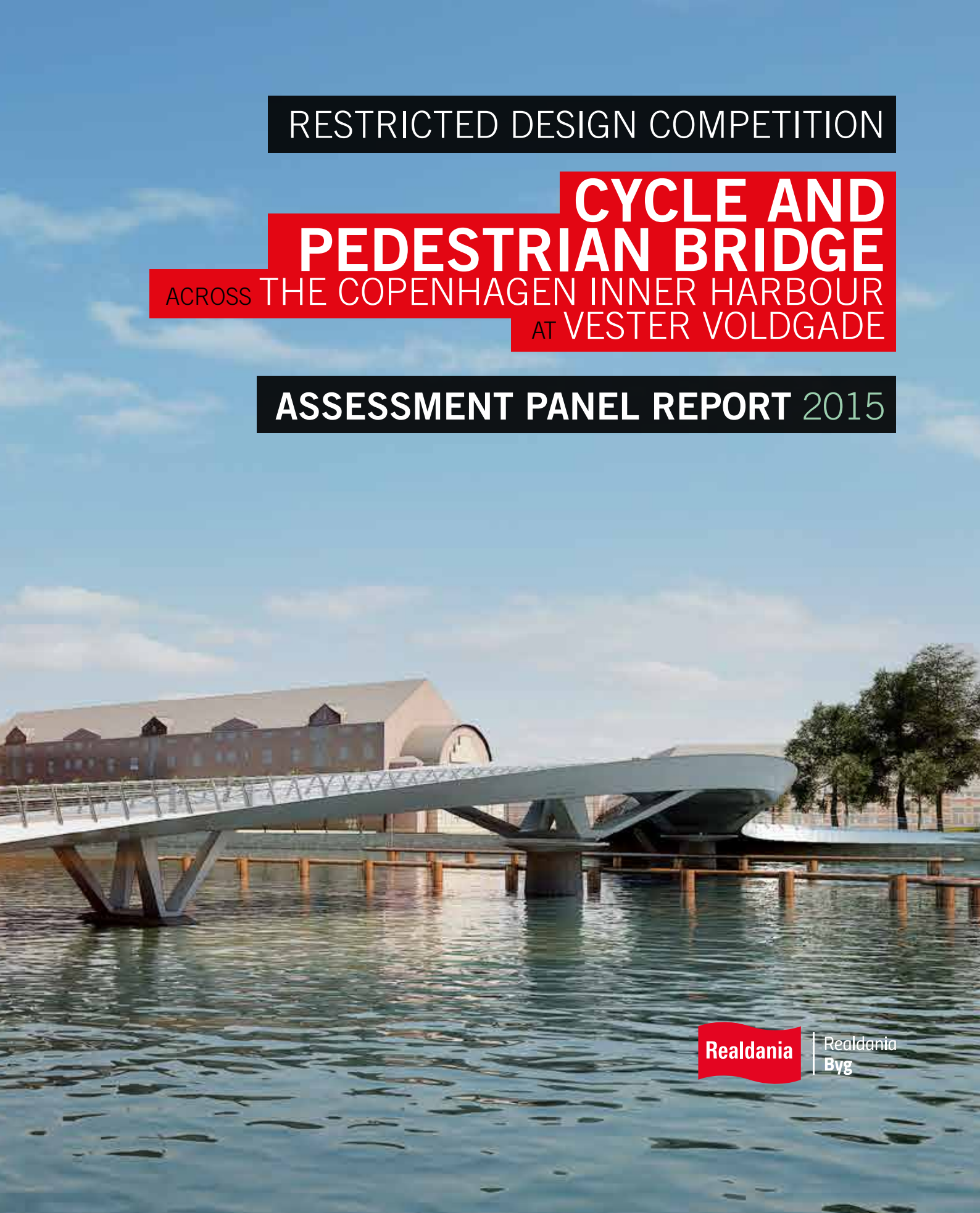
RESTRICTED DESIGN COMPETITION

CYCLE AND PEDESTRIAN BRIDGE

ACROSS THE COPENHAGEN INNER HARBOUR AT VESTER VOLDGADE

ASSESSMENT PANEL REPORT 2015



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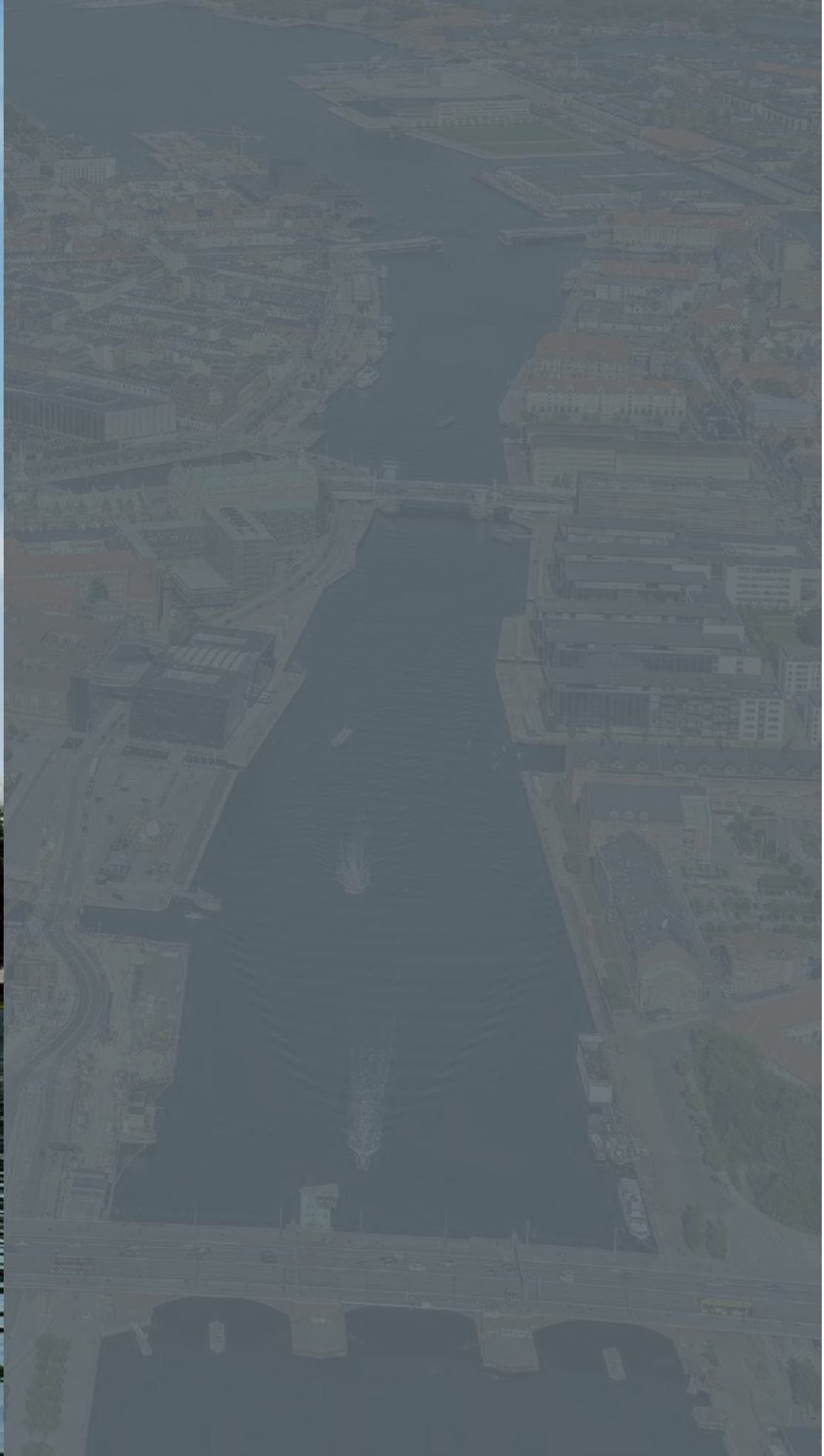

ASSESSMENT PANEL REPORT
RESTRICTED DESIGN COMPETITION

CYCLE AND PEDESTRIAN BRIDGE ACROSS THE COPENHAGEN INNER HARBOUR AT VESTER VOLDGADE

Realdania | Realdania Byg

STAGE 1

Entry 1

Entry 2

Entry 3

Entry 4

Entry 5

STAGE 2

Entry 3

Entry 4

WINNING ENTRY

THANK YOU FOR YOUR ENTRIES

Entry 3

Prepared by
BUROHAPPOLD ENGINEERING
WILKINSON EYRE ARCHITECTS
URBAN AGENCY APS
EADON CONSULTING LTD
SPEIRS + MAJOR LLP
NIRAS A/D

FROM 37 COMPETENT TEAMS TO ONE WINNER

On 30 October 2014 Realdania Byg A/S and the City of Copenhagen launched a restricted design competition followed by a negotiated procedure for the design of an openable cycle and pedestrian bridge across the Inner Harbour in Copenhagen, to be located immediately to the north of the existing Langebro Bridge.

Thirty-seven Danish and international teams applied for prequalification. They were all highly competent teams interested in locating and designing a bridge at this very complex site in Copenhagen. We were of course very proud of and pleased about their interest. Five teams were invited to participate in Stage 1 of the design competition.

After the assessment of the entries submitted in Stage 1, a unanimous assessment panel agreed on selecting two entries as equal winners. The two teams behind the entries were subsequently invited to participate in a negotiated procedure (Stage 2). Both entries are characterised by high technical, architectural and urban planning qualities, and both developed favourably during the interesting and constructive negotiation procedure.

After completion of the negotiated procedure, Entry 3 was selected as the final winner of the competition. The entry was prepared by team BuroHappold Engineering.

The assessment panel would like to thank all five teams for their entries, each of which has provided valuable input to the process and the final outcome.

We look forward to realising the attractive winning design for the new cycle and pedestrian bridge that is to be an important element in the development of Copenhagen as a green, sustainable waterfront city with the world's best cycle bridge.

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COMPETITION FACTS

THE COMPETITION

Competition promoter

Realdania Byg A/S in collaboration with the City of Copenhagen.

Competition type

A restricted anonymous design competition with five participants followed by a negotiated procedure.

Competition brief

The competition brief was prepared by Realdania together with the City of Copenhagen and Arkitektkonkurrencer.dk.

ASSESSMENT PANEL

Anne Skovbo, chief executive, Finance Administration, City of Copenhagen (chair)
After Stage 1, Anne Skovbo was replaced by Ingvar Sejr Hansen, head of department, Centre for Urban Development, City of Copenhagen
Torben Gleesborg, chief executive, Technical and Environmental Administration, City of Copenhagen
Tina Saabye, city architect, City of Copenhagen
Hans Peter Svendler, executive director, Realdania
Peter Cederfeld, chief executive, Realdania Byg A/S
Erik Bystrup, architect MAA MDD (independent assessor)
Martin Svenning Nielsen, engineer FRI (independent assessor)
Lisbeth Westergaard, landscape architect MAA (independent assessor)

Advisers to the assessment panel

Peter Fangel Poulsen, project director, Realdania Byg A/S
Mads Falbe-Hansen, project manager, Realdania Byg A/S
Anne Lærke Jørgensen, project manager, Technical and Environmental Administration, City of Copenhagen
Leif Müller, construction technology adviser, Technical and Environmental Administration, City of Copenhagen
Preben Thormod Pedersen, client adviser, Moe A/S

Secretary to the assessment panel

Anne-Mette Bølling, Arkitektkonkurrencer.dk.

Negotiation team

Peter Fangel Poulsen, project diretor, Realdania Byg A/S
Mads Falbe-Hansen, project manager, Realdania Byg A/S
Preben Thormod Pedersen, client adviser, Moe A/S

PARTICIPANTS

The following five teams, listed in alphabetical order, participated in the competition:

- Team A: Arup
- Team B: BuroHappold Engineering, Wilkinson Eyre Architects, Urban Agency ApS, Speirs + Major LLP, Eadon Consulting Ltd
- Team C: COWI A/S, Dissing+Weitling, Kragh & Berglund
- Team D: EKJ Rådgivende Ingeniører as, Leuschenring & Rundquist, Svensak Teknikingeniörer AB – Sting
- Team E: Tractabel Engineering, DFA Dietmar Feichtinger Architects, Michel Desvigne Paysagiste

FEE

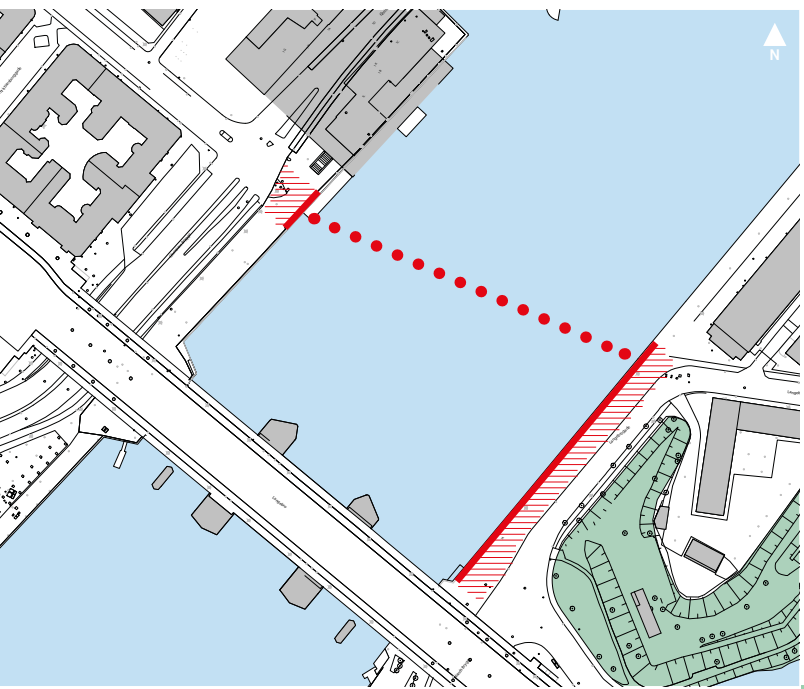
All teams participating in Stage 1 of the competition received a fee of DKK 250,000 exclusive of VAT. The teams participating in Stage 2 of the competition received an additional fee of DKK 200,000 exclusive of VAT.

ASSESSMENT CRITERIA

The entries were assessed on the basis of the proposed design for an openable cycle and pedestrian bridge and associated land installations that met the wishes and requirements set out in the competition brief. It was a prerequisite that entries could be realised within the allocated budget of DKK 90 million. The following assessment criteria were stated in the competition brief:

- It is important that the bridge fits into its unique location and that it has a design characterised by simplicity and lightness that respects the nearby listed Langebro bridge and the surrounding historic buildings and spaces, as well as the future Realdania building at the Brewery Site.

A proposal for the design of an openable cycle and pedestrian bridge across the Inner Harbour in Copenhagen, starting at Vester Voldgade immediately to the north of the Langebro Bridge, with associated land installations on each side of the basin.



