


Bending test on large-scale GLT beams with well-known beam setup

Report

Author(s):

Stadelmann, Philipp; Fink, Gerhard; [Frangi, Andrea](#) 

Publication date:

2021-08-30

Permanent link:

<https://doi.org/10.3929/ethz-b-000501779>

Rights / license:

[Creative Commons Attribution 4.0 International](#)

Test report

**Bending test on large-scale GLT beams
with well-known beam setup**

Philipp Stadelmann (ETH Zurich)

Gerhard Fink (Aalto University)

Andrea Frangi (ETH Zurich)

2021

Contents

1	GL24h-11m-1	1
2	GL24h-11m-2	5
3	GL24h-11m-3	9
4	GL24h-11m-4	13
5	GL24h-19m-1	17
6	GL24h-19m-2	21
7	GL32h-11m-1	25
8	GL32h-11m-2	29
9	GL32h-11m-3	33
10	GL32h-11m-4	37
11	GL32h-19m-1	41
12	GL32h-19m-2	46

GL24h-11m-1

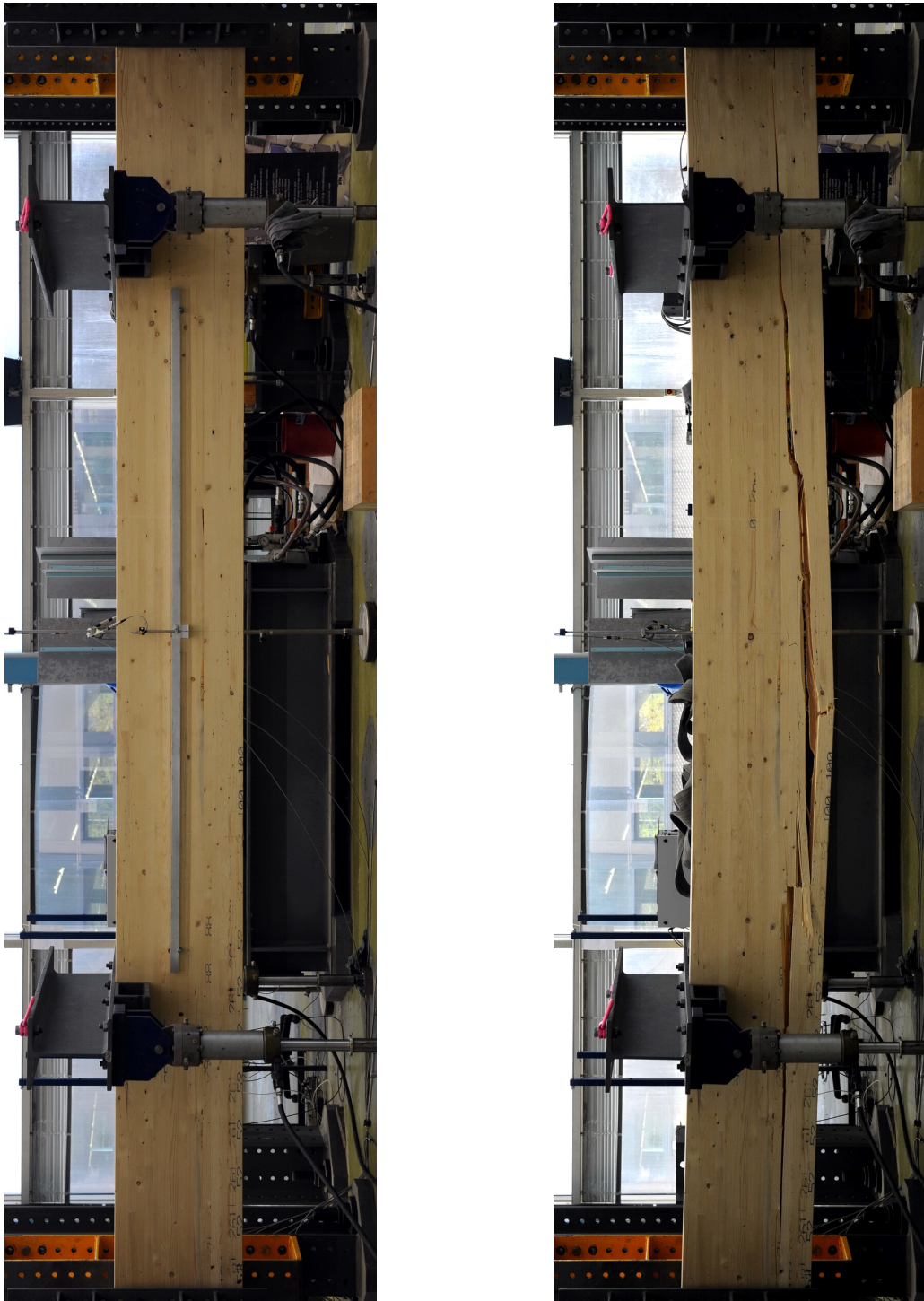


Fig. 1: Illustrations of beam GL24h-11m-1 (central area): (left) before testing, (right) after testing.



(a) front side ($l \approx 5.3$ m)



(b) back side ($l \approx 5.4$ m)



(c) lowest lamella ($l \approx 5.3$ m)



(d) lowest and 2nd lowest lamella ($l \approx 5.3$ m)



(e) 3rd lowest lamella ($l \approx 4.5$ m)



(f) 4th lowest lamella ($l \approx 6.5$ m)

Fig. 2: Illustrations of the failure of GL24h-11m-1.

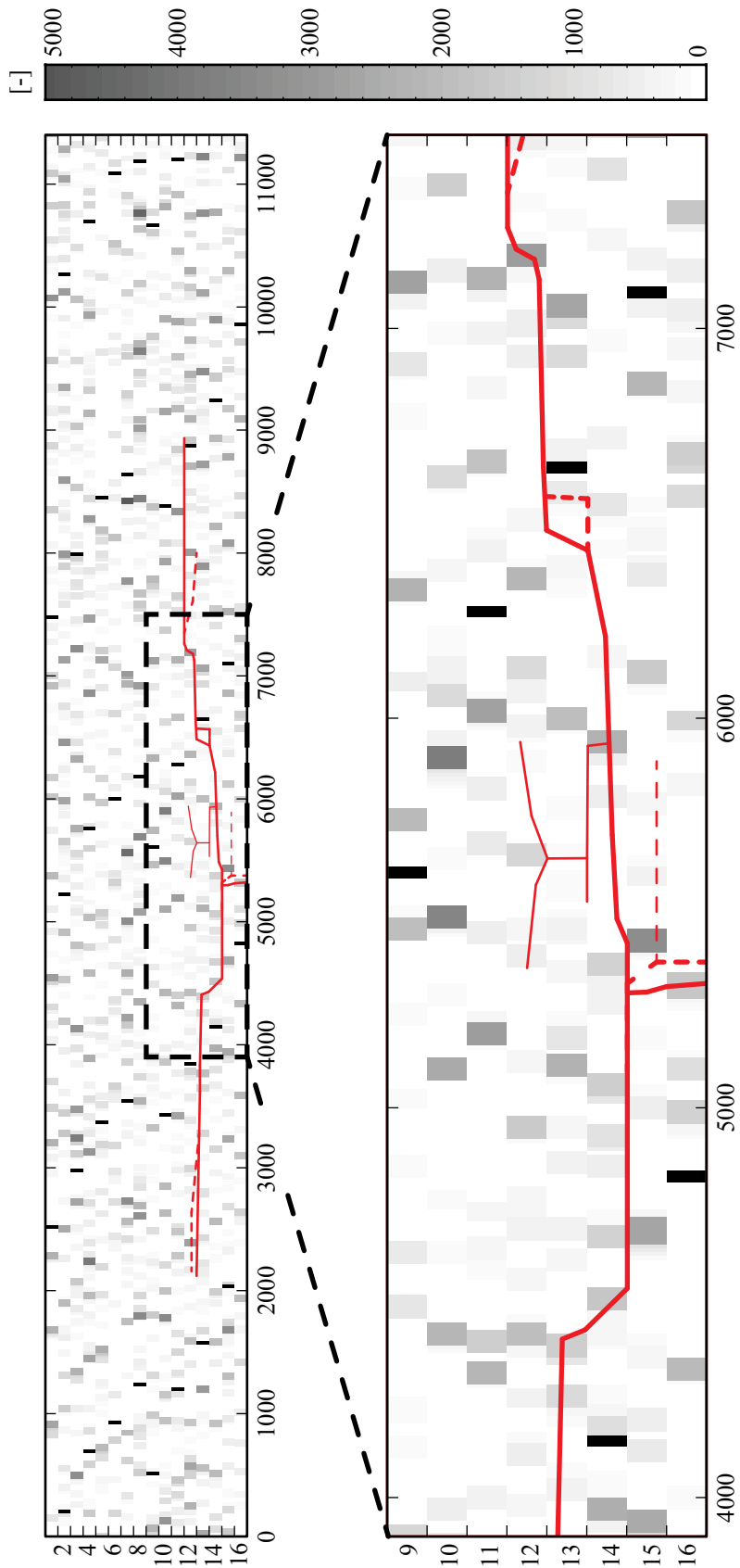


Fig. 3: Setup of GL24h-11m-1: Knot-profile (K_m -values from GoldenEye-706).

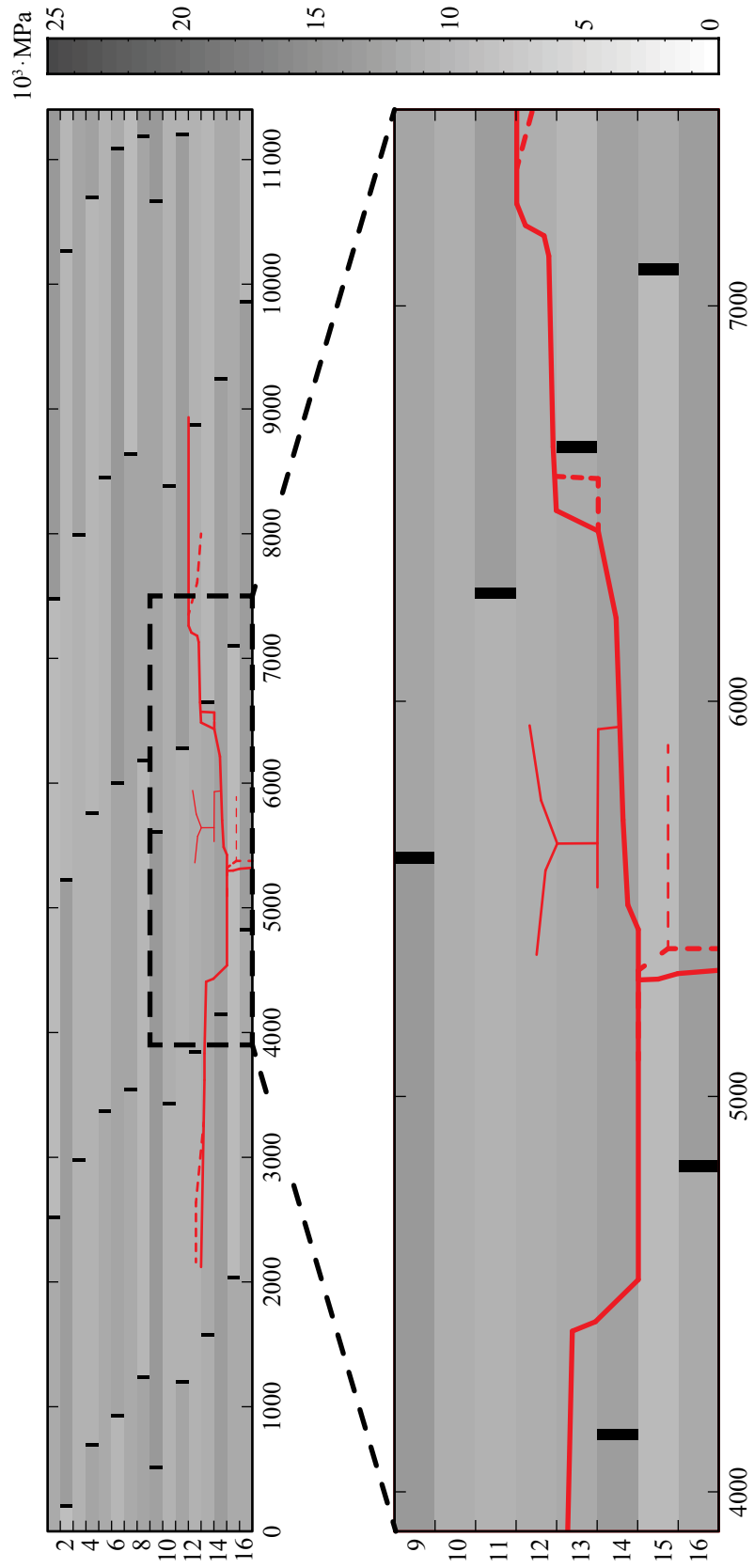


Fig. 4: Setup of GL24h-11m-1: Dynamic modulus of elasticity (E_m -values from GoldenEye-706).

GL24h-11m-2

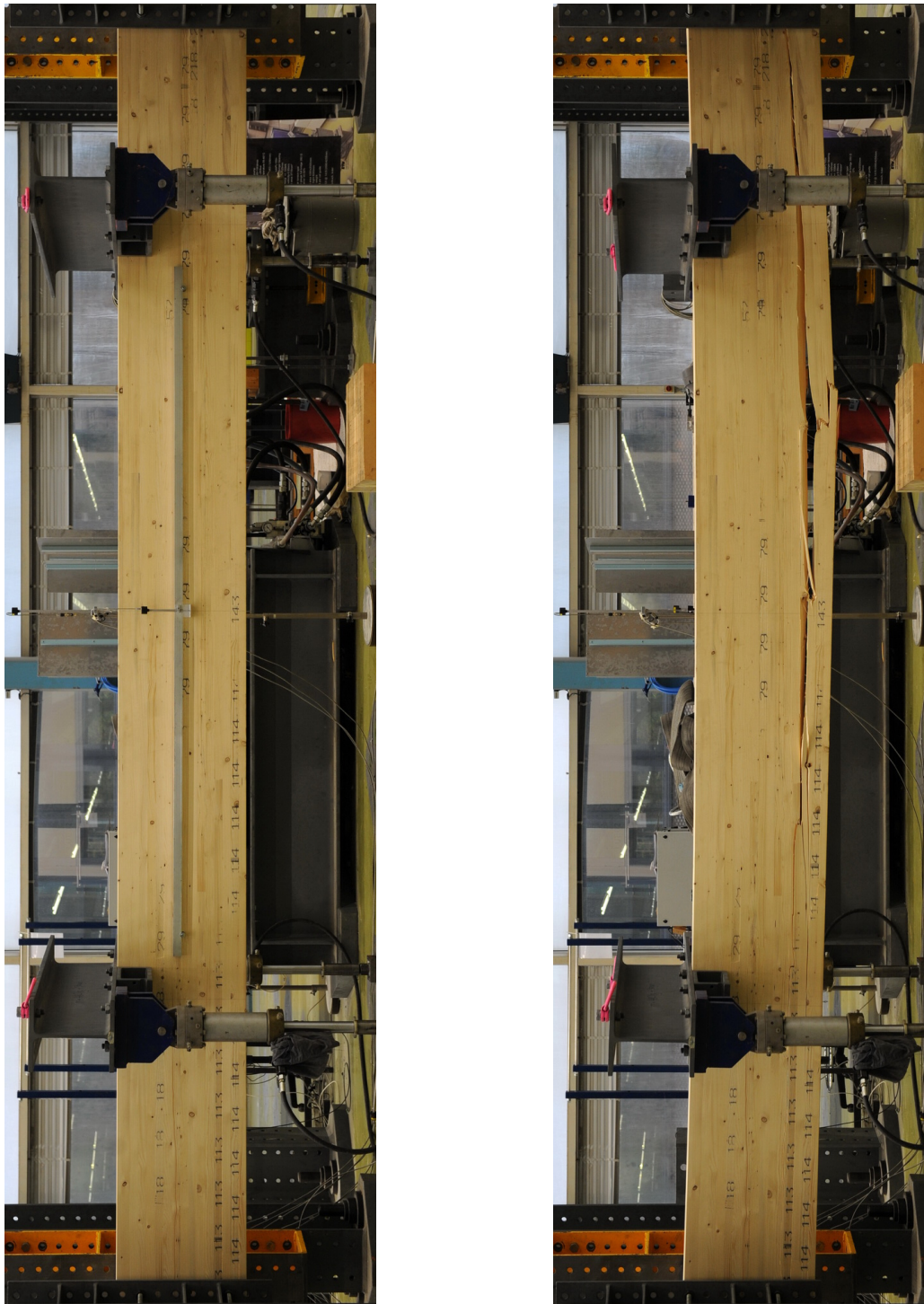


Fig. 5: Illustrations of beam GL24h-11m-2 (central area): (left) before testing, (right) after testing.



(a) front side ($l \approx 6.7$ m)



(b) back side ($l \approx 6.4 - 6.8$ m)



(c) lowest lamella ($l \approx 6.8$ m)



(d) 2nd lowest lamella ($l \approx 6.6$ m)



(e) 3rd lowest lamella ($l \approx 5.0 - 5.8$ m)



(f) 4th lowest lamella ($l \approx 4.7$ m)

Fig. 6: Illustrations of the failure of GL24h-11m-2.

