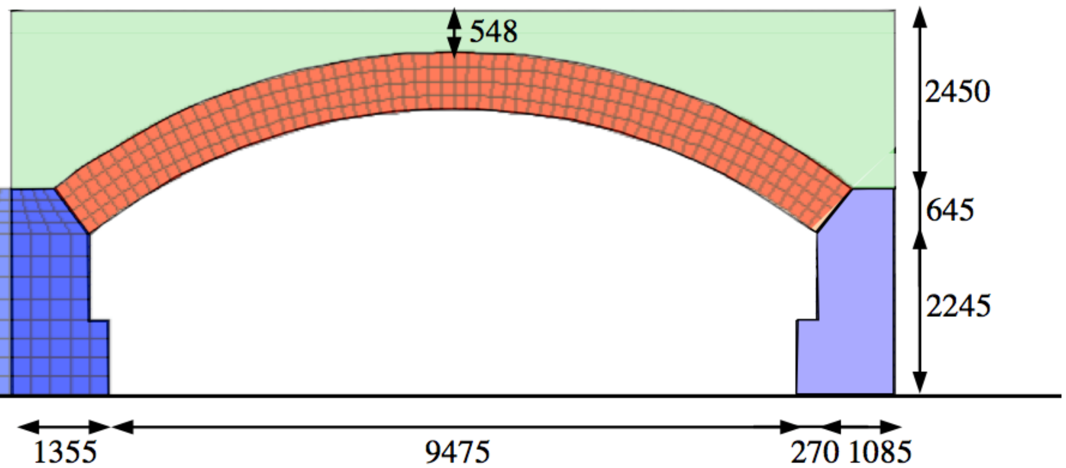
BRIDGE GEOMETRIC CONFIGURATION



Parameter	Backfill	Arch / Piers
Specific weight	γ_S = 18 KN/m^3	γ_S = 18 KN/m^3
Elastic modulus	E =1400 MPa	E =4000 MPa
Poisson's coefficient	n = 0.20	n = 0.20
Constitutive law	Elastic-Plastic	Elastic-Plastic
Material model	Mohr-Coulomb	Drucker-Prager
Friction angle	φ' = 30°	φ' = 64.8°
Cohesion	c = 0.08 MPa	c = 0.43 MPa
Compression strength	f_c = 0.27 MPa	f_c = 3.85 MPa
Tensile strength	f_t = 0.09 MPa	f_t = 0.19 MPa

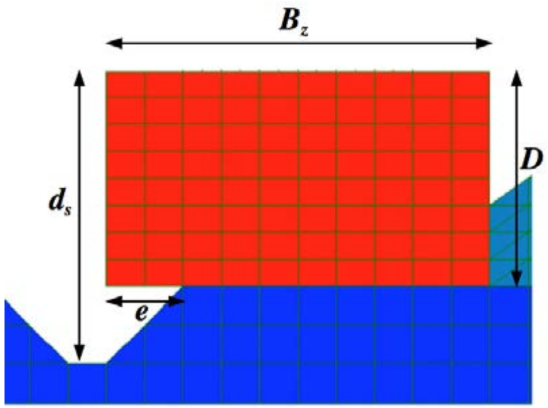
F.E. models were implemented with Strand7 v2.4 considering a 2-D plane strain.