- It is important that both cycle and pedestrian traffic to and from the bridge can take place in an easily accessible safe flow from nearby cycle routes, cycle paths and pavements.
- It is important that the bridge is an aesthetically pleasing experience in its setting and that it is conducive to and enhances the desirable visual line between Vester Voldgade and the eastern end of Langebrogade.
- It is important that accessibility is good for both pedestrians and cyclists, including people with reduced mobility or other impairments, and that people can move around on the bridge in a way that is safe and secure for everyone.
- It is important that the bridge functions well technically and is reliable in daily use, and that operation and maintenance costs are generally kept to a minimum.
- It is important that the cost estimate submitted demonstrates in a compelling way that costs will stay within the budgetary framework defined for the project and that the lead consultant's fee is competitive and consistent with the scope and nature of the assignment.

RESULT

Winner

Entry 3/16440 was selected as the winning entry in the competition.

Announcement

The competition result was announced on 25 June 2015.

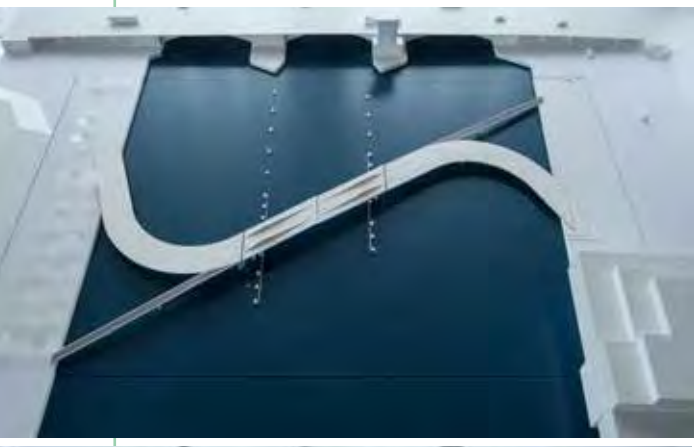
Bridge link

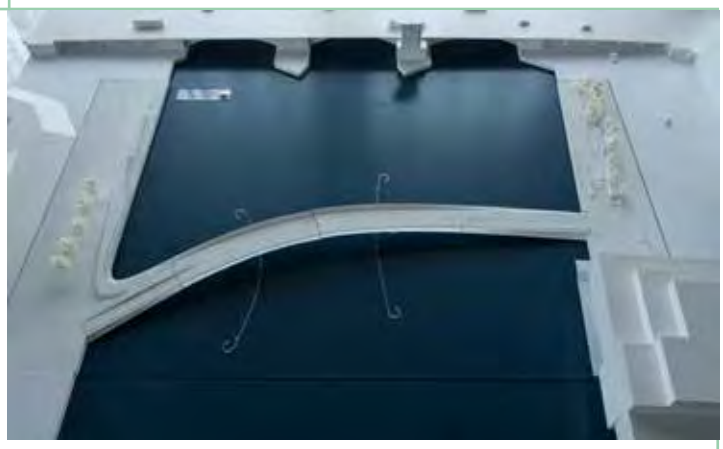
Bridge abutment

Land installations

Model photos, Stage 1

Entry 1





Entry 3

Entry 4

Entry 2

Entry 5

INTRODUCTION

THE ASSESSMENT PANEL'S GENERAL REMARKS

THE ASSIGNMENT

It has not been easy for entrants to prepare responses to the competition assignment described. They had to take all of the following constraints into account:

- The historical setting
- The complex nature of the urban space
- The area of impact of the Langebro bridge
- The large building volumes close to the site and the proximity of the ramparts
- The complexity of the relationship between navigation height and bridge gradients

Combined, all these aspects have created a scenario that was clearly difficult for entrants to navigate. The link across the harbour basin was in fact sharply defined by the historical reference: the former bridge that connected the streets Vester Voldgade and Langebrogade. However, the harbour space is not equally clearly defined. It is characterised both by the spatial dominance and dark shadow of the Langebro bridge and by the highly heterogeneous elements on either side of the water surface: the Christianshavn ramparts and the former sugar mill on the east side and, on the west side, the residual space flanked by the Ny Christiansborg building and the new Brewhouse Site project. These are different elements with individual forms of expression and appearances.

The bridge needs to have its own expression in this complex urban setting so that it will both connect the various elements and attract attention to its own obvious qualities.

ENTRIES SUBMITTED IN STAGE 1

Five very different responses to the brief were submitted in this competition. The main difference is in the way in which entrants have addressed the constraints set out in the competition brief. This is particularly true of the bridge trajectory, in that no two proposals are identical in this respect.

The brief's accentuation of the historical trajectory combined with a free choice of landing site on the eastern side of the harbour basin appears to be the reason for the significant diversity of the proposed schemes. Only one entry retains the relatively clear constraint described in the brief, while the other entries illustrate a variety of trajectories across the harbour basin.

All entrants have endeavoured to achieve a light and simple appearance that pays heed to the surroundings. This also applies to the bridge piers and the underside of the bridge, as both elements will be visible to people going to or from the bridge or passing underneath it on the water. Some entries are very successful in doing this, especially Entry 3 and Entry 4.

However, there is no doubt that the challenge described in the brief, which was to create a bridge offering a clear navigation height of 5.4 metres and access gradients of 45‰ for bridge users, has caused the great differences between the various concepts presented.

The entries range from schemes presenting bridges that meet the quay edge exactly at the level available (Entry 5) to schemes that reflect the option of using the abutment area at the quay to accommodate part of the gradient.

The material chosen for the bridge spans is generally surface-treated and painted steel. The supporting bridge piers are generally made of concrete and given their own individual expression. These are well-known materials that have proved able to withstand the marine environment, provided that the structural design and the execution are of high quality. All entries feature LED light incorporated into the handrails to provide light on the bridge deck, which is an appropriate and energy-saving solution.

The entries also deal with the spaces around the bridge abutments in highly different ways, both at the greater urban scale and at the immediate small scale. As regards the greater scale, most entries treat the two quaysides as two different urban spaces that are more or less integrated into the existing urban fabric.

Entry 2 is the only entry that sees the two abutment areas as part of a single urban space that spans the harbour basin, thus creating a new space that is independent of the context of the site.

The assessment panel paid particular attention to the entries that treat the east and west sides differently, as the two urban environments have strong individual identities. It is in the passage across the harbour that interesting things happen and thus in the narrative of going from one unique city district to another. Entry 3 elegantly integrates the

> **Two entries stand apart because of their compelling conceptual clarity and complete detailing.**

bridge abutment on the east side in a way that creates a special space between the new bridge and the existing Langebro bridge. Entry 5 lands very accurately on the edge of the quay, which means that the existing quaysides remain unchanged and free passage is ensured.

With regard to the western side of the harbour basin, all entries with the exception of Entry 2 – which expands the space – take their point of departure in the urban space project already designed. In most entries, the terrain is elevated towards Christians Brygge to negotiate the height difference. All entries reflect the difficulty entrants have had in terms of striking the right balance between flows of pedestrians and flows of cyclists, especially as regards the physical differentiation between the two flows. The assessment panel found no obvious solution to this problem in any of the entries.

On the east side, entrants propose a classical space with granite surfacing and benches for rest and relaxation that interacts with the existing context. The different points of contact chosen for the abutments create different perceptions of the water space between the new bridge and the Langebro bridge. Entry 3 attractively intertwines the bridge and the quay edge, and Entry 4 creates a space that allows room for houseboats.

It was obvious to the panel that the topographic levels of the abutments had caused entrants difficulties. Most entrants consider these levels only in very general terms, without sufficiently clearly presenting solutions characterised by a high level of safety and accessibility between traffic flows.

CONCLUSION STAGE 1

It is obvious that the entrants' ability to read the site and its constraints differs widely. Entry 4 illustrates a very confident approach to the positioning of the bridge at the site, while Entry 5 clearly has problems in that respect.

Likewise, the design and detailing of the various proposals cover a wide range of approaches, ranging from a relatively sketchy approach in Entry 1 to proposals characterised by good intentions but an architecturally unclear idiom such as Entry 2 and entries that feature a good and successful response to the assignment in terms of both architectural and technical design such as Entry 3 and Entry 4.

Two entries stand apart because of their compelling conceptual clarity and complete detailing. Those two entries are Entry 3 and Entry 4, which a unanimous assessment panel selected as the two winning entries in the design competition. Both entrants have been invited to participate in further negotiations.

ENTRIES SUBMITTED IN STAGE 2

During the negotiated procedure, the two proposals selected were further developed and a number of amendments and adjustments were made to both proposals.

In Entry 3, the cross-section design of the bridge was optimised and traffic flows were changed to distribute cyclists and pedestrians differently on the bridge.

In Entry 4, the S-shaped line of the bridge was changed into a more direct link across the harbour basin.

In order to optimise traffic management and the integration of the bridge into the overall urban space, the abutments and bridge/quay interfaces on each side of the harbour basin were further developed in both schemes.

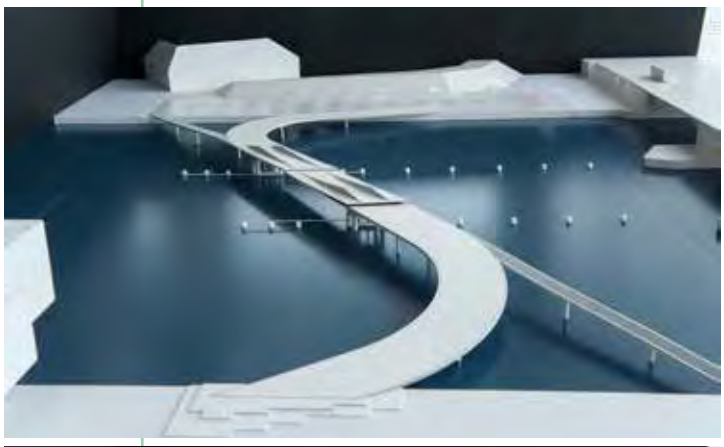
CONCLUSION STAGE 2

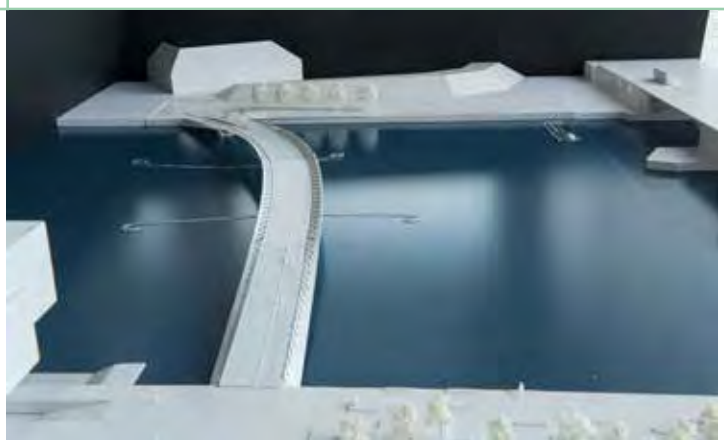
In the opinion of the assessment panel, the revised cost estimates for Entry 3 and Entry 4 were almost identical after adjustment for different general assumptions.

The assessment panel unanimously agreed that Entry 3 best met the wishes and requirements for a cycle and pedestrian bridge at the harbour site. The entry presents a clear and compelling overall concept combined with the powerful design idiom needed to provide Copenhagen with a new high-quality bridge that the city and its residents can be proud of.

Model photos, Stage 1

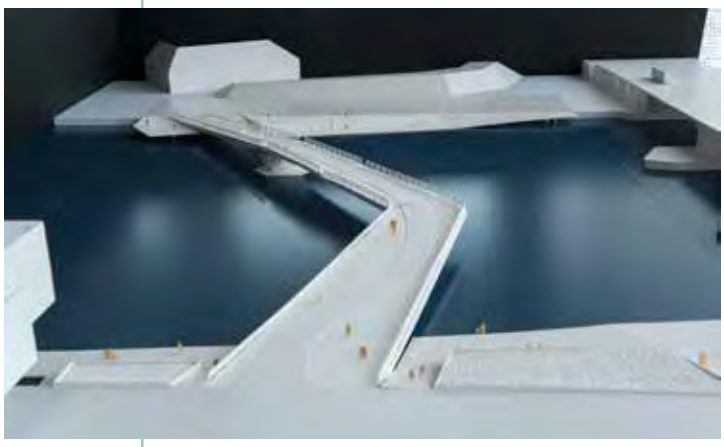
Entry 1





Entry 3

Entry 4



Entry 2

Entry 5

”

It is the opinion of the assessment panel that the main quality of this entry is the vivid suppleness achieved by means of the ‘floating sectional profile’. The entry presents a strong approach to the narrative of the city as a whole as well as to the narrative of the area close to the abutments.

FINAL WINNER

FINAL WINNER
OF THE COMPETITION
JOINT WINNER STAGE 1

ENTRY 3 / 16440 FINAL WINNER JOINT WINNER OF STAGE 1

TEAM **BUROHAPPOLD ENGINEERING**

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NIRAS A/S

GENERAL REMARKS STAGE 1

The entrant uses the phrase 'a simple curved line' to describe the overall concept of the entry. This concept is clearly evident in the design of the bridge deck and the details proposed for it, which make it stand out as a gracious, sinuous curve which catches the light in the double-curved sides that define the spatial flow of the bridge. This appearance is maintained and highlighted in the dark hours by recessed luminaires in the bridge handrails.

The bridge location has been 'carefully arranged to reconnect the misaligned axes of Vester Voldgade and Langebrogade', which is achieved by means of a curved alignment of the two street trajectories.

In order to provide the required navigation clearances, the upper surface of the bridge deck reaches the western quayside about 0.5 metres above the quay. On the eastern side, the bridge is split into two decks to separate pedestrians and cyclists. On this side, too, there is a height difference of about 1.5 metres, which implies a need for remodelling the quayside and the quay area to achieve the required gradient of 45‰.

The underside of the bridge is treated as a third elevation articulating the 'repeating rhythm of the transverse deck structure' which reflects the design structure.

When the bridge opens, two turning sections disengage from each other and move to a position alongside the navigation channel. The entrant describes this as an element of surprise, as 'opening bridges provide potential for surprise and spectacle'. The assessment panel found this argument debatable, as it suggests a design conflict between the bridge concept and the opening mechanism.

It is the opinion of the assessment panel that the main quality of this entry is the vivid suppleness achieved by means of the 'floating sectional profile'. The profile begins as a pleasant invitation at the abutments and continues as a more rigid curve and wings that twist up and down inductively. This sequence also embraces the railings, which follow

Location plan

their own movement in the opposite direction. The assessment panel considered this to be an excellent spatial flow.

LAND INSTALLATIONS

The vision illustrated in this entry will fit into the overall cityscape and create a link at a place where the city will be experienced in new contexts. A clear movement spans the inner harbour, connecting the abutments and creating new spaces, while also taking the greater scale into account by creating bearings towards City Hall Square and the ramparts in Christianshavn.

The abutments provide great options in terms of integrating new spaces in the urban settings on either side of the inner harbour. The abutments are sharply defined and relate to the continuation of Vester Voldgade and the Brewery Site to the east. To the west, where the bridge is split in two, the two abutments will visually prolong the Langebrogade street and also create a new urban space in the direction of the Langebro bridge.

On the eastern side, the bridge meets the quayside at level +3.42, which means that there is an overheight of 1.55 cm. This difference is negotiated in the southbound leg at a gradient of 4.2%. The cycle path meets the edge of the quay at level +2.37. The 47 cm overheight is offset in the northern ramp.