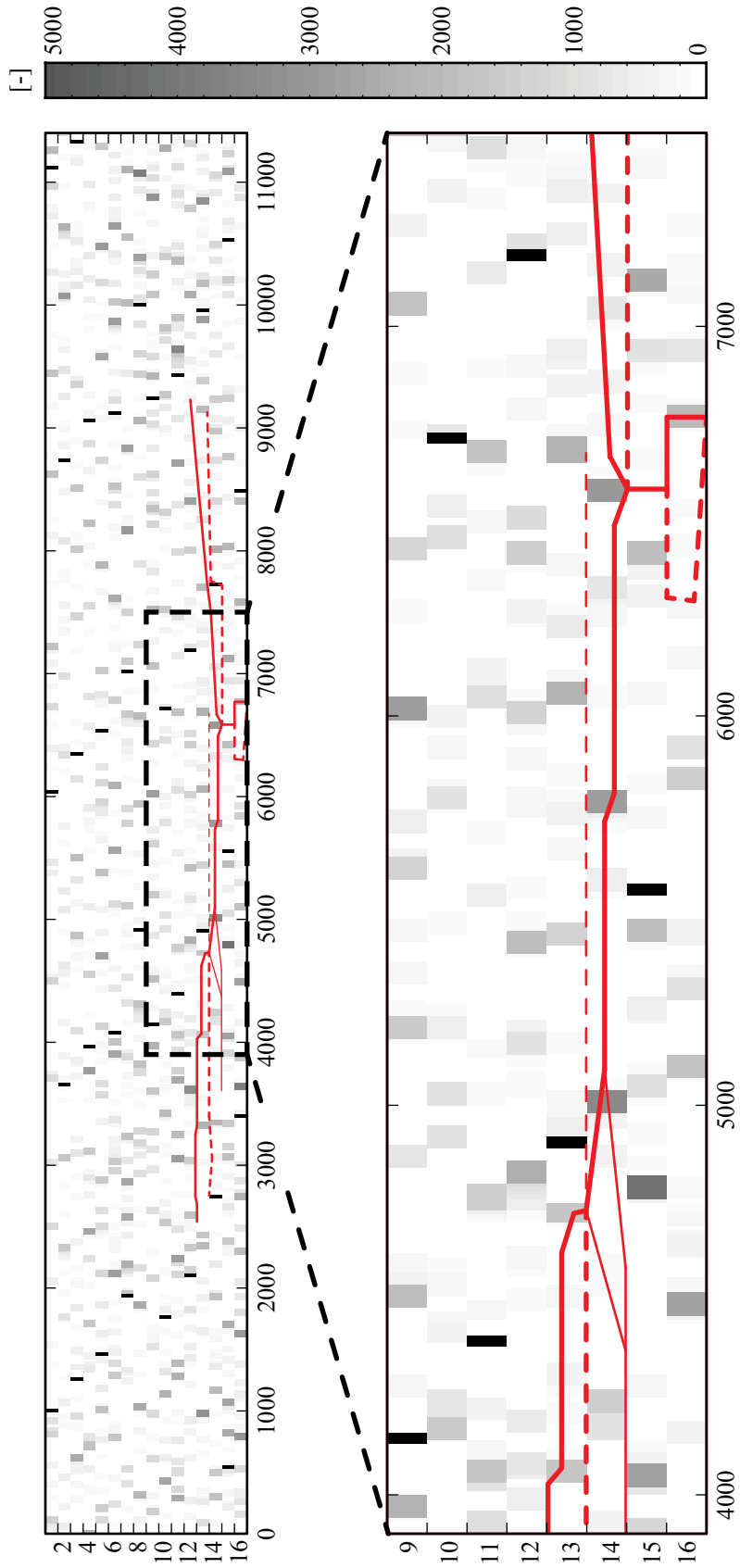


Fig. 7: Setup of GL24h-11m-2: Knot-profile (K_m -values from GoldenEye-706).

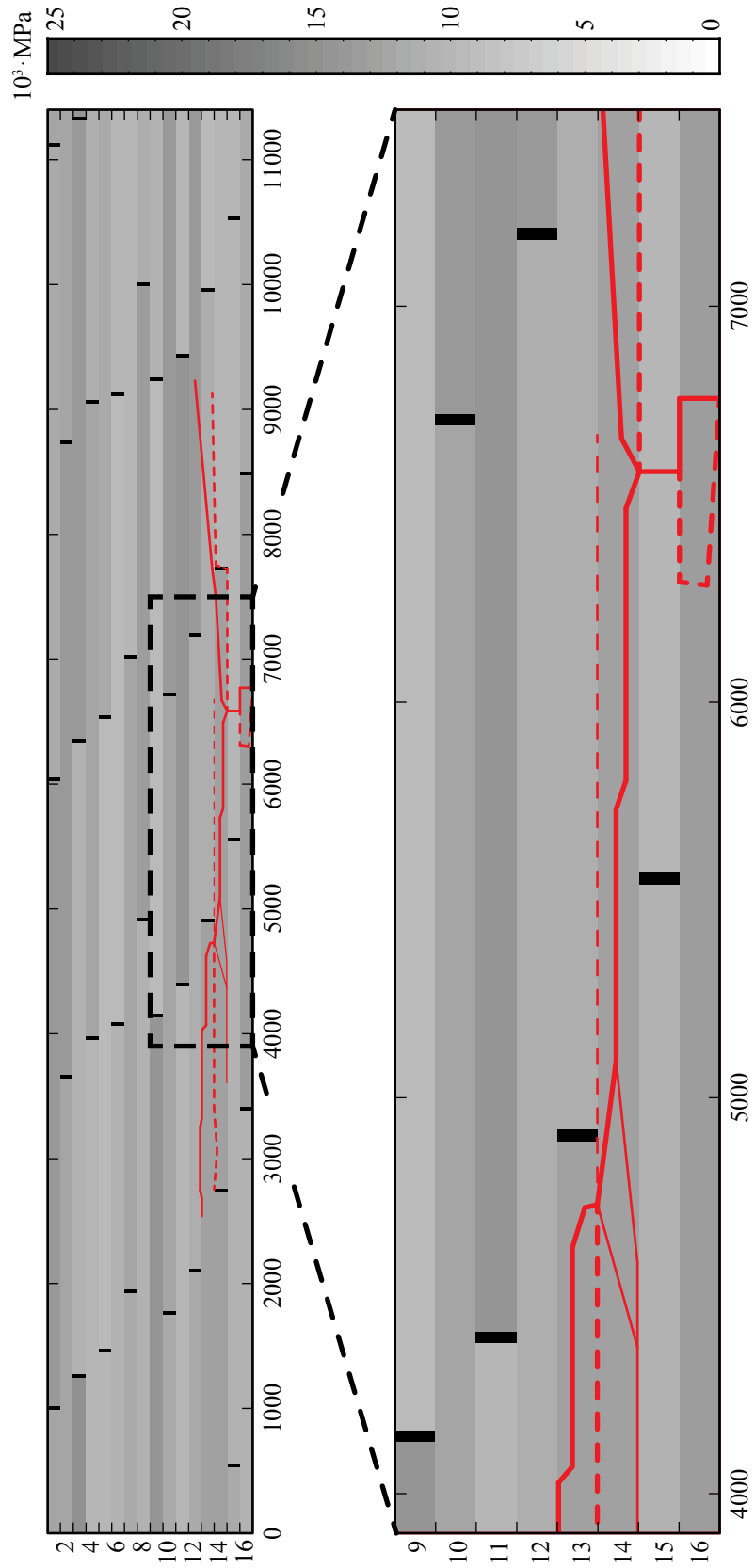


Fig. 8: Setup of GL24h-11m-2: Dynamic modulus of elasticity (E_m -values from GoldenEye-706).

GL24h-11m-3

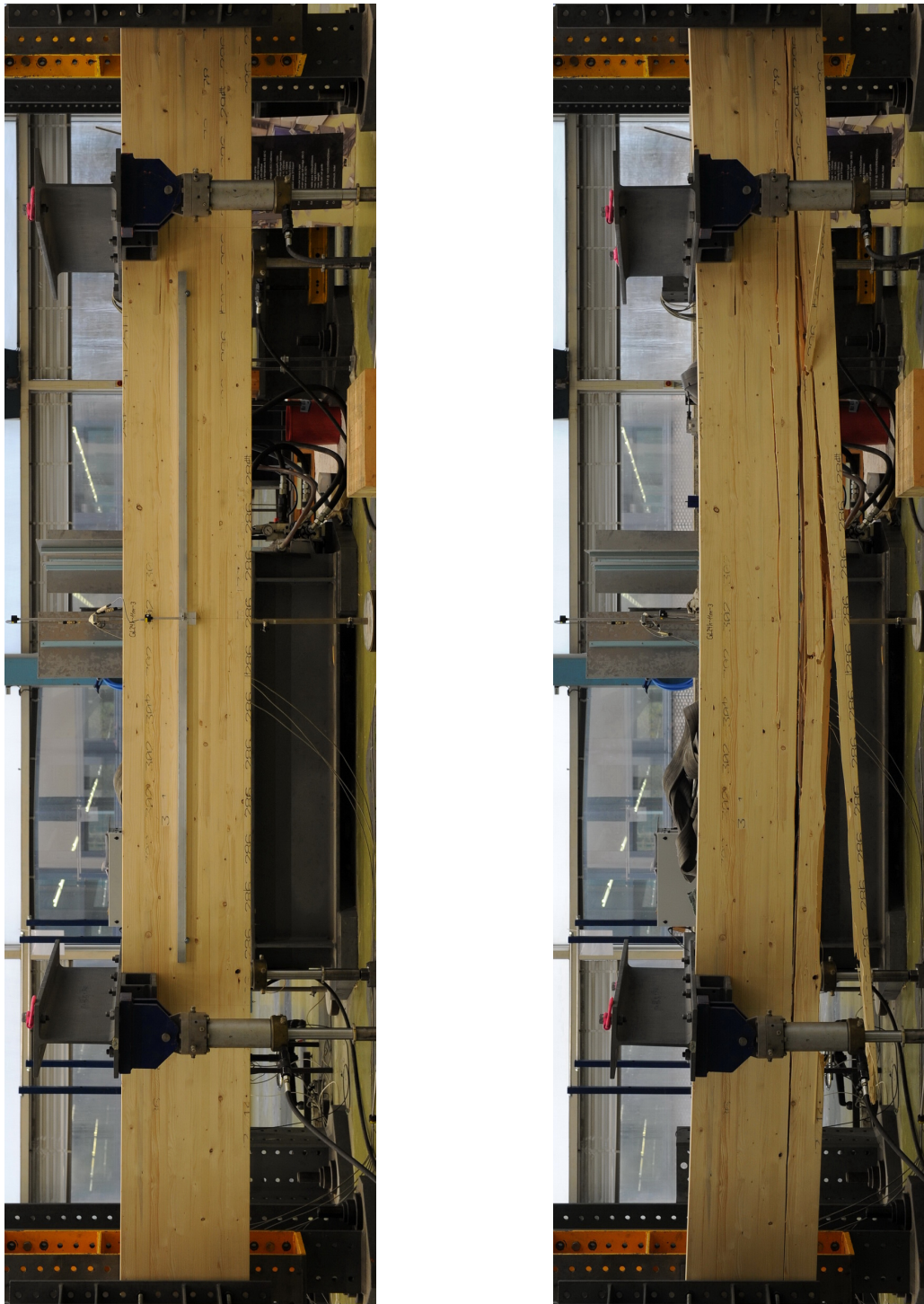


Fig. 9: Illustrations of beam GL24h-11m-3 (central area): (left) before testing, (right) after testing.



(a) front side ($l \approx 5.5$ m)



(b) back side ($l \approx 5.7$ m)



(c) lowest lamella ($l \approx 3.5$ m)



(d) 2nd lowest lamella ($l \approx 5.7$ m)



(e) 3rd lowest lamella ($l \approx 5.5$ m)



(f) 3rd lowest lamella ($l \approx 6.0 - 6.5$ m)



(g) 4th lowest lamella ($l \approx 5.2$ m)



(h) 4th lowest lamella ($l \approx 7.0$ m)

Fig. 10: Illustrations of the failure of GL24h-11m-3.

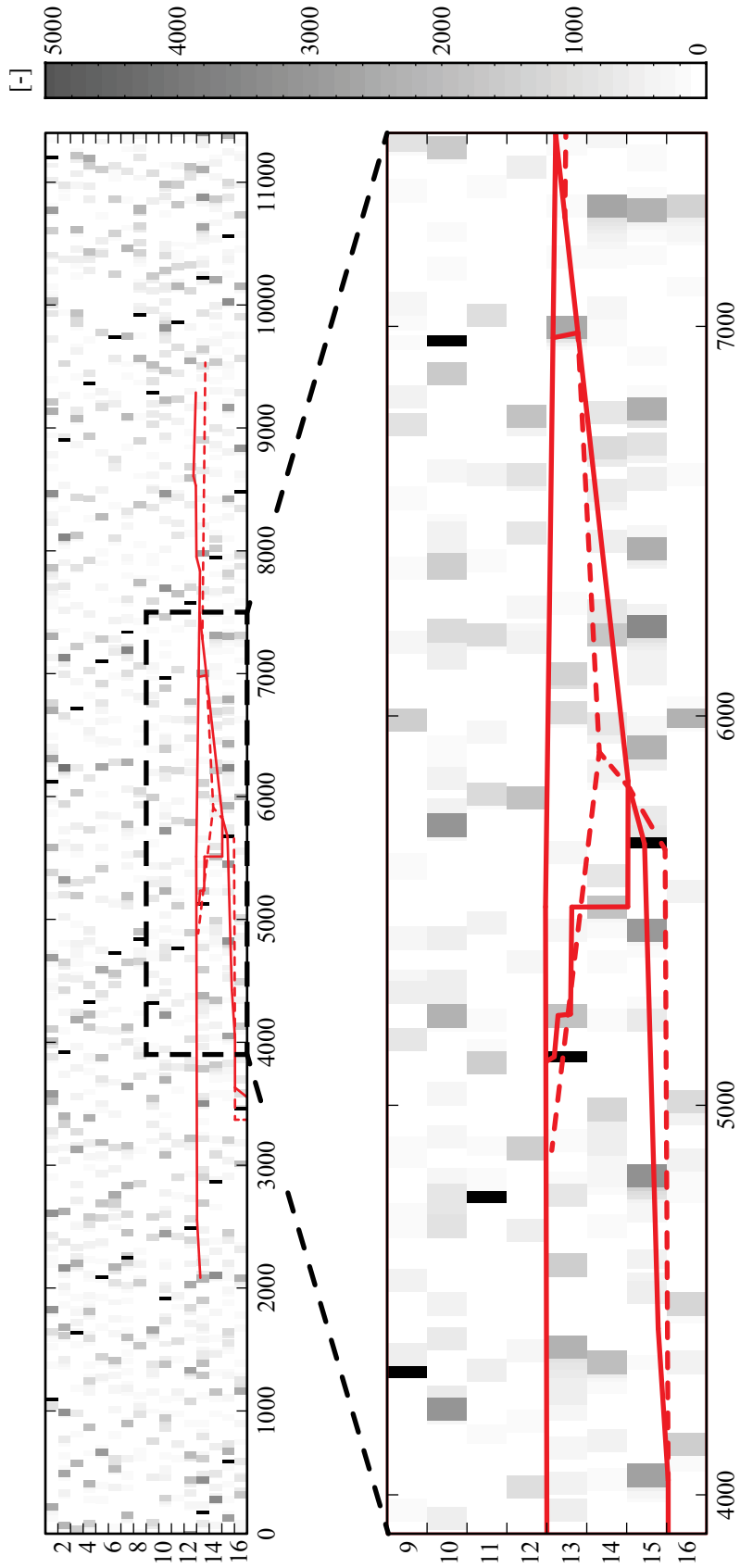


Fig. 11: Setup of GL24h-11m-3: Knot-profile (K_m -values from GoldenEye-706).