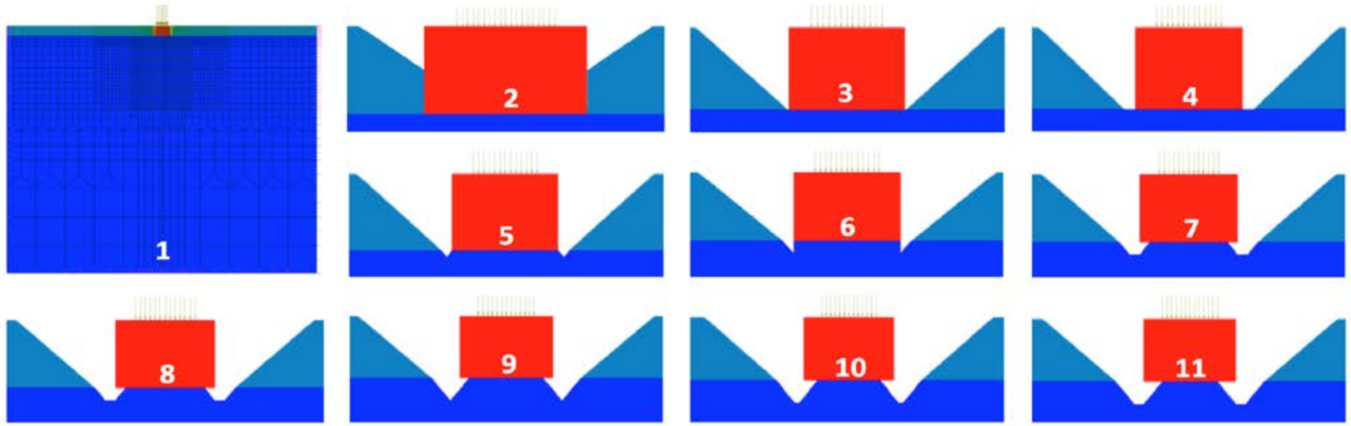


SCOUR LAYOUT

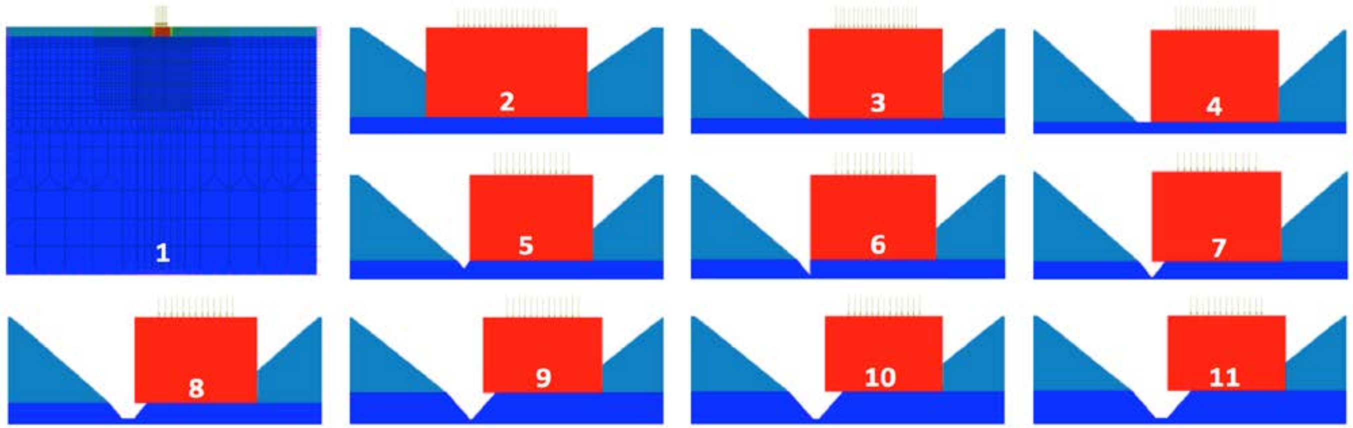
11 increasing scour layouts were considered in both cases:



SIMMETRICAL

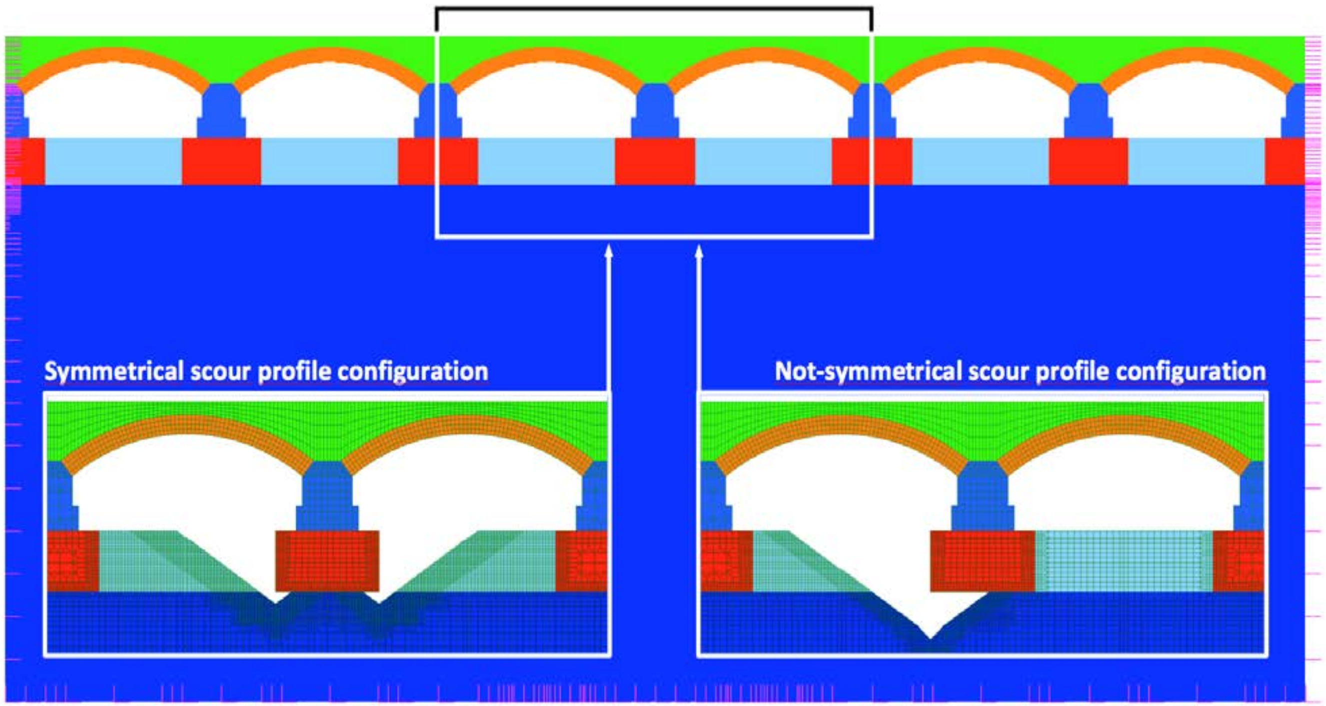


NOT-SIMMETRICAL

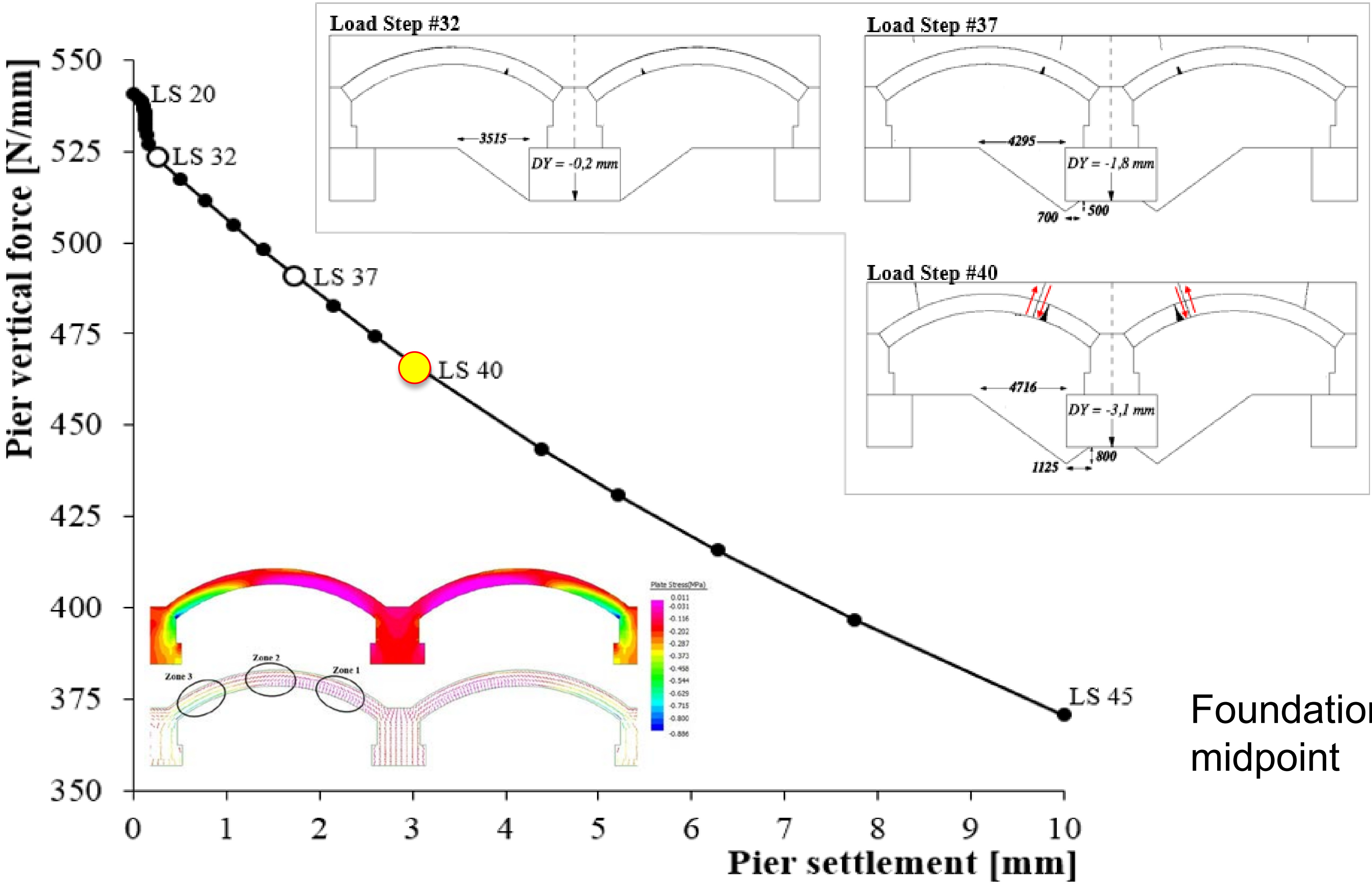


F.E. MODEL ANALYSIS

- Tensional stress evolution in the arches was monitored with the aim to identify potential kinematic collapse mechanisms, and the related scour configuration able to induce bridge structural failure.
- Non-linear construction stage analyses performed for increasing local scour profiles ($\varphi' = 35°$).



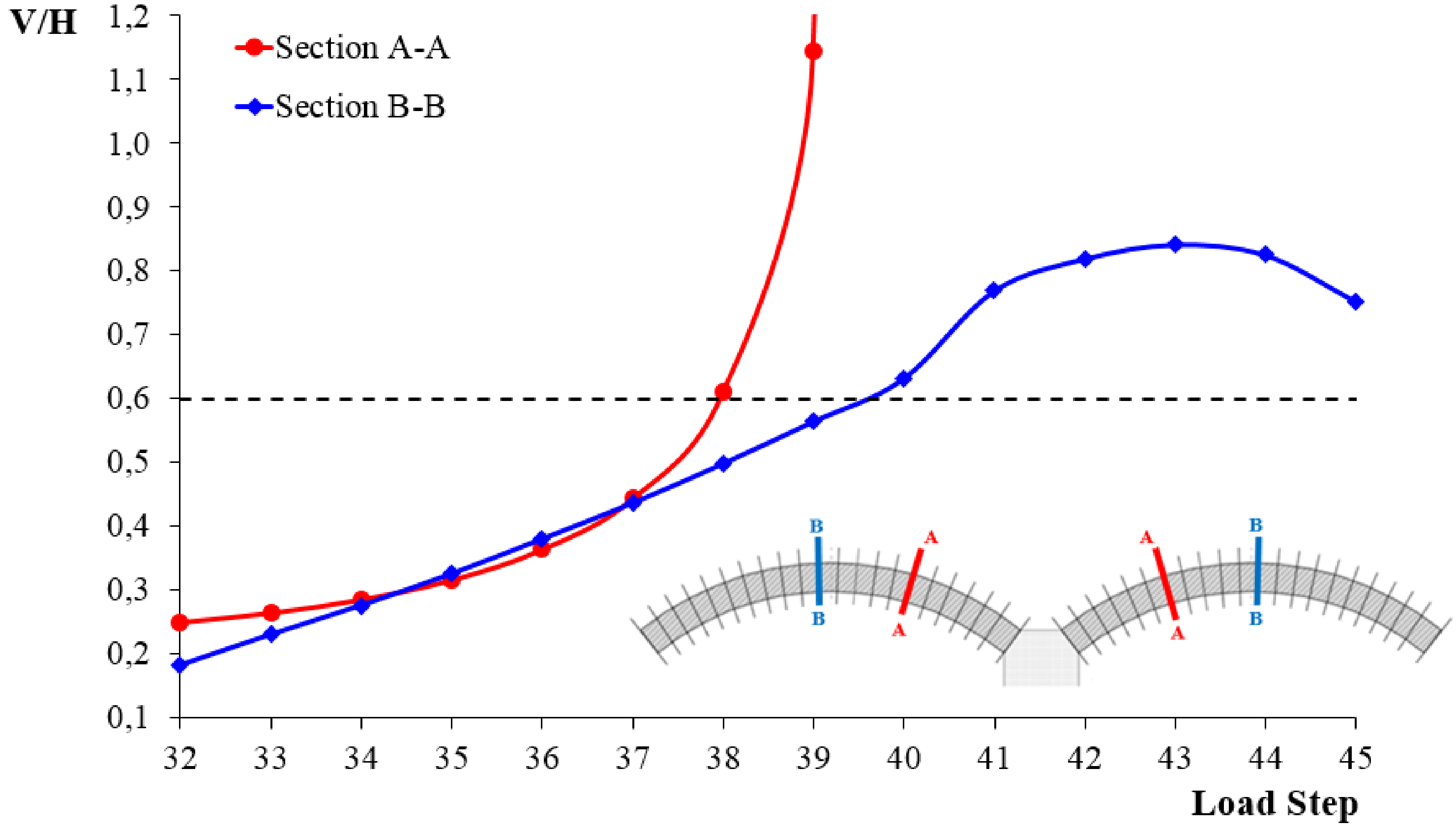
RESULTS: SYMMETRICAL CASE



Foundation midpoint

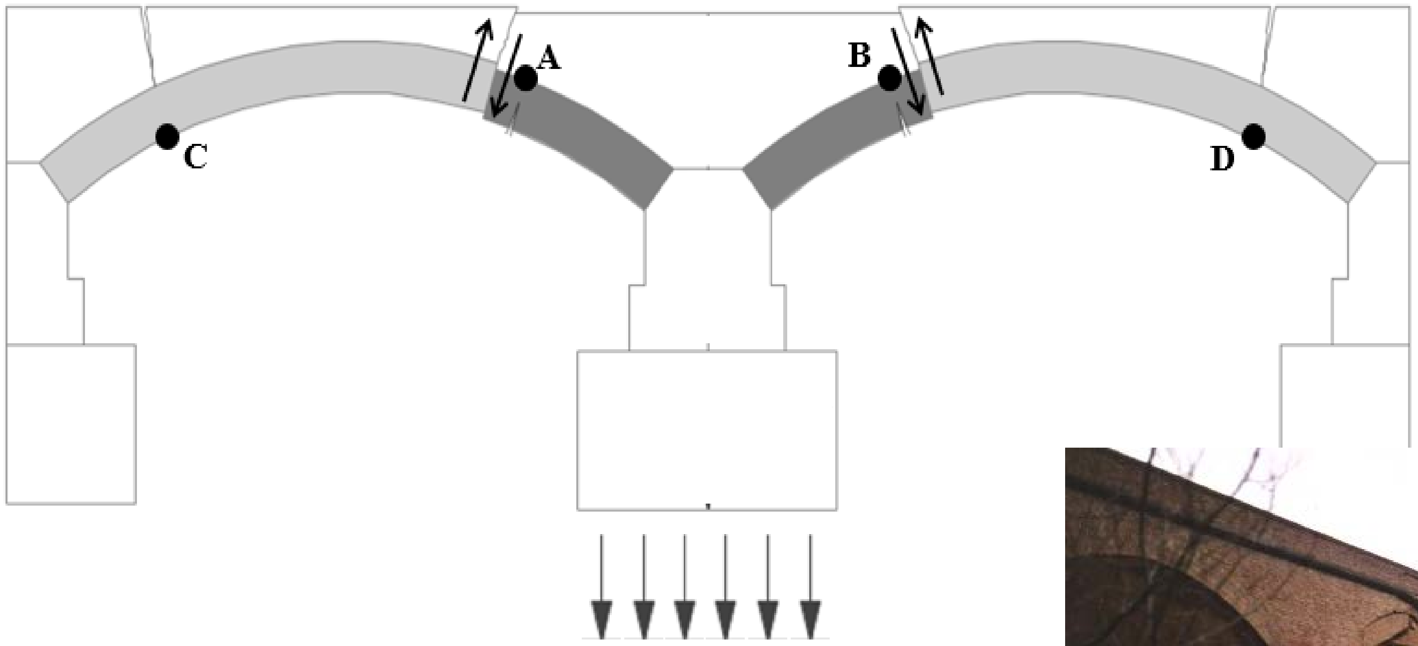
RESULTS: SYMMETRICAL CASE

- Drucker-Prager does not consider friction between arch blocks: however, it is indirectly derived. Evaluation of *V/H* ratio for each load step and comparison with threshold [Drosopoulos et al. 2006].



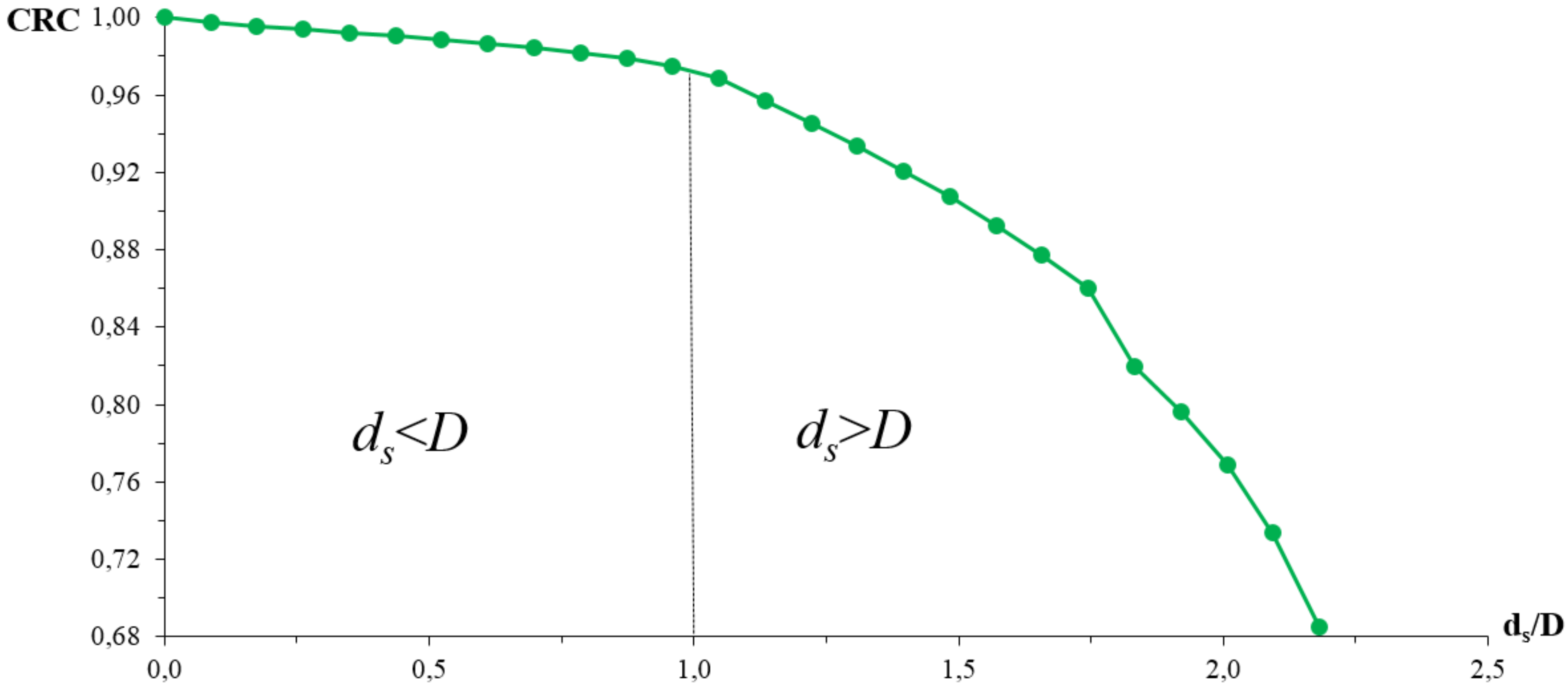
RESULTS: SYMMETRICAL CASE

- For higher displacement values, other additional hinges appear at the arches intrados close to piers adjacent to the settled central one.

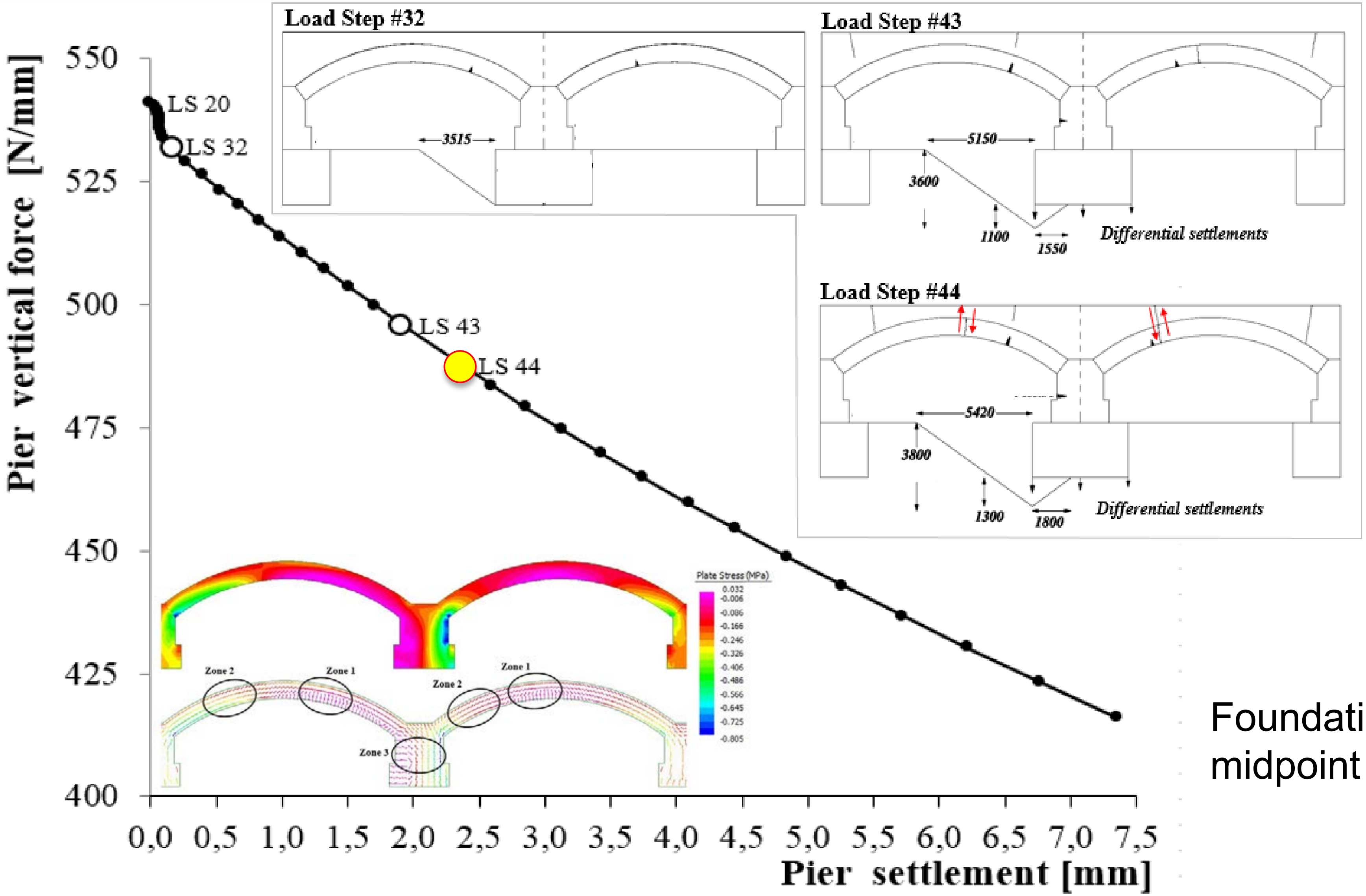


RESULTS: SYMMETRICAL CASE

- Relationship between a constrain reaction coefficient (*CRC*), (i.e. dimensionless coefficient representative of the reduction of the pier foundation vertical reaction) and dimensionless scour depth d_s/D:, seems able to quantitatively describe the phenomenon and defining threshold values.



RESULTS: NOT SYMMETRICAL CASE



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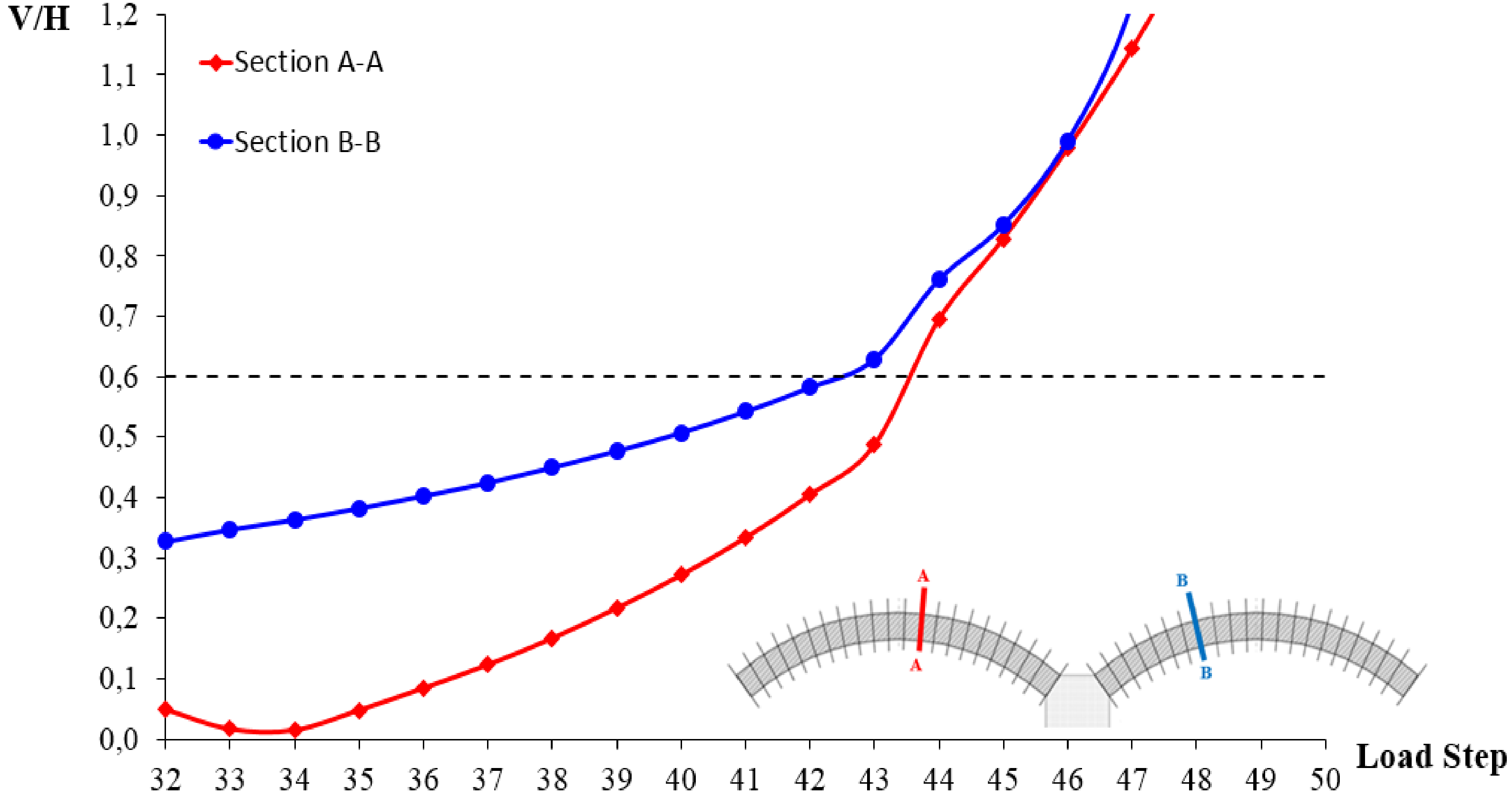
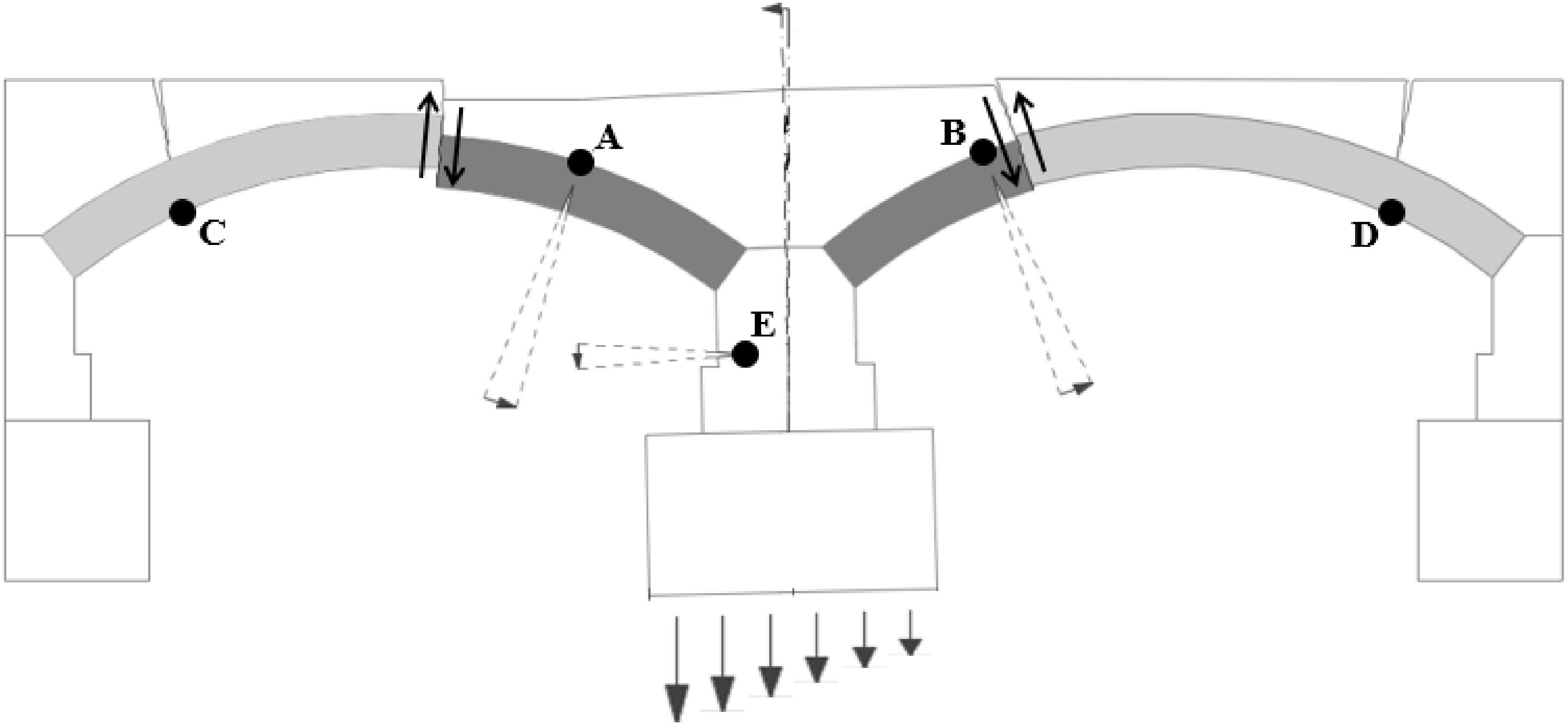


RESULTS: NOT SYMMETRICAL CASE

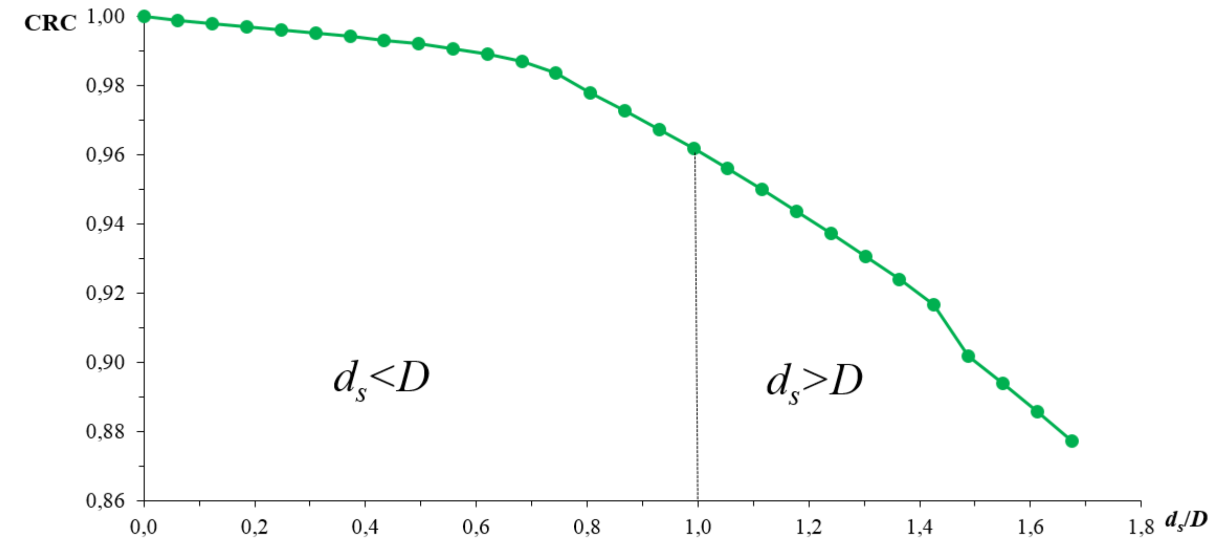
- Failure mechanism is characterized by two asymmetric sections with respect to the settled pier subject to rigid block sliding, two sections close to the adjacent piers in which hinges are localized at the arch intrados, cracking and a consequent hinge at the pier mid-height left.

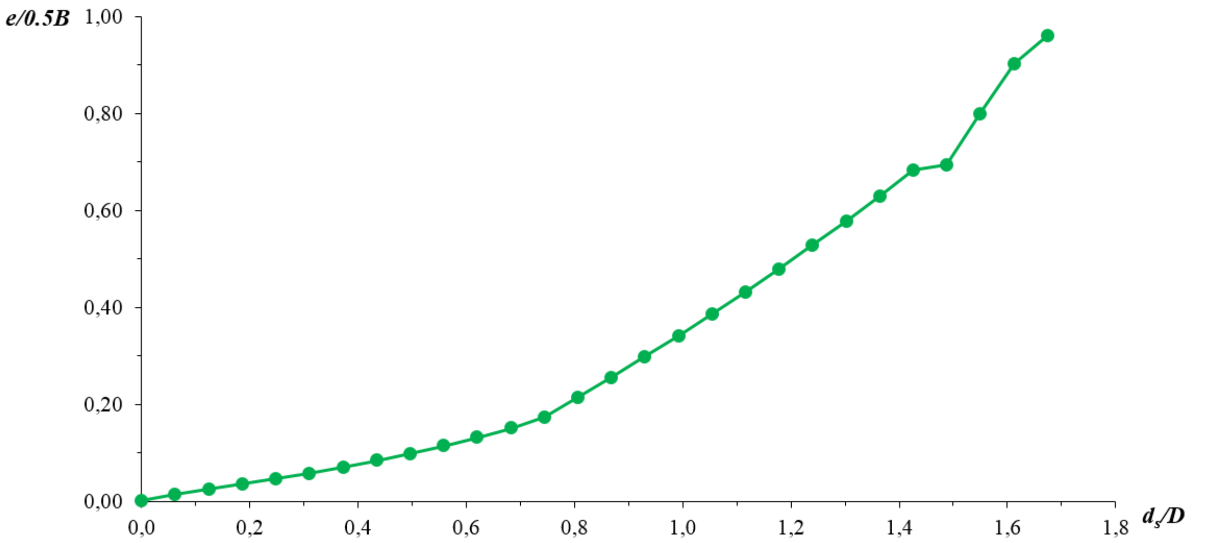


RESULTS: NOT SYMMETRICAL CASE

- For d_s/D values lower than 0.8, *CRC* slightly decreases to 0.98, whereas for higher values, *CRC* reduction is remarkable.

- The dimensionless eccentricity of pier reaction *e/(0.5B)* is less than 0.2 until d_s/D<0.8, whereas increases up to the threshold value of 1 for a dimensionless scour depth d_s/D equal to 1.7.





CONCLUSIONS

- For d_s/D values lower than 1, scouring has a negligible influence on the structural response of masonry arch bridges, whereas when erosion starts to erode under the pier foundation base, settlements become evident, inducing cracking phenomena at the arch intrados.

- The failure of the structural system is reached when it turns into rigid blocks subject to relative sliding. This change of the structural scheme is mainly due to the settlement-induced increase of the *V*/*H* ratio up to 0.6 in some critical arch sections.

- Cracking phenomena appear at pier mid-height if differential settlements affect pier foundation and are indicators of the presence of eccentricity of the pier axial force.

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THANKS FOR YOUR ATTENTION!

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