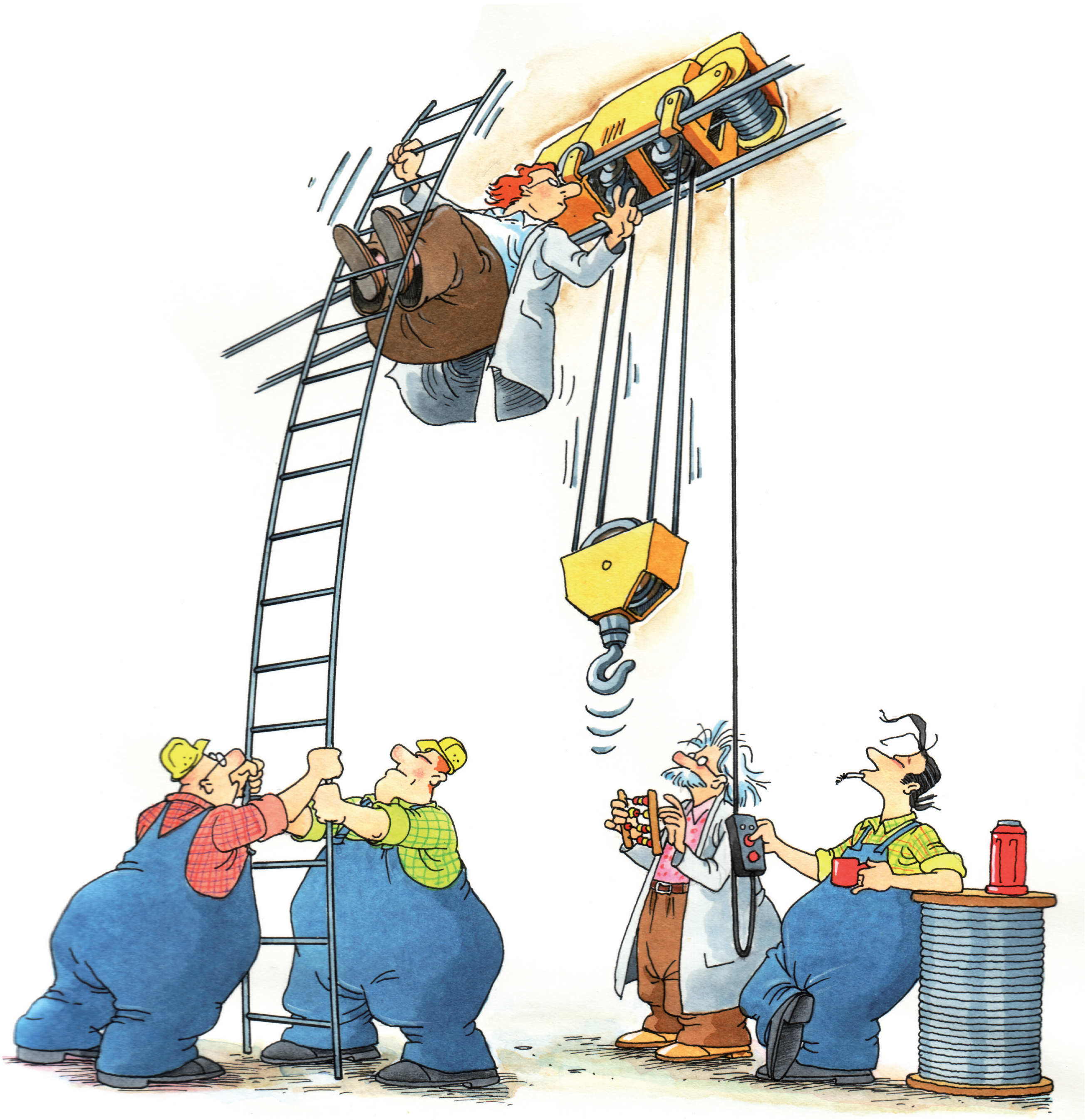
WIRE ROPE
TECHNOLOGY AACHEN



Analysis of the bending cycle distribution of 1- to 8-part electric hoists

Analysis of the bending cycle distribution of 1- to 8-part electric hoists

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Content

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1. Introduction

During the hoisting operation of a crane, not all sections of the hoist rope are subjected to the same number of bending cycles. Instead, the distribution of the bending cycles depends on the geometry of the reeving system and on the mode of operation of the crane.

The author has written a program which calculates and displays the distribution of the bending cycles along the rope length and the maximum number of bending cycles depending on the lifting height.

As an example of the possibilities of such software, the distribution of bending cycles of 1- to 8-part electric hoists, according to Fig. 1, will be analyzed in the following paper.

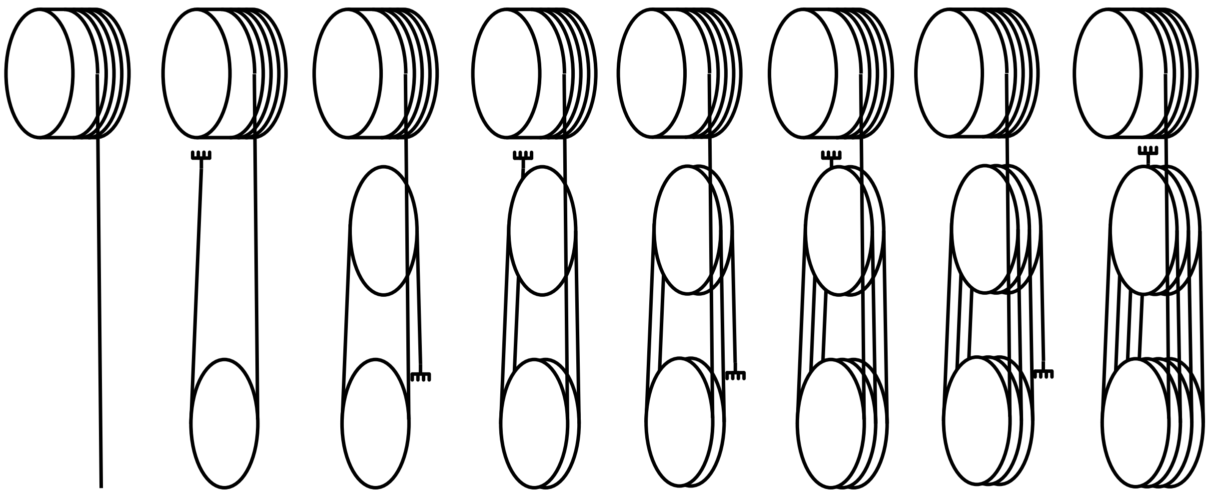

Fig. 1: Schematic arrangements of the 1- to 8-part hoists

For all hoists, the distribution will be analyzed for lifting heights of 25%, 50%, 75% and 100% of the maximum possible lifting height. In addition, the distribution of bending cycles will be analyzed under the assumption that these four lifting heights will occur with the same frequency.

At the end, a proposal for an estimation of the maximum number of bending cycles for different lifting heights will be presented.

Figure 2 shows the data of the 8 electric hoists. The rope diameter has been set to d = 16 mm, the sheave and drum diameters to D = 320 mm (= 20 x d). The maximum distances between the sheaves have been set to 16 m for all hoists, and the maximum lifting height to 15m. In addition, a reserve rope length on the drum (the “dead turns”) has been allowed for on all hoists.

	No. of parts [-]	No. of sheaves [-]	Rope length [mm]
Hoist 1	1	0	19.000
Hoist 2	2	1	35.503
Hoist 3	3	2	52.005
Hoist 4	4	3	68.508
Hoist 5	5	4	85.011
Hoist 7	6	5	101.513
Hoist 7	7	6	118.016
Hoist 8	8	7	134.519

Fig. 2: Data of the analyzed hoists

In the following, the results of every one of the 8 hoists will be presented on two pages each. The results are shown as a function of the rope length, displayed as a percentage of the total rope length according to Fig. 2.

In the final chapter some general conclusions are drawn.

2. The single-part hoist

Fig. 3 shows the maximum number of bending cycles for one full hoisting cycle (=1x lifting, 1x lowering) as a function of the lifting height. Fig. 5 (next page) shows the distribution of bending cycles as a function of the rope length (expressed in % of the total rope length) for one full hoisting cycle (=1x lifting, 1x lowering) for lifting heights of 25%, 50%, 75% and 100% of the maximum lifting height.

Fig. 4 shows the average number of bending cycles for a hoist which lifts the block to these four heights with the same frequency.

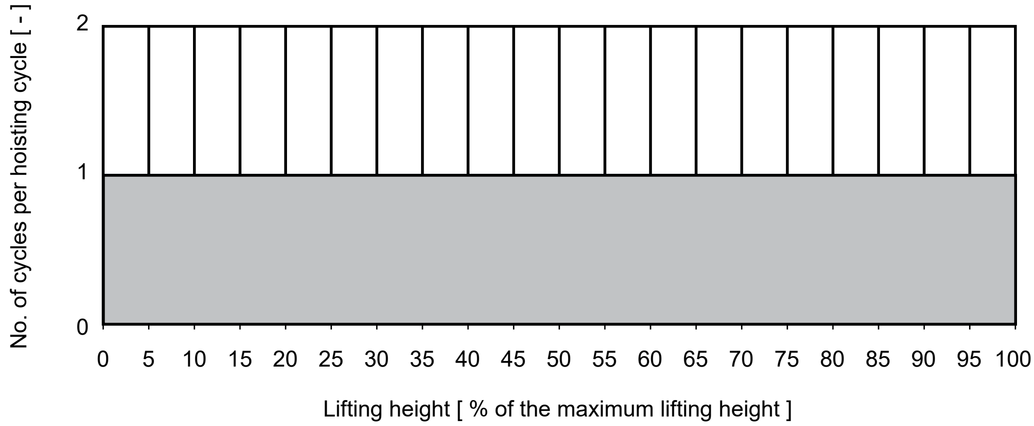

Fig. 3: Maximum number of cycles depending on the lifting height

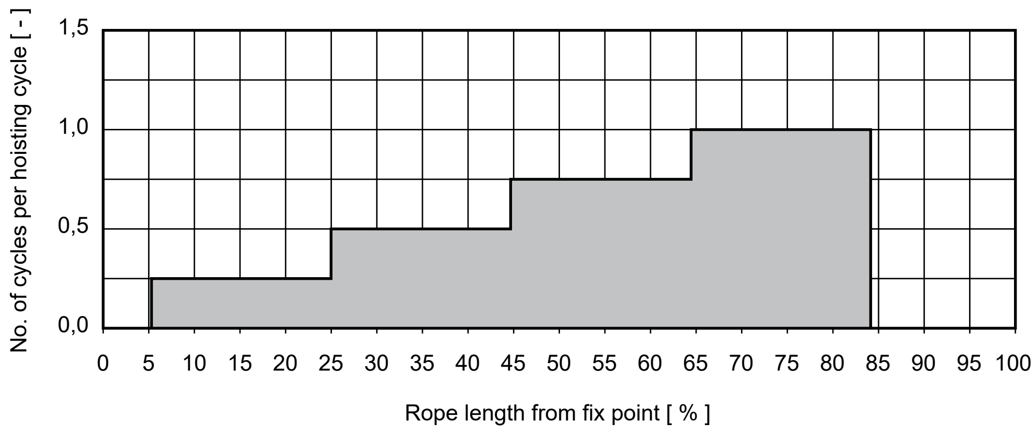

Fig. 4: Distribution of bending cycles per hoisting cycle if lifting heights of 25%, 50%, 75% and 100% of the maximum lifting height occur with the same frequency

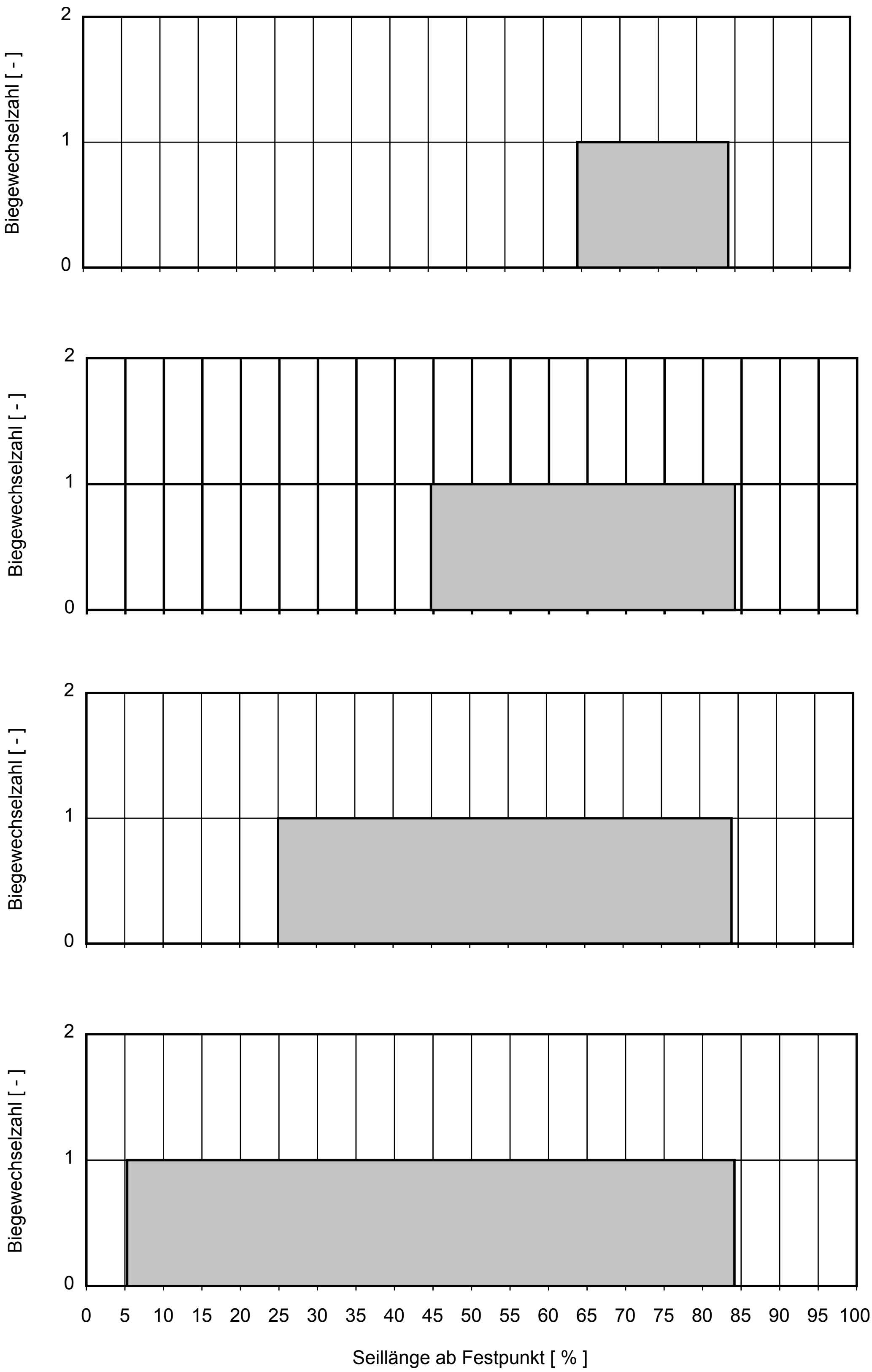

Fig. 5: Number of bending cycles depending on the rope length for lifting heights of 25%, 50%, 75% and 100% of the maximum lifting height (single-part hoist)

3. The 2-part hoist

Fig. 6 shows the maximum number of bending cycles for one full hoisting cycle (=1x lifting, 1x lowering) as a function of the lifting height. Fig. 8 (next page) shows the distribution of bending cycles as a function of the rope length (expressed in % of the total rope length) for one full hoisting cycle (=1x lifting, 1x lowering) for lifting heights of 25%, 50%, 75% and 100% of the maximum lifting height.

Fig. 7 shows the average number of bending cycles for a hoist which lifts the block to these four heights with the same frequency.

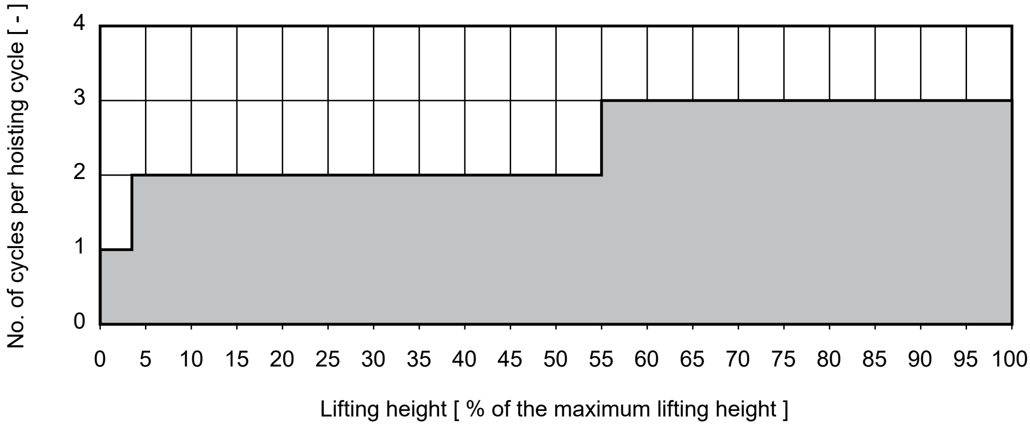

Fig. 6: Maximum number of cycles depending on the lifting height

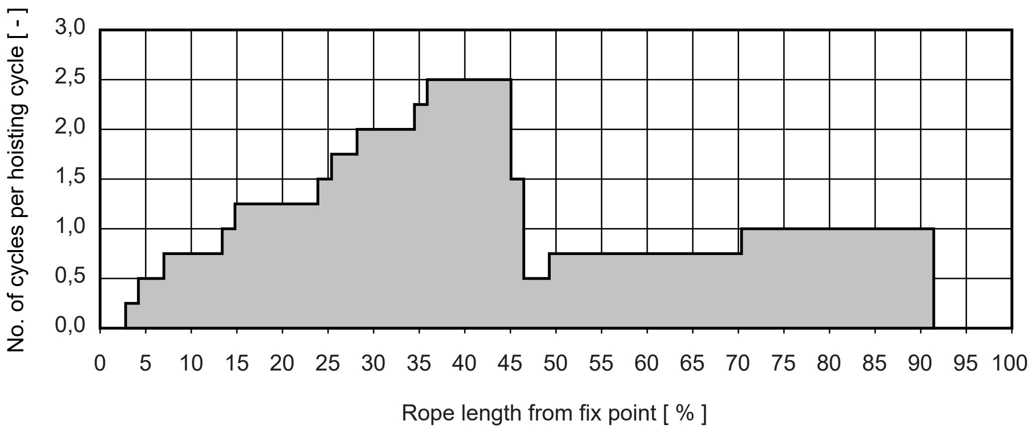

Fig. 7: Distribution of bending cycles per hoisting cycle if lifting heights of 25%, 50%, 75% and 100% of the maximum lifting height occur with the same frequency

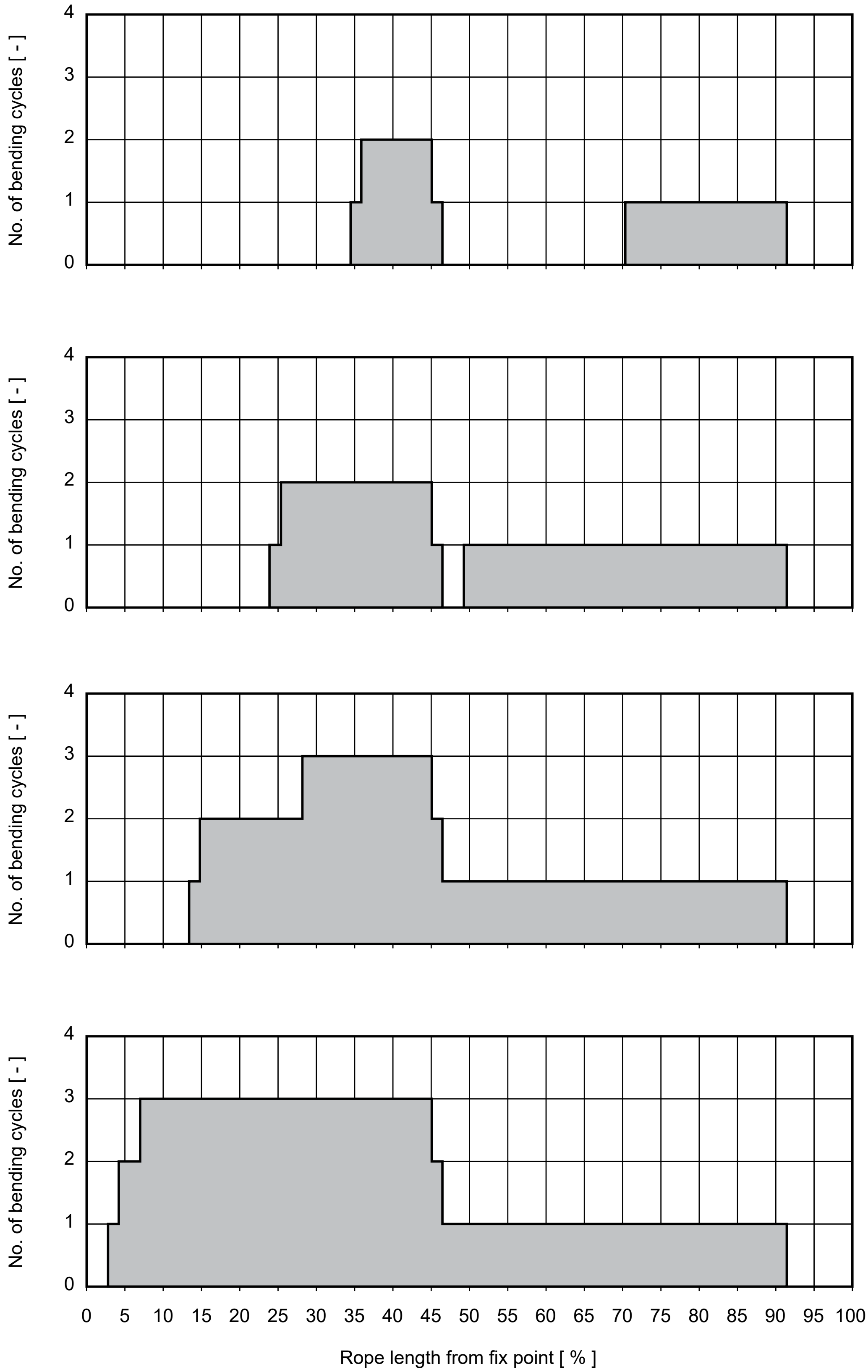

Fig. 8: Number of bending cycles depending on the rope length for lifting heights of 25%, 50%, 75% and 100% of the maximum lifting height (2-part hoist)

4. The 3-part hoist

Fig. 9 shows the maximum number of bending cycles for one full hoisting cycle (=1x lifting, 1x lowering) as a function of the lifting height. Fig. 11 (next page) shows the distribution of bending cycles as a function of the rope length (expressed in % of the total rope length) for one full hoisting cycle (=1x lifting, 1x lowering) for lifting heights of 25%, 50%, 75% and 100% of the maximum lifting height.

Fig. 10 shows the average number of bending cycles for a hoist which lifts the block to these four heights with the same frequency.

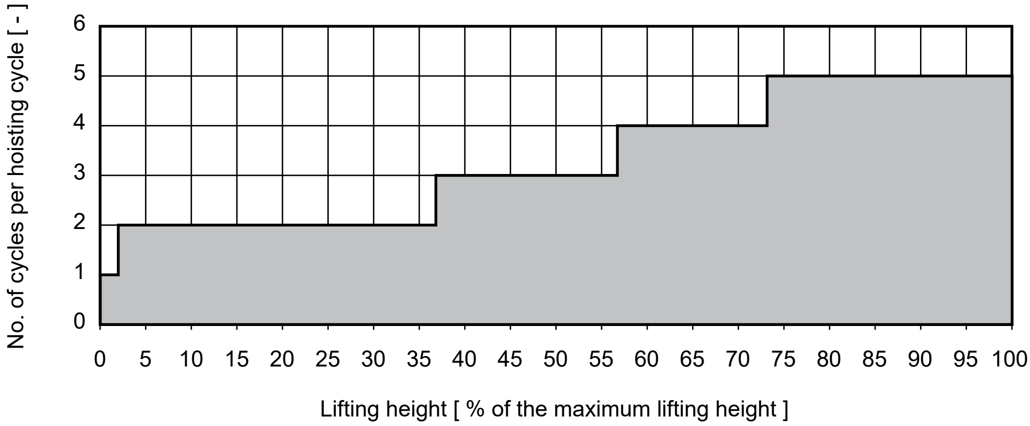

Fig. 9: Maximum number of cycles depending on the lifting height

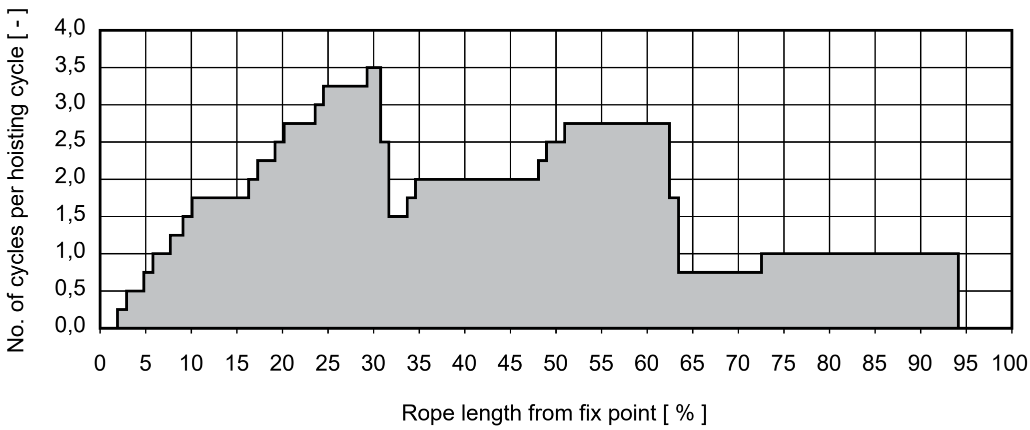

Fig. 10: Distribution of bending cycles per hoisting cycle if lifting heights of 25%, 50%, 75% and 100% of the maximum lifting height occur with the same frequency

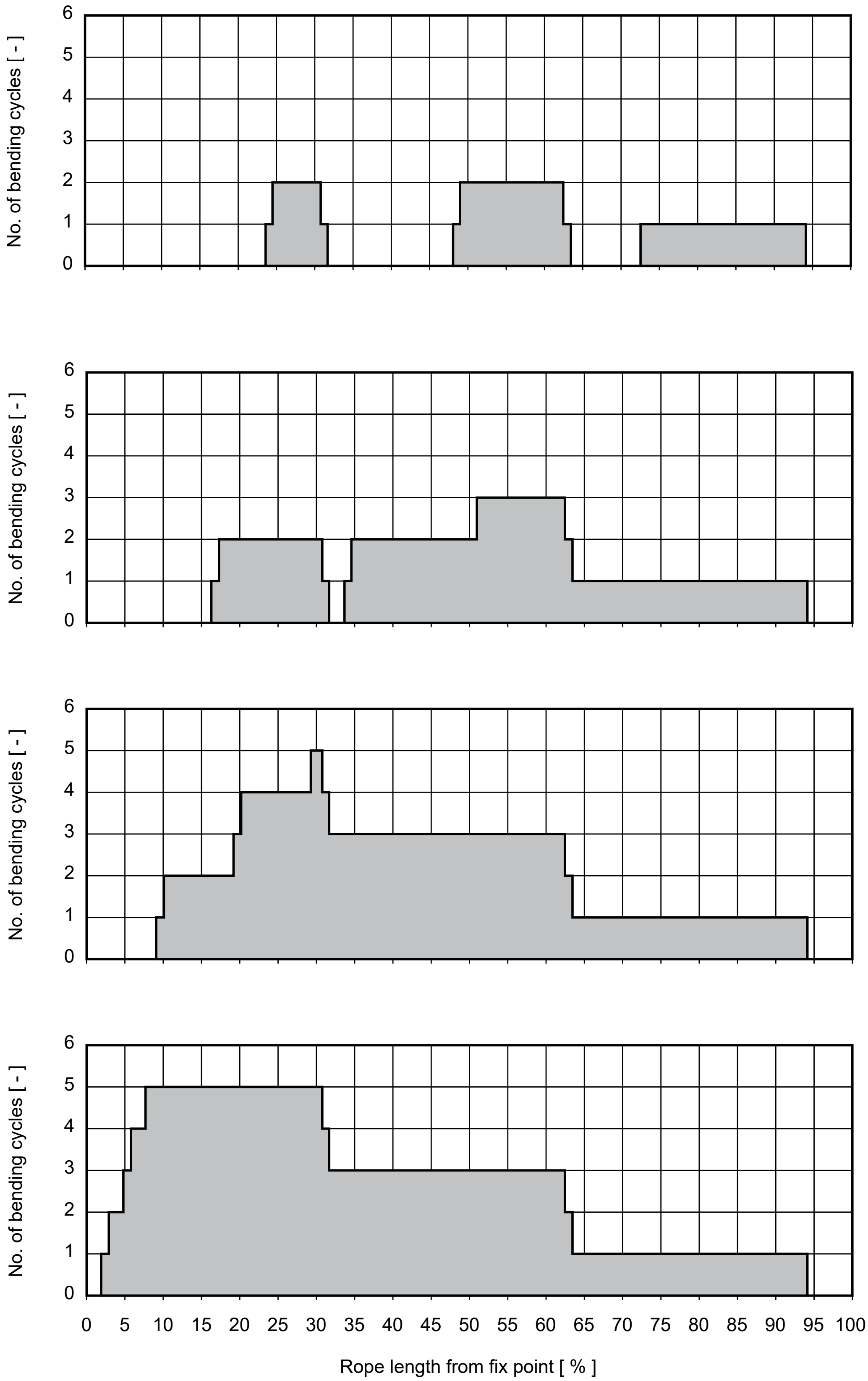

Fig. 11: Number of bending cycles depending on the rope length for lifting heights of 25%, 50%, 75% and 100% of the maximum lifting height (3-part hoist)

5. The 4-part hoist

Fig. 12 shows the maximum number of bending cycles for one full hoisting cycle (=1x lifting, 1x lowering) as a function of the lifting height. Fig. 14 (next page) shows the distribution of bending cycles as a function of the rope length (expressed in % of the total rope length) for one full hoisting cycle (= 1x lifting, 1x lowering) for lifting heights of 25%, 50%, 75% and 100% of the maximum lifting height.

Fig. 13 shows the average number of bending cycles for a hoist which lifts the block to these four heights with the same frequency.

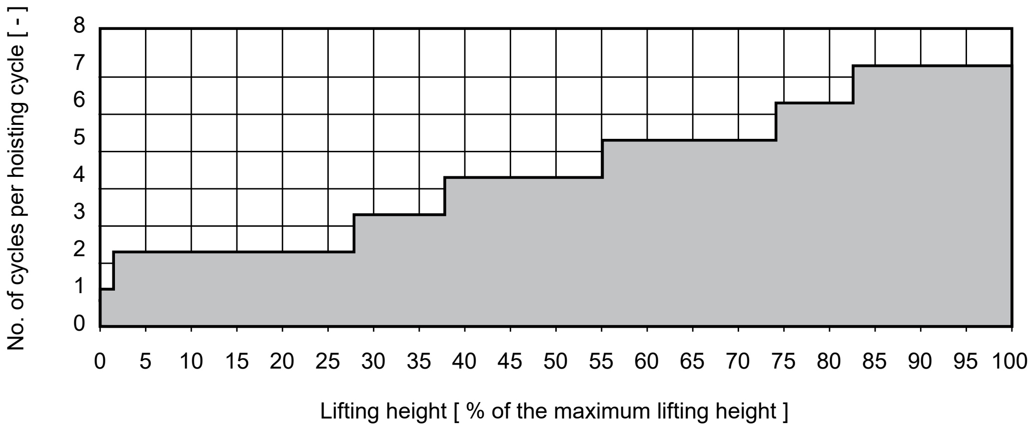

Fig. 12: Maximum number of cycles depending on the lifting height

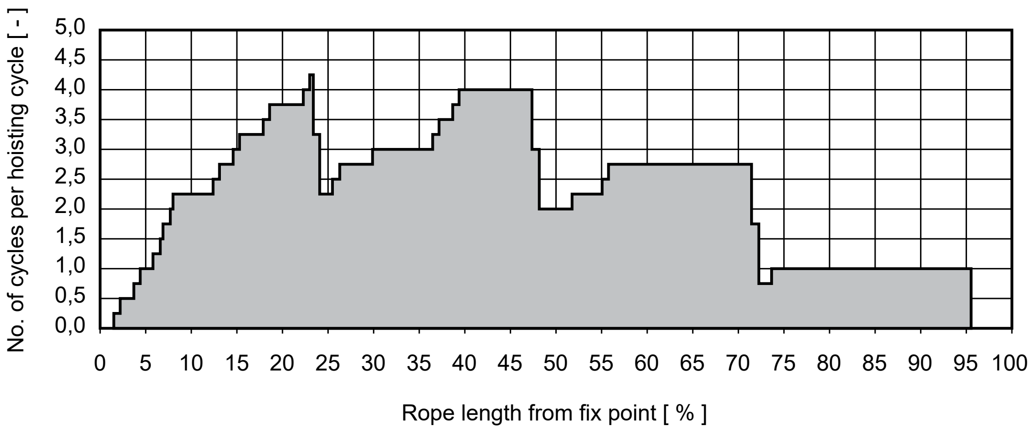

Fig. 13: Distribution of bending cycles per hoisting cycle if lifting heights of 25%, 50%, 75% and 100% of the maximum lifting height occur with the same frequency

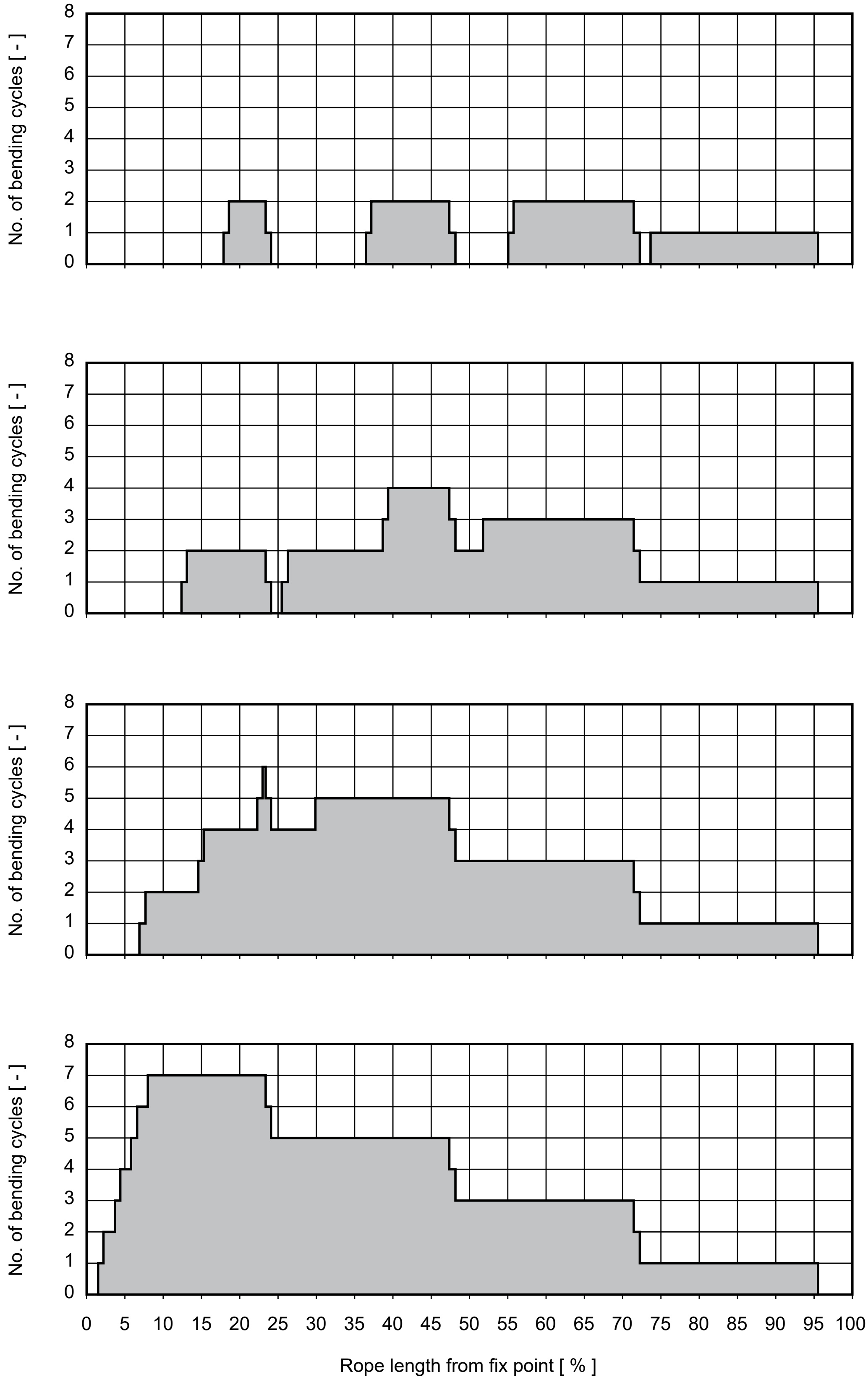

Fig. 14: Number of bending cycles depending on the rope length for lifting heights of 25%, 50%, 75% and 100% of the maximum lifting height (4-part hoist)

6. The 5-part hoist

Fig. 15 shows the maximum number of bending cycles for one full hoisting cycle (=1x lifting, 1x lowering) as a function of the lifting height. Fig. 17 (next page) shows the distribution of bending cycles as a function of the rope length (expressed in % of the total rope length) for one full hoisting cycle (=1x lifting, 1x lowering) for lifting heights of 25%, 50%, 75% and 100% of the maximum lifting height.

Fig. 16 shows the average number of bending cycles for a hoist which lifts the block to these four heights with the same frequency.

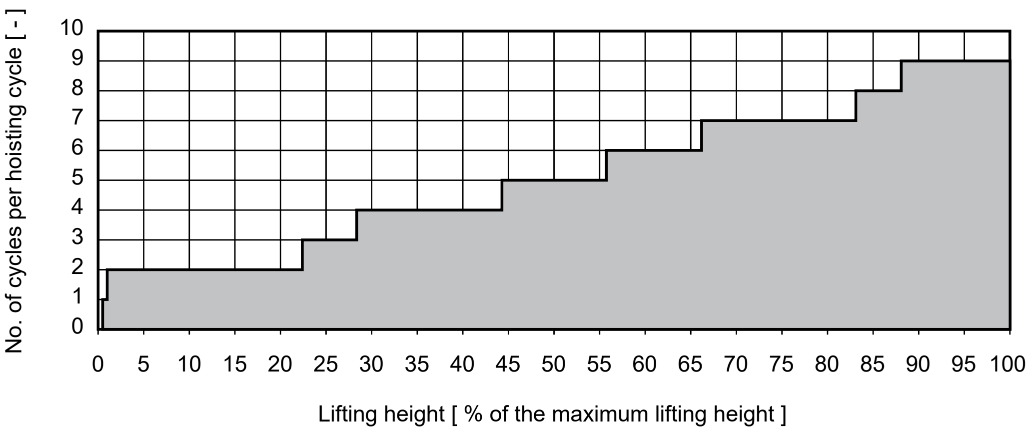

Fig. 15: Maximum number of cycles depending on the lifting height

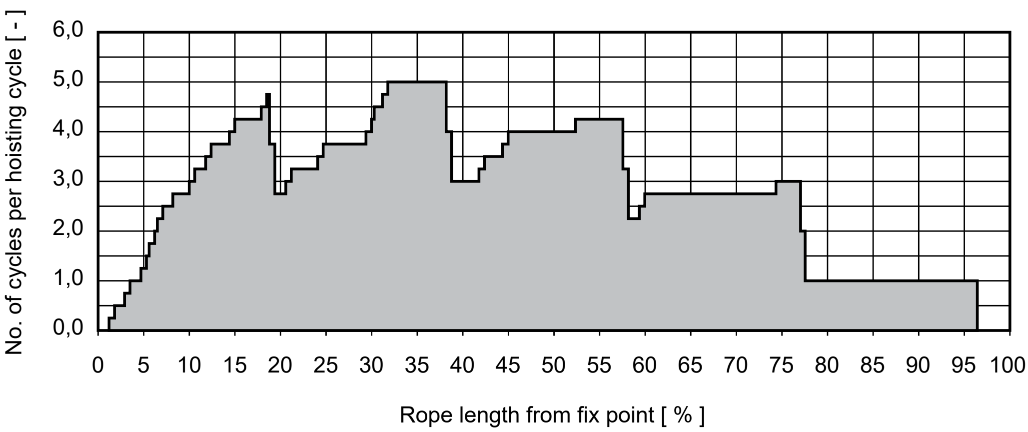

Fig. 16: Distribution of bending cycles per hoisting cycle if lifting heights of 25%, 50%, 75% and 100% of the maximum lifting height occur with the same frequency

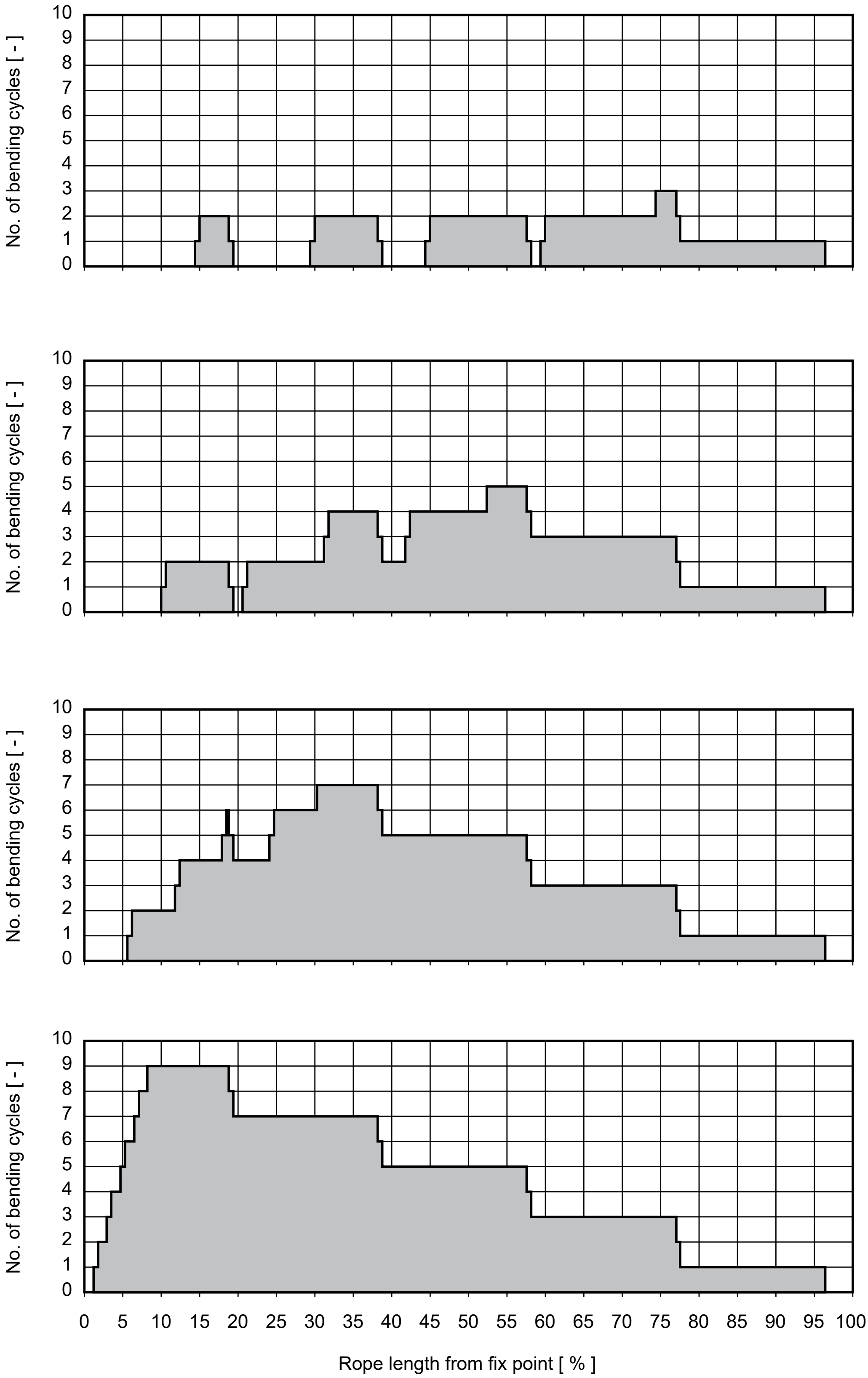

Fig. 17: Number of bending cycles depending on the rope length for lifting heights of 25%, 50%, 75% and 100% of the maximum lifting height (5-part hoist)

7. The 6-part hoist

Fig. 18 shows the maximum number of bending cycles for one full hoisting cycle (=1x lifting, 1x lowering) as a function of the lifting height. Fig. 20 (next page) shows the distribution of bending cycles as a function of the rope length (expressed in % of the total rope length) for one full hoisting cycle (=1x lifting, 1x lowering) for lifting heights of 25%, 50%, 75% and 100% of the maximum lifting height.

Fig. 19 shows the average number of bending cycles for a hoist which lifts the block to these four heights with the same frequency.

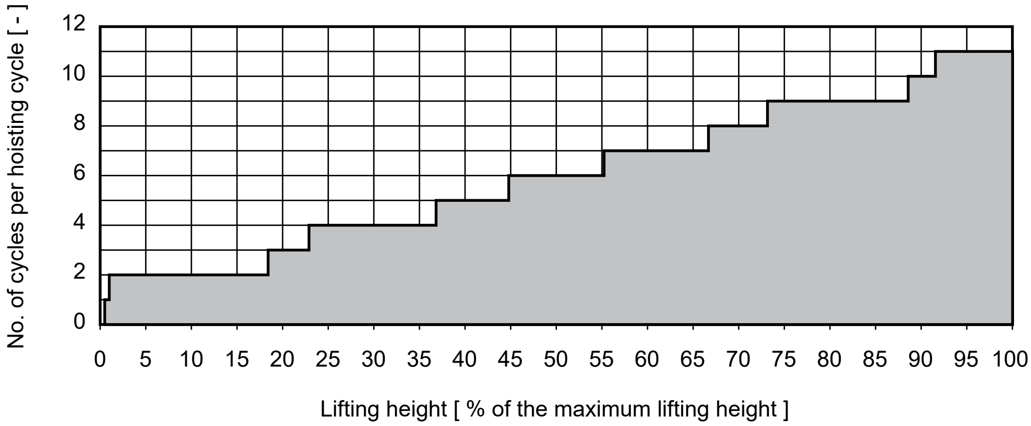

Fig. 18: Maximum number of cycles depending on the lifting height

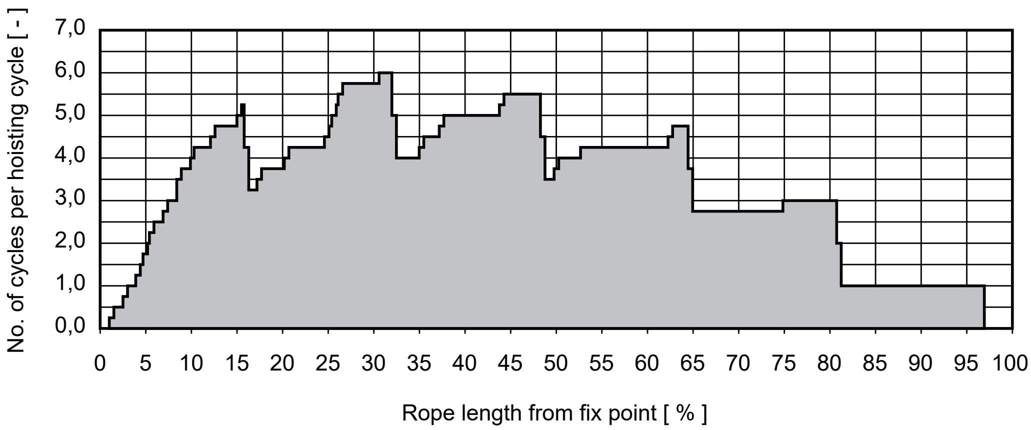

Fig. 19: Distribution of bending cycles per hoisting cycle if lifting heights of 25%, 50%, 75% and 100% of the maximum lifting height occur with the same frequency

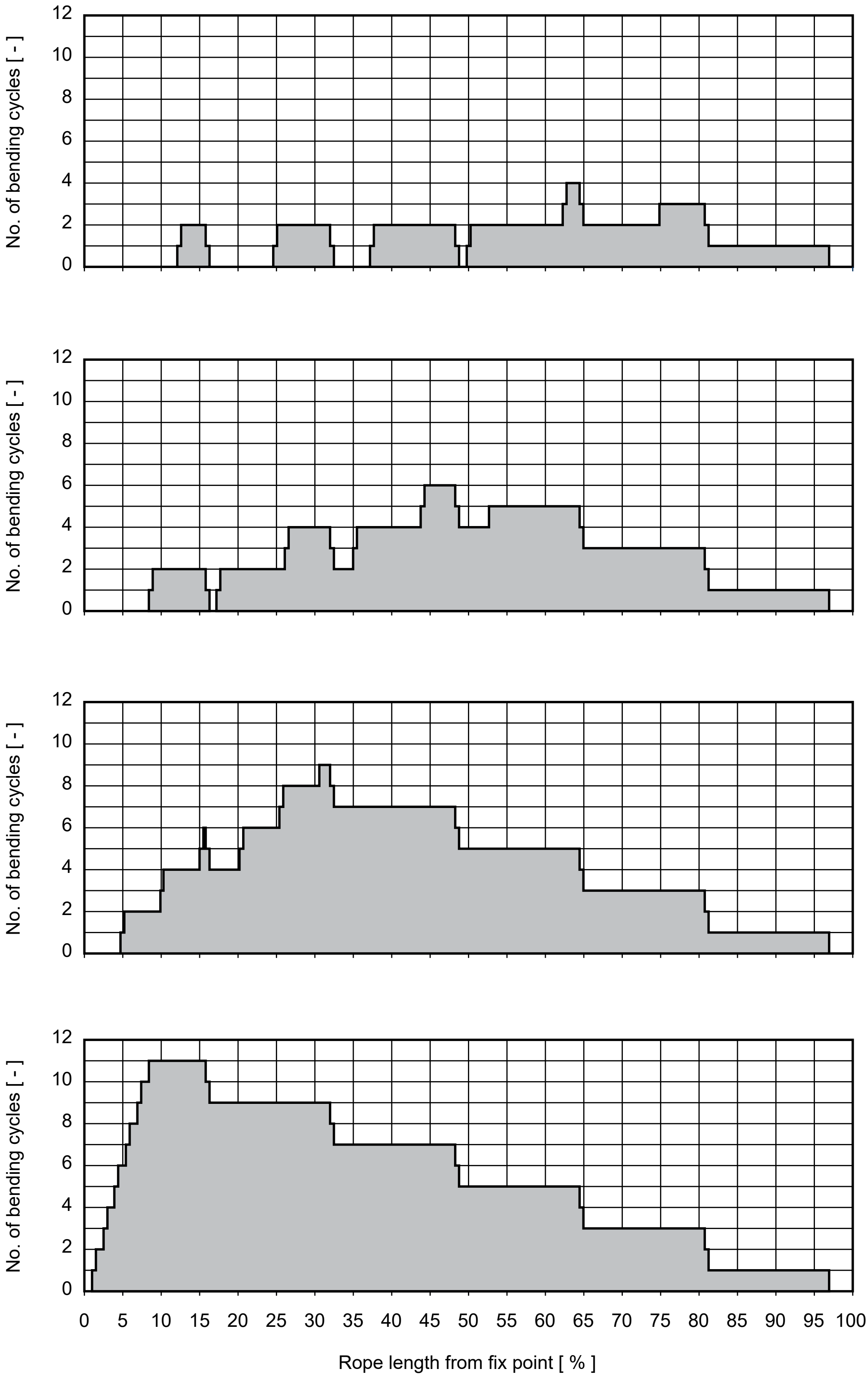

Fig. 20: Number of bending cycles depending on the rope length for lifting heights of 25%, 50%, 75% and 100% of the maximum lifting height (6-part hoist)

8. The 7-part hoist

Fig. 21 shows the maximum number of bending cycles for one full hoisting cycle (=1x lifting, 1x lowering) as a function of the lifting height. Fig. 23 (next page) shows the distribution of bending cycles as a function of the rope length (expressed in % of the total rope length) for one full hoisting cycle (=1x lifting, 1x lowering) for lifting heights of 25%, 50%, 75% and 100% of the maximum lifting height.

Fig. 22 shows the average number of bending cycles for a hoist which lifts the block to these four heights with the same frequency.

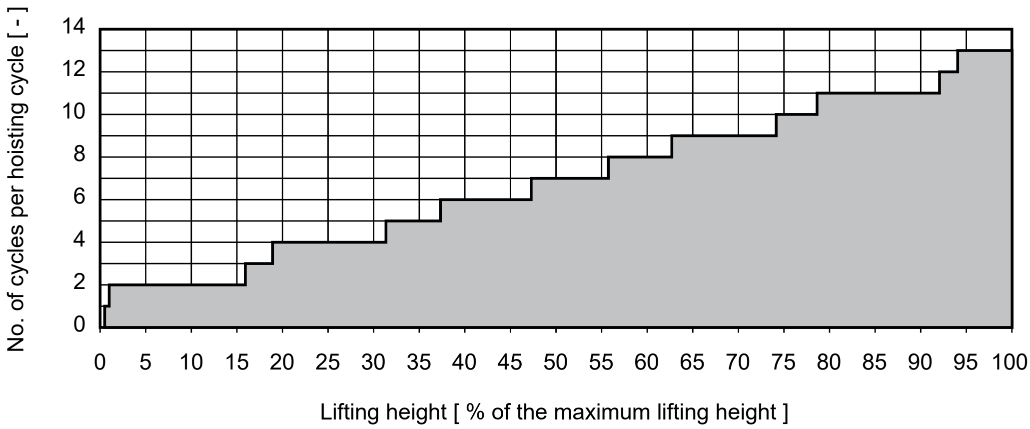

Fig. 21: Maximum number of cycles depending on the lifting height

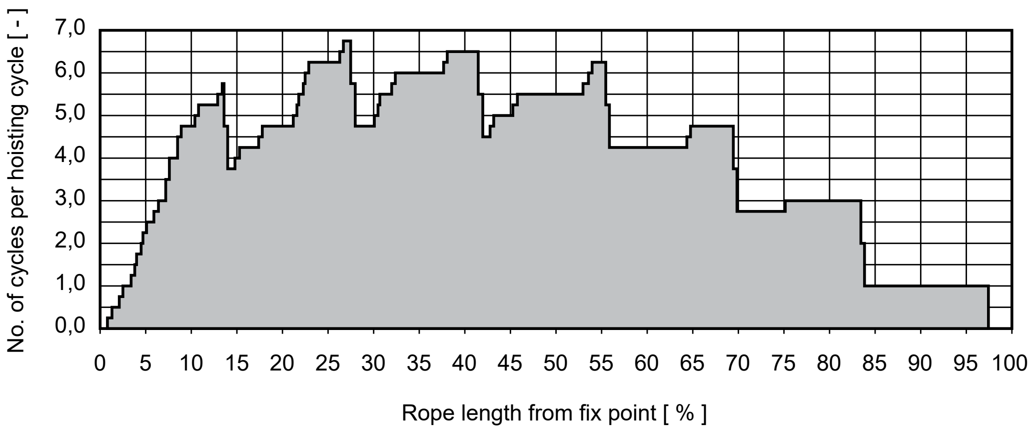

Fig. 22: Distribution of bending cycles per hoisting cycle if lifting heights of 25%, 50%, 75% and 100% of the maximum lifting height occur with the same frequency

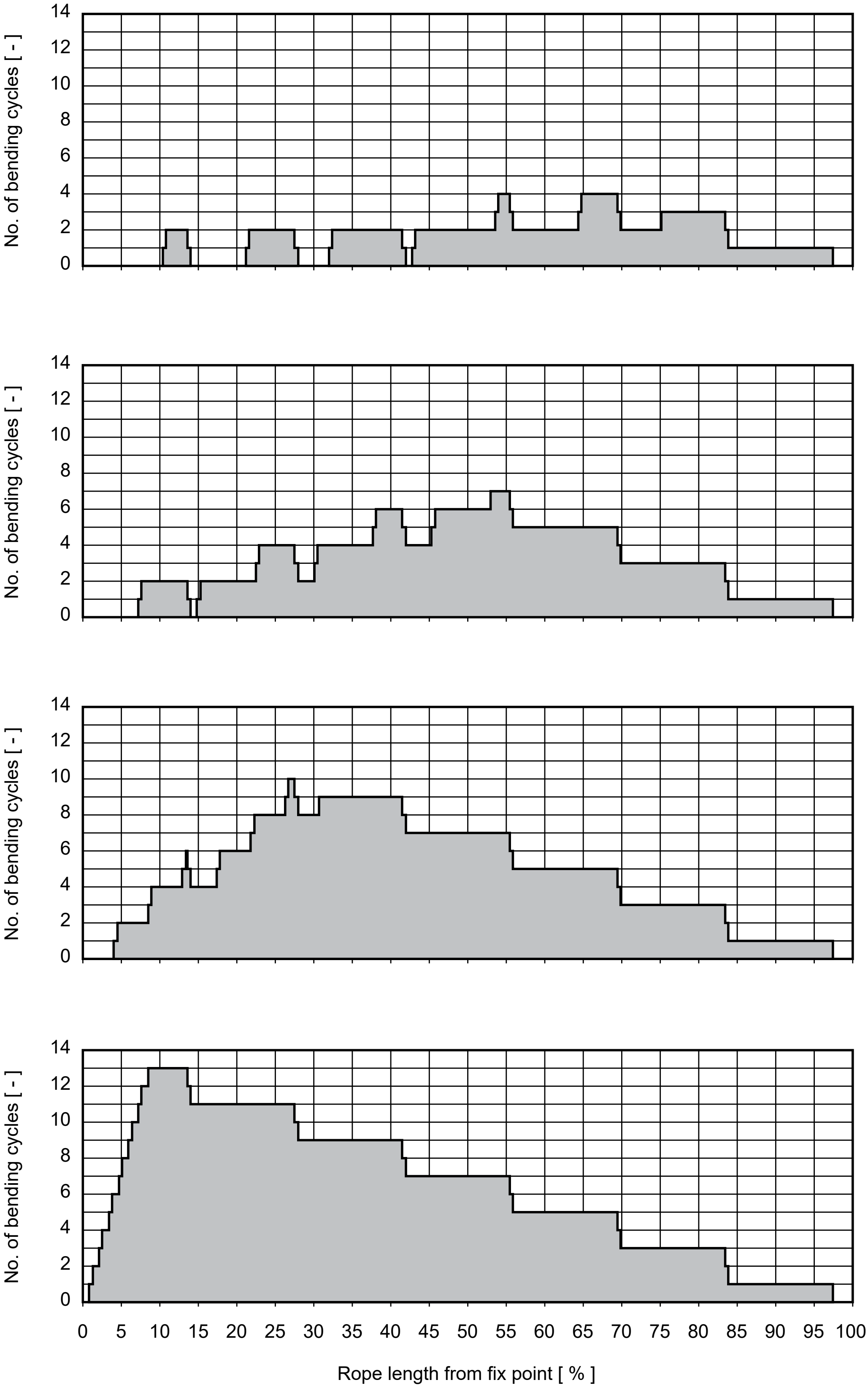

Fig. 23: Number of bending cycles depending on the rope length for lifting heights of 25%, 50%, 75% and 100% of the maximum lifting height (7-part hoist)

9. The 8-part hoist

Fig. 24 shows the maximum number of bending cycles for one full hoisting cycle (=1x lifting, 1x lowering) as a function of the lifting height. Fig. 26 (next page) shows the distribution of bending cycles as a function of the rope length (expressed in % of the total rope length) for one full hoisting cycle (=1x lifting, 1x lowering) for lifting heights of 25%, 50%, 75% and 100% of the maximum lifting height.

Fig. 25 shows the average number of bending cycles for a hoist which lifts the block to these four heights with the same frequency.

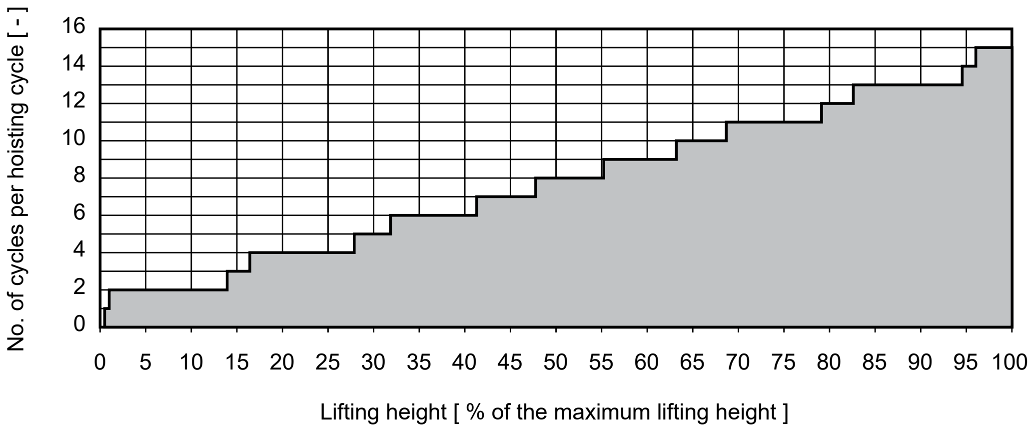

Fig. 24: Maximum number of cycles depending on the lifting height

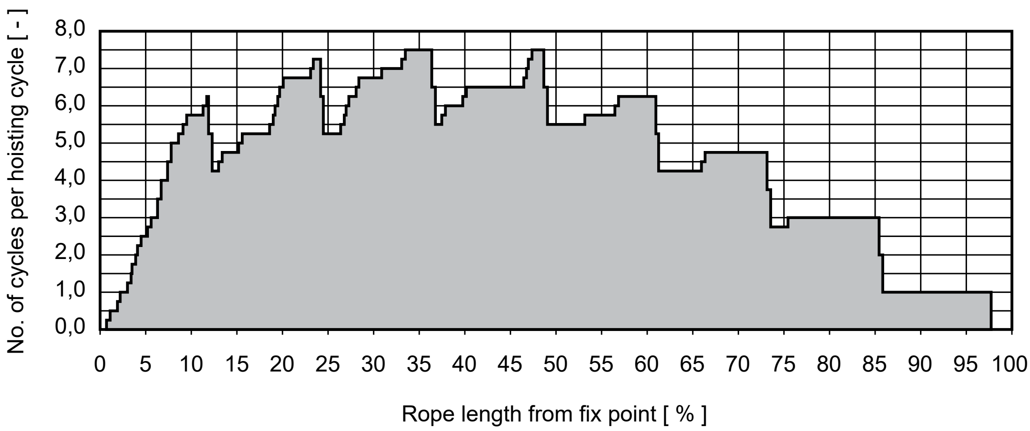

Fig. 25: Distribution of bending cycles per hoisting cycle if lifting heights of 25%, 50%, 75% and 100% of the maximum lifting height occur with the same frequency

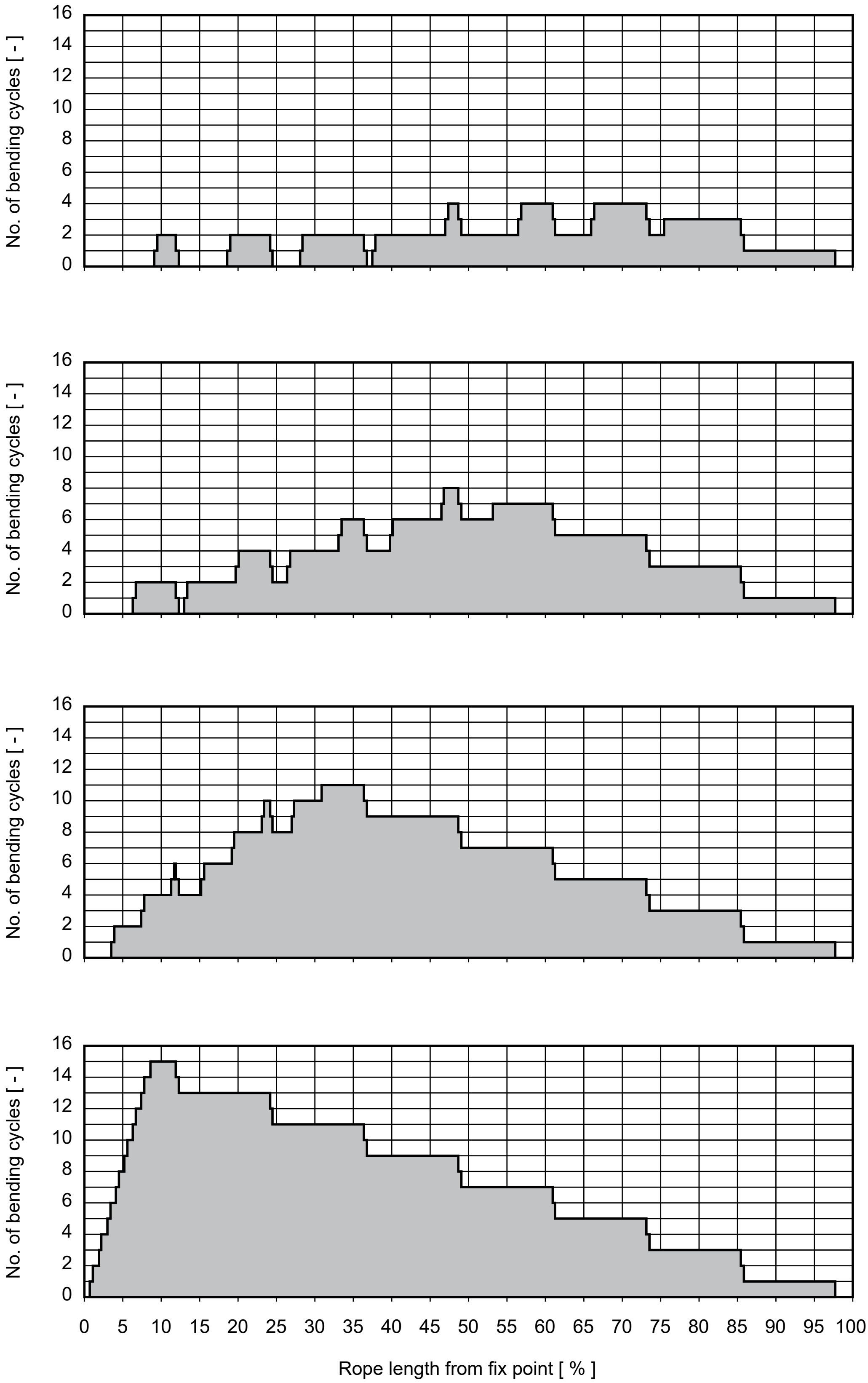

Fig. 26: Number of bending cycles depending on the rope length for lifting heights of 25%, 50%, 75% and 100% of the maximum lifting height (8-part hoist)

10. Summary

During every lifting operation, the most stressed rope section can, at most, pass over every sheave once (= 1 bending cycle each) and spool onto the drum (= 1/2 bending cycle). During every lowering operation it can at maximum spool off the drum (= 1/2 bending cycle) and pass over every sheave once (= 1 bending cycle each). In total, the maximum number of bending cycles which can be generated during a full hoisting cycle (=1x lifting, 1x lowering) is therefore equal to twice the number of sheaves plus one. For 100% lifting height we obtain the following formula:

Maximum number of bending cycles per lift = 2 • number of sheaves +1.

Fig. 27 shows the maximum number of bending cycles which the eight hoists generate with lifting heights of 25%, 50%, 75% and 100% of the maximum possible lifting height. As can been seen, the maximum possible number of bending cycles (= 2 • number of sheaves +1) is generated by every one of the hoists in hoisting cycles lifting to 100% of the maximum possible lifting height.

Number of parts [-]	Number of sheaves [-]	BC for 25% lift. height [-]	BC for 50% lift. height [-]	BC for 75% lift. height [-]	BC for 100% lift. height [-]
1	0	1	1	1	1
2	1	2	2	3	3
3	2	2	3	5	5
4	3	2	4	6	7
5	4	3	5	7	9
6	5	4	6	9	11
7	6	4	7	10	13
8	7	4	8	11	15

Fig. 27: Maximum number of bending cycles (BC) depending on the lifting height

In hoisting cycles lifting to only 50% of the maximum possible lifting height, the maximum number of bending cycles generated corresponds to the number of rope parts. 50% lifting height:

Maximum number of bending cycles per lift = number of rope parts.

Number of parts [-]	Number of sheaves [-]	Number of bending cycles [-]	Approxi-mation [-]	Error [%]
1	0	1.00	2.00	100
2	1	2.50	2.80	12
3	2	3.50	3.60	2.9
4	3	4.25	4.40	3.5
5	4	5.00	5.20	4.0
6	5	6.00	6.00	0.0
7	6	6.75	6.80	0.7
8	7	7.50	7.60	1.3

Fig. 28: Distribution of bending cycles per hoisting cycle if lifting heights of 25%, 50%, 75% and 100% of the maximum lifting height occur with the same frequency

Fig. 28 shows the average number of bending cycles which are generated when the block is lifted to lifting heights of 25%, 50%, 75% and 100% with the same frequency.

The number of bending cycles per hoisting cycle can be approximated by the following equation:

Maximum number of bending cycles per lift = 1.2 + 0.8 • number of rope parts

Fig. 28 compares the number of bending cycles calculated by this formula with the real number. As can be seen, the approximation is very good for all hoists with sheaves, i.e. for all hoists except the single-part hoist. The formula either predicts the exact figure or calculates a slightly higher figure. The prediction will, therefore, always be on the conservative side.

Fig. 29 compares the real number of bending cycles with the number of bending cycles predicted by the formula.

For the analysis presented here, the geometry of the reeving system has deliberately been chosen so that the reeving itself is located close to the drum. With increasing distance from the drum the maximum possible number of bending cycles per hoisting cycle can only decrease. Therefore, the formulas presented here will also be on the conservative side for increasing distances from the drum.

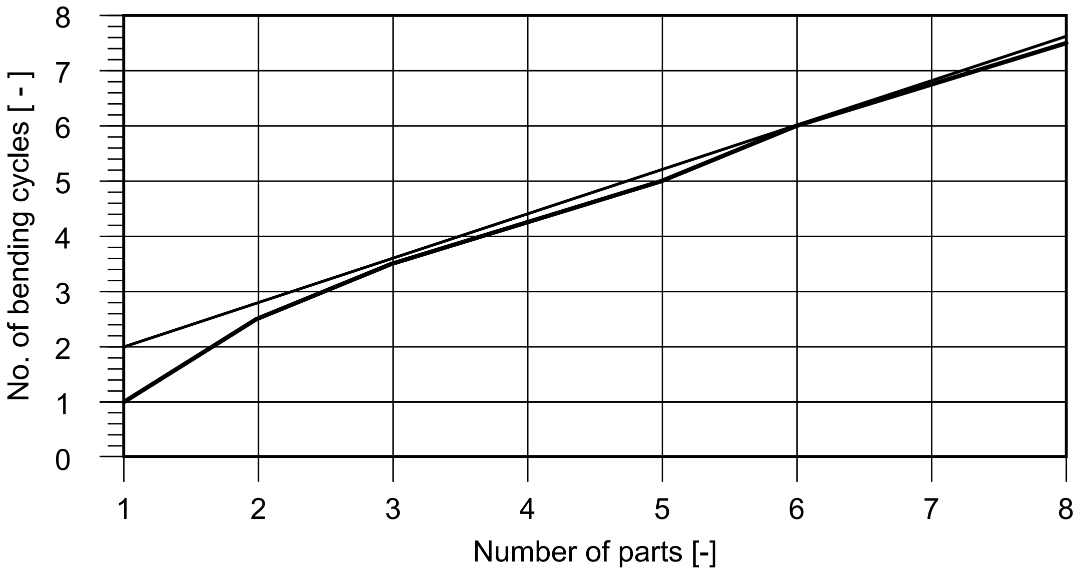

Fig. 29: Real number of bending cycles (thick line) and approximation (dotted line)

Of course, similar analyzes can also be made for your individual rope drive. The results will be the more accurate the more details of the mode of operation of the machine are known. Do not hesitate to contact the author.

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