The urban space around the abutment integrates the bridge with the quayside, thus creating an area with a unique identity. Three long concrete plinths offset the difference in terrain levels between the bridge and the abutment and frame a granite-paved square with trees that invites people to stroll or sit down for a while. Stairs connect the two ramps and make it easier for pedestrians to go in the direction of Langebrogade.

On the Brewery side to the west, the bridge meets the edge of the quay at level +2.20, and the difference in levels is offset by means of a small increase in the height of the terrain. However, it is unclear how the meeting of the flow of pedestrians walking along the waterfront and the flow of people coming from Vester Voldgade to cross the bridge is managed. In addition, the integration of the bridge into the design is insufficiently clear.

The entry presents a strong approach to the narrative of the city as a whole as well as to the narrative of the area close to the abutments. There is a natural flow across the inner harbour that clearly creates the impression of going from one city district to another. On the eastern side, the bridge landing elegantly blends into a new urban space that creates 'a site' between the new bridge and the old Langebro bridge. This space also complements the large water space between the two bridges.

PEDESTRIAN AND CYCLE TRAFFIC

The layout with a ramp for pedestrians to the south and a ramp for cyclists to the north needs reconsideration, as cyclists may be expected to opt for the shortcut offered by the southern ramp, and pedestrians may be expected to prefer the cycle ramp to the north. It is likely that there will therefore be an undesirable mix of cyclists and pedestrians that may cause inconvenience. When elaborating the design, the entrant is to ensure a logical and appropriate segregation of traffic across the bridge and safe traffic management on and at the abutments with a focus on accessibility. In addition, the design must fit into adjacent urban spaces.

The western side also poses a challenge, as many pedestrian flows cross the flow of cyclists there. Since the Brewery Site and the only possible way of crossing Christians Brygge are located to the north of the bridge, pedestrians walking on the southern side of the bridge will have to cross the flow of cyclists in order to go north, which will lead to some conflicts between cyclists and pedestrians and thus a lower level of safety and convenience for both groups.

Another consequence of the choice of a two-span turning bridge is that the waiting areas on either side of the bridge become relatively short, and it will be necessary to devise a solution that reduces the risk of cyclists occupying the road area when the bridge is open.

BRIDGE TECHNOLOGY

The entry presents a five-span bridge across the harbour basin with double cantilevered rotating decks above the navigation passage. The superstructure of the bridge is designed as a box section bridge with double longitudinal box girders at either side of the bridge, connected with transverse ribs members under the bridge deck. The cross-section design varies considerably along the bridge, with the 'bridge wings' twisting up or down to achieve the desired visual effect while at the same time ensuring appropriate structural and geometrical conditions locally.

The cross-section height thus varies considerably along the length of the bridge. The general structural principles and opening methods proposed are well known and would be appropriate for the bridge project. Since the complex bridge deck geometry is crucial in terms of the visual appearance of the bridge, the panel carried out an initial assessment of the main dimensions of the bridge on the basis of the requirements set out in the competition brief. The conclusion was that it is realistic to assume that the dimensions illustrated can in fact be achieved.

The movable bridge decks are described as being 'balanced' with a counterweight in the steel columns underneath. The assessment panel is of the opinion that additional counterweight seems to be necessary and that it should be integrated into the bridge deck.

The entrant states that the rotational movement of the bridge is achieved by means of two electrical motors for each rotating deck, located in closed technical rooms integrated into the two central 'rotating pillars'.

The entrant states that the dynamic behaviour of the bridge has been investigated and that the investigations revealed no needs for improvement of the dynamic properties of the bridge.

The foundation principle proposed is the same for all supports and is described as concrete pillars (alternatively steel pillars) founded in the

limestone. A prefabricated concrete element which will be emptied and filled with concrete in situ will be installed on the pillars. All the foundations are high, their top being close to the water surface level. The top of the rotating piers is stated to be at level +2.45.
The railings are described as inclined sceptres connected by horizontal steel infill wires and handrails. Because of the great variation in the cross-section, the railings also vary considerably along the length of the bridge. Just like the design of the bridge deck, the railing design is highly complex.
Construction of the bridge is proposed to be done by sailing the bridge elements to the site and lifting them in place once the rotating pillars and abutments have been installed.

OPERATION AND MAINTENANCE

The primary costs relating to future operation and maintenance of the bridge illustrated in this entry will be associated with the following overall elements: Machinery for the operation of the opening bridge spans, surface treatment, bridge deck surfacing.
The entrant states that the bridge is to be equipped with two motors for each rotating deck and that these motors are to be installed in a 'closed' technical room in the decks of the rotating pillars, which would provide a good basis for optimal operation and maintenance of the machinery. The entrant gives a good description of the method proposed for replacement of the slew bearing, but generally access to the technical rooms is limited, which may cause problems with regard to replacement of other large elements, for example the motors. It is therefore important that these aspects be carefully considered in the detailed design of the bridge. The risk of flooding in the technical rooms is believed to be minimal as the top of the rotating pillars is raised to level +2.45.
According to the entrant, all exterior steel in the superstructure is to be surface treated, but no further description of the paint system is given. The box girders will be hermetically sealed and without surface treatment on the inside.
A man-made surfacing material will be used on the bridge deck. Draining of the bridge is described in general terms and is based on the collection of water in longitudinal drainage channels from which it is discharged into the harbour basin.

ASSESSMENT OF BRIDGE TECHNOLOGY

A general observation is that the complex design of the bridge will imply many specific requirements in relation to execution. The mechanism connecting the two rotating decks will also make great demands on performance in the execution phase, both in terms of general tolerances and in terms of the actual connection. The assessment panel would have liked to have a description of the joint/connection between approach spans and rotating spans that is to manage variations (primarily in temperatures) in addition to ensuring efficient connection to the rotating decks. The suggested design of the elevated foundations will imply considerable deflection and torque in the pillars, especially as far as the rotating pillars are concerned. It is the panel's opinion that hollow (cast) steel pillars would be more suitable than the concrete pillars described. The panel also recommends considering a lowering of the foundations of the rotating pillars so that they will rest on the harbour bed, as this would increase the robustness of these important elements.

COSTS

The panel generally considers the estimate submitted to be overly optimistic. It is in particular the panel's opinion that the complexity of the bridge is underrated in the unit prices applied.

CONCLUSION

It is the opinion of the assessment panel that the main quality of this entry is the expressive suppleness achieved by means of the 'floating profile'. The cross-section begins with an open invitation at the abutments, following which the curve becomes more rigid and the wings twist inductively up and down.
This flow embraces the railings that follow their own opposite direction. It is the panel's opinion that this is an excellent approach to the spatial flow.
The entry stands out strongly in the narrative of the overall cityscape and in the narrative of the areas close to the abutments. There is a natural flow across the inner harbour that will clearly make bridge users feel that they are moving from one city district to another. On the eastern side, the bridge abutment elegantly blends into a new urban space that creates 'a site' between the new bridge and the old Langebro bridge. This space also complements the large water space between the two bridges.
A unanimous assessment panel decided to select this entry as a joint winner of Stage 1 of the design competition.

GENERAL REMARKS STAGE 2

In the negotiation round (Stage 2), the compelling location of the bridge in the urban space was maintained in this entry. Consistent with the objective of the competition, the bridge remains a supple link between Vester Voldgade and Langebrogade. The line of the bridge creates a direct, unobstructed flow that leaves no doubt about how to go from one city district to another. The architectural flow of the bridge creates an attractive open water space in front of the Brewery Site as well as a central vantage point providing both overview and views of the surroundings.
The simple segregation of cyclists and pedestrians testifies to fine understanding of function and experience in movement across the bridge.
The abutments are different in design because of different conditions, but the overall design clearly gives priority to the west side at the expense of the east side. The even level on the west side takes the main entrance to the Brewery Site building and the very complex traffic scenario at the site into account in a compelling way.

At the conclusion of Stage 2, the bridge abutment on the east side had not been convincingly designed. The high level of the abutment is incorporated into a structure that may be perceived as a barrier to flows along the waterfront, while the sharp bend of the cycle lane to the south seems somewhat problematic. However, the assessment panel was convinced that these matters can be resolved in further development of the design.

In Stage 2 of the competition, the cross-section of the bridge was optimised, the width of the bridge being reduced by about one metre as a result of more slender bridge wings and a greater angle of the wings.

The foundation principle for all intermediary supports in the harbour basin was changed in Stage 2 in order to increase robustness considerably.

The solutions and work methods proposed are generally well known and will ensure successful construction and subsequent operation at reasonable cost. Altogether, this bridge design is extremely interesting from a technical point of view, and the entry as a whole has been thoroughly designed on the basis of sound and proven methods.

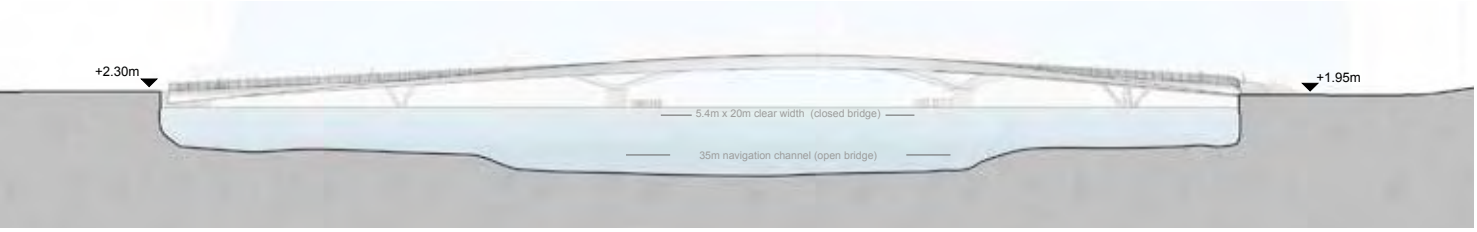
CONCLUSION

The very clear line across the harbour basin illustrated in this scheme is without doubt the best proposal for a bridge submitted in this competition, featuring a clear and simple traffic flow between the two city districts that the bridge connects. The exact location of the bridge across the harbour basin creates an uninterrupted water space in front of the Brewery Site and generally provides open space around the bridge, the Brewery Site and the many important historic elements in the area.

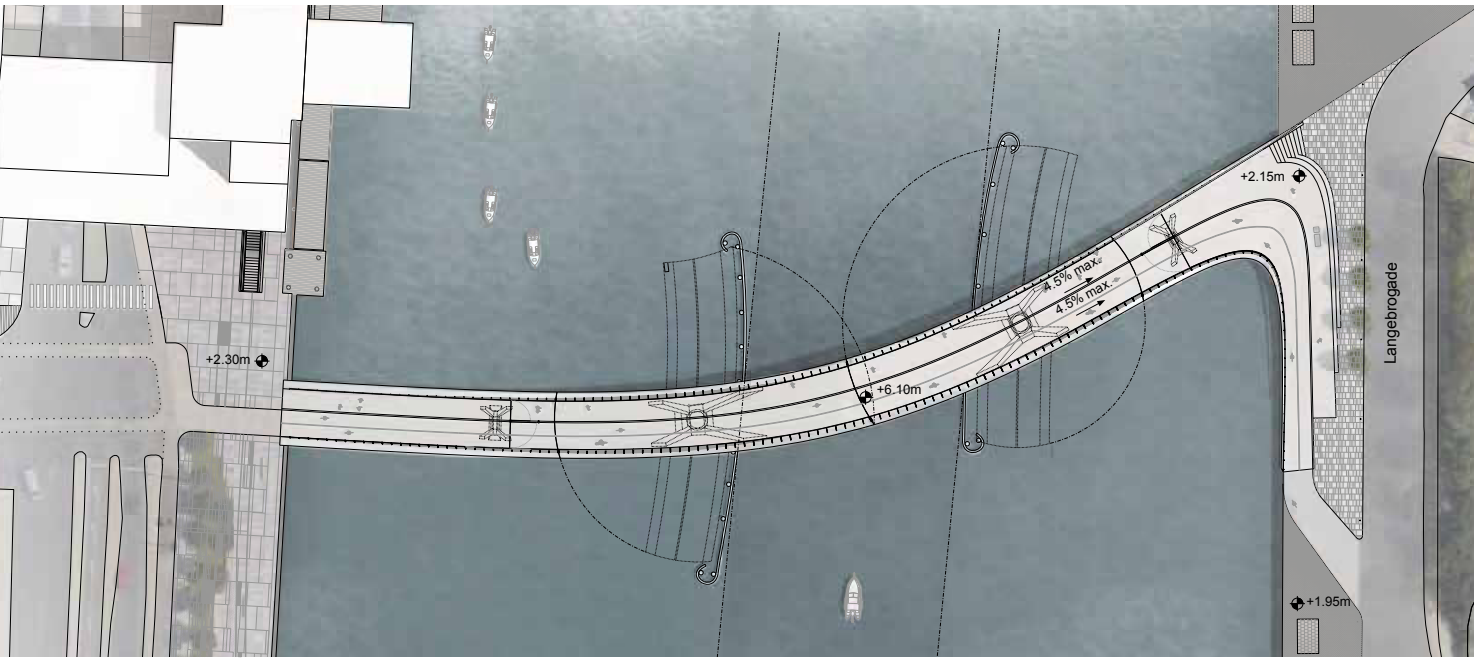
In addition, the entry is the competition's most compelling proposal for integration of architectural and structural design. The architectural design is function of the structural design, and form and function fuse into an innovative, dynamic bridge of the highest international standard.

A unanimous assessment panel therefore selected Entry 3 as the final winner of the competition.

