Paper 20 – Economising mooring and guiding constructions at lock approaches in inland waterways – the Dutch experience.

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ABSTRACT: As a result of diminishing budgets for maintenance, the Dutch waterway authority Rijkswaterstaat is amongst others in search for economizing infrastructural facilities for commercial inland vessels along its waterways. One type of those facilities are the mooring constructions for line up- and waiting areas at lock approaches. Another type are the guiding constructions for entering the lock chamber, the so called funnels. The mooring and guiding constructions basicly exist of piles, connected by crossbeams and can be designed in either a fixed or a floating version, depending on the fall of the waterway.

1 INTRODUCTION

Research was carried out in 2011 by Rijkswaterstaat [1] in the SW part of the Netherlands (Zeeland), where several locks are situated. Those lock approaches are provided by approxamitely 10.000 meters of mooring and guiding constructions. The main question was if a reduction was possible in the length of those constructions.

A classic design for lock approaches can be found in the Dutch Waterway Guidelines 2011 [2] and is illustrated in figure 1 below.

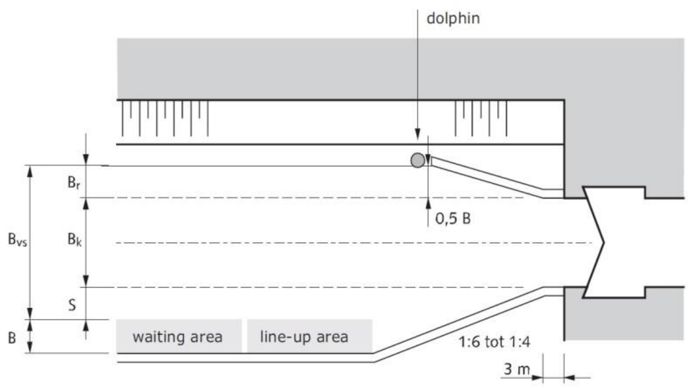

Figure 1: Design of holding basin for a lock with a one-sided line-up area

In the research report [1] the present situation of the Kreekrak locks (classic design) and concepts for alternative lay outs were given (see figures 2, 3 and 4). In alternatives 1 and 2a there was a 100 m gap between line up area and funnel.

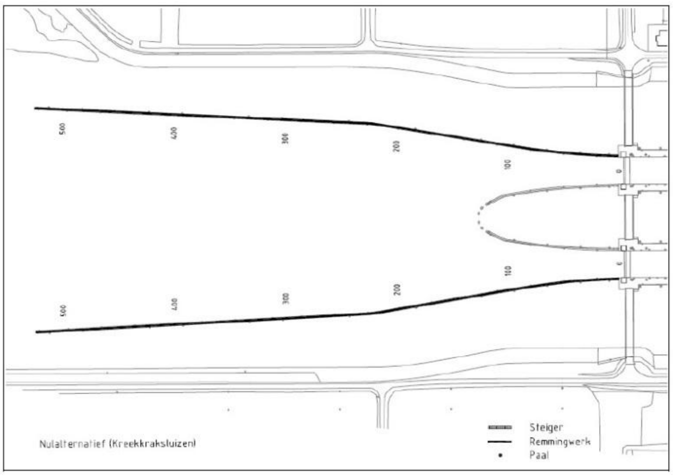

Figure 2: Present situation

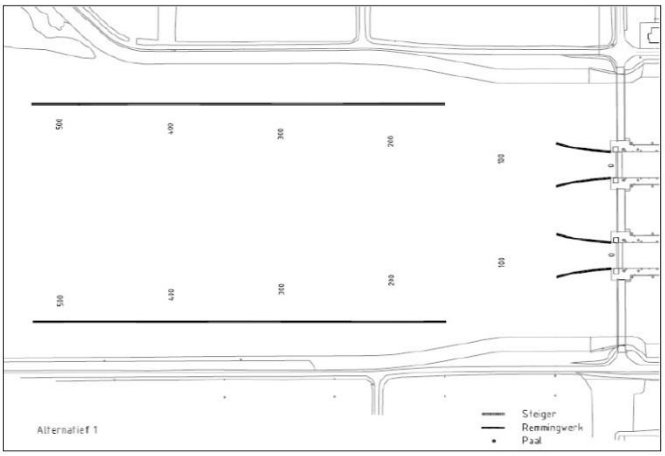

Figure 3: Alternative 2

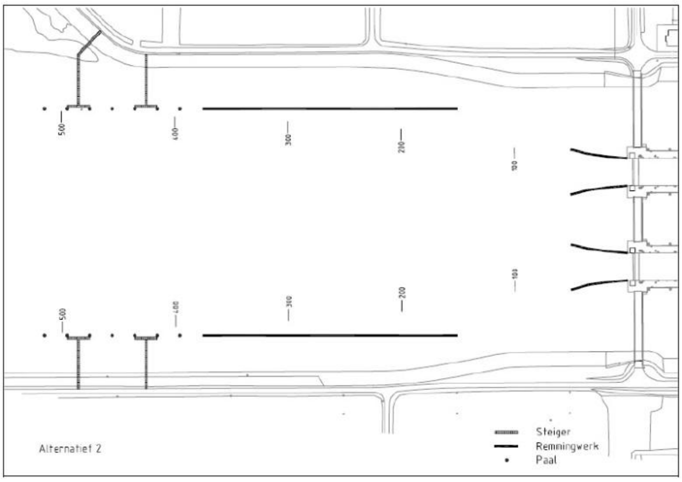

Figure 4: Alternative 2a

Regarding some doubts to introduce this (r)evolutionary concept of alternative 2 right away, the Marin Institute in the Netherlands was asked for a second opinion by Rijkswaterstaat in 2013 [3].

2 THE MARIN RESEARCH

2.1 *Introduction*

The primary goal of the research by the Marin Institute was to determine whether the concept of the gap between line up area and funnel was safe, considering the lesser manoeuvrability of (empty) push convoys and (smaller) motorvessels without bow steering. The secondary goal was to study aspects like the necessity of crossbeams on piles at line up- and waiting areas, the form of the connection between funnel and lockgate, and the necessity and dimensions of provisions on solitary piles for mooring.

2.2 *Operationalisation of the Marin research*

As stated before, push convoys and smaller motorvessels of Rijkswaterstaat classes B1 and B2 resp. M1 and M2 [see Appendix 1] were identified as having potentially the largest problems with the new design concept, especially in situations with strong sidewind.

These ship types were analysed for their passage of two locks: the Beatrix locks, which were to be extended shortly with one extra lock and the Krammer locks, having ofter stronger winds as a result of a closer location to the sea.

In short, the 2 target groups of ships were studied in 3 ways:

1. An inventory of the mains for manoeuvring of the target ships that passed the locks mentioned;
2. The use of the mooring- and guiding constructions by the target ships;
3. The frequency of appearance of high risk situations (the combination of strong sidewind/bad sight and the passage of the empty target ships).

Ad. 1 The inventory was executed by a questionnaire; skippers were questioned by telephone.

Ad. 2 The use of the mooring was examined by both the questionnaire mentioned and additionally a workshop among skippers with large experience on the target ships.

Ad. 3 These frequencies were determined by means of queries from databases from Rijkswaterstaat and the Royal Netherlands Meteorological Institute (KNMI). The latter concerned direction and speed of the wind (average data for 10 minutes periods).

3 RESULTS OF THE QUESTIONNAIRE

3.1 *Smaller motorvessels (M1 and M2)*

It appeared that approximately 91% of these motorvessels was provided with a bow truster or rudder.

Helmsmen would moor at the line up- and waiting area, rather than keeping the ship steady afloat in wind conditions. Sliding along the full guiding construction by vessels without bow truster from line up area into the lock is not done because the risk of damage. In those cases the skipper prefers to land on the upper part of the funnel, not far from the lock gate.

3.2 *Push convoys (B1 and B2)*

Only 9% of the B1 and B2 push convoys appeared to be provided by a bow truster at the pushed unit.

As a result, skippers declared to moor at the line up- and waiting area when waiting. Moreover they slide along the guiding constructions regularly to move into the lock. Some of the respondents pointed out that this was the only way to get inside the lock. Pushed units without bow trusters are seldom navigated if the wind force exceeds Bft 6.

4 WIND CONDITIONS DURING PASSAGES

4.1 *Introduction*

Data of target ships, passing the Krammersluis resp. the Beatrixsluis in both directions were combined with meteorological data (wind force and direction) from adjacent stations. The Marin Institute determined at the time of passage the average windforce and –direction in the 10 minutes period concerned.

4.2 *Results of the data analysis*

In the case of the Krammersluis, approximately 12% of the passages appeared at windforce of 5 Bft and over. This concerns roughly for one third push convoys and for two third the smaller motorvessels.

Concerning the Beatrixsluis, this share is 3%, equally divided over the two vessel types.

Dealing with windforces of 6 Bft and over, the shares are 2% (Krammersluis) and 0.2% (Beatrixsluis).

5 WORKSHOP RESULTS

5.1 *Introduction*

Aim of the workshop was to present the participants a few alternatives for design and discuss them from a practical and operational point of view. Plans concerning the Beatrixsluis, where a planned extra lock was to be fit in a spatial limited lock approach, was one of the occasions of the alternatives. Aspects were:

- Function of funnel and guiding constructions
- Form of the funnel (length, mouth, gradient and connection to the lock head)
- Necessity of a connection between funnel and line up area
- Assembly of the line up area: continuing cross beams and solitary piles
- Compilation of the piles

5.2 *Results of the* workshop

The *function of the funnel* is twofold: facilitating vessels to slide into the lock gate and catching the sidewinds. These functions are of great importance due to the inevitable low speed and consequently vulnerability of vessels for sidewind, compared to the passage of bridgeopenings.

Regarding the *form of the funnel,* one aspect is the form of the connecting part to the lock head. According the Dutch Waterway Guidelines 2011 [1], this connection should have a curvature when locks are less wider than 1 m. as the so called ‘minimum capacity lock’. This is to prevent vessels from getting jammed or hitting the opposite wall. Participants in the workshop stressed that this curved connection is not necessary. An alternative prevention is placing the first part of the guiding construction straight, extending the wall of the lock chamber. The length needed for this straight part is given by the next formula:

$$L > (B_k \cos(\alpha) - B)/\sin(\alpha)$$

In which:

L = length of the connecting straight part
B_k = width of the lock chamber
B = beam of the reference vessel
α = gradient of the funnel

A direct transition from the straight part to the funnel with a gradient of 1 : 4 is for the push convoys acceptable.

To be able to line the vessel straight up for entrance of the lock, the distance between the line up area and the lock head should be at least the length of one pushed unit (76 m).

Referring the *connection between funnel and line up area*, it came out that this is not needed in situations with low traffic.

If this part is left out, it can be replaced by solitary piles to protect the funnel, but this solution is less suitable for the vessels regarding the risk of collision. Vessels without bow truster will need substantially more time to unmoor and line up for the lock gate. In a lesser degree this goes for vessels with bow truster as well. In situations with high traffic (>10.000 vessels annually) this delay is not acceptable. For the optimal use of the capacity of the lock a connection is necessary. A second motivation for a connection is the higher safety and ease in the lock approach: while waiting, vessels will to a higher degree moor on the line up area. As a result there is more space and clearer picture of the traffic for vessels to sail in and out of the locks. Also there is no need to navigate to the upper side (lee-side) of the lock approach while waiting, thus causing potentially risky crossing courses with other traffic.

Regarding the *assembly of the line up area*, Marin concluded that this area should be provided with an ongoing construction with cross beams at locks with a high intensity / capacity quotient (I/C ratio).

An extra advantage of this ongoing construction is the lesser damage when manoeuvers go wrong, compared to solitary piles.

At locks with a low I/C ratio, the line up area can consist of solitary piles. As limiting value the I/C ratio can be taken, leading to 15 minutes of waiting time. These parameters can be determined by traffic models, like Sivak. Alternatively, 10.000 vessels annually can be taken as limiting value.

Participants showed a strong preference for a floating construction (see figure 5 below with cross section), so they don't have to take variations in waterlevels into account.

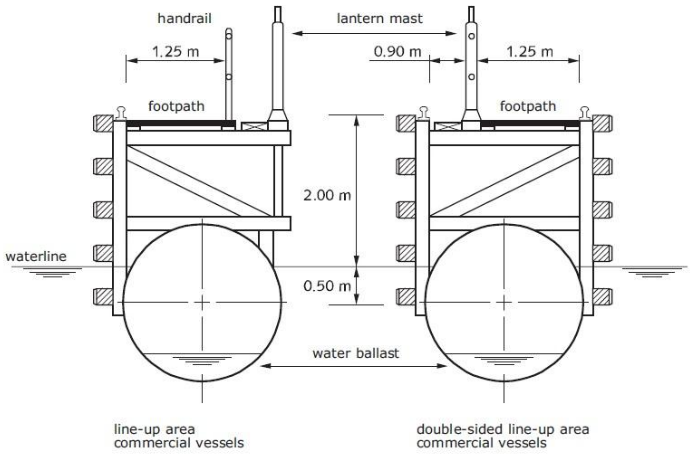

Figure 5: Example of a floating fender for commercial vessels

A line up area, consisting of a partly ongoing construction, partly solitary piles can only be usefull if the target motorvessel is assured to find a mooring place at the ongoing part. Because this is not the case, this combined construction is not recommended by Marin.

Next to the line up area, the *waiting area* is situated. The waiting area can consist in all cases of solitary piles.

Concerning the *compilation of the piles*, they should be provided at the locks' waiting area with flat fendering of more then 60 cm width, to assure that a vessel always touches with 1 rib.

6 IMPLEMENTATION

The findings in the Marin report will be implemented in the Dutch Guidelines for Waterways 2011 [2]. A revision of these Guidelines is foreseen in 2016.

REFERENCES

1. Brolsma, J.U. 2011, Onderzoek remmingwerken Zeeland – Nut en noodzaak van de remmingwerken bij grote sluizen in Zeeland (Research on guiding constructions Zeeland – Use and necessity of guiding constructions at larger locks in Zeeland), report of *Rijkswaterstaat Dienst Verkeer en Scheepvaart.*
2. Brolsma, J.U. and K. Roelse 2011, Waterway Guidelines 2011 (meant for waterway design from a vessel traffic perspective), *Rijkswaterstaat Dienst Verkeer en Scheepvaart*. (http://www.rijkswaterstaat.nl/en/images/Waterway%20guidelines%202011_tcm224-320740.pdf)
3. Hove, D. ten 2014, Versobering remmingwerken in de voorhavens van sluizen (Economising mooring and guiding constrcutions at lock approaches), *MSCN Maritime Institute Netherlands*.

APPENDIX 1. Rijkswaterstaat 2010 classification.

CEMT Class	Motor vessels							Pushed convoys (Barges)							Coupled units (Convoys)							Headroom *
	RWS Class	Characteristics of reference vessel**				Classification		RWS Class	Characteristics of reference pushed convoy**				Classification		RWS Class	Characteristics of reference coupled unit**				Classification		
		Designation	Beam	Length	Draught (laden)	Cargo capacity	Beam and length		Combination	Beam	Length	Draught (laden)	Cargo capacity	Beam and length		Combination	Beam	Length	Draught (laden)	Cargo capacity	Beam and length	Incl. 30 cm spare headroom
			m	m	m	t	m			m	m	m	t	m			m	m	m	t	m	m
0	M0	Other				1-250	B<= 5.00 of L<= 38.00															
I	M1	Péniche	5.05	38.5	2.5	251-400	B= 5.01-5.10 and L>=38.01	BO1		5.2	55	1.9	0-400	B<=5.20 and L= all	C1l	2 péniches long	5.05	77-80	2.5	<= 900	B<= 5.1 and L=all	5.25*
															C1b	2 péniches wide	10.1	38.5	2.5	<= 900	B=9.61-12.60 and L<= 80.00	5.25*
II	M2	Kempenaar	6.6	50-55	2.6	401-650	B=5.11-6.70 and L>=38.01	BO2		6.6	60-70	2.6	401-600	B=5.21-6.70 and L=all								6.1
III	M3	Hagenaar	7.2	55-70	2.6	651-800	B=6.71-7.30 and L>=38.01	BO3		7.5	80	2.6	601-800	B=6.71-7.60 and L=all								6.4
	M4	Dortmund Eems (L < = 74 m)	8.2	67-73	2.7	801-1050	B=7.31-8.30 and L=38.01-74.00	BO4		8.2	85	2.7	801-1250	B=7.61-8.40 and L=all								6.6
	M6	Ext. Dortmund Eems (L > 74 m)	8.2	80-85	2.7	1051-1250	B=7.31-8.30 and L>=74.01															6.4
IVa	M6	Rhine-Herne Vessel (L <= 86 m)	9.5	80-85	2.9	1251-1750	B=8.31-9.60 and L=38.01-86.00	BI	Europa I pushed convoy	9.5	85-105	3.0	1251-1800	B=8.41-9.60 and L=all								7.0*
	M7	Ext. Rhine-Herne (L > 86 m)	9.5	105	3.0	1751-2050	B=8.31-9.60 and L>=86.01															7.0*
IVb															C2l	Class IV + Europa I long	9.5	170-185	3.0	901-3350	B=5.11-9.60 and L=all	7.0*
Va	M8	Large Rhine Vessel (L <=111 m)	11.4	110	3.5	2051-3300	B= 9.61-11.50 and L=38.01- 111.00	BII-1	Europa II pushed convoy	11.4	95-110	3.5	1801-2450	B=9.61-15.10 and L<=111.00								9.1*
	M9	Extended Large Rhine Vessel (L >111 m)	11.4	135	3.5	3301-4000	B= 9.61-11.50 and L>= 111.01	BIIa-1	Europa IIa pushed convoy	11.4	92-110	4.0	2451-3200	B=9.61-15.10 and L<=111.00								9.1*
								BIIL-1	Europa II long	11.4	125-135	4.0	3201-3950	B=9.61-15.10 and L=111.01-146.00								9.1*
Vb								BII-2l	2-barge pushed convoy long	11.4	170-190	3.5-4.0	3951-7050	B=9.61-15.10 and L>=146.01	C3l	Class Va + Europa II long	11.4	170-190	3.5-4.0	3351-7250	B=9.61-12.60 and L>=80.01	9.1*
VIa	M10	Ref. vessel 13.6 * 110 m	13.60	110	4.0	4001-4300	B=11.61-14.30 and L=38.01- 111.00	BII-2b	2-barge pushed convoy wide	22.8	95-145	3.5-4.0	3951-7050	B=15.11-24.00 and L<=146.00	C2b	Class IV + Europa I wide	19.0	85-105	3.0	901-3350	B=12.61-19.10 and L<=136.00	7.0* only for class IV coupled unit
	M11	Ref. vessel 14.2 * 135 m	14.20	135	4.0	4301-5600	B=11.61-14.30 and L>= 111.01								C3b	Class Va +Europa II wide	22.8	95-110	3.5-4.0	3351-7250	B>19.10 and L<=136	9.1*
	M12	Rhinemax Vessel	17.0	135	4.0	>= 5601	B>= 14.31 and L>= 38.01															
VIb								BII-4	4-barge pushed convoy (incl. 3-barge long)	22.8	185-195	3.5-4.0	7051-12000 (7051-9000)	B=15.11-24.00 and L=146.01-200	C4	Class Va + 3 Europa II	22.8	185	3.5-4.0	>=7251	B>12.60 and L>=136.01	9.1*
VIc								BII-6l	6-barge pushed convoy long (incl 5-barge long)	22.8	270	3.5-4.0	12001-18000 (12001-15000)	B=15.11-24.00 and L>=200.01								9.1*
VIIa								BII-6b	6-barge pushed convoy wide (incl. 5-barge wide)	34.2	195	3.5-4.0	12001-18000 (12001-15000)	B>=24.01 and L=all								9.1*

* In classes I, IV, V and higher the headroom has been adjusted for 2, 3 and 4 layers of containers respectively (headroom on canals relative to reference high water level = 1% exceedance/year)

** The characteristics of the reference vessels have a margin of error of ± 1 metre in the length, and ± 10 cm in the beam.

NB:
1: A reference vessel is a vessel whose dimensions determine the dimensions of the waterway and the engineering structures on or in it.
2: New waterways and enlarged waterways are based on the largest reference vessel within a CEMT class.
3. Classes M3, M4, M6, M8, M10 and M11 may be used only for the renovation of existing waterways, locks and bridges.
4: The smallest dimensions of a reference vessel represent the lower threshold for categorising a waterway in a particular standardised class.