



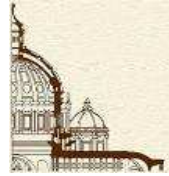
UNIVERSITA' DI ROMA "TOR VERGATA"

DIPARTIMENTO DI INGEGNERIA CIVILE

LABORATORIO STRUTTURE E PROVE MATERIALI

via del Politecnico, 1

00133 Roma



TEST ON PRECAST TUNNEL SEGMENT WITH FIBERGLASS REINFORCEMENT

CUSTOMER: ATP S.p.A.

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PROF. ING. ALBERTO MEDA

PROF. ING. ZILA RINALDI



PREFACE

The flexural test on precast segment with fibreglass reinforcement was carried out in the Laboratory of Materials and Structures of the Civil Engineering Department of the University of Rome Tor Vergata.

Responsible of the tests are Prof. Alberto Meda and Prof. Zila Rinaldi.

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1. SEGMENT GEOMETRY

The test is carried out on a precast tunnel segment characterised by a thickness of 250 mm, a length of about 1585 mm and a width of about 1200 mm (Fig. 1).

The segment is reinforced with a fiber glass cage (FGR – fiber glass reinforcement), made of 13+13 \varnothing 14 longitudinal bars, 13+13 \varnothing 12 straight crossbars and 42 \varnothing 14 brackets hoops on the perimeter (Fig. 2) with minimum cover of 15 mm.

The segment was cast with concrete characterized by a cubic strength equal to 61.7 MPa.

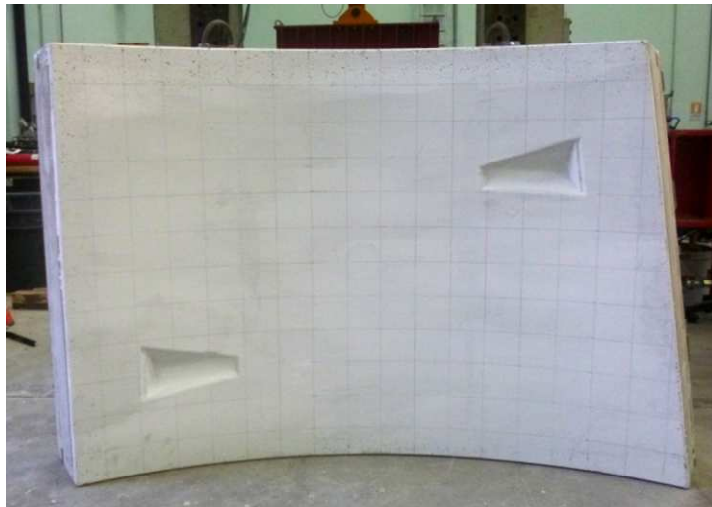


Figure 1. Segment geometry



Figure 2. Fiber Glass cage



2. BENDING TESTING PROCEDURE

The test was performed with the loading set-up illustrated in Figure 3 and Figure 4, in displacement control, under a contrast frame of 4000 kN by adopting a 1000kN electromechanical jacket, with a PID control and by imposing a stroke speed of 10 – 16 $\mu\text{m}/\text{sec}$.

The segment was placed on cylindrical supports and the load, applied at midspan, was transversally distributed by adopting a steel beam as shown in Figures 3 and 4.

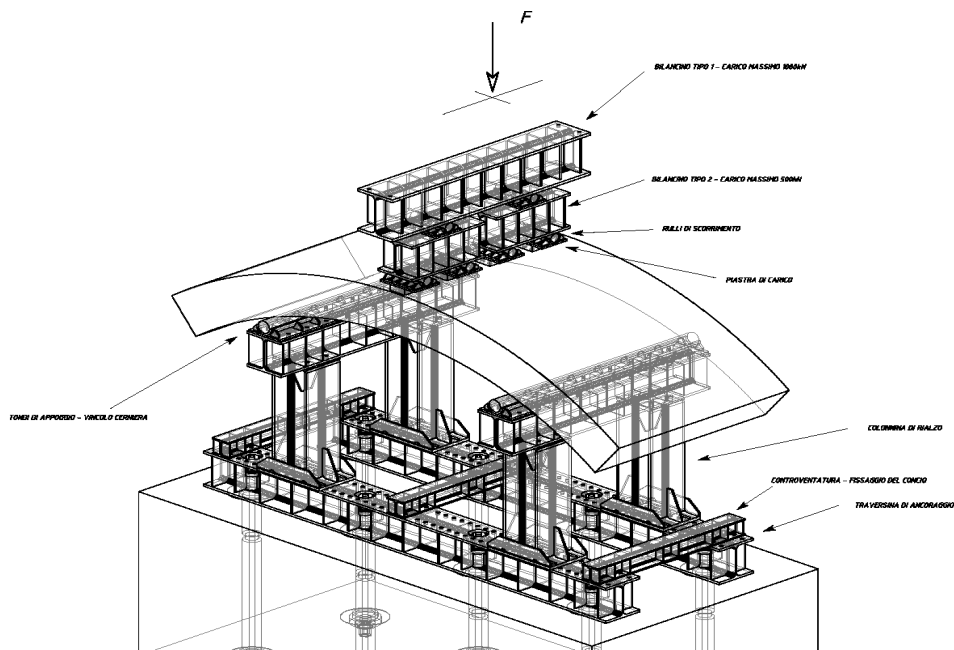


Figure 3. Bending test set-up: scheme



Figure 4. Bending test set-up

During the test, the following measures were continuously registered:

- the load F , measured by means of a 1000kN load cell with a precision of 0.2%;
- the midspan displacement measured by means of three potentiometer wire transducers placed along the transverse line (Fig. 5);
- the crack opening at midspan, measured by means of two LVDTs (Fig. 5).

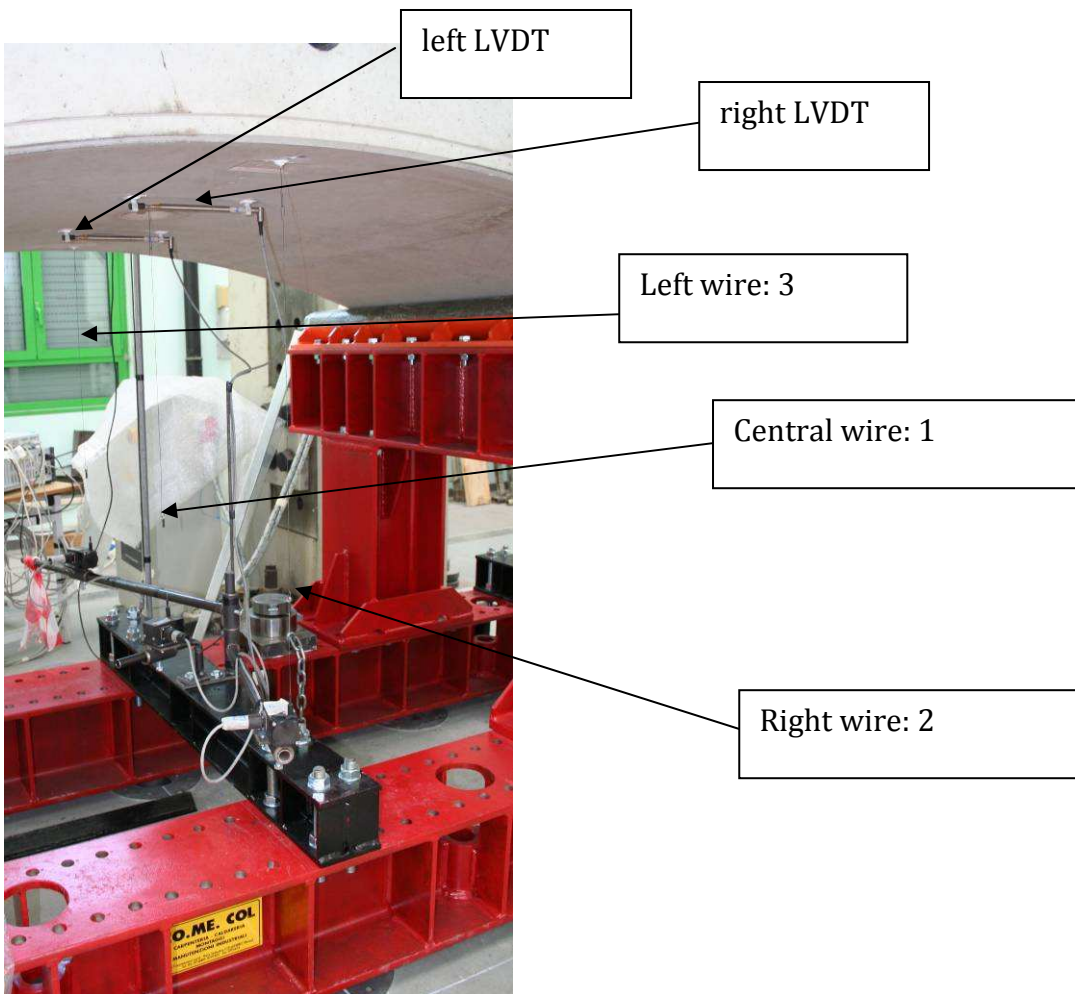


Figure 5. Bending test instrumentation



3. RESULTS

The results of the bending test on the segment named “150”, carried out the 25.10.2013 are here reported.

The bending test set up is highlighted in Figure 6.



Figure 6. Segment 150: Test set-up

The test procedure and the adopted instrumentation have been described in the previous paragraph.

In Figure 7 it is plotted the load – displacement relationship related to the three wire transducers (Fig. 5).

It is worth remarking that the three instruments, located in the midspan, measured almost coincident displacement values up to a displacement of 30mm, highlighting a homogeneous behaviour of the segment in this direction.

The **maximum load** is equal to about **430 kN**.

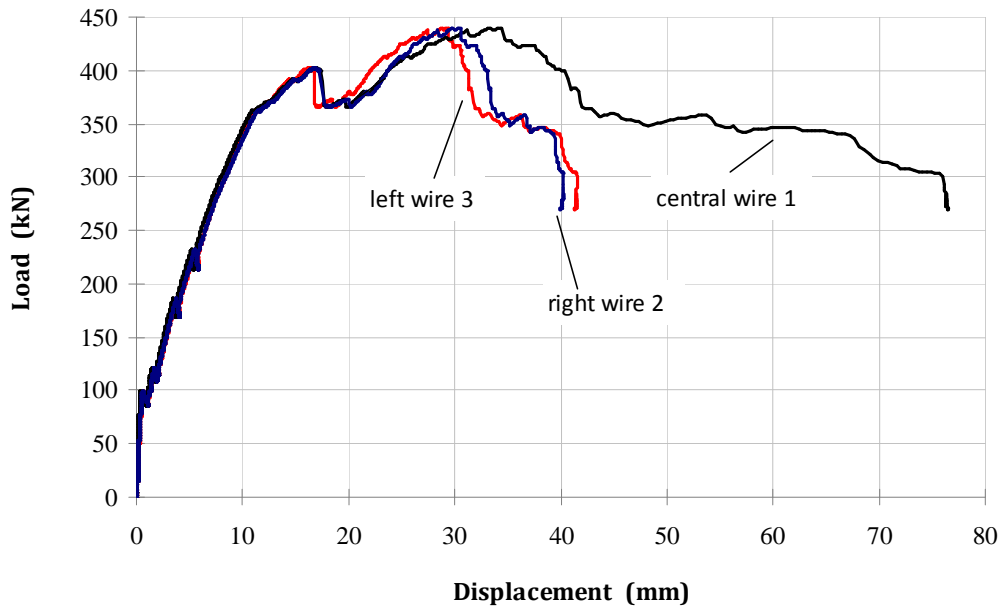


Figure 7. Load displacement curves.

The first crack appeared for a load level of about 97.5 kN (Fig. 8 and Fig. 9)



Figure 8. First crack, lateral surfaces



Figure 9. First crack, intrados surface



The crack pattern for a load level of **120 kN** is shown in the following Figure 10.

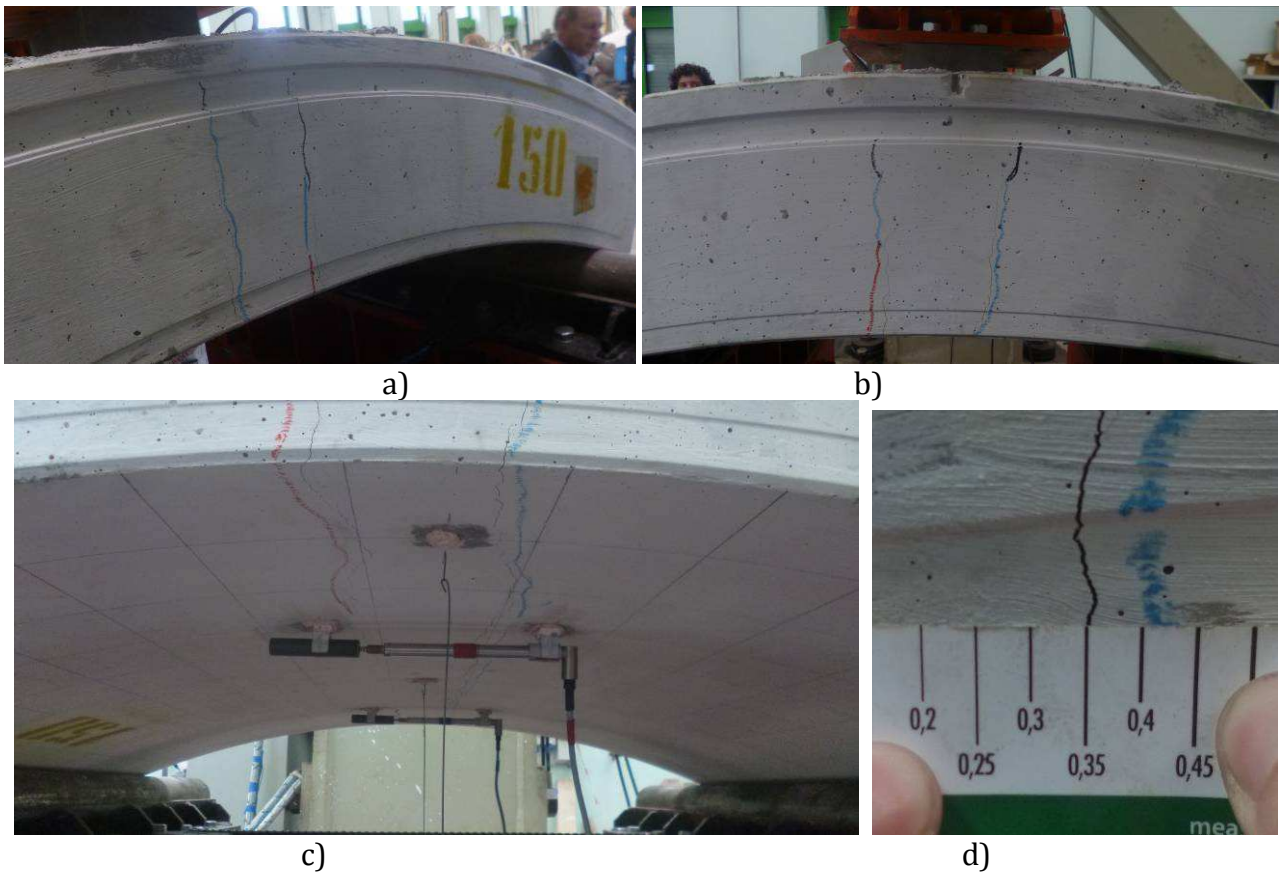


Figure 10. Load level 120 kN. Crack pattern; a) left lateral face, b) right lateral face; c) intrados, d) maximum crack width

The maximum crack width is equal to about 0.35 mm, as highlighted in Figure 10d.

The crack pattern for a load level of **185 kN** is shown in the following Figures 11 and 12. The maximum crack width is equal to about 0.8 mm, as highlighted in Figure 12b.

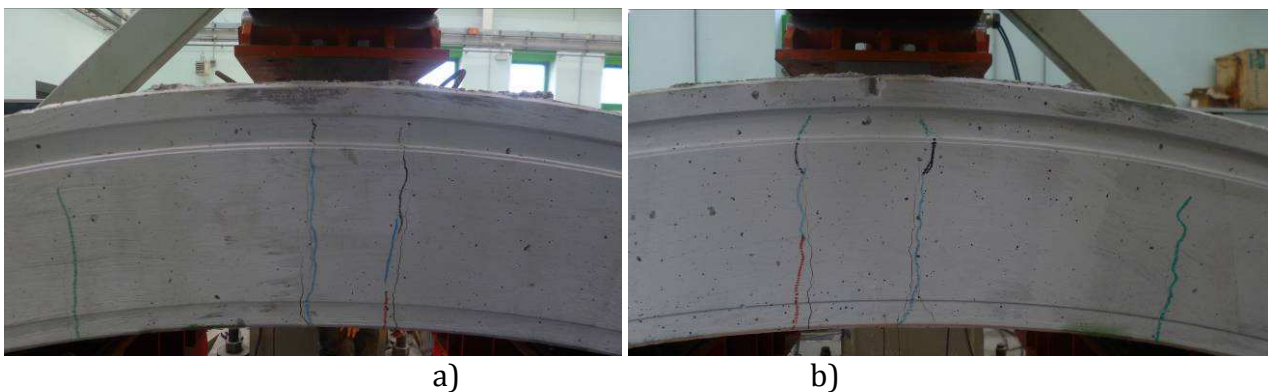


Figure 11. Load level 185 kN. Crack pattern; a) left lateral surface, b) right lateral surface.



Figure 12. Load level 185 kN. Crack pattern; a) intrados, b) maximum crack width

The failure condition is shown in Figures 13 and 14.



Figure 13. Failure condition right lateral surface



Figure 14. Failure condition



The final crack pattern, at the end of the test is summarised in Figure 15.

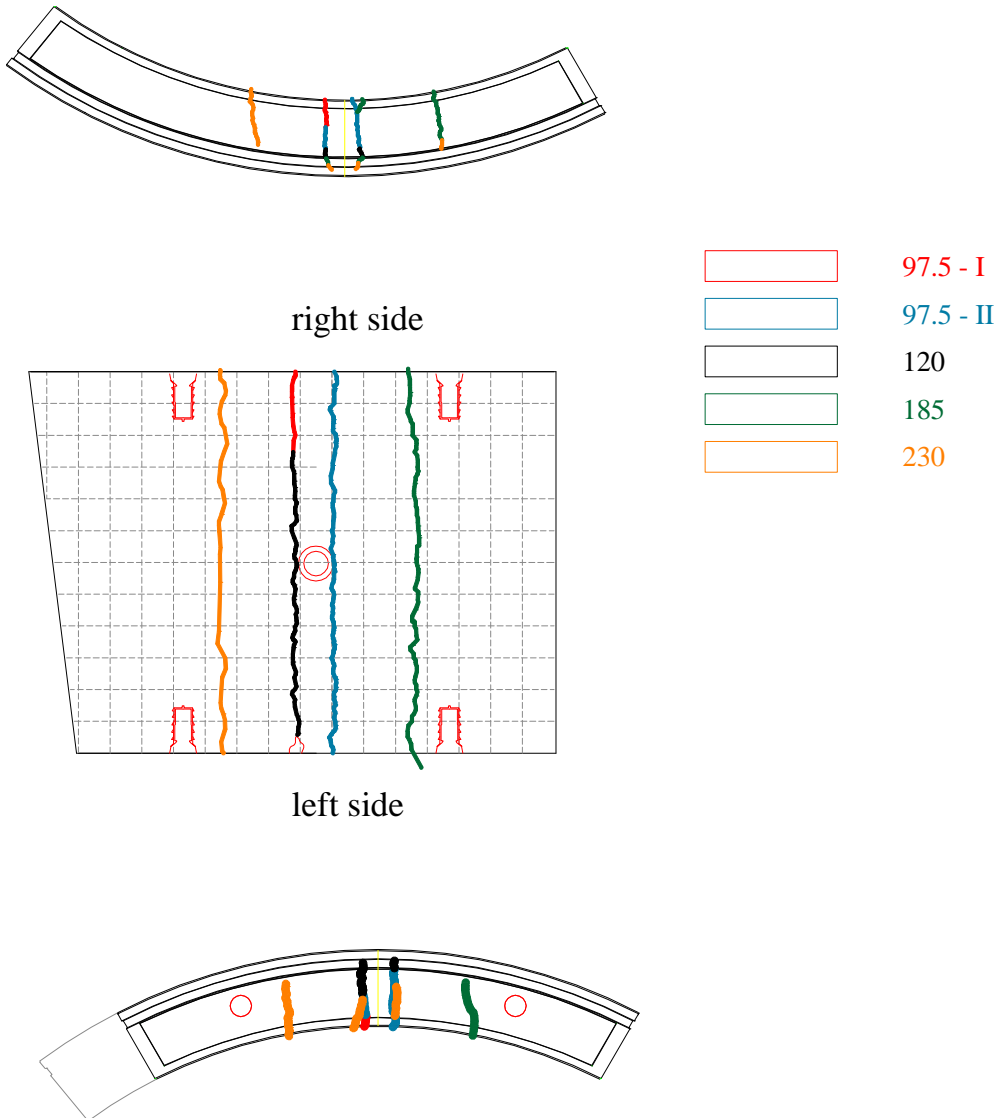


Figure 15. Crack pattern

The crack width is evaluated on the basis of the two LVDTs measures. In Figure 16 the LVDTs displacements are plotted versus the load. The instruments detached from the surface for a displacement of about 5 mm.

The measured values refer to the two main cracks that get across the instruments (Fig. 12).

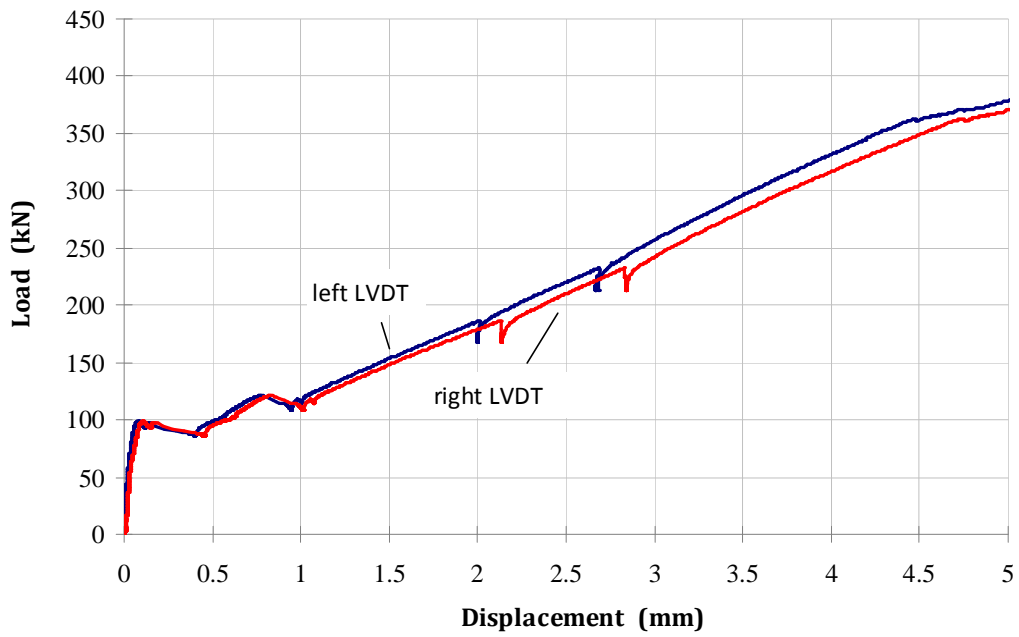


Figure 16. Segment 150. Force-displacement diagram (LVDTs)



CONCLUSIONS

The technical report shows the results of a bending tests carried out in the Laboratory of the University of Rome "Tor Vergata" on a precast segments with fiber glass reinforcement.

The load -displacement diagrams and the evolution of the crack pattern are highlighted and pictures related to each test are summarised in this report.

Roma, 08.01.2014

Prof. Ing. Alberto Meda

A handwritten signature in black ink that reads "Alberto Meda".

Prof. Ing. Zila Rinaldi

A handwritten signature in black ink that reads "Zila Rinaldi".