Longitudinal section

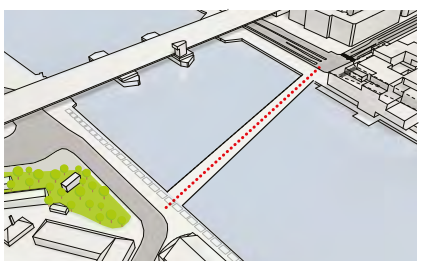


Elevation

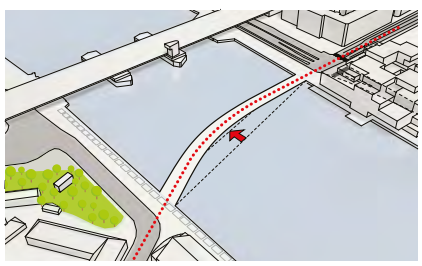


Plan

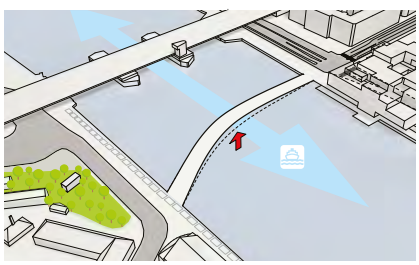
Conceptual illustrations



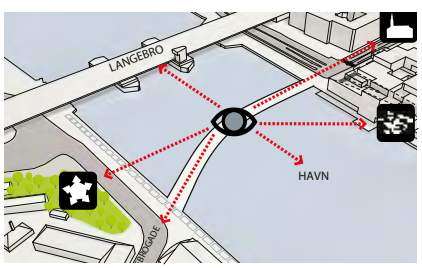
Direct connection between Vester Voldgade-Langebrogade



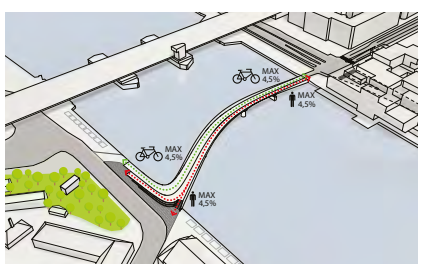
Bridge curves for extra length and to continue street alignment



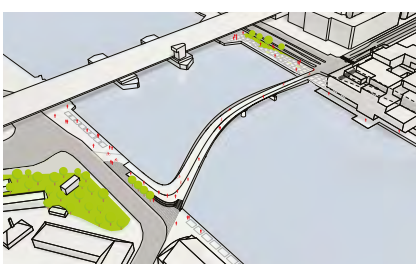
Bridge raised for ship navigation



Bridge acts as a vantage point in all directions



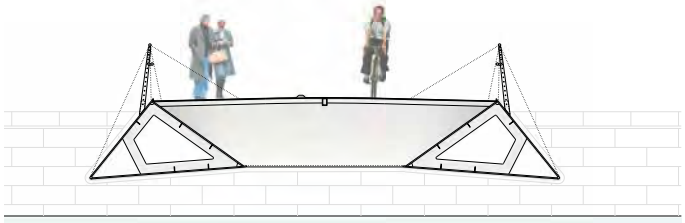
Bridge divided into pedestrian and cycle paths

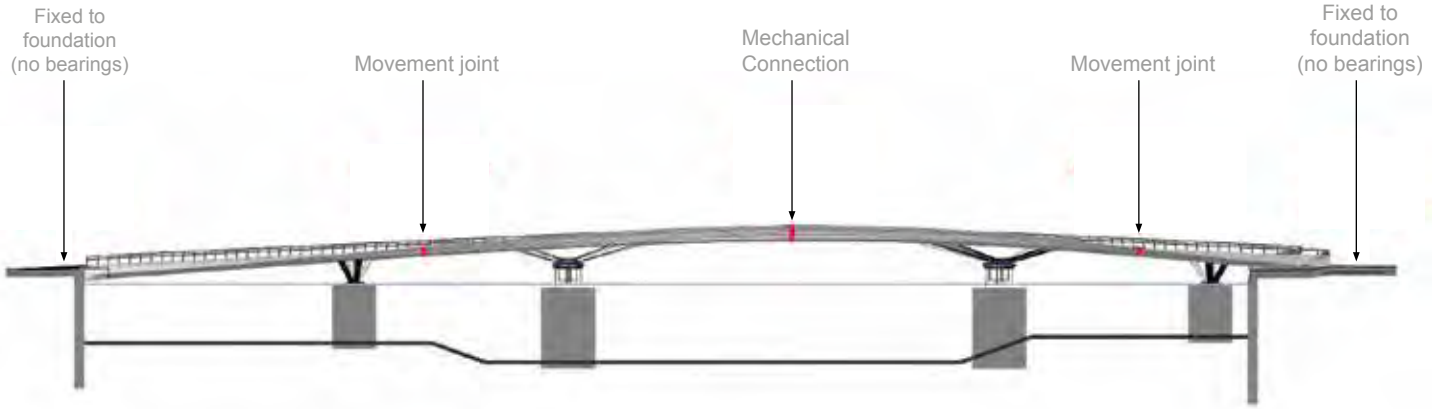


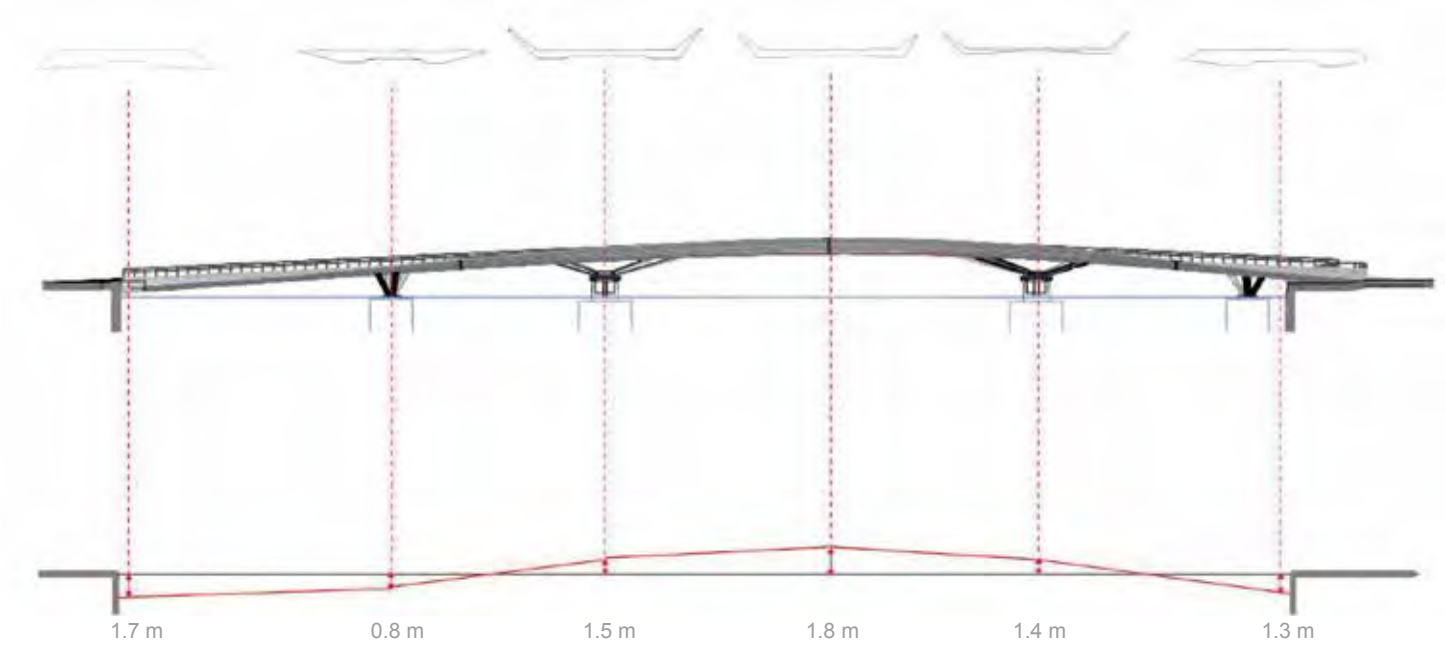
Landscape and bridge seamlessly merge in to one another

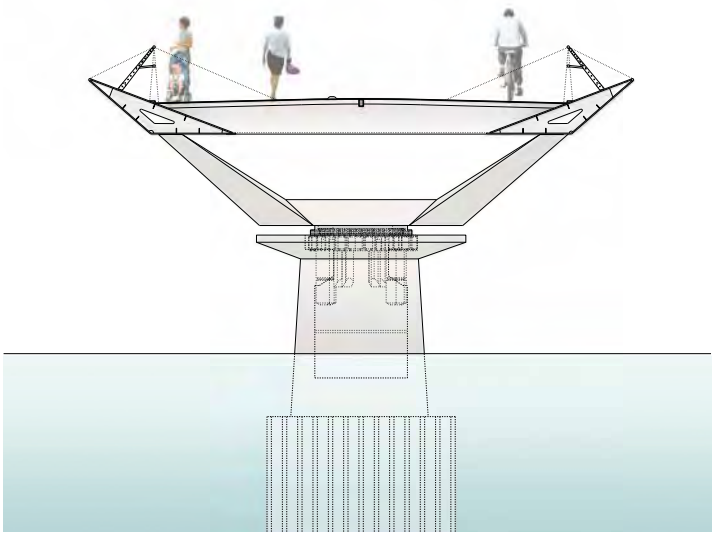
Closed and open bridge

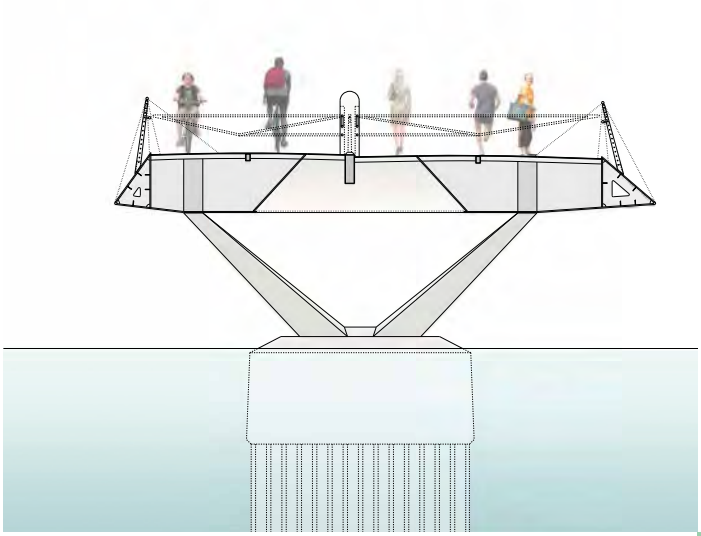
Cross-section



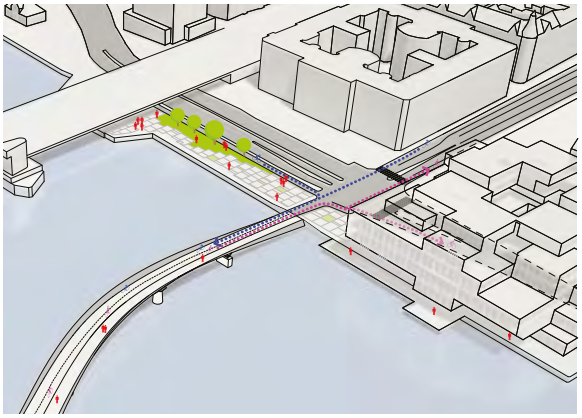

Fixed to foundation (no bearings)
Movement joint
Mechanical Connection
Movement joint
Fixed to foundation (no bearings)
Bridge structure


1.7 m
0.8 m
1.5 m
1.8 m
1.4 m
1.3 m
Floating cross-section



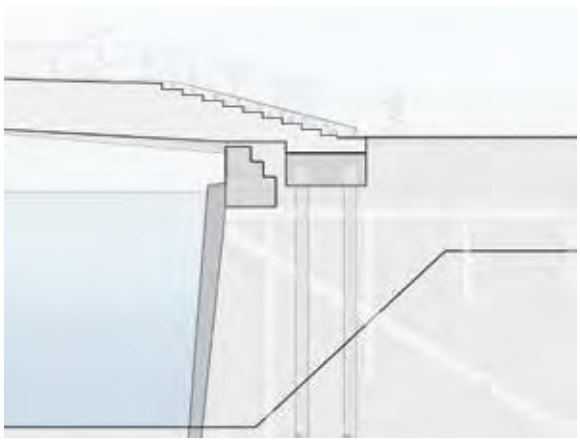


Western bridge abutment



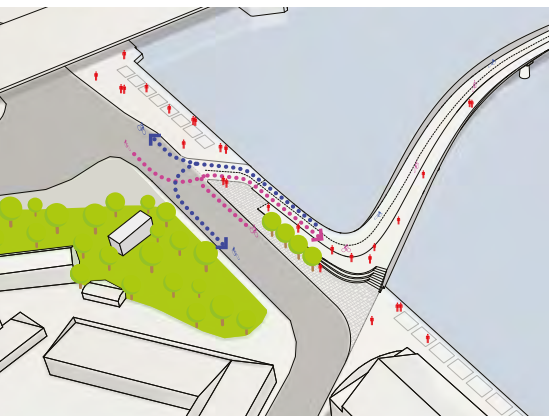
Traffic flows, west side

Section of eastern abutment



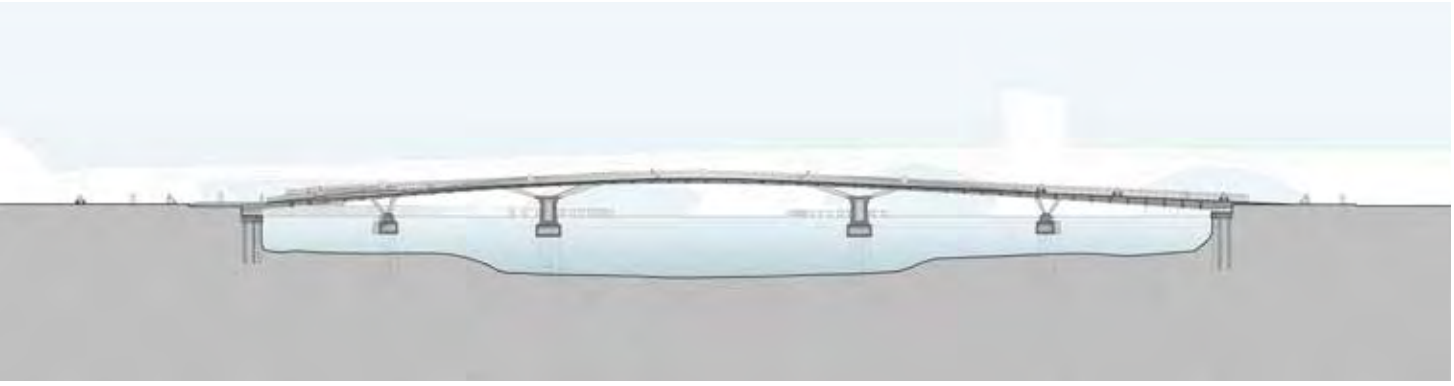
Traffic flows, east side

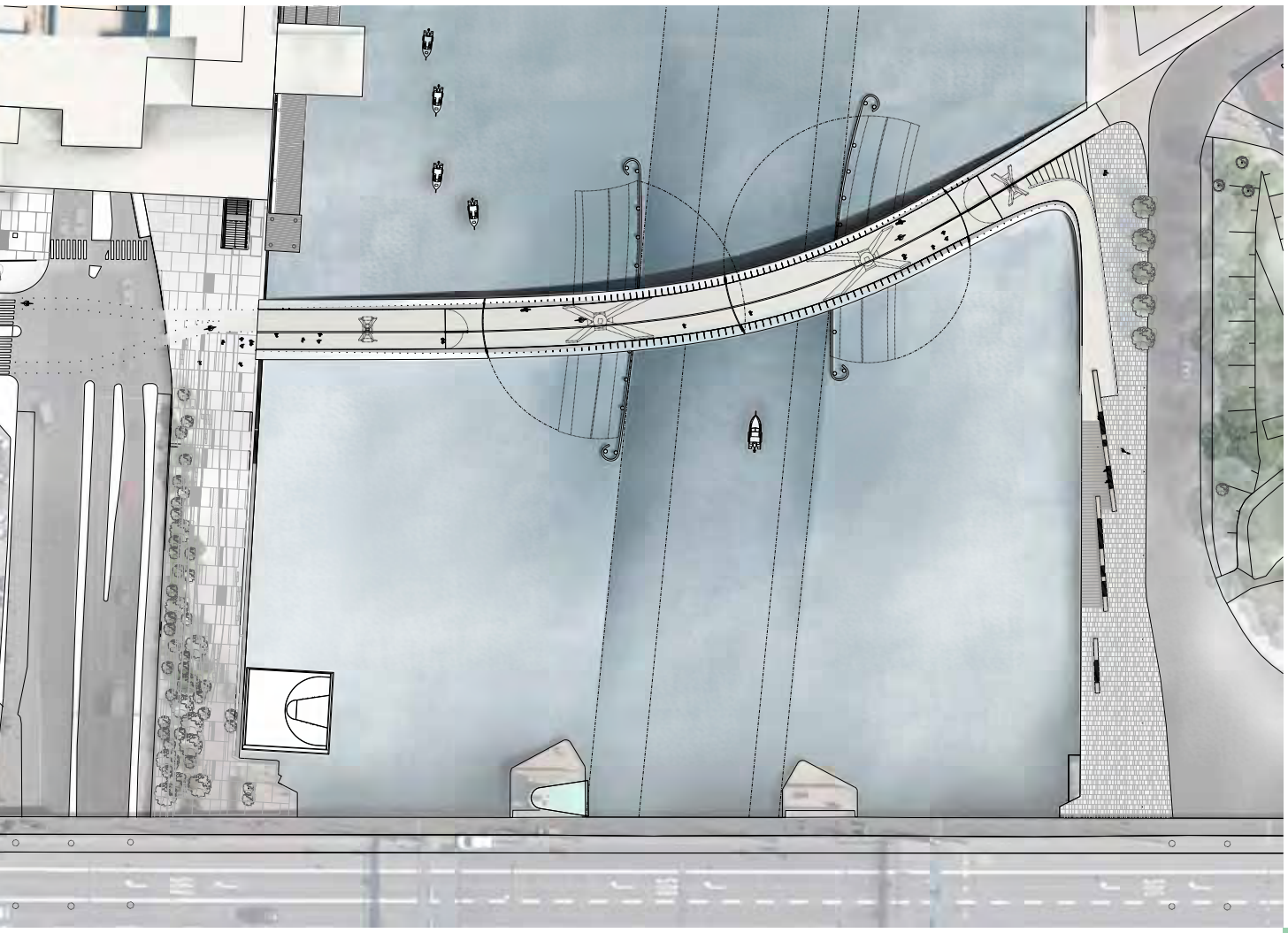
Eastern abutment



Eastern abutment
This solution is not optimal and needs further development in the future process (assessment panel)

ILLUSTRATIONS FROM STAGE 1, DESIGN COMPETITION





”The clear strength of this entry is its confident architectural composition and its use of the structural elements of which a bridge is composed. The structural design is well prepared with a strong focus on detailing the technical solutions chosen.

JOINT WINNER
STAGE 1

JOINT WINNER STAGE 1

ENTRY 4 / 19884 JOINT WINNER STAGE 1

TEAM **COWI A/S**

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GENERAL REMARKS STAGE 1

The entrant uses the following words to describe the main concept presented in this entry: "Simplicity, tranquillity and dignity. An element that anchors the site, creating cohesion."

The outcome is a slender S-shaped bridge that continues the line of the Langebrogade street across the harbour basin and features central opening leaves that rise above the water in the sightline of Vester Voldgade. According to the entrant, this layout creates new harbour spaces while at the same time respecting the large buildings in the area.

Soft curves at the end of the bridge trajectory ensure that 'the speed of cyclists travelling down the bridge is reduced' and 'add length to the bridge, thus making it possible to achieve a maximum gradient of 4.5% with only a modest elevation of the landing points'. In the assessment panel's opinion, the abutments will have to be raised by a little less than 0.5 metres at one abutment and by about 0.75 metres at the other, which means that the quaysides will have to be modified considerably to accommodate the top of the bridge deck. The proposed meeting of the bridge deck and the quay is well articulated and compelling, but the assessment panel did not find that the quay surfaces are credibly designed in terms of compliance with the gradient requirement.

The architectural expression of the bridge is created by means of an elegant and consistent composition of surfaces that are seen from different places: the quays, the water surface or the bridge deck. In particular, there is a fine interplay between the underside of the bridge and the bridge piers. This solution is simple and unadulterated, and will be very compelling when the bridge leaves are open and flank the end of the Vester Voldgade street.

The bridge deck with its central separation of boxes and railings reflects this functional and aesthetically well-balanced approach in a nuanced interplay that is in fact completed by the incorporation of the road barriers.

The assessment panel's opinion is that the S-shaped trajectory is not the optimal way of linking the lines of the Vester Voldgade and Lange-

brogade streets, and it does not meet the specification in the competition brief that it was desirable to retain the historical trajectory. The main line of the proposed bridge deviates from the historical line and the rounded endings fail to convince. In addition, the geometrical combination of straight and curved elements along the line of the bridge results in a visually unfortunate flow that will be particularly evident when seen in a foreshortened perspective from the quayside.

LAND INSTALLATIONS

The entrant has focused on the bridge abutments to make sure they have a minimal, unobtrusive footprint on either quayside. The bridge features a curve at each abutment, which creates spatial distance to the Brewhouse Site and room for houseboats close to the ramparts on the other side.

The bridge connects two types of spaces, and the vision in this entry is based on the difference between them: the modern space at the Brewhouse and the classical space at the ramparts which serve as a green backdrop.

On the Brewhouse side, the bridge meets the quay edge at level +2.23, which means that there is an overheight of 44 cm. This overheight is offset in the increase towards Christians Brygge. Where traffic flows cross above the promenade, cyclists travelling across the promenade have right of way. The area where cyclists will pass is marked by steel nails with incorporated LED lighting.

On the eastern side, a classical urban space is created, featuring a promenade where different types of trees will be planted to reflect the motif on the ramparts. A long bench forms a demarcation line between trees, vehicular traffic and the waterfront promenade. The actual promenade is paved with granite slabs and cobblestones. An area with hard asphalt surfacing crosses the promenade to mark the zone to be used by cyclists.

The bridge meets the quay edge at level +2.69, which means that there is an overheight of 75 cm. This difference is offset along a ramp towards Langebrogade. The quay side is elevated on both sides of the abutments, which creates a hilly north-south landscape along the waterfront.

The assessment panel was favourable to the idea of making the abutments simple, locating them unobtrusively along the edge while still incorporating them into the context of the quaysides. However, the eastern abutment remains unresolved, as it is unclear how the elevated abutment can form part of the terrain without becoming a barrier on the north-south waterfront promenade and without requiring elevation of the Langebrogade street to meet accessibility requirements. On the western side, the longer distance between the bridge and the junction works well, as it will reduce the speed of cyclists and provide a larger waiting area in front of the bridge. In addition, a spacious area is created in front of the stairs leading to the Brewhouse Site. The curved shapes are not compelling in spite of the fine spaces created. With regard to the experience and the narrative of the large scale across the harbour basin, the bearings and directions appear unclear, and the visual flow described between Vester Voldgade and the green ramparts that are delineated by the underside of the bridge appears more like a conceptual device than a design that would actually work.

The large water space between the new bridge and the Langebro bridge is important in the urban context and also important in terms of accentuating the perception of a single open harbour basin. The technical installations on either side of the bridge should play a secondary role in relation to this space.

PEDESTRIAN AND CYCLE TRAFFIC

The way the bridge reaches the western side of the harbour basin to the south of the Vester Voldgade street means that the distance between the bridge and the road junction is greater than it would have been if the bridge had reached the quay orthogonally. This extra distance means that cyclists can reduce their speed while approaching the junction and that there is a large waiting area in front of the bridge, which is a positive feature.

On the eastern side, the bridge reaches the quay at the bend of the Langebrogade street, which creates some distance to the junction and also makes it easier to gain a good overview for cyclists wishing to cross Langebrogade. In addition, the promenade crossing becomes straightforward and easy to understand. However, the considerable elevation of the terrain means that cyclists coming from the bridge will enter Langebrogade at a relatively high speed, which is not desirable no matter where the bridge reaches the quay.

BRIDGE TECHNOLOGY

The design proposed features five bridge spans with double opening leaves above the navigation passage. The bridge superstructure is designed as a conventional closed box girder bridge with an elevated 'fin' at the centre of the bridge deck. The cross-section varies along the length of the bridge as a result of the suspension of the opening leaves and the approach spans at both leaf piers. The height of the cross-section thus varies considerably along the length of the bridge.

The opening of the leaves is ensured by a centrally located hydraulic piston for each leaf, installed in enclosed technical rooms in each of the two leaf piers. The hydraulic pumps, etc are installed in underground technical rooms in both quays.

The central joint between the two opening leaves features a displacement joint with forks or alternatively bolts. Where the opening leaves meet the approach spans, the design features an expansion joint.

The bridge superstructure rests on cast-in mountings on top of the bridge piers. The opening leaves are attached to the pier by means of two hinged spherical bearings and a central thrust ball bearing. The bridge piers, including the leaf piers, are of concrete. The dynamic behaviour of the bridge will be enhanced by means of tuned mass dampers at the ends of the two opening leaves.

The same foundation principle is applied to all supports: drilled concrete piles founded in the limestone. A cofferdam (sheet piling) will be established around all piles to allow dry execution of all foundations

and concreting work. The top levels of the pivot piers are stated to be +2.40 and +2.60.
Railings are illustrated as closely spaced sceptres connected by two 'horizontal' handrails.
The bridge elements will be sailed to the site and lifted in place once the bridge substructure has been completed.

OPERATION AND MAINTENANCE

The primary costs relating to future operation and maintenance of the bridge illustrated in this entry will be associated with the following overall elements: Machinery for the operation of the opening bridge spans, surface treatment, bridge deck surfacing.
The proposed solution with a hydraulic piston inside a 'closed' leaf pier and underground technical rooms in the quays would be a good basis for operation and maintenance of the machinery. However, given the difficulty of accessing the inside of the bridge 'fins' where the pipes are located, the relatively long route for hydraulic pipes between the technical rooms and the leaf piers is not optimal. It must be ensured that the hydraulic piston can be replaced in the event of failure. Access to the leaf piers is only possible when the bridge is open, which makes inspection and repair of cylinders, etc difficult. In contrast, the technical rooms on the quays provide easy access to pumps, etc. The joint between the leaves must feature maximum robustness. It is the assessment panel's opinion that the risk of flooding of the leaf piers is minimal because of the elevated top levels of the piers (level +2.45).
All exterior steel in the superstructure is to be surface treated with a high-class paint system (C-5M). The inside of the box girders will be corrosion protected by means of a dehumidification system, but no surface treatment will be applied.
A synthetic coating will be applied to the bridge deck.
The entrant provides only a general description of the proposed draining of the bridge based on the collection of water in gutters along the bridge, from which the water will be discharged into the harbour basin.

ASSESSMENT OF BRIDGE TECHNOLOGY

This entry is very well prepared with a great focus on detailing technical solutions. The solutions proposed are robust and well known, and they will be suitable for the bridge across the harbour basin. In the opinion of the assessment panel, the main dimensions stated are realistic. The joint between the two opening leaves will call for great accuracy in execution, no matter which of the proposed principles is applied. An orthogonal joint could make the connection simpler. The panel would have liked to see a description of the joint/connection between the approach spans and the opening spans.
The proposed design and execution of the substructure are conducive to safe execution as the work can be carried out in a dry setting.

COSTS

In the opinion of the assessment panel, the cost estimate is generally too optimistic, particularly as regards the bridge substructure including the leaf piers, for which the estimate seems to be very low.

CONCLUSION

The assessment panel was favourable to the entrant's endeavour to make the abutments simple, locating them at the quay edge in an unobtrusive manner while still incorporating them into the quay context. On the western side, the long distance between the bridge and the junction is good, as it will make cyclists reduce their speed and provide a large waiting area close to the bridge. In addition, an attractive space is created in front of the stairs leading to the Brewery Site.
The clear strength of this entry is its confident architectural composition and its use of the structural elements of which a bridge is composed. The bridge deck, underside, railings, piers and equipment are confidently incorporated into the main concept. There is no attempt to achieve special effects, only usable and well tested solutions that interact very well.
The structural design is well prepared with a strong focus on detailing the technical solutions chosen. These solutions are robust and well tested, and thus suitable for the bridge across the inner harbour. A unanimous assessment panel therefore selected this entry as joint winner of Stage 1 of the design competition.

GENERAL REMARKS STAGE 2

In the negotiation round (stage 2) the bridge trajectory originally proposed was changed to create a better line across the harbour basin and a more direct connection to the quays on both sides. Unfortunately the location of the curved part of the bridge is such that it impinges on the space in front of the Brewery Site.
The overall concept of the bridge remains inconsistent because of the mix of geometrical elements and shapes. The top of the bridge deck is characterised by a longitudinal box girder and the geometry defining it, while the underside of the bridge features a triangular geometry that shapes the bridge piers, the deck and the opening leaves. This geometrical duality is combined with a trajectory across the harbour basin that features both straight and curved elements, the result being a composite design. As in Stage 1, the main quality of the bridge is its overall expression when it is open.
In Stage 2, the bridge was given a much clearer shape that reinforces the location of the abutments on the two quaysides and creates a more credible coherence with the flows of the city. The bridge abutments rest on the quaysides and create visually unobstructed passage along the waterfront promenades. The abutment gradient requirements are met by means of a basically even distribution of gradients on the two sides, which results in a small 'hump' that would have to be addressed in connection with any further development of the design, despite the otherwise good layout.
The landscaping at the western abutment is simple, featuring a raised area sloping towards the existing terrain and incorporated into the design of the open square. This design would need further development

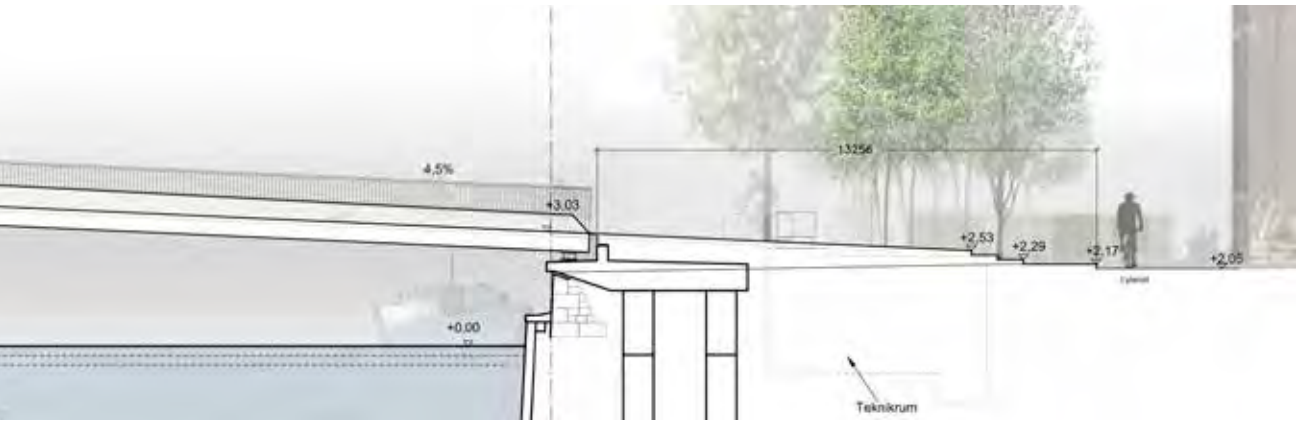
in order to ensure better access to the Brewery Site.
On the eastern side, the quay has been raised to address differences in levels between the bridge abutment area and the existing terrain. This elevation affects a 50-60 metre long area, which means that movement along the waterfront will take place on sloping ground. Seen in conjunction with the fact that the cycle lane is sunk by 5 cm, this cannot be considered free passage. The current scheme would also require further development on the east side in order to ensure optimal traffic flows and coherence between the bridge and nearby urban spaces. Apart from the changed trajectory, the bascule bridge structure is the same in terms of structure and technology. Entry 4 thus remains a very well prepared proposal featuring well-known and proven technical solutions that would ensure successful realisation of the bridge.
The proposed bridge design would make it possible to keep future operation and maintenance costs low.

CONCLUSION

In overall terms, this is technically a very good design. The entrant has been faced with some of the same challenges as the winning entrant regarding traffic management on the east side of the bridge. In this case, too, it is the opinion of the assessment panel that it would be possible to solve the problems successfully.

The assessment panel's overall opinion about this entry is that, despite its many fine qualities, it represents an approach to bridge design that is more conservative and conventional than the location deserves. This is the reason why the panel preferred Entry 3 as the final winner of the competition.

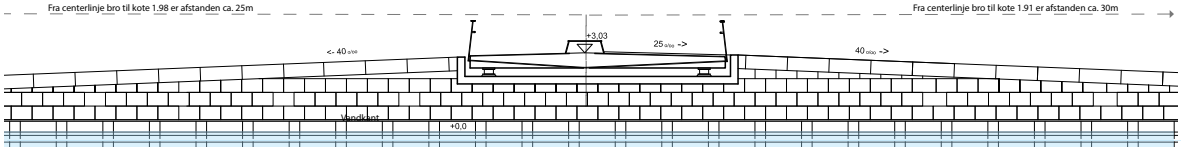
Site plan



Section of eastern bridge abutment

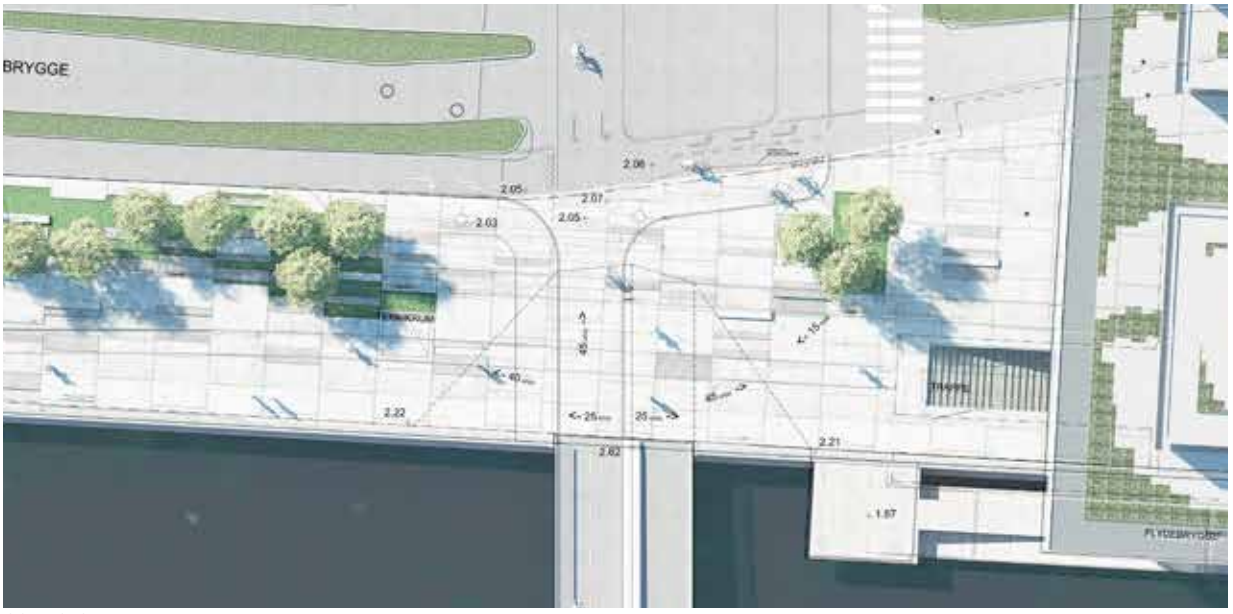
Section of western bridge abutment

ændsbrygge. Planudsnit 1:200



Plan and section of eastern bridge abutment

Plan and section of western bridge abutment



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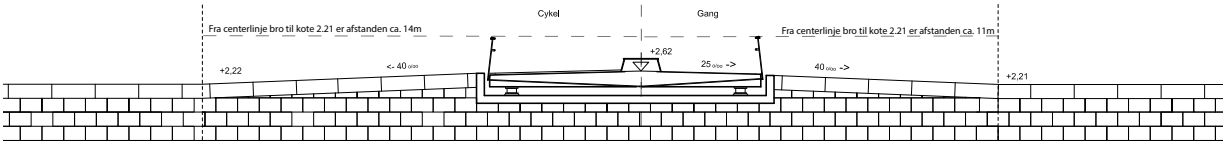
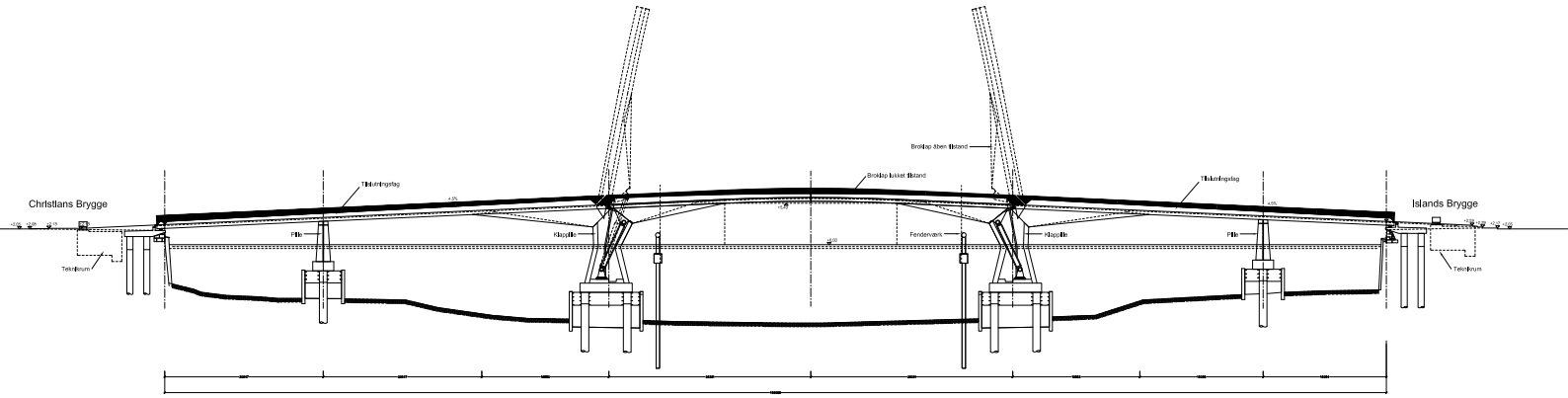
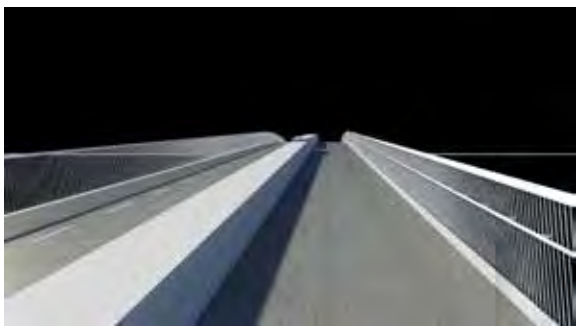
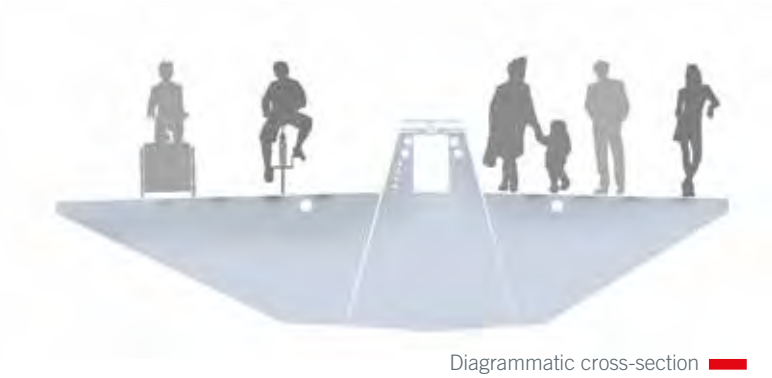




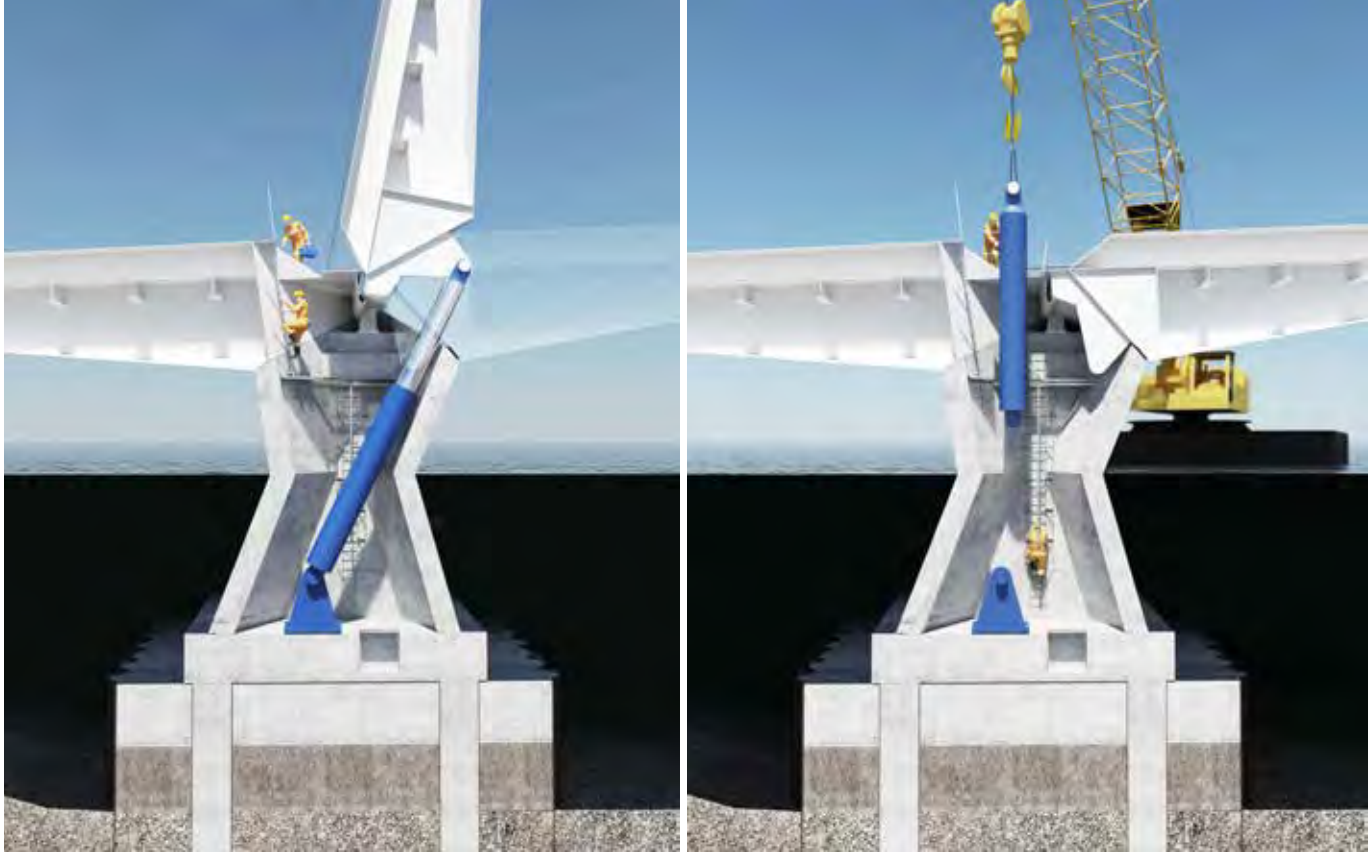
Longitudinal section



Railing



Diagrammatic cross-section



Section of leaf pier

ILLUSTRATIONS FROM STAGE 1 OF THE DESIGN COMPETITION

OTHER ENTRIES

OTHER ENTRIES

ENTRY 1 / 16685 PARTICIPANT STAGE 1

TEAM **EKJ RÅDGIVENDE INGENIØRER**

EKJ RÅDGIVENDE INGENIØRER AS COPYRIGHT

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GENERAL REMARKS STAGE 1

This entry 'takes its starting point in the traffic flows set out in the competition brief', and 'like other cycle paths in Copenhagen', the bridge features 'shortcuts in the form of additions located as a continuation of the Langebrogade street'. The bridge adapts to the western side with its 'delicate abutment' which 'ensures that cyclists will reduce speed on their way towards the junction, as they have to change direction, which will slow them down. 'On the eastern side, the bridge meets the quay immediately in front of the western part of the ramparts in Christianshavn'. The main concept of this entry is an S-shaped trajectory combined with two 'shortcuts'. The bridge hinges to the western quay area in an outward-going movement that provides space for the Brewery Site project. To the east, it turns south towards the Langebro bridge. The 'shortcuts' are two continuations of the trajectory of the Langebrogade street that meet the main bridge at the corner of the Langebro bridge and the Ny Christiansborg building on one side and the Langebrogade street on the other.

The bridge features two opening leaves and a characteristic bridge deck structure based on a hexagonal load-bearing principle that is visible from the quays, the water surface and to some extent also from above by means of apertures for uplights in the bridge deck.

The bridge proposed has an architectural idiom that achieves a balance between the two merged trajectories and the distinctive underside of the bridge. The assessment panel was favourable to the idea of the 'shortcuts' giving bridge users several options for crossing the harbour basin, but it found the combination illustrated too unresolved in relation to the overall requirement for a main trajectory set out in the competition brief.

The assessment panel found the hexagonal load-bearing principle interesting as a visual feature but was sceptical about the appropriateness of the design, one reason being that it is a high-maintenance solution because of the open underside. In addition, the design was considered to be at odds with the historical site.

The entry is of a very general and schematic nature.

Site plan

LAND INSTALLATIONS

The urban space around the eastern abutment is intended to interact with the ramparts and the historical structures. The entrant suggests a surface of cobblestones that is polished in areas for pedestrians and cyclists and unpolished in areas to be used by cars. The cobblestone surface continues across the road towards the ramparts. The uniform surfacing along the quay edges is broken by areas with rock dust that are to be used for activities such as petanque and physical exercise. A few benches are located along the edge of the quays. Plane trees with tall trunks are planted in a 6x6 metre grid to shape space and reflect the scale of adjacent buildings.

The urban space to the east is a contrast to the urban space to the west, which is more urban and also interacts with the Brewery Site project. The western abutment features a design that is unobtrusive relative to the urban space project already prepared. The differences in topographic levels is negotiated by means of a gradual increase in the terrain towards Christians Brygge. The treatment of the terrain at the two abutments is not described in detail. The abutments at the two shortcuts are not described in detail either, which makes their location unjustified in relation to their integration into the eastern and western urban spaces.

The assessment panel was favourable to the design of the eastern urban space in the context of the classic urban nature described and found that it would be a fine supplement to the western space. The spatial scale seems right for the site. The cobbled surfaces described will help segregate traffic flows, but polished cobblestones are far from optimal for cycle traffic. The location of the abutments illustrated in this entry highlights traffic flows rather than the historical axis. The result thus becomes highly schematic and fails to convey the site and its context empathically. The sloping abutments are not integrated into the spaces as both of them partially 'turn their back' to the natural flow along the waterfront promenade. This is particularly true on the eastern side, where the access toLangebrogade appears to be completely disconnected despite the proposed shortcut.

PEDESTRIAN AND CYCLE TRAFFIC

Traffic flows on the bridge will be along the dual-direction central cycle path and two pedestrian areas on either side of the cycle path, each being no more than 2.2 metres wide. The separation of cyclists and pedestrians will be ensured by tactile markings in the surface, which means that cyclists and pedestrians will in principle be able to move around freely across the bridge. The shortcuts are no more than 2.2 metres wide and features open grilles on the surface. The entrant has not suggested any measures to deter cyclists from using the shortcuts. At the bridge abutments, the waterfront promenade is laid out as a shared space without any separation of cyclists and pedestrians.

BRIDGE TECHNOLOGY

The entry features a bridge with nine spans across the inner harbour and dual opening leaves across the navigation passage. It is a lattice girder bridge with two longitudinal lattice girders that are braced and reinforced by hexagonal honeycombs, the detailing of which is somewhat unclear.

At the opening leaves, the lattice girders go up above the bridge deck to increase their cross-sectional capacity, so at this point the lattice girders will be a visible part of the bridge deck. Elsewhere, the lattice girders are under the bridge deck. The opening leaves will be operated by two hydraulic cylinders for each opening leaf. The cylinders are located immediately under the bridge deck and attached to the leaf pier. The hydraulic pumps are located in plant rooms at the two quay edges. The entrant states that hydraulic pipes are concealed in the bridge deck, but there is no explanation of how this is to be done in the honeycomb structure proposed.

All columns/supports are of steel, and the two leaf piers feature a special design. All steel in the superstructure, including the honeycomb reinforcement, is only to be surface treated in the form of hot-dip galvanising. The entry contains no description of any surface treatment of steel columns. The bridge deck is generally coated with a synthetic material, but the ramp features open, hot-dip galvanised steel grilles. Neither the description nor the drawings in the entry provide any information about the draining of bridge structures.

According to the description provided, the foundation principles are the same for all the supports: hollow steel piles founded in the limestone and filled with concrete. At the leaf pier support, precast concrete elements are assumed installt on top of the steel piles. The components are cast together using in-situ concrete, and the steel columns are installed on top. The entry has no drawings or sketches of the bridge substructure, including the two opening leaves that will be subject to considerable loads whenever the bridge opens. According to the entrant, problems of self-excited vibration will be mitigated by means of vibration dampers (which are not further described).

The foundation principle proposed is the same for all supports and is described as hollow steel piles founded in the limestone and possibly filled with concrete. At the leaf piers, precast concrete elements are installed at the top of the steel piles. The components are cast together using in-situ concrete, and steel columns are installed on top. At the ends, pile caps are installed on top of the steel piles.

There is no detailed description of the railings, but horizontal elements between sceptres are described as stainless steel wires.

The entry has no detailed description of the installation of the bridge, but the panel assumed that the bridge elements are to be sailed to the site and lifted in place.

ASSESSMENT OF BRIDGE TECHNOLOGY

The general structural principles proposed are well known, and the assessment panel found that they would be suitable for the inner harbour bridge. However, the reinforcing honeycomb structure was not found to be optimal from a technical point of view. Instead, the necessary stiffening/reinforcement of the lattice girders could be ensured in a much simpler way by means of conventional bracing. The honey-

> **The assessment panel found the hexagonal load-bearing principle interesting as a visual feature but the design was considered to be at odds with the historical site.**

comb solution also increases the complexity of execution, as the other reinforcing elements of the bridge, the hydraulic system pipes and space for the tuned mass dampers would also present considerable challenges in connection with the execution of the work. In the opinion of the assessment panel, the proposed hot-dip galvanising of the bridge would not provide adequate corrosion protection, and a high-class coating system would have been better. However, it would probably not be possible to use such coating in combination with the honeycomb structure, which features an extensive surface area and several surfaces and joints that are difficult to access.

No main dimensions are stated in the entry, but based on the drawings provided, the assessment panel found the heights of the structures realistic. Given the supports described, the opening leaves will be fixed to the leaf piers, but the entrant fails to explain how the approach spans are to be fixed in the longitudinal direction. Similarly, there is no description of the joint/connection between the approach spans and the opening leaves, which – if the approach spans are fixed at the quay edges – must be able to cope with variations (primarily in temperature) as well as ensuring an effective connection to the opening leaves. There is only sporadic description of the execution process and the installation of the superstructure, and no clear description of the draining of the bridge.

OPERATION AND MAINTENANCE

The primary costs relating to future operation and maintenance of the bridge illustrated in this entry will be associated with the following overall elements: Machinery for the operation of the opening bridge spans, surface treatment, bridge deck surfacing.

The hydraulic cylinders, which are not protected against the marine environment, will require more maintenance than a bridge with a closed leaf pier.

The surface treatment proposed, ie hot-dip galvanising alone, cannot be recommended, as it would not, in the opinion of the assessment panel, make it possible to achieve the corrosion class and durability required. However, the honeycomb structure proposed is not suitable for conventional surface treatment.

COSTS

The cost estimate submitted is broken down as required in the competition brief. The general assessment of the entry is that the estimate submitted is characterised by considerable uncertainty because of the sketchy nature of the material provided. The estimate is generally found to be too optimistic and fails to take into account the additional costs resulting from the honeycomb structure proposed for reinforcement of the bridge.

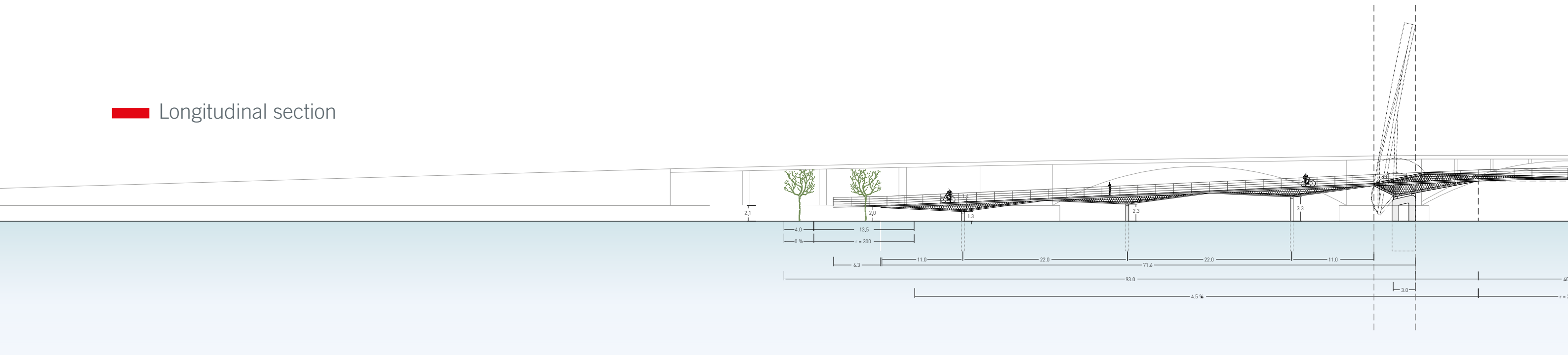
CONCLUSION

The assessment panel found the hexagonal load-bearing principle interesting from a visual point of view, but was sceptical about the adequacy of the design, one reason being that the structure proposed features a high-maintenance design in the form of the open underside. In addition, the design appears at odds with the historical site.

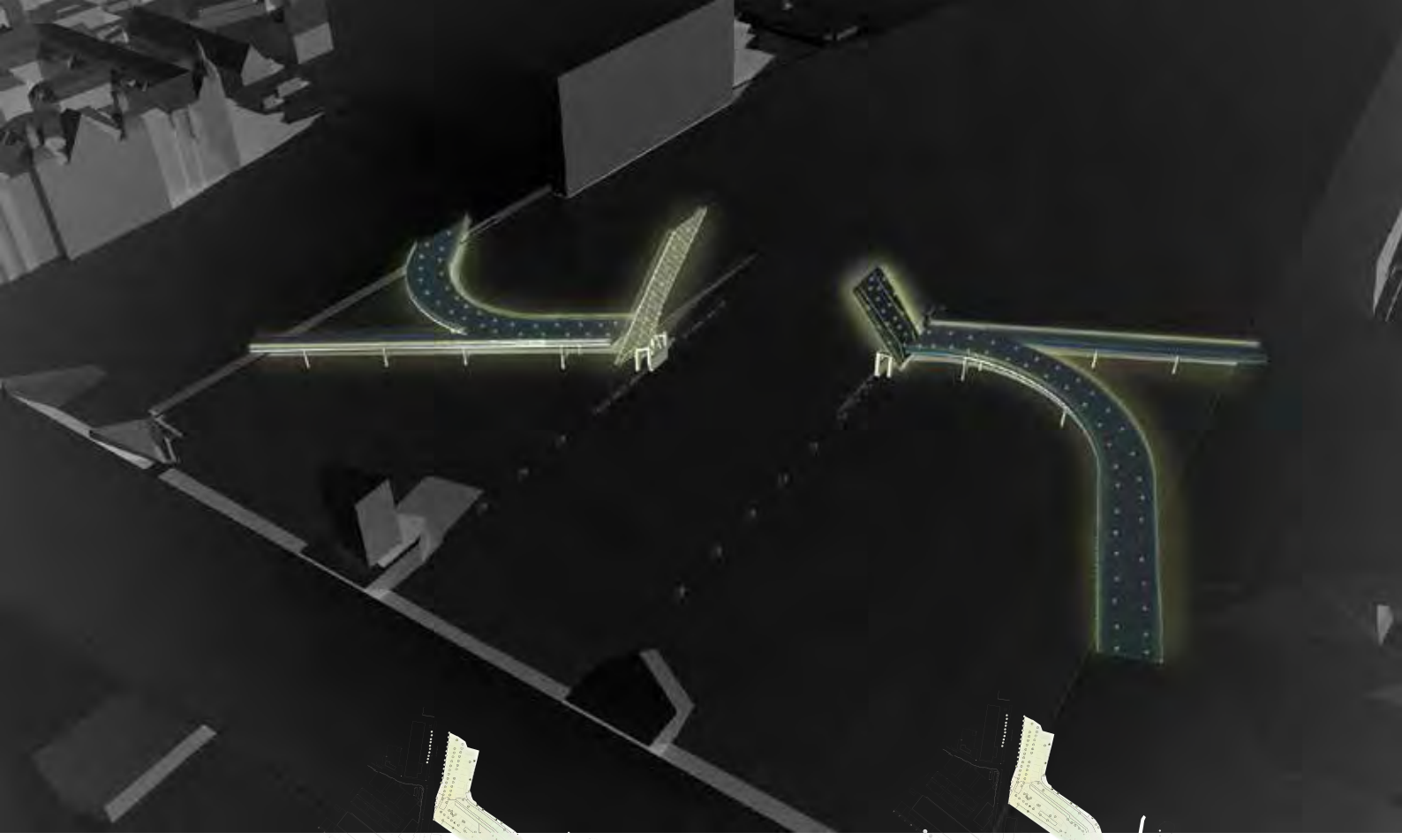
The location of the abutments highlights traffic flows rather than the historical axis. The idiom therefore becomes very schematic and fails to convey good understanding of the site and its context. The sloping abutments are not integrated into the spaces they enter, as both abutments partially 'turn their backs' to the natural flow along the waterfront promenades. The access to the Langebrogade street on the eastern side appears particularly disconnected despite the proposed shortcut.

The cost estimate is broken down as required in the competition brief. A general comment on the entry is that the estimate is characterised by considerable uncertainty because of the sketchy nature of the material submitted. In general, the estimate seems to be too optimistic and fails to take the considerable additional costs of the proposed honeycomb structure into account. These are the reasons why this entry was not selected for participation in the negotiated procedure.

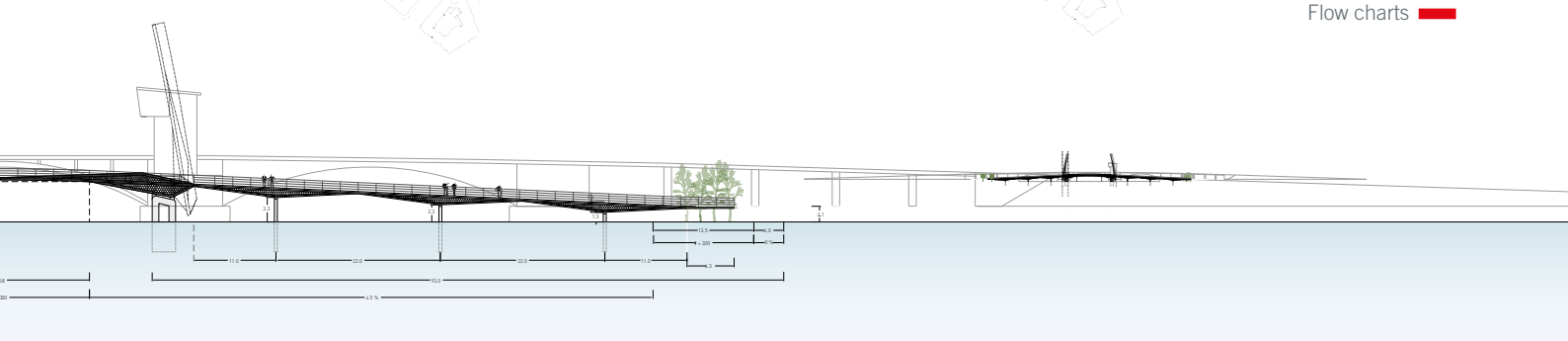
Plan



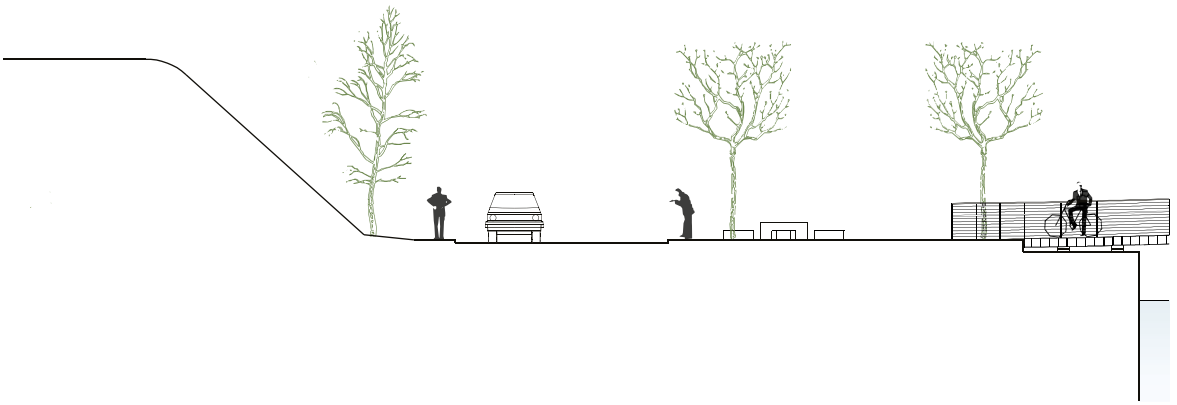
Longitudinal section

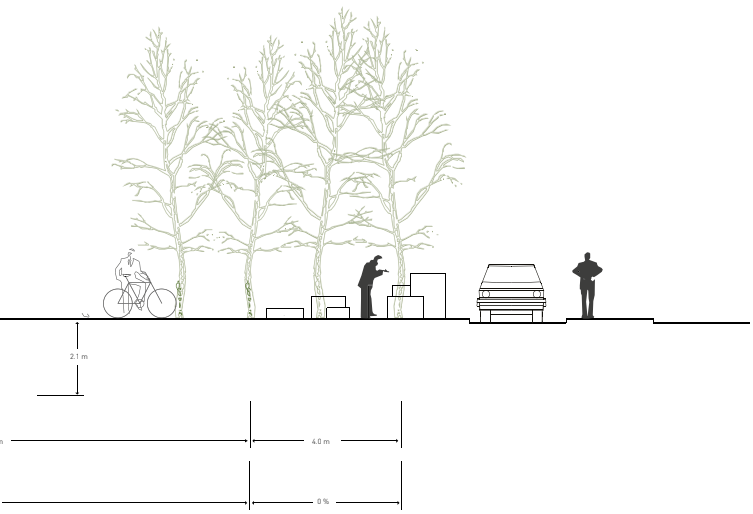



Flow charts

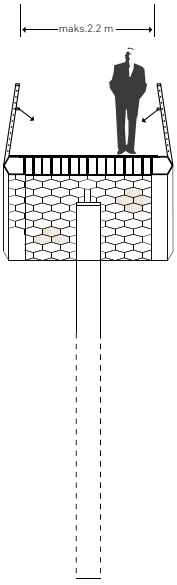


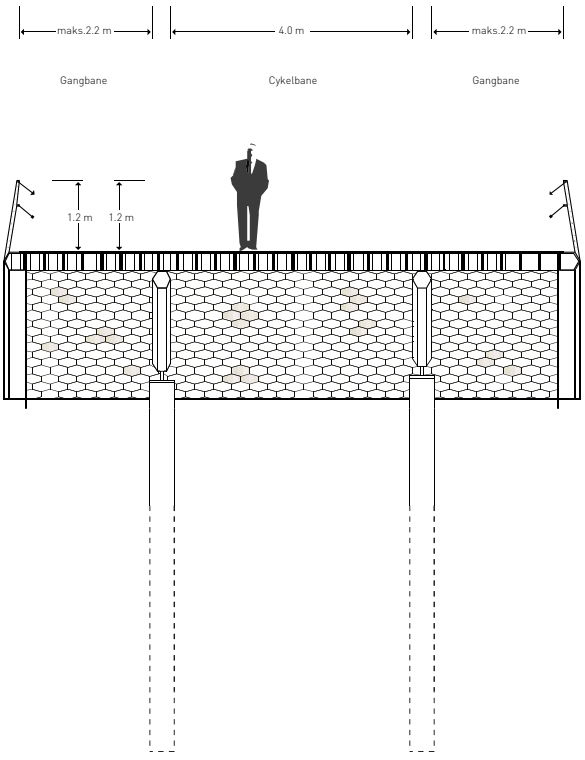
Western bridge abutment

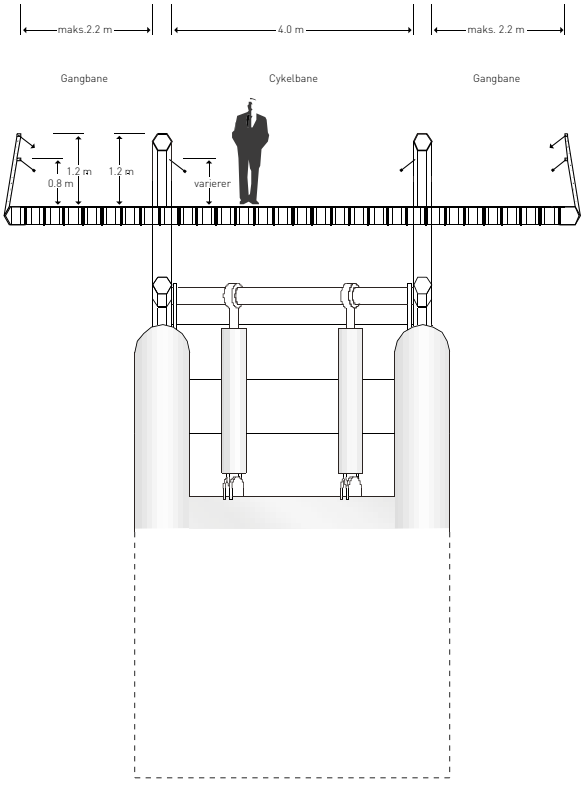




Eastern bridge abutment







Structural design

ENTRY 2 / 18495 PARTICIPANT STAGE 1

ARUP

GENERAL REMARKS STAGE 1

The point of departure of this entry was 'the historical urban narrative that goes back to the original ramparts around Copenhagen' combined with 'a softly curved cycle path' that makes it possible 'to achieve the desirable height above the navigation passage while at the same time ensuring compliance with the requirement for the bridge gradient'. A focal point is that 'the curved line of the bicycle path and the two main angles of the bridge offer new views of the city' and that 'even surfaces and a simple geometry' help ensure acceptable costs. Landscape elements which 'create interesting, active urban spaces along the waterfront that celebrate the unique history and characteristics of the two sides of the harbour basin' are proposed along both quays.

The outcome is a bridge that captures Vester Voldgade and the square in front of the Brewhouse Site with great width, bends towards the Langebro bridge immediately before the navigation channel and the opening leaves and then tapers towards the Langebrogade street.

The assessment panel found the overall concept of this entry interesting and noted that the 'bend' creates a space in the harbour basin in front of the Brewery Site while at the same time continuing the trajectory of Vester Voldgade and especially Langebrogade. However, the panel was not convinced by the layout of the bridge deck featuring the cycle path as a freely shaped element. The architectural coherence appears unresolved.

The panel noted the good intention to reduce the number of bridge piers to the two piers that support the opening leaves, but also reached the conclusion that the result is regrettably a relatively complex cross-section and a consequent minimal height clearance.

LAND INSTALLATIONS

The entrant wishes to create two visually coherent urban spaces along the harbour basin, seeing such coherence as an important parameter in terms of invigorating urban life. This is done both at the large scale by means of new connections across the city and at the small scale by means of closer contact with the water on either side of the harbour basin.

The abutments on either side of the harbour basin are designed to harmonise with the shape of the bridge and create space for activities throughout the year, such as markets and art exhibitions. The eastern abutment provides direct access to the Langebrogade street and actually serves as a prolongation of the street. The western abutment is oblique and features an angle towards the Brewery Site. The entry contains no specific indication of the topographic levels of the abutments.

The eastern abutment has three zones: a zone that accentuates the special characteristics of the ramparts, a zone where pedestrians and cyclists have priority and a new waterfront zone with wooden terraces

Location plan

on the outside of the quay where they provide direct contact with the water surface.

The road is made smaller and the granite surfacing continues to the ramparts where planting is done to make the slopes serve as a green and luxuriant backdrop for the urban space. The terraces running down to the water surface enable people to stay and rest, and they may also serve as an outdoor dining and seating area for the houseboats that are currently moored there. A 50-metre long superbench that serves the dual purpose of seating and road-user separation is placed in this space.

At the western landing the entrant proposes large granite tiles and more luxurious planting as well as terraced wooden surfaces that expand the space on the outside of the quay structure.

The assessment panel was favourable to the entrant's proposal for a recreational waterfront space. However, the description of the new idiom that is to provide an unobstructed environment for cyclists and pedestrians does not adequately address the major problems caused where the flows of cyclists and pedestrians cross each other.

The entrant wishes to ensure visual connection by creating a single uniting space across the harbour basin. Such an approach would be appropriate if the two urban environments on the two sides of the harbour basin did not already have a strong narrative that could be further developed. However, at this very site in the city the two urban environments are so different and have independent identities that are so strong that the interesting element is precisely the passage across the harbour basin and thus the experience of moving from one unique city district to another. In the assessment panel's opinion, the narrative is strongest in the architectural idiom of the bridge, reinforced by the abutments being integrated into the existing urban environments. The two abutments appear to be too complex for the site and the context. In addition, the abutments are not included in the cost estimate and are therefore 'optional' relative to the budget provided.

PEDESTRIAN AND CYCLE TRAFFIC

The dual-direction cycle path is located at the centre of the bridge and has pedestrian areas that are at least two metres wide on its two sides. The areas for pedestrians and cyclists are only separated by means of a change of colour in the surfacing and a tactile guiding line. It is thus possible for people to move freely across the bridge over its entire width. The cycle path meanders towards Christians Brygge in order to reduce the speed of cyclists as they approach the junction and to prepare them for crossing traffic.

The bridge features a number of movable benches. Because they are movable, they represent a great challenge to cycling safety, the bridge opening and the general operation of the bridge, as they may be placed across cycle paths, on the opening leaves or where they obstruct the passage of service vehicles.

BRIDGE TECHNOLOGY

This entry features a three-span bridge across the harbour basin, with dual opening leaves above the navigation passage. The superstructure of the bridge is designed as a conventional orthotropic steel box girder of varying width ranging from 9.6 metres to 20.0 metres. The cross-section height of the opening leaves varies from 0.6 metres at the centre to 1.8 metres at the leaf pier.

"The assessment panel found the overall concept of this entry interesting, although the architectural coherence appears unresolved and the two abutments too complex for the site and the context.

The two approach spans have a uniform cross-section height of 1.8 metres. The operation of the two opening leaves is ensured by two hydraulic cylinders for each opening leaf, located directly below the bridge deck and attached to the leaf pier. The hydraulic cylinders and hydraulic pumps are located in plant rooms in the leaf piers.

The leaf piers are concrete piers with recesses for the hydraulic cylinders on the front facing the navigation passage. Self-excited vibration problems will be mitigated by means of vibration dampers in both opening leaves and approach spans. All steel in the superstructure is to be surface-treated, but the entry makes no mention of any paint or other coating.

The inside of the box girders are stated to be airtight and without surface treatment. A resin finish is used on the bridge deck, featuring different colours for pedestrian and cycling areas.

The foundation principle is stated to be the same for all supports: hollow steel piles founded in the limestone and possibly with cast concrete. A prefabricated concrete element is to be installed on top of the steel piles. It will be cast in situ, and steel columns will be installed on it. At the abutments, pilecaps will be installed on the top of the steel pillars.

The railings are not described in any detail but are assumed to be of stainless steel.

The bridge elements will be sailed to the site and lifted in place after completion of the leaf piers and abutments.

OPERATION AND MAINTENANCE

The primary costs relating to future operation and maintenance of the bridge illustrated in this entry will be associated with the following overall elements: Machinery for the operation of the opening bridge spans, surface treatment, bridge deck surfacing.

The proposed use of two hydraulic cylinders for each opening leaf, installed in a 'closed' plant room in the leaf piers, will be a robust basis for optimal operation and maintenance of the machinery. The endeavour should be to design the equipment in a way that makes it possible to open the leaves using only a single cylinder so that each cylinder can be replaced without requiring any supplementary measures. The greatest challenge is to ensure that flooding of the plant rooms in the leaf piers will not occur, for which reason the design of the leaf piers and the recesses proposed needs to be reconsidered.

Given the regular exterior surfaces illustrated, the proposed principle for corrosion protection based on surface treatment of exterior surfaces and hermetically sealed box girders would provide a good basis for optimal maintenance. However, it is important that a high-class paint system (corrosion class C5-M) be used, preferably after priming with a metal spray. Such treatment would increase construction costs but also ensure a maximum lifetime of the surface treatment as a whole.

The resin finish described should be based on a type-approved resin with an anticipated product lifetime of about twenty years

ASSESSMENT OF BRIDGE TECHNOLOGY

The overall structural principles proposed are well known and suitable for this bridge project. It is the assessment panel's opinion that the structural heights illustrated for the opening leaves are realistic, but that the approach spans are very slender.

The entry does not include any description of the joint/connection between approach spans and opening leaves. If the approach spans run all the way to the edge of the quay, the joint/connection must be able to adapt to variations (mainly temperature variations) in addition to ensuring effective connection to the opening leaves.

It is the assessment panel's opinion that the illustrated design of the leaf piers with the plant rooms and recesses for the hydraulic cylinders implies a considerable risk of flooding of the plant rooms.

COSTS

The cost estimate submitted is broken down as required in the competition brief. Generally, the estimate is believed to be too optimistic, and a number of the unit prices stated are believed to be too low. Likewise, the amount set aside for contingencies is considered insufficient in the light of the early stage of the design.

CONCLUSION

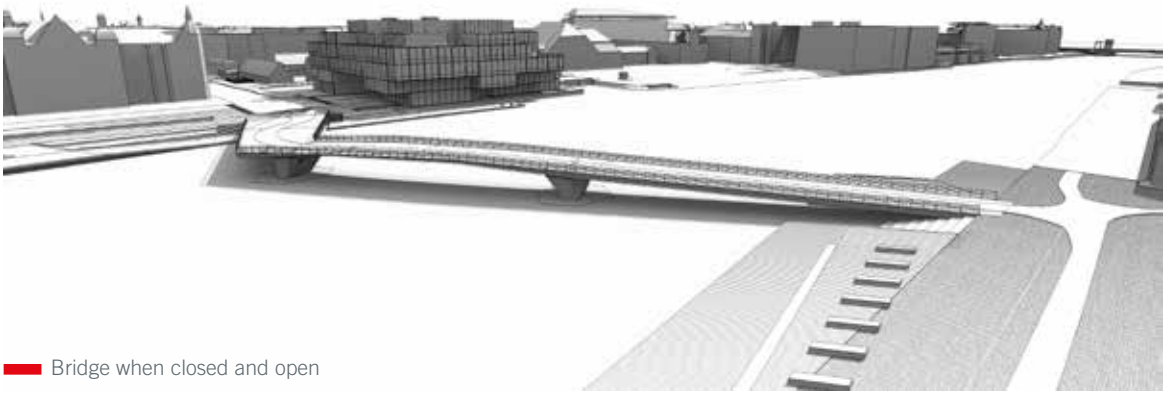
The assessment panel found the overall concept presented in this entry interesting and noted that the 'bend' creates spