For
City of Copenhagen

Document type
Memo

Date
March 2024

Langebro bridge - renovation of bascule span

Registration of internal condition of counterweights by non-destructive methods.

RAMBOLL

Bright ideas.
Sustainable change.

Langebro bridge - renovation of bascule span

Registration of internal condition of counterweights by non-destructive methods.

Project name	**Langebro, outline proposal for renovation of bascule leaves**
Project no.	**1100056833**
Recipient	**City of Copenhagen**
Document type	**Memo**
Version	**0.5.0**
Date	**2024-03-20**
Prepared by	**BL**
Controlled by	**CLP**
Approved by	**BL**

Rambøll
Hannemanns Allé 53
DK-2300 København S

T +45 5161 1000
https://dk.ramboll.com

Contents

1. The task/summary

Langebro is a bascule bridge in central Copenhagen, inaugurated in 1954.

The counterweights of the bridge leaves consist of riveted steel boxes cast with concrete, which contain a large amount of scrap steel to increase the density and thus minimize the required size of the counterweights. The steel boxes are provided with internal steel bulkheads lengthwise and crosswise to increase rigidity and load-carrying capacity.

Under the influence of many years of seeping water, significant rust attacks have occurred on steel (both structural steel and embedded scrap) and degradation of concrete. Through thickness measurements (ultrasound and drilling holes) from the outside, a varying degree of cross-sectional loss has been found on the outer steel plates due to corrosion, although not to a degree that currently gives rise to acute concern. The condition of the inner steel bulkheads is unknown, which is a problem as they are essential for load-carrying capacity.

The City of Copenhagen requests contact with companies that can use non-destructive methods to record the condition of internal steel structures and the aggregate concrete. The condition registration must be used to qualify the City’s assessment of the current need for renovation and the risk of unannounced breaks in the years leading up to a major renovation of the bascule leaves.

In the following, the counterweights and the current challenges are described in more detail.

2. Description of the counterweights

2.1 General operation (for information)

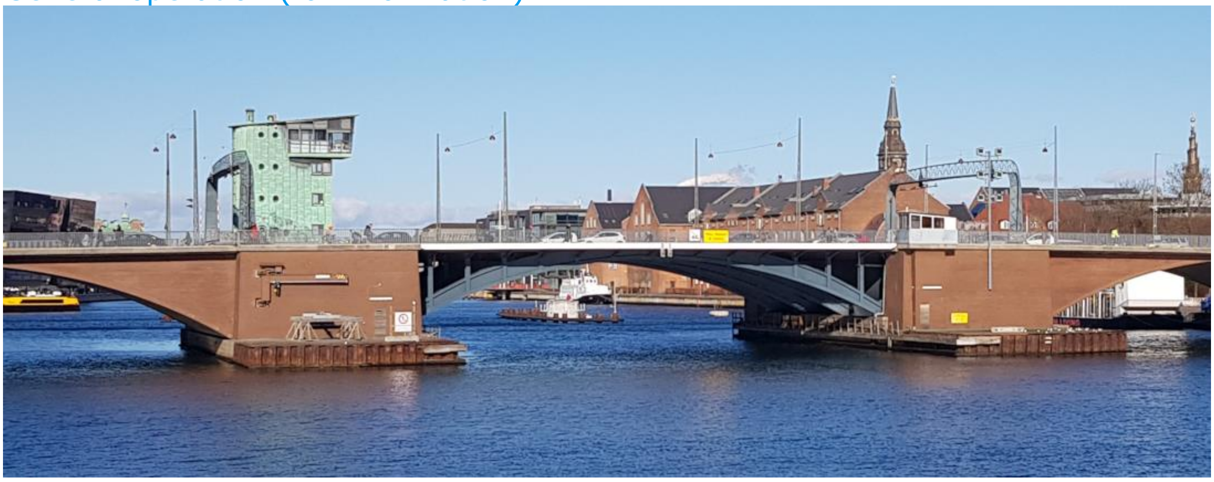

Figure 1 Langebro's bascule span seen from the south.

Langebro's navigation section is a double-leaf bascule bridge, i.e., it consists of two bridge leaves that meet in the middle when they are in the closed state.

Below are simplified sketches and drawing sections that illustrate the most important bridge elements in connection with the renovation of the counterweights. Figure 2 is a stylized drawing of the main elements in one bridge leaf, while Figure 4 illustrates that a bridge leaf is supported by four parallel main girders (arch/grid planes).

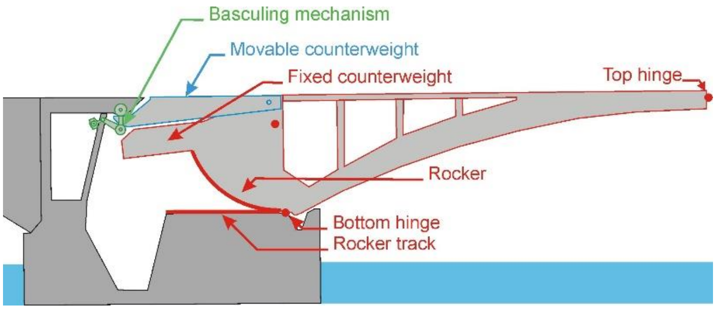

Figure 2 Section through one bridge leaf. When the bridge is opened, the rocker of the bridge leaf rolls backwards along the rocker tracks.

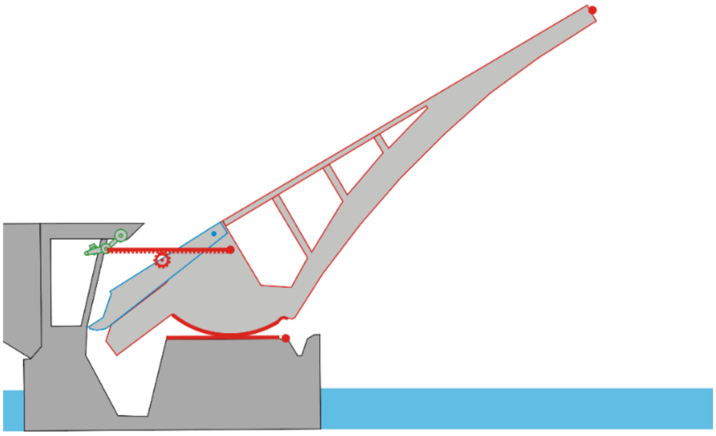

Figure 3 Bridge leaf in half-open state

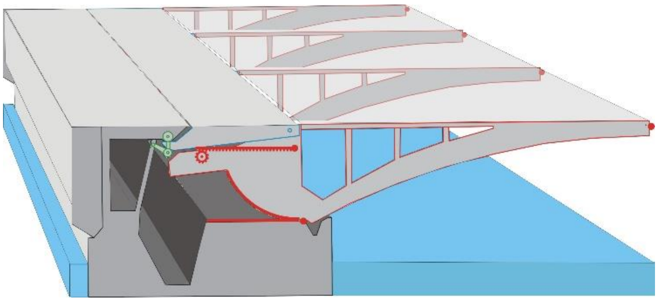

Figure 4 Simplified 3D representation of one bridge leaf. Each leaf has four main girders (arch trusses, approx. 8 meters apart), which meet with the corresponding four on the opposite bridge leaf when the bridge is closed, thus forming four arches across the navigation channel.

2.2 The structure of the counterweights

Figure 5 below is a more detailed drawing of the counterweight arrangement, based on the original construction drawings.

The bridge's counterweights are split in two. At the bottom, a fixed counterweight that is mounted on the bridge leaf, and above it a movable counterweight that is hinged to the bridge leaf at one end (to the right in the figures) and can be lifted free at the other end. When it rests on the fixed counterweight, the leaf is in balance and can be rolled backwards along the rocker track with limited force to open the bridge. When the movable counterweight is lifted free, the leaf is nose-heavy and rests stably against the opposite leaf.

Both the movable and the fixed counterweight consist of a riveted steel box with internal longitudinal and transverse steel bulkheads. The box is filled with concrete, which to create the greatest possible weight is filled with scrap steel. The steel scrap is thrown loosely into the fresh concrete and lies randomly distributed in the concrete. The amount of steel scrap is not precisely known, but the amount is large, perhaps in the order of 1000 kg/m ^{3} .

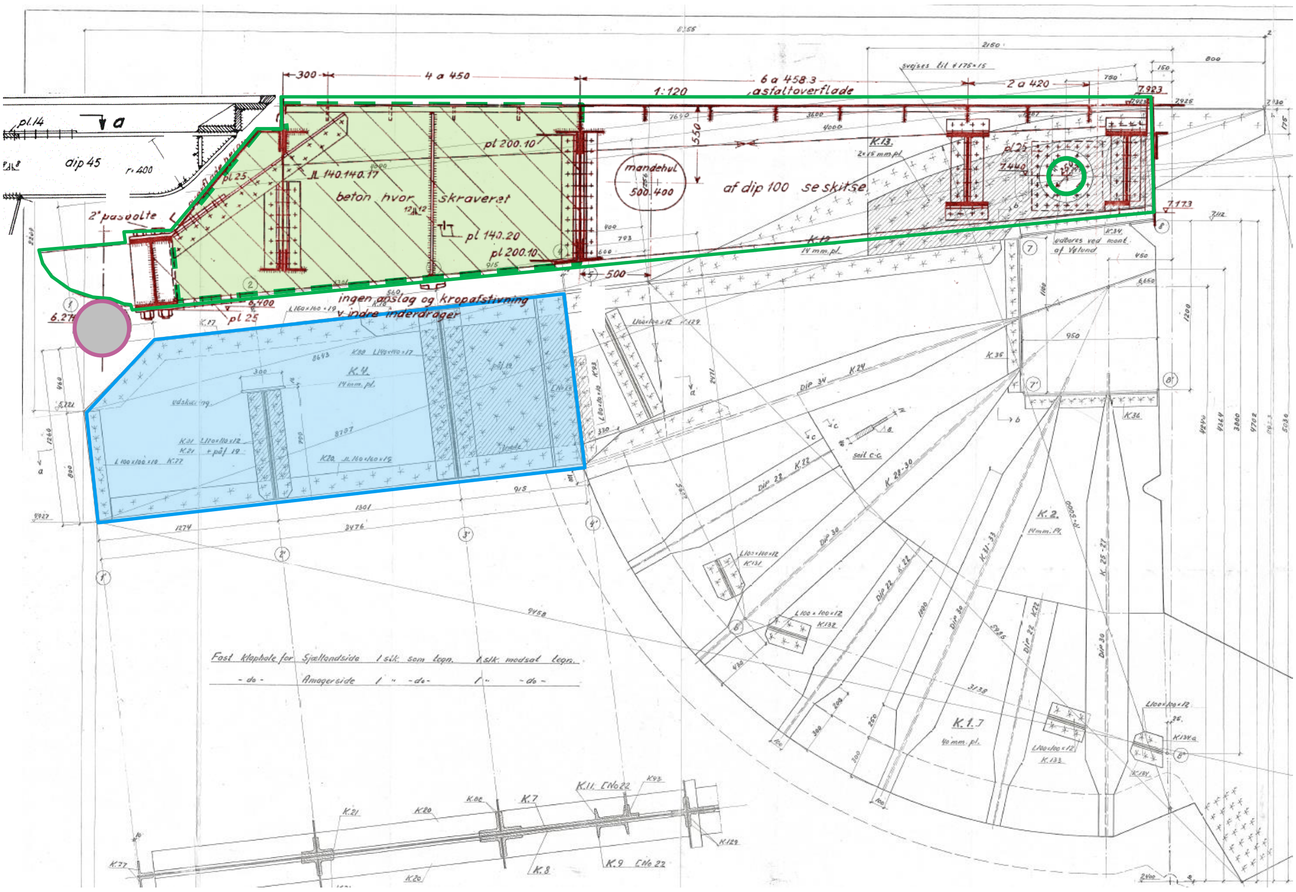

Figure 5 Movable and fixed counterweight (movable counterweight with green outline and ballast in green shade. Fixed counterweight with blue outline and ballast in blue shade).

Figure 6 Photo, underside of the fixed counterweight. The rows of rivets lengthwise and crosswise show the location of internal steel bulkheads.

The main components of the counterweights:

1. "The movable counterweight" refers to the entire construction in steel and concrete that is shown with a fully extended green outline in Figure 5, and which revolves around the hinge bearing as an integrated whole during tilting. Note that the riding surface is an integral part of the movable counterweight. The top plate has previously been cut up, the upper side of the concrete renovated, and a new top plate fitted and provided with a road surface in the form of cast asphalt. It cannot be expected that there will be direct contact between the concrete and the top plate.

2. "Ballast" in the movable counterweight refers to the concrete with embedded steel scrap, incl. the steel case in which it is cast, marked with green shading and dashed green outline in the figures. Note that the movable counterweight was placed bottom-up during the casting of the concrete, so that what is today the underside, is a free concrete surface. Due to the deterioration of concrete, concrete has peeled off from the underside of the movable counterweight over the years. This causes the free concrete surface to be very uneven and of very varying strength/hardness.
   There is no ballast in the middle of the three sections, only in the outer ones, cf. Figure 7 below. This means that the ballast in each movable counterweight consists of two separate sections.
   Each of the outer sections measures approx. 7.8 m in the transverse direction of the bridge, 2.1 m in the longitudinal direction of the bridge at the top (at the bottom approx. 2.8 m) and 1.3 m in height at the highest point.

3. "The fixed counterweight" refers to the concrete with embedded steel scrap, incl. the steel case in which it is cast, marked with a solid blue outline and blue shading in the figures. The fixed counterweight is firmly connected to the four rockers and spans between them, with a span of the order of 8 m.
   It measures approx. 24 m in the transverse direction of the bridge, 3.5 m in the longitudinal direction of the bridge and 1.6 m in height. The free concrete surface on the upper

side of the fixed counterweight is very uneven and of very varying strength/hardness, as this concrete is also badly deteriorated.

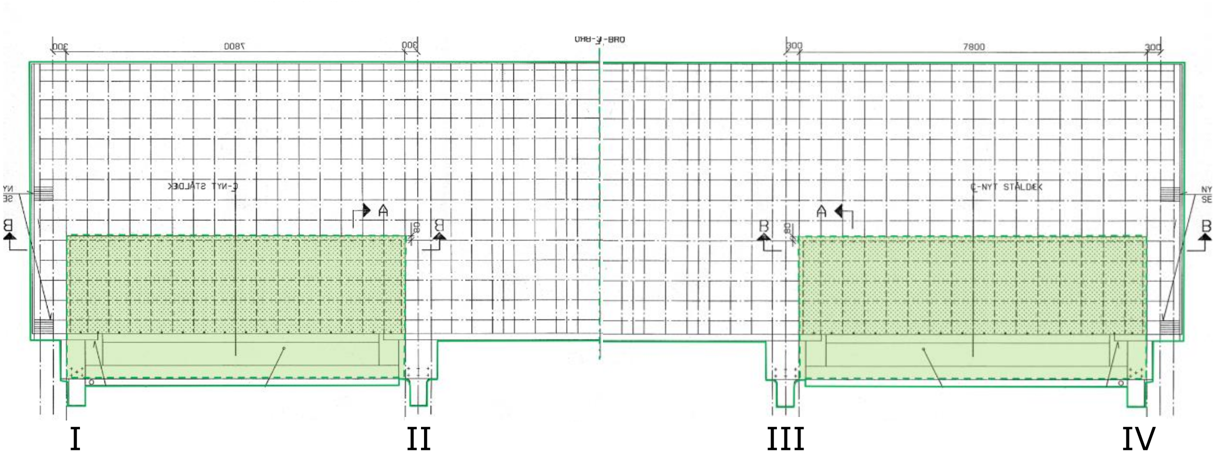

Figure 7 Plan of movable counterweight. The movable counterweight includes the entire structure marked with a green unbroken outline. The ballast is marked with green shading. Note that there is only ballast between main girders I and II and between III and IV, but not between II and III.

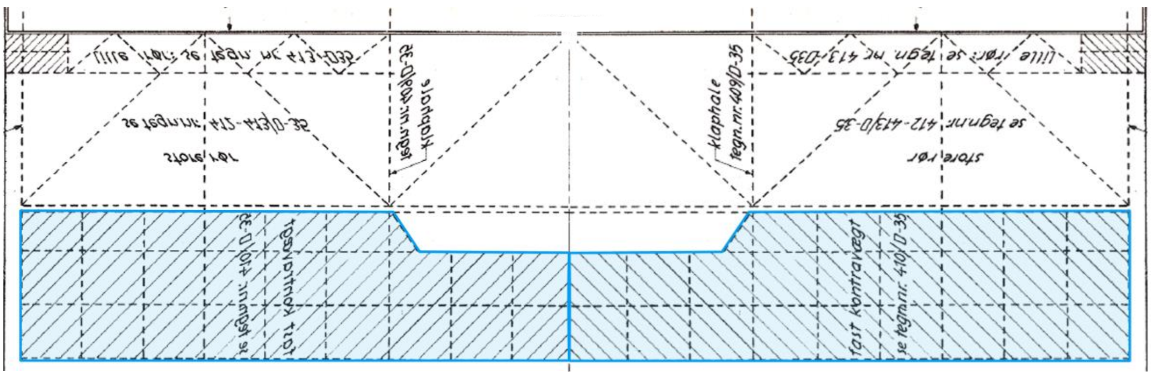

Figure 8 Plan of fixed counterweight. The fixed counterweight denotes the concrete with the surrounding steel box, marked with a blue outline and blue shadow. The inner steel bulkheads are marked with dotted lines.

3. Challenges in condition registration

The most significant challenges in relation to register the condition of the interior of the counter-weights using non-destructive methods are assessed to be:

- The access conditions around the counterweights are very narrow due to other structures, so not all outer surfaces can be immediately accessed with larger equipment. In particular, the distance between the movable counterweight and the fixed counterweight is very small – about 20 cm or less.
- The free concrete surfaces are – in addition to being very inaccessible between movable and fixed counterweight – very uneven and porous.
- The randomly placed steel scrap in the concrete can be expected to significantly interfere with ultrasound, X-rays and the like. This makes it very difficult to get a full picture of the condition of both the concrete and the internal steel bulkheads.
- The concrete must be expected to be cracked and very inhomogeneous.