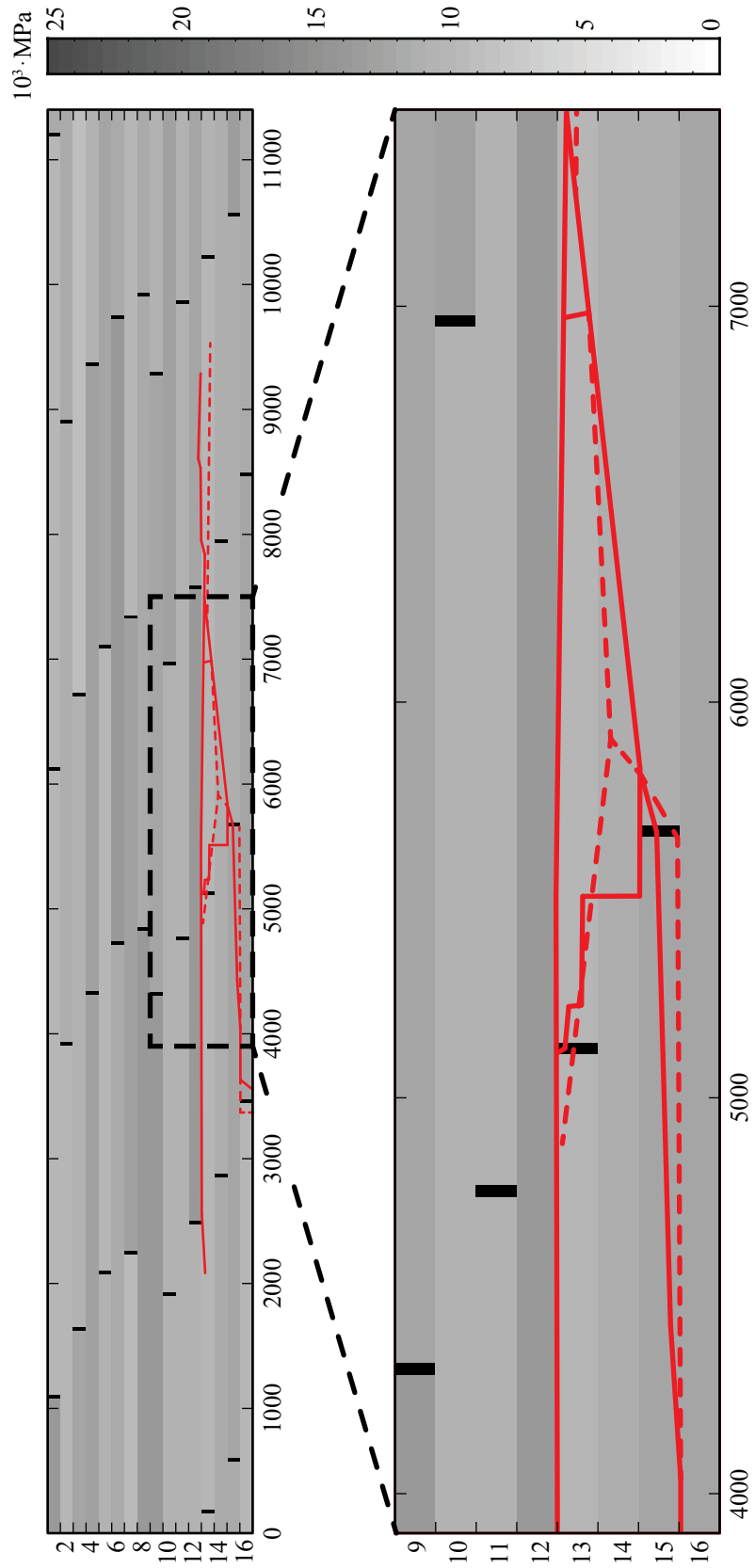


Fig. 12: Setup of GL24h-11m-3: Dynamic modulus of elasticity (E_m -values from GoldenEye-706).

GL24h-11m-4

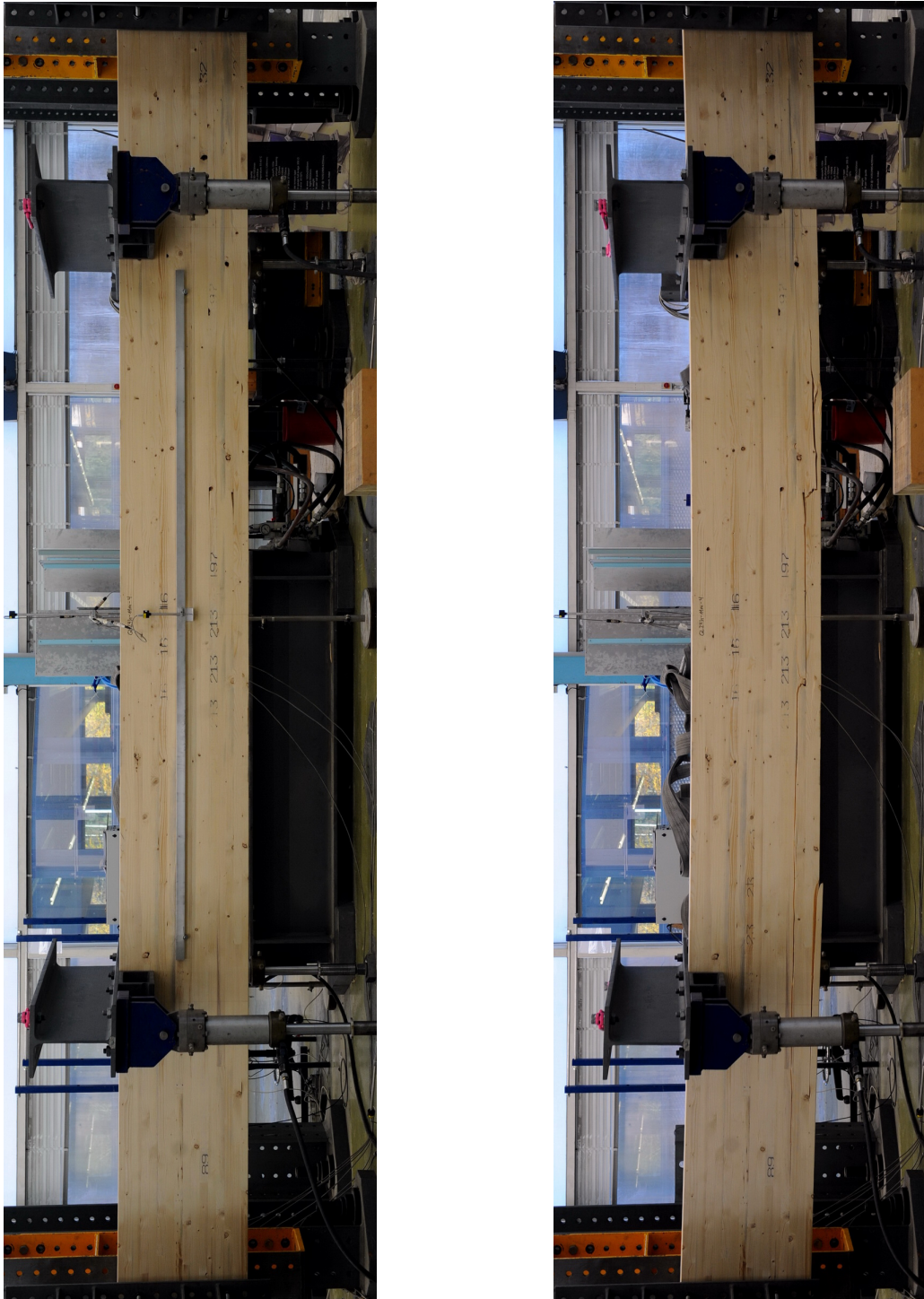


Fig. 13: Illustrations of beam GL24h-11m-4 (central area): (left) before testing, (right) after testing.



(a) front side ($l \approx 6.8$ m)



(b) back side ($l \approx 6.3$ m)



(c) lowest lamella ($l \approx 6.8$ m)



(d) 2nd lowest lamella ($l \approx 6.3$ m)



(e) 3rd lowest lamella ($l \approx 4.6$ m)



(f) 3rd lowest lamella ($l \approx 5.4$ m)

Fig. 14: Illustrations of the failure of GL24h-11m-4.

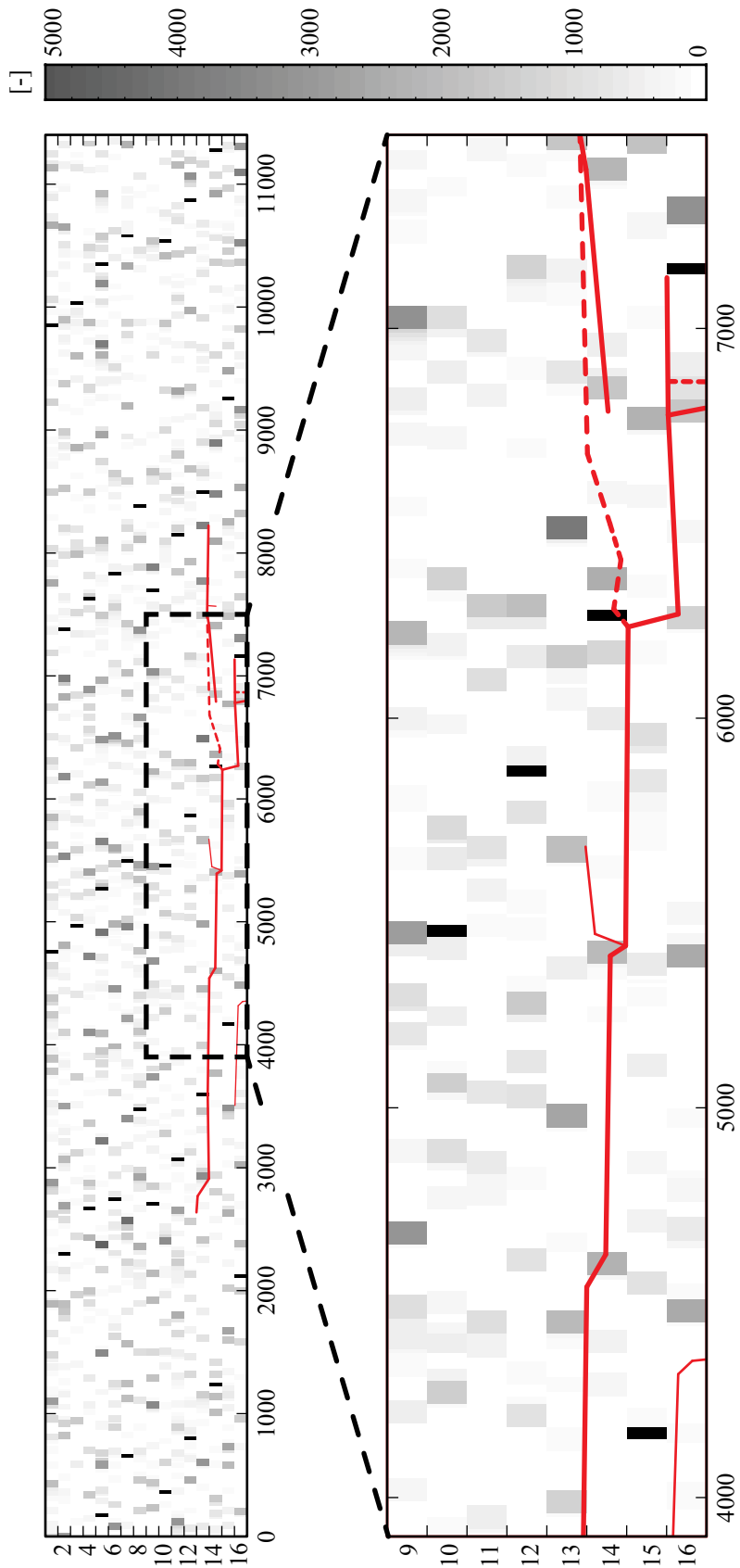


Fig. 15: Setup of GL24h-11m-4: Knot-profile (K_m -values from GoldenEye-706).

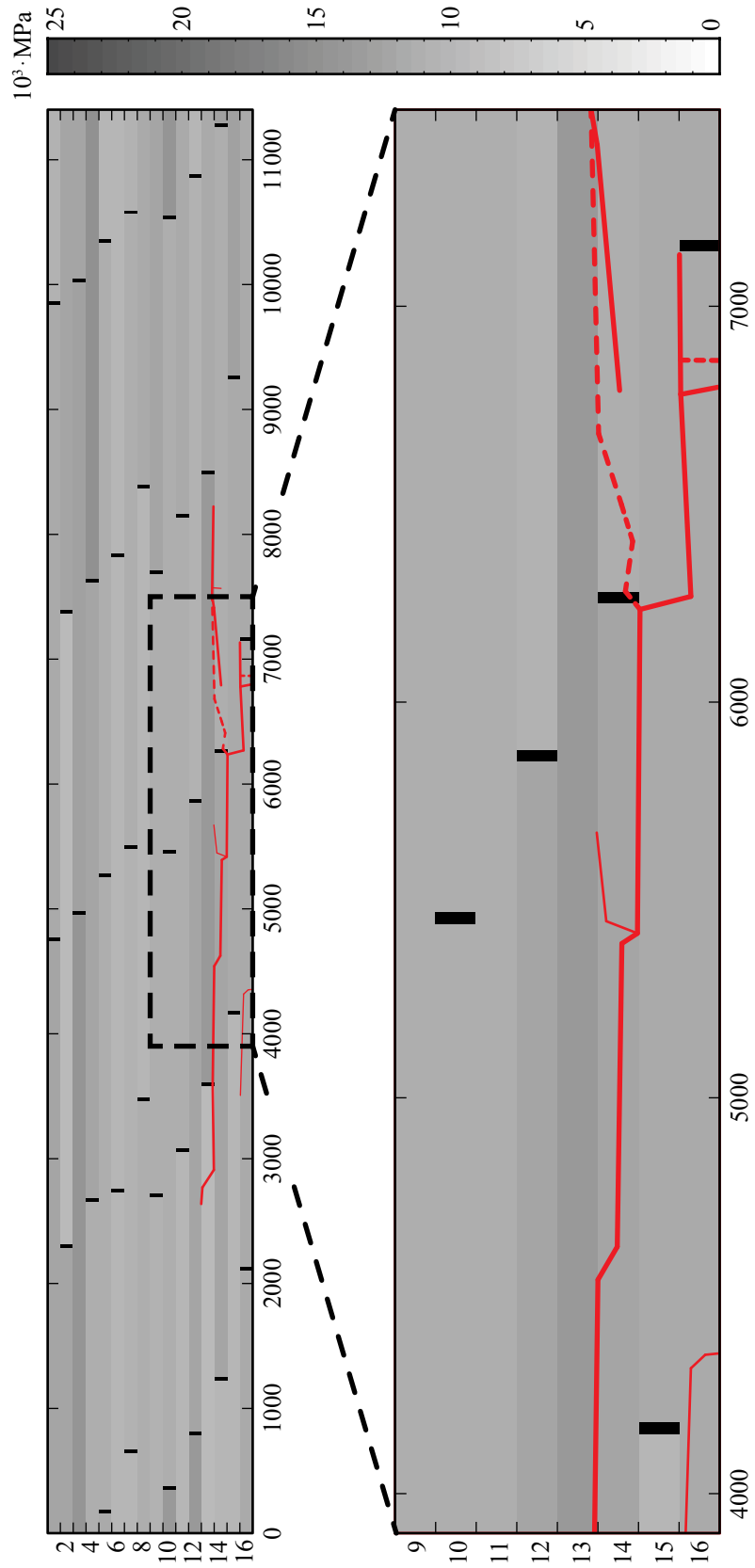


Fig. 16: Setup of GL24h-11m-4: Dynamic modulus of elasticity (E_m -values from GoldenEye-706).

GL24h-19m-1



Fig. 17: Illustration of GL24h-19m-1: after testing.



Fig. 18: Illustration of beam GL24h-19m-1 after testing (area between central buckling stabilisers)



(a) lowest lamella



(b) 2nd lowest lamella ($l \approx 8.5$ m)



(c) 3rd lowest lamella ($l \approx 9.0$ m)



(d) sixth lowest lamella ($l \approx 7.3$ m)

Fig. 19: Illustrations of the failure of GL24h-19m-1.

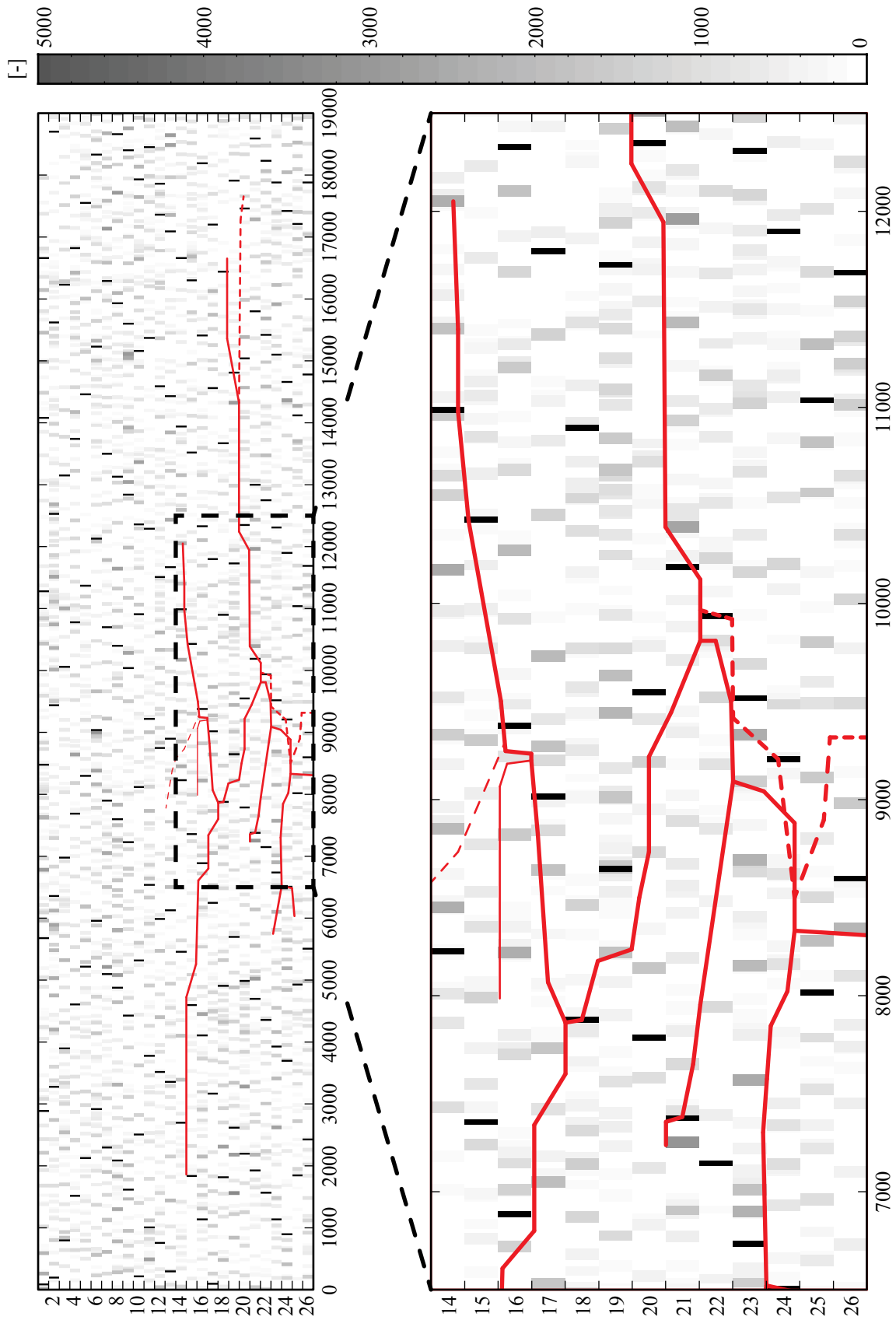


Fig. 20: Setup of GL24h-19m-1: Knot-profile (K_m -values from GoldenEye-706).

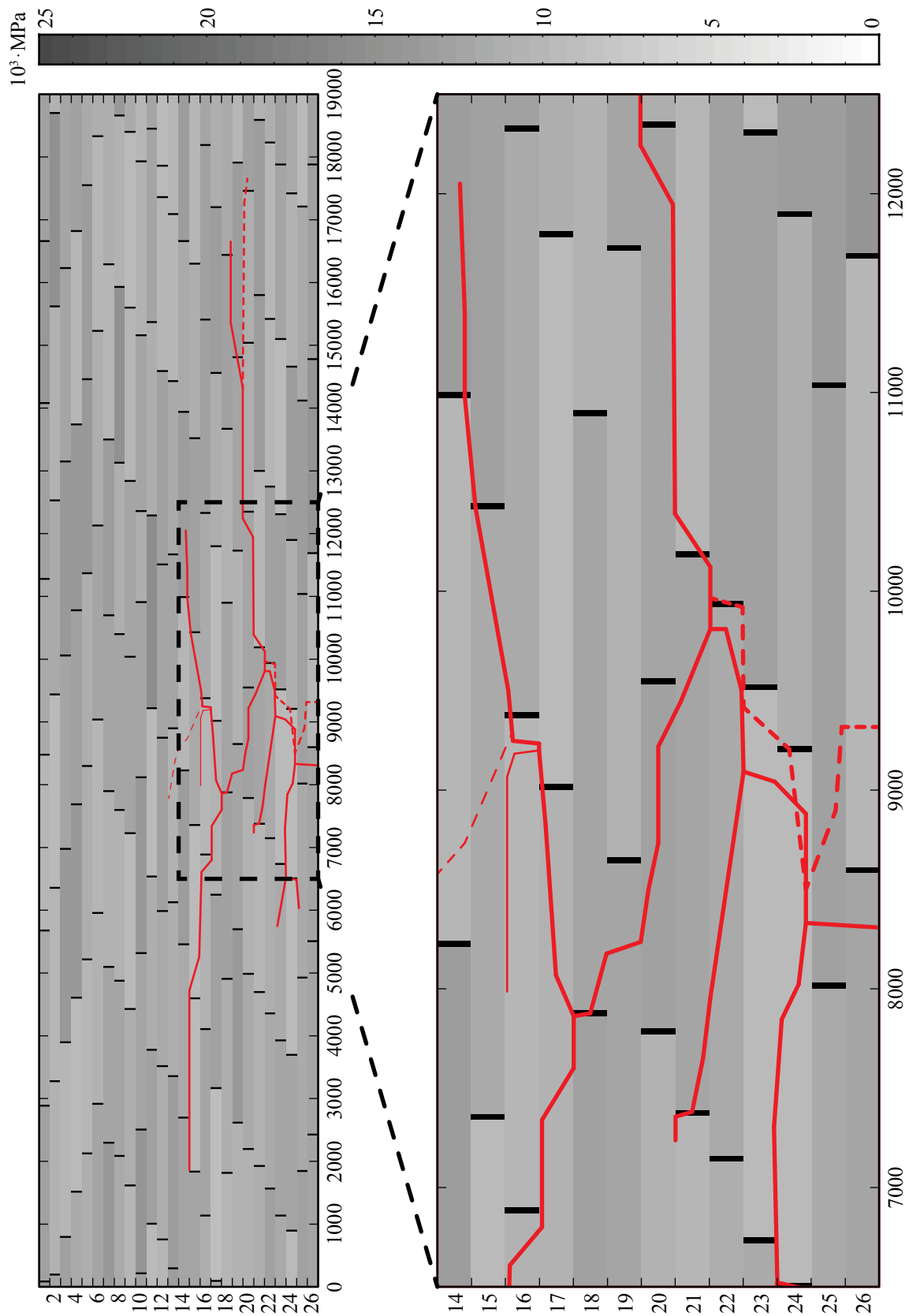


Fig. 21: Setup of GL24h-19m-1: Dynamic modulus of elasticity (E_m -values from GoldenEye-706).

GL24h-19m-2



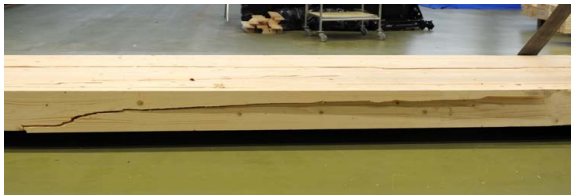
Fig. 22: Illustration of GL24h-19m-2: after testing.



(a) front side ($l \approx 6.3 - 8.5$ m), upper crack from 2nd failure cycle



(b) back side ($l \approx 5.0 - 6.1$ m), upper crack from 2nd failure cycle



(c) lowest lamella ($l \approx 6.1 - 8.5$ m)



(d) 3rd lowest lamella ($l \approx 6.9 - 8.0$ m)



(e) lowest lamella ($l \approx 6.1 - 7.5$ m)



(f) 3rd and 4th lowest lamella ($l \approx 6.6 - 6.9$ m)



(g) 4th lowest lamella ($l \approx 6.6 - 8.5$ m)



(h) 5th lowest lamella ($l \approx 11.2$ m)

Fig. 23: Illustrations of the failure of GL24h-19m-2.

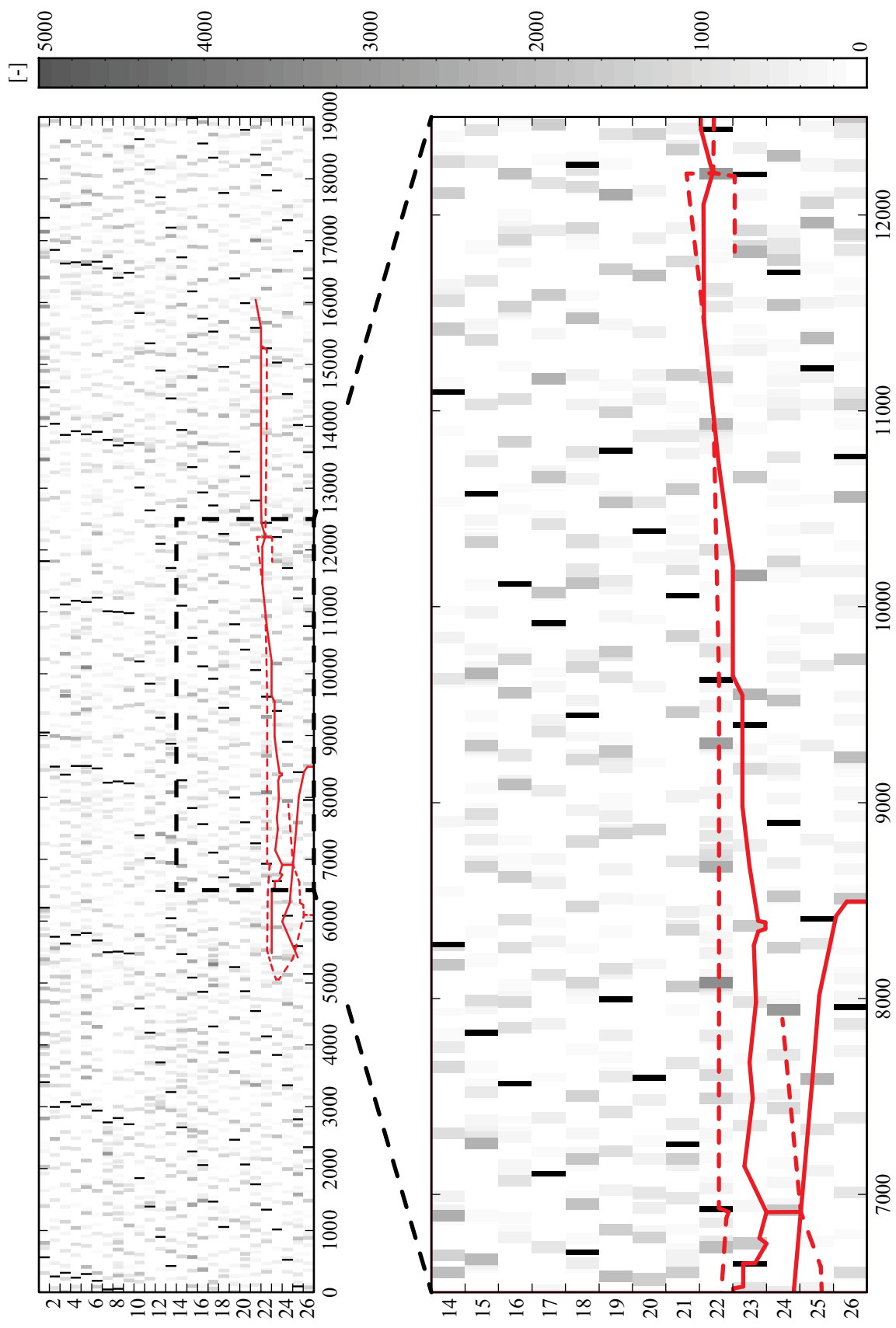


Fig. 24: Setup of GL24h-19m-2: Knot-profile (K_m -values from GoldenEye-706).

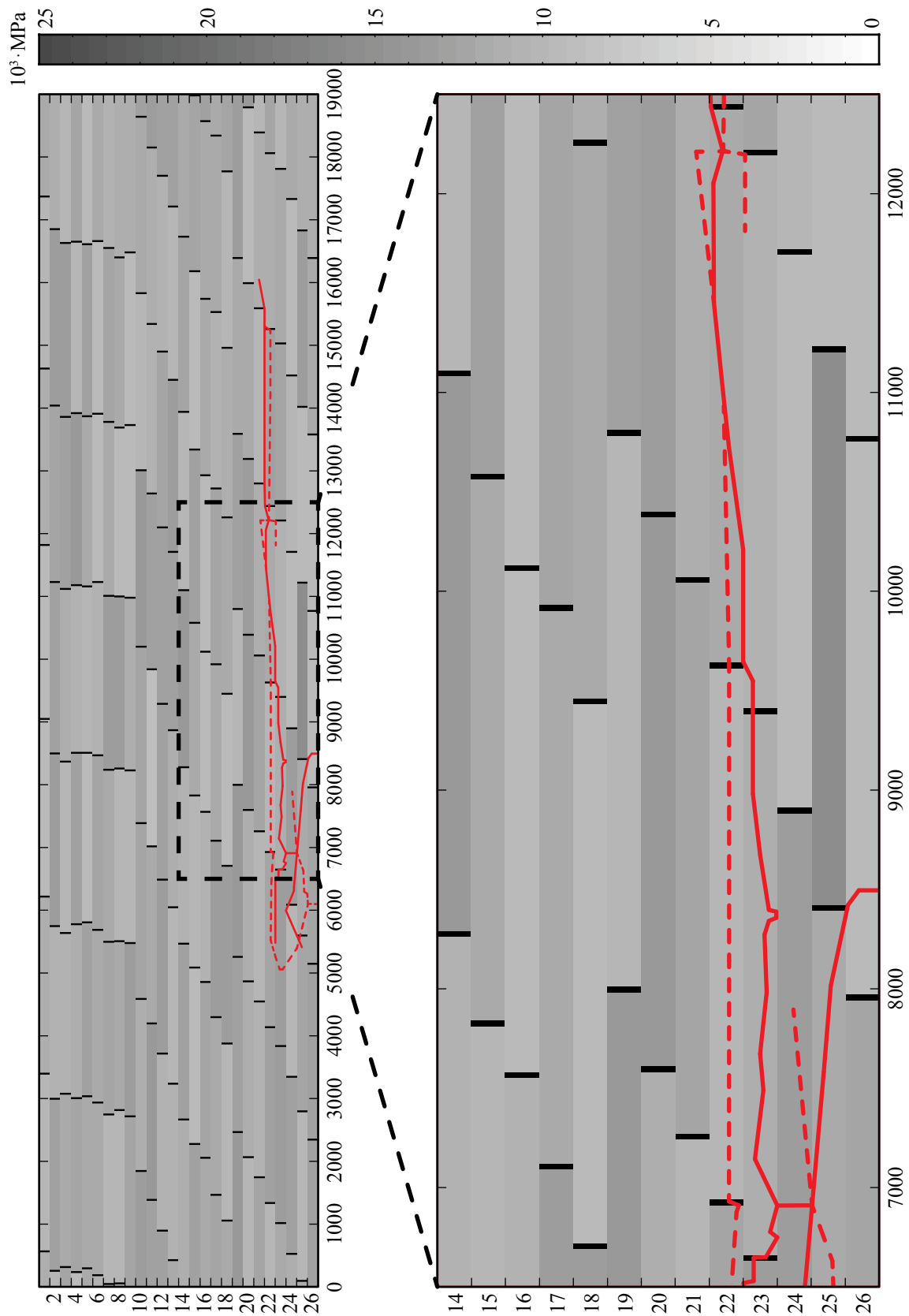


Fig. 25: Setup of GL24h-19m-2: Dynamic modulus of elasticity (E_m -values from GoldenEye-706).

GL32h-11m-1

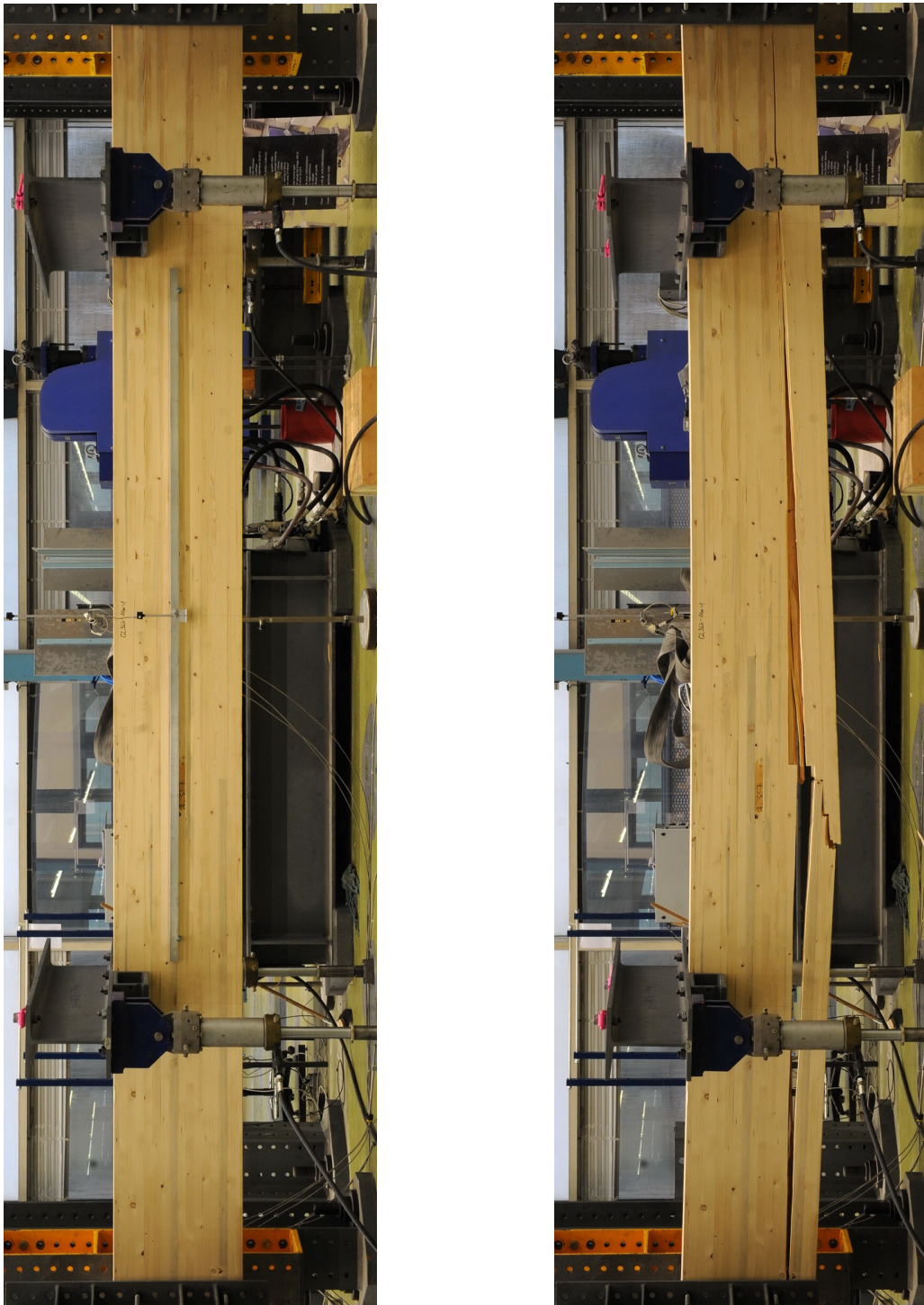


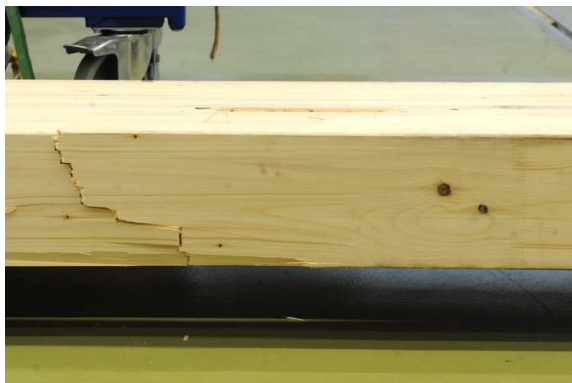
Fig. 26: Illustrations of beam GL32h-11m-1 (central area): (left) before testing, (right) after testing.



(a) front side ($l \approx 4.7 - 5.0$ m)



(b) back side ($l \approx 4.8 - 4.9$ m)



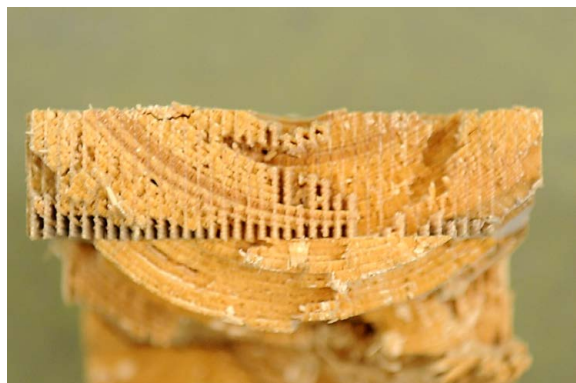
(c) lowest lamella ($l \approx 4.7 - 4.8$ m)



(d) lowest and 2nd lowest lamella ($l \approx 4.8$ m)



(e) 3rd lowest lamella ($l \approx 4.9$ m)



(f) 3rd lowest lamella ($l \approx 4.9$ m)

Fig. 27: Illustrations of the failure of GL32h-11m-1.

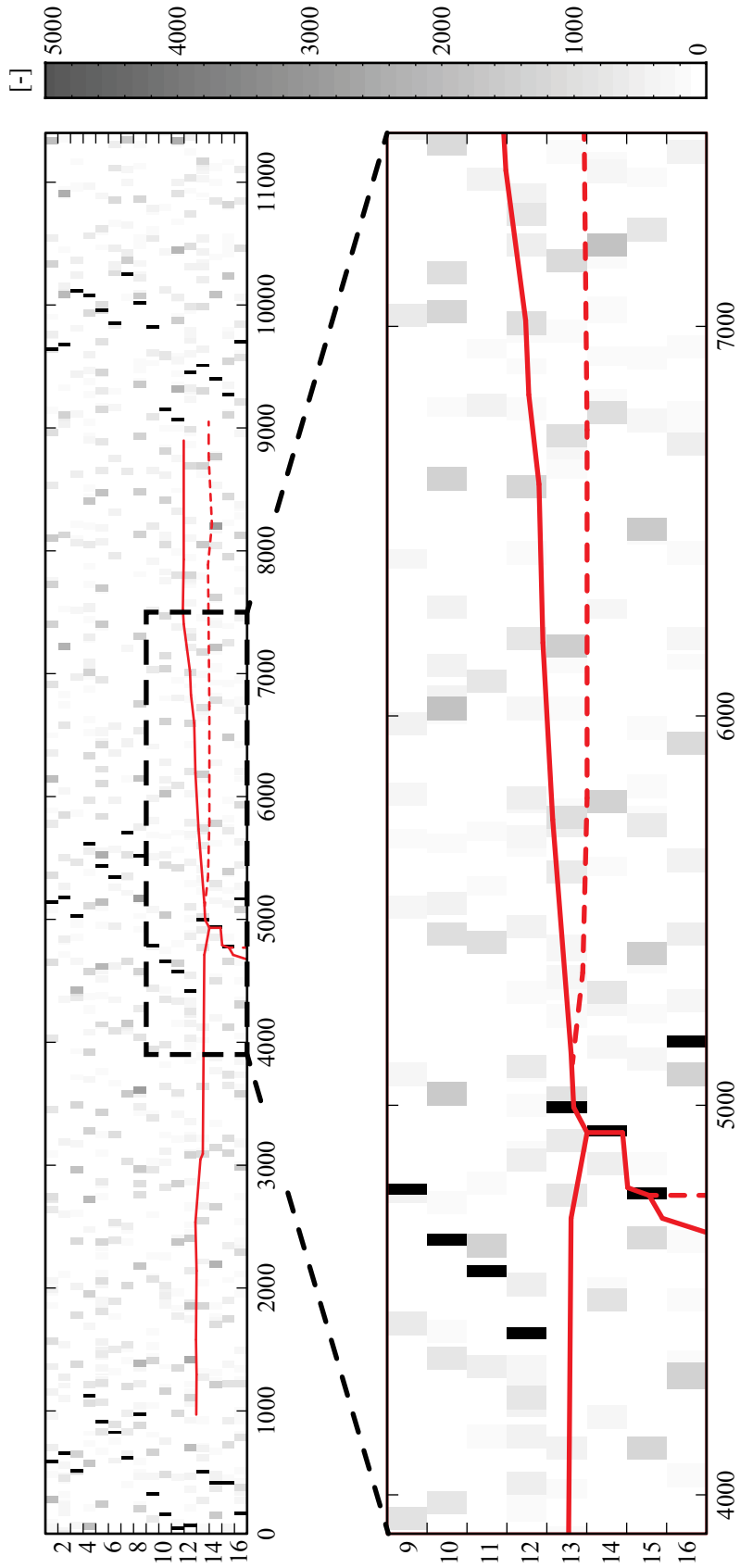


Fig. 28: Setup of GL32h-11m-1: Knot-profile (K_m -values from GoldenEye-706).

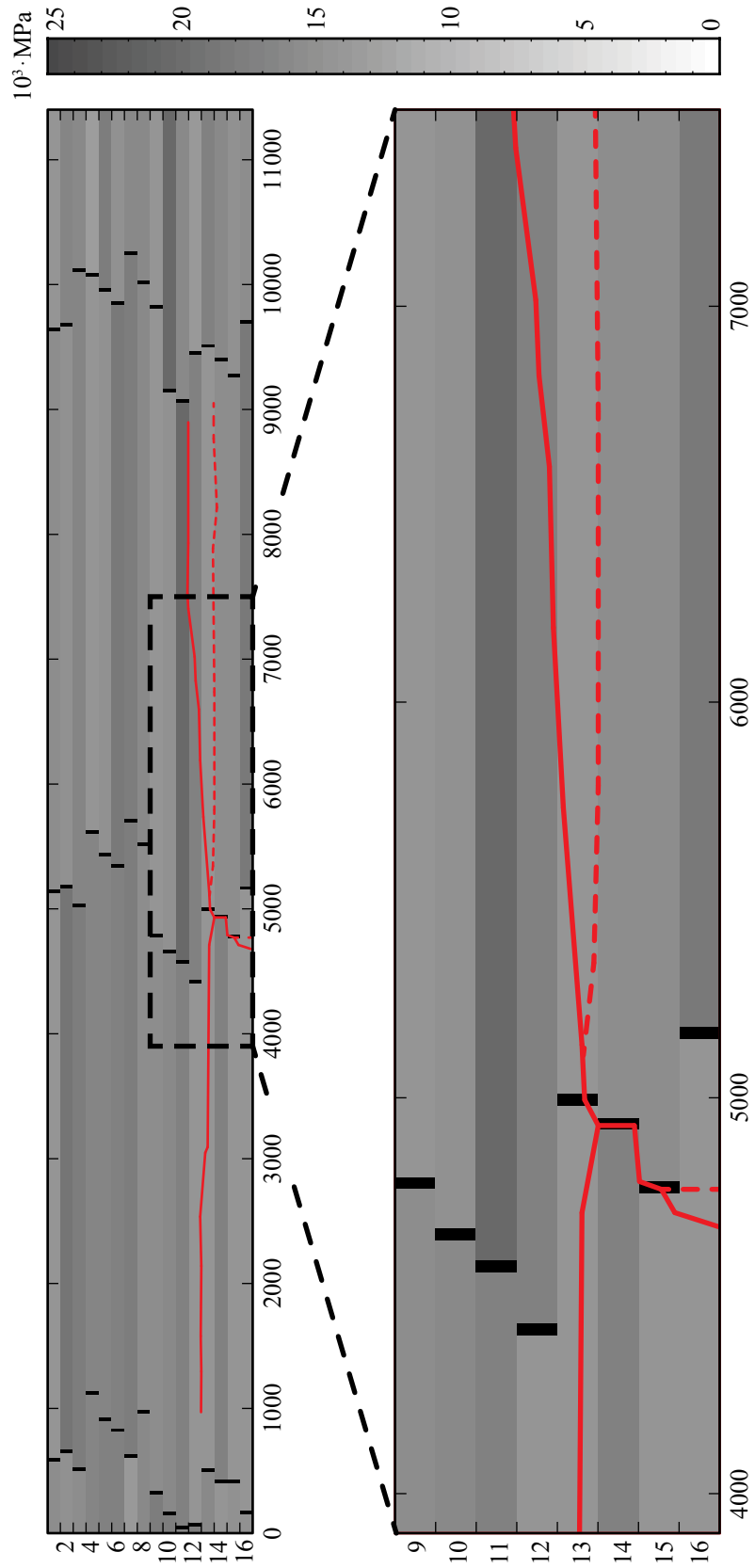


Fig. 29: Setup of GL32h-11m-1: Dynamic modulus of elasticity (E_m -values from GoldenEye-706).

GL32h-11m-2

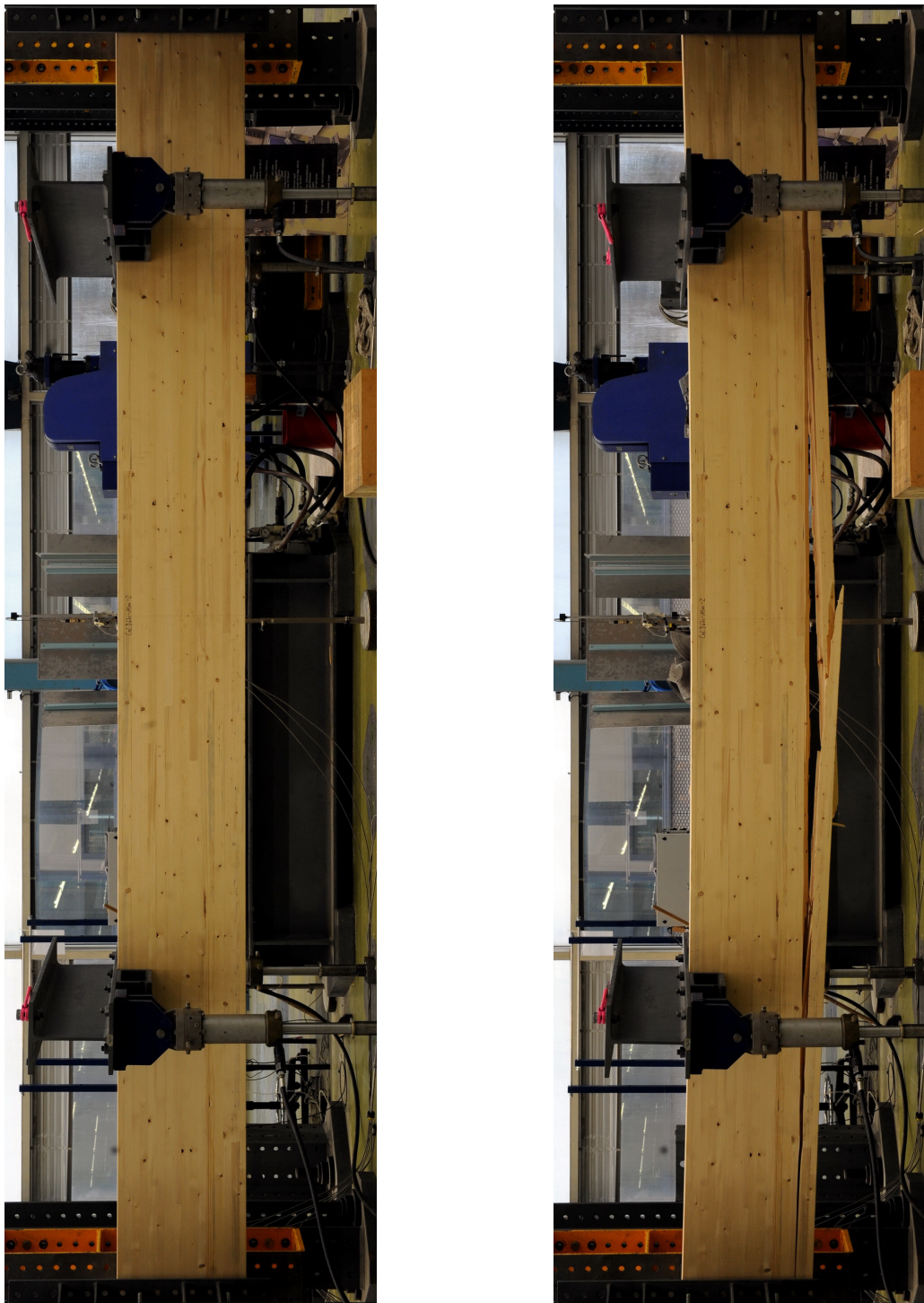


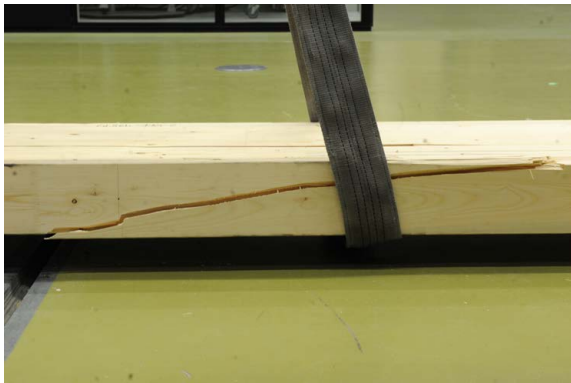
Fig. 30: Illustrations of beam GL32h-11m-2 (central area): (left) before testing, (right) after testing.



(a) front side ($l \approx 5.5$ m)



(b) back side ($l \approx 5.0$ m)



(c) lowest lamella ($l \approx 4.8 - 5.8$ m)



(d) lowest and 2nd lowest lamella ($l \approx 4.8 - 5.8$ m)



(e) 2nd lowest lamella ($l \approx 4.2$ m)



(f) 2nd lowest lamella ($l \approx 5.5$ m)

Fig. 31: Illustrations of the failure of GL32h-11m-2.

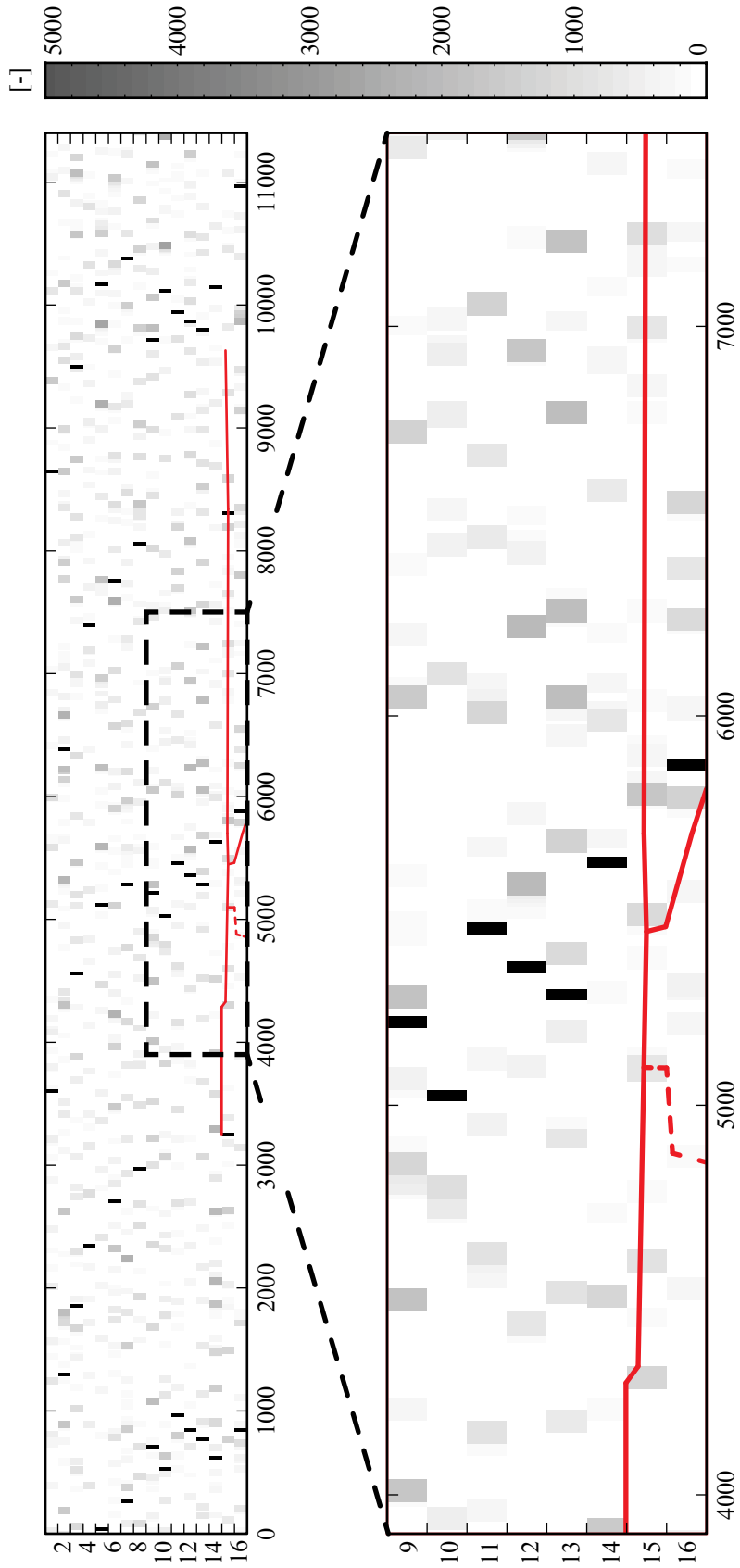


Fig. 32: Setup of GL32h-11m-2: Knot-profile (K_m -values from GoldenEye-706).

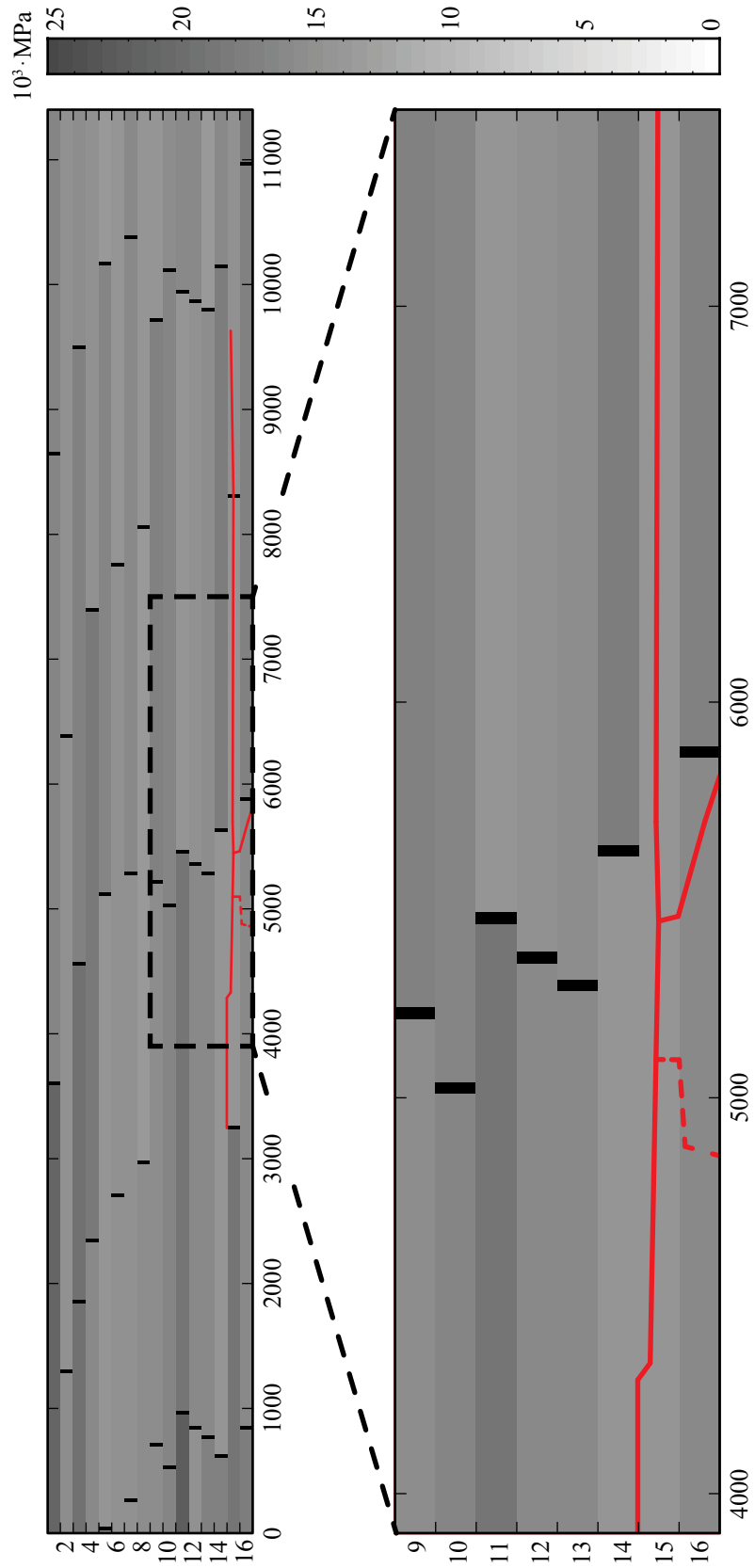


Fig. 33: Setup of GL32h-11m-2: Dynamic modulus of elasticity (E_m -values from GoldenEye-706).

GL32h-11m-3

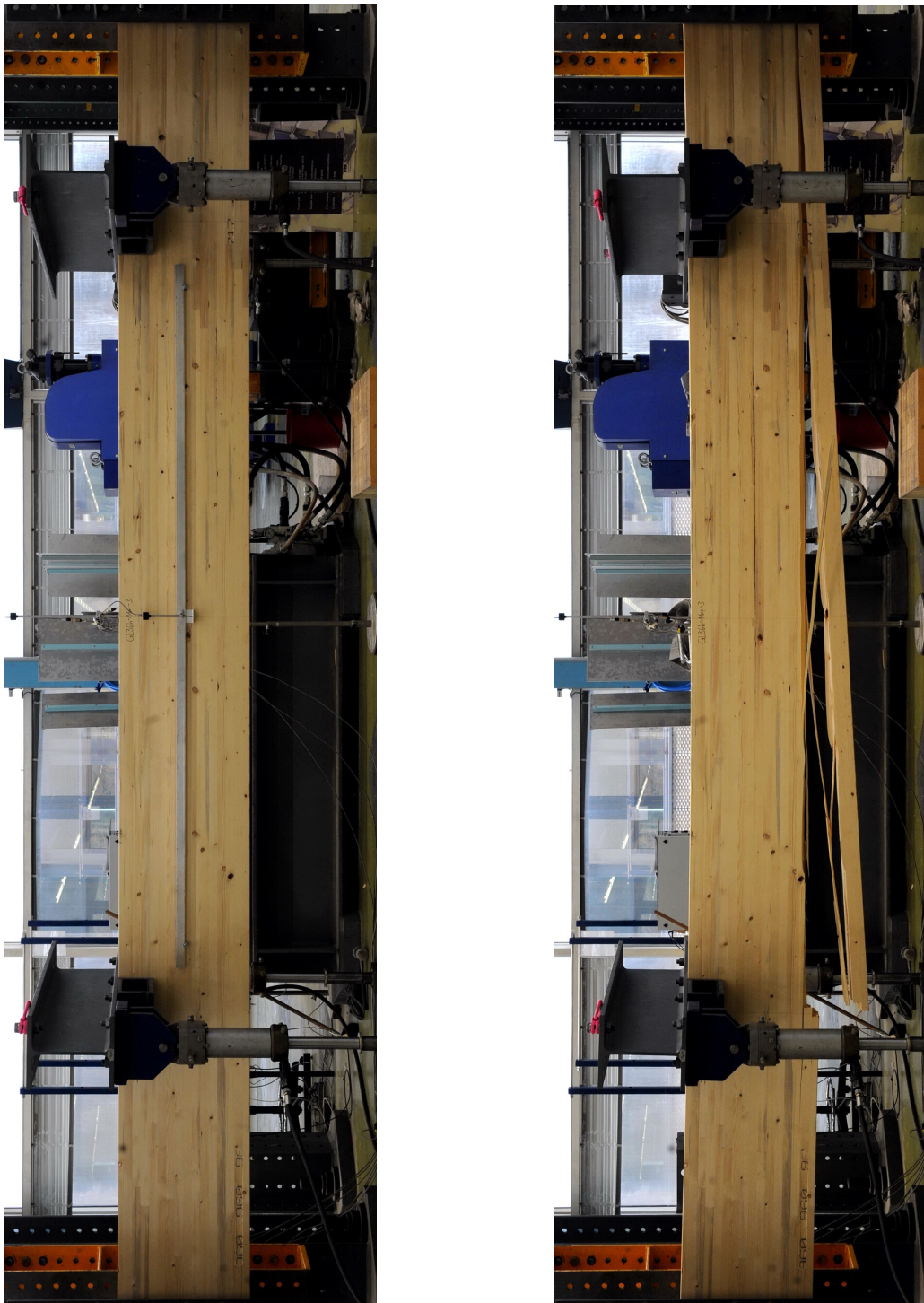


Fig. 34: Illustrations of beam GL32h-11m-3 (central area): (left) before testing, (right) after testing.



(a) front side ($l \approx 3.9$ m)



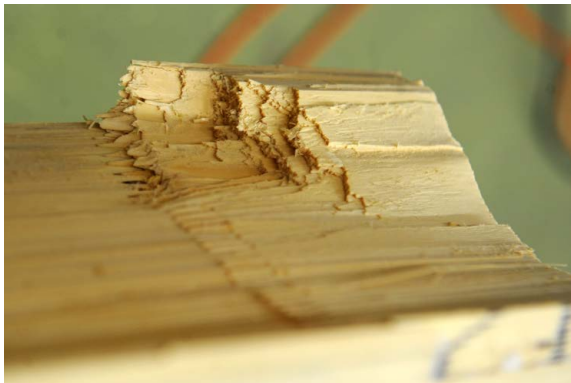
(b) back side ($l \approx 3.9$ m)



(c) lowest lamella ($l \approx 3.9$ m)



(d) lowest and 2nd lowest lamella ($l \approx 3.9$ m)



(e) 3rd lowest lamella ($l \approx 7.4$ m)



(f) 3rd lowest lamella ($l \approx 7.4$ m), back side

Fig. 35: Illustrations of the failure of GL32h-11m-3.

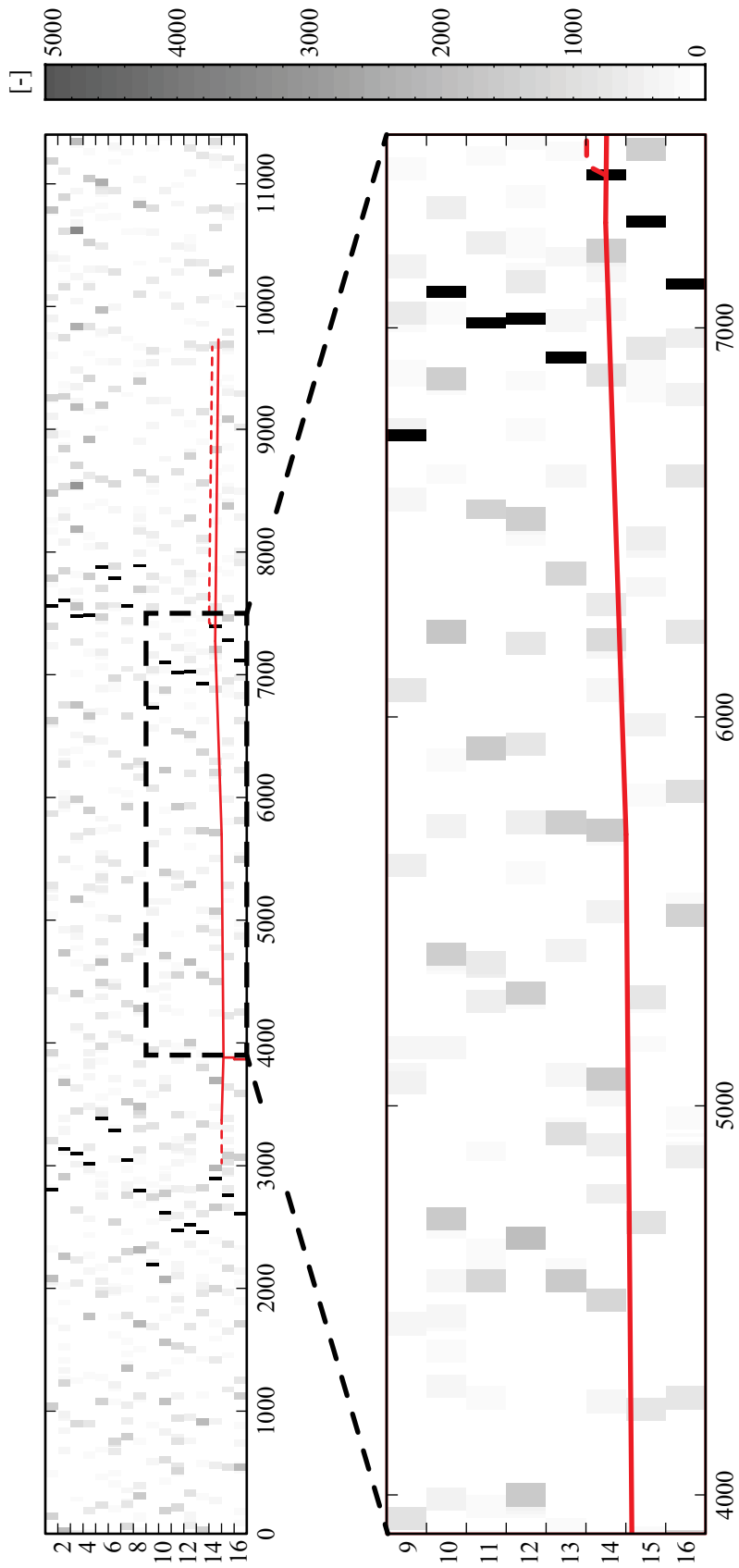


Fig. 36: Setup of GL32h-11m-3: Knot-profile (K_m -values from GoldenEye-706).

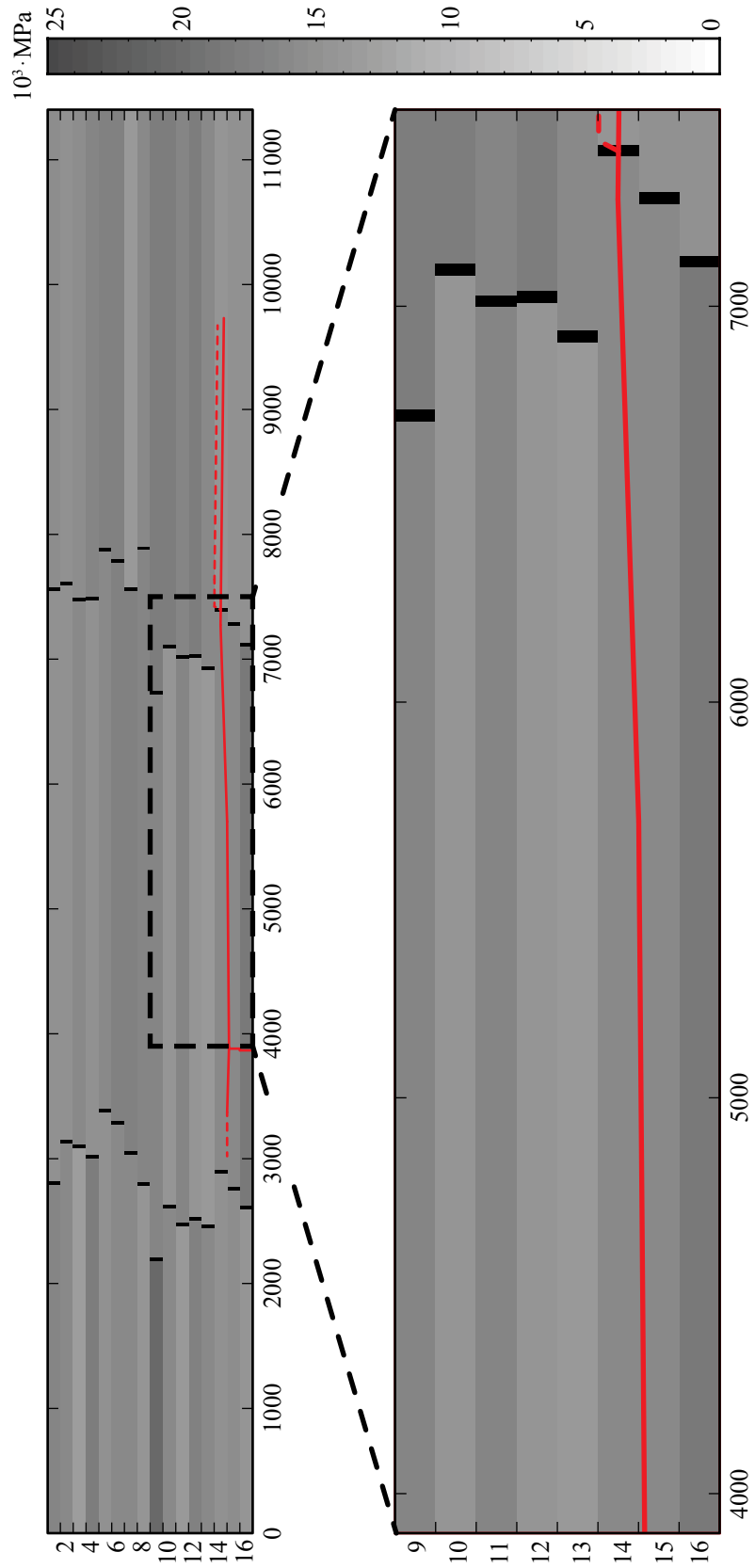


Fig. 37: Setup of GL32h-11m-3: Dynamic modulus of elasticity (E_m -values from GoldenEye-706).

GL32h-11m-4

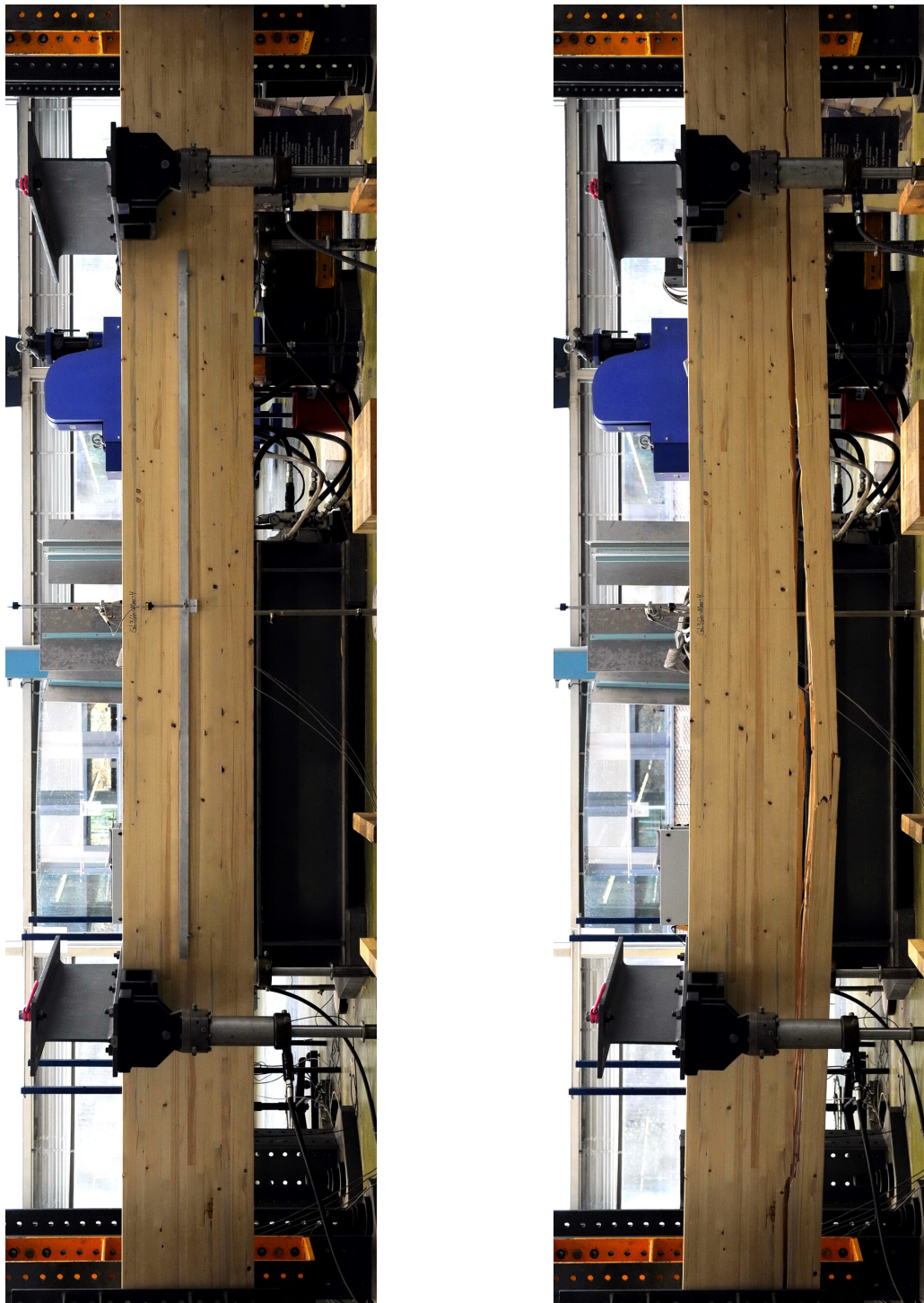


Fig. 38: Illustrations of beam GL32h-11m-4 (central area): (left) before testing, (right) after testing.



(a) front side ($l \approx 5.0$ m)



(b) back side ($l \approx 5.0$ m)



(c) lowest lamella ($l \approx 5.0$ m)



(d) CS next to failed section ($l \approx 4.7$ m)



(e) failed section ($l \approx 4.8$ m)



(f) failed section ($l \approx 5.0$ m), back side



(g) 3rd lowest lamella ($l \approx 5.2$ m)



(h) 4th lowest lamella ($l \approx 3.2$ m), partly from 2nd failure cycle

Fig. 39: Illustrations of the failure of GL32h-11m-4.

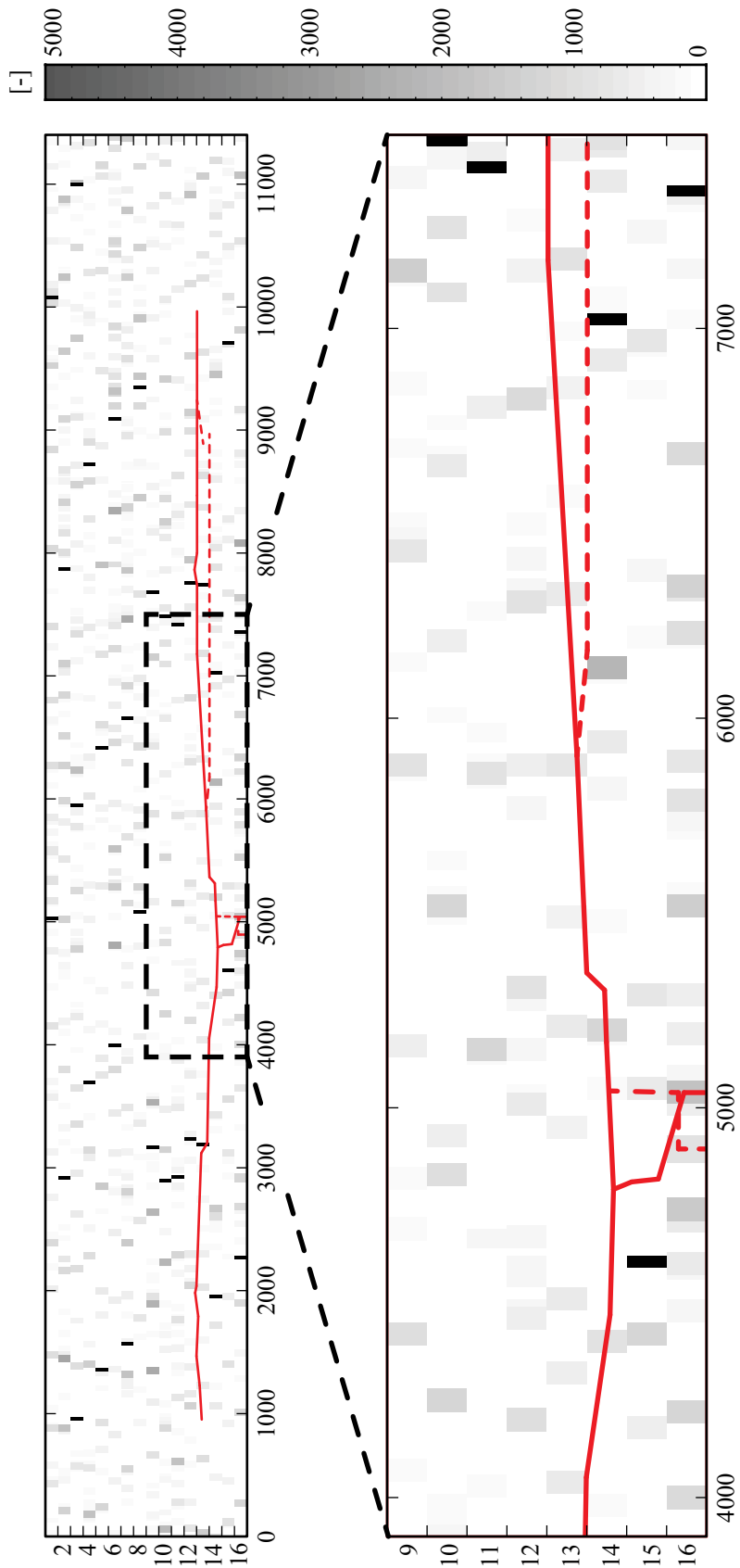


Fig. 40: Setup of GL32h-11m-4: Knot-profile (K_m -values from GoldenEye-706).

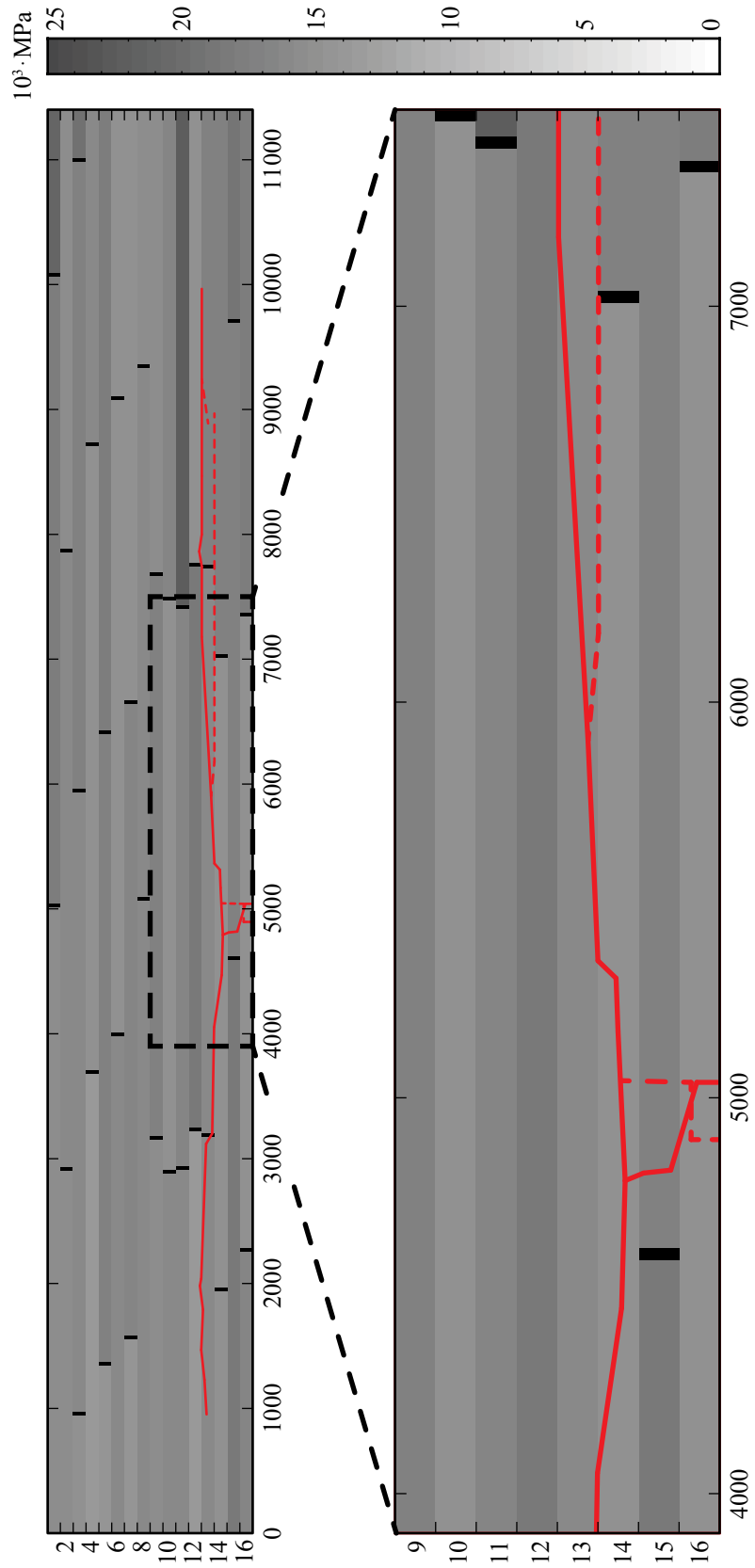


Fig. 41: Setup of GL32h-11m-4: Dynamic modulus of elasticity (E_m -values from GoldenEye-706).

GL32h-19m-1

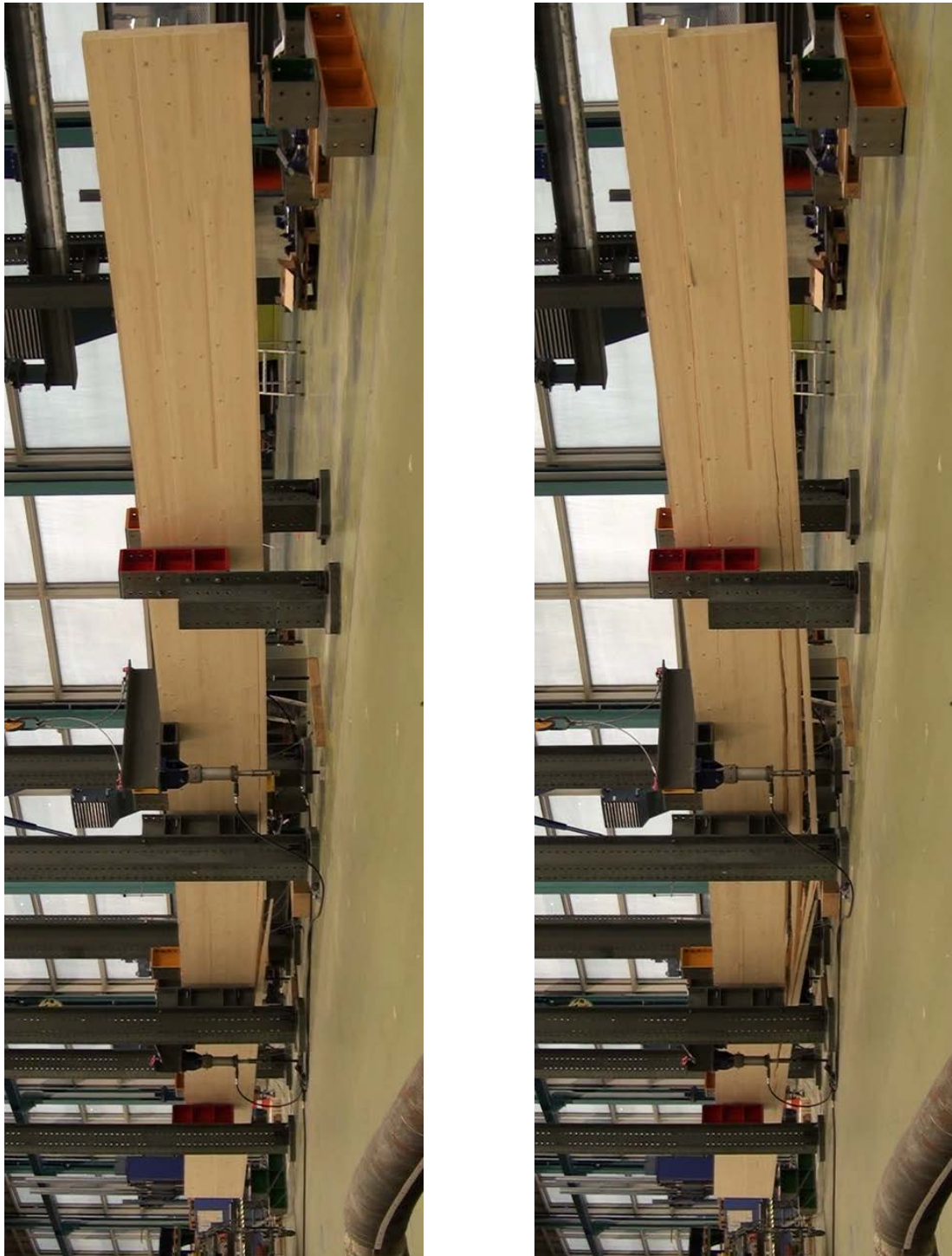


Fig. 42: Illustrations of GL32h-19m-1: (left) after first rupture, (right) after ultimate failure.



Fig. 43: Illustration of GL32h-19m-1 after first rupture (area between central buckling stabilisers).



Fig. 44: Illustration of GL32h-19m-1 after ultimate failure (area between central buckling stabilisers).



(a) lowest lamella ($l \approx 9.8 - 8.5$ m)



(b) lowest lamella ($l \approx 5.0$ m)



(c) 2nd lowest lamella ($l \approx 6.4$ m), back side



(d) 2nd lowest lamella ($l \approx 7.1$ m)



(e) 3rd lowest lamella ($l \approx 6.3$ m)



(f) 3rd lowest lamella ($l \approx 6.4$ m), back side



(g) 4th lowest lamella ($l \approx 8.8$ m)

Fig. 45: Illustrations of the failure of GL32h-19m-1.

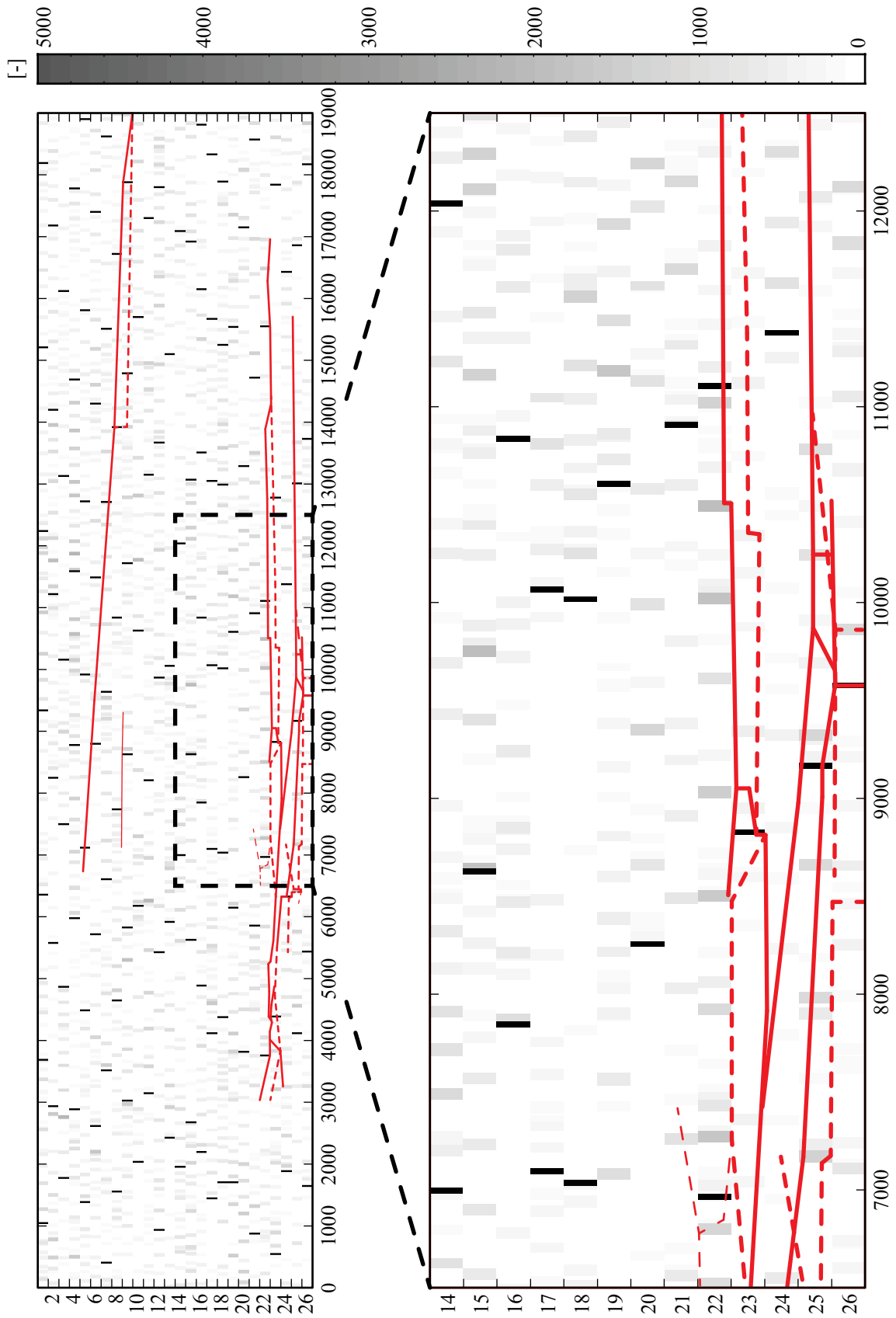


Fig. 46: Setup of GL32h-19m-1: Knot-profile (K_m -values from GoldenEye-706).

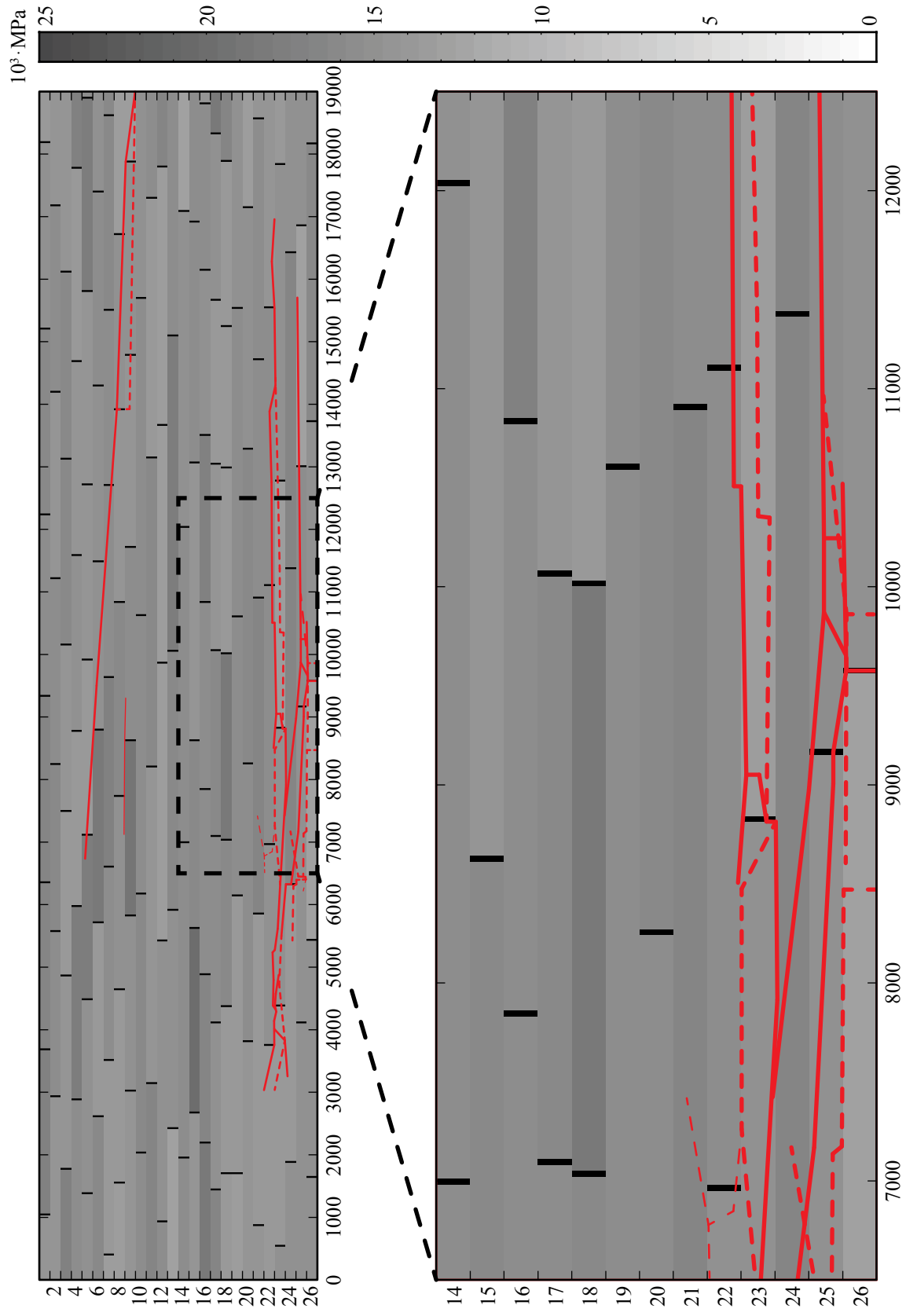


Fig. 47: Setup of GL32h-19m-1: Dynamic modulus of elasticity (E_m -values from GoldenEye-706).

GL32h-19m-2



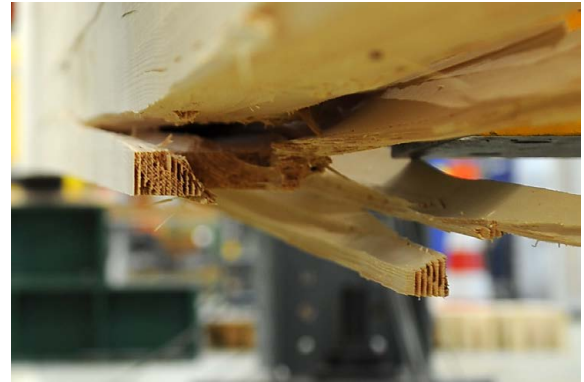
Fig. 48: Illustration of GL32h-19m-2: after testing.



Fig. 49: Illustration of beam GL32h-19m-2 after testing (area between central buckling stabilisers).



(a) lowest lamella ($l \approx 7.8$ m)



(b) lowest lamella ($l \approx 7.8$ m)



(c) 2nd lowest lamella ($l \approx 9.7 - 10.8$ m)



(d) 2nd lowest lamella ($l \approx 9.7$ m), back side

Fig. 50: Illustrations of the failure of GL32h-19m-2 (1).



(a) 3rd lowest lamella ($l \approx 9.5 - 10.5$ m)



(b) 3rd lowest lamella ($l \approx 11.9$ m)



(c) 4th lowest lamella ($l \approx 7.0$ m)



(d) 6th lowest lamella ($l \approx 8.0$ m), back side



(e) 7th lowest lamella ($l \approx 10.3$ m)



(f) 8th and 9th lowest lamella ($l \approx 6.0$ m), back side

Fig. 51: Illustrations of the failure of GL32h-19m-2 (2).

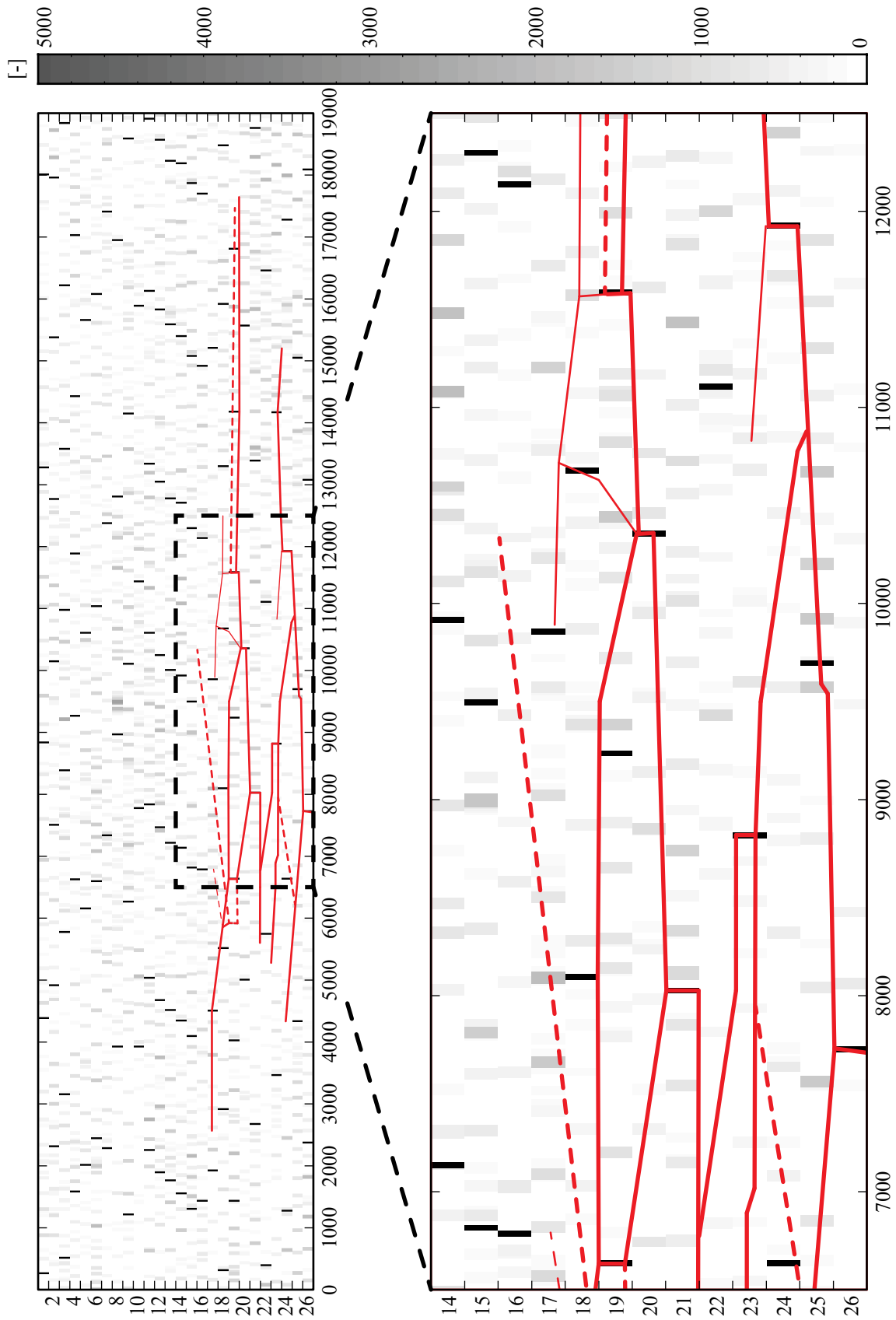


Fig. 52: Setup of GL32h-19m-2: Knot-profile (K_m -values from GoldenEye-706).

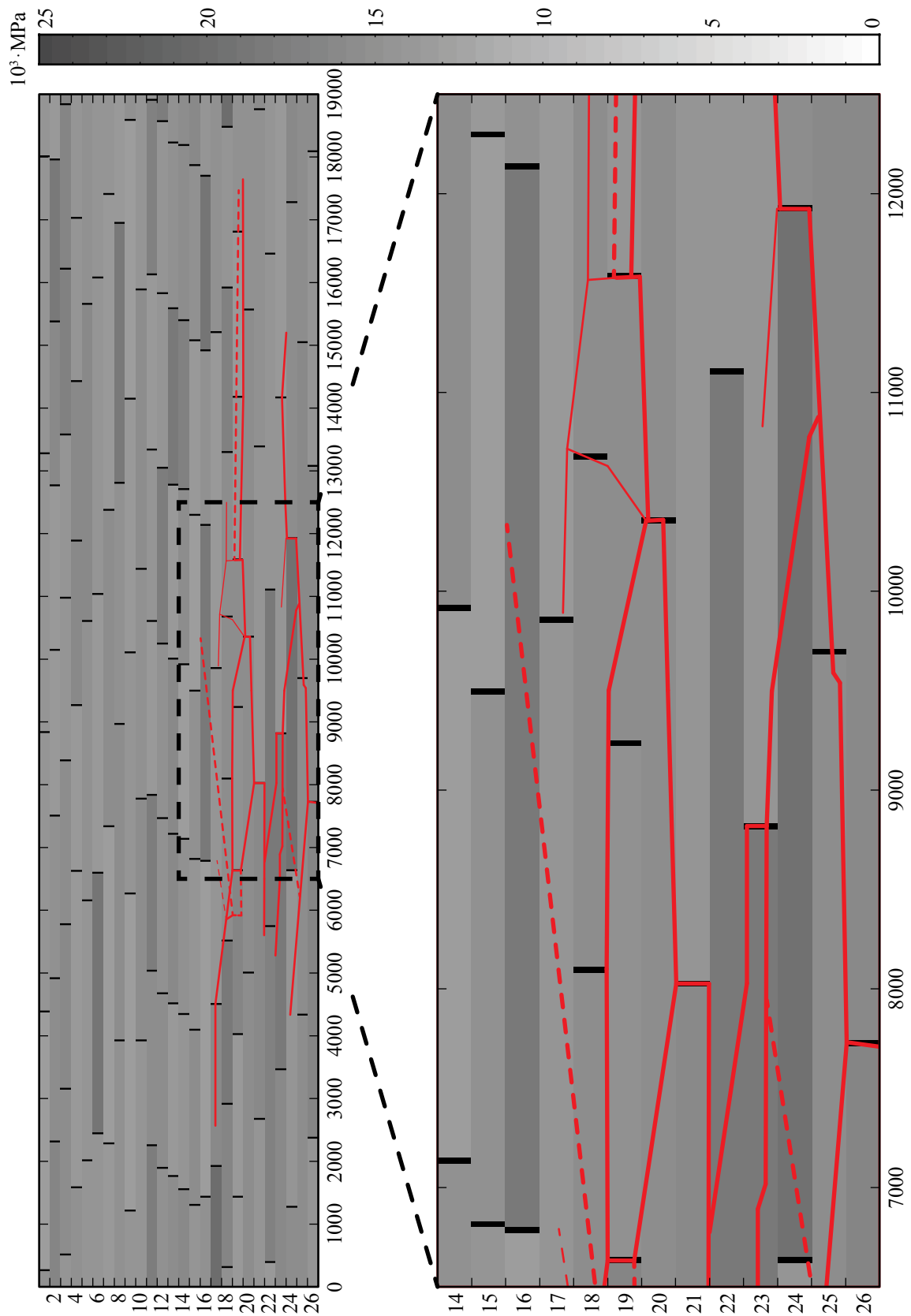


Fig. 53: Setup of GL32h-19m-2: Dynamic modulus of elasticity (E_m -values from GoldenEye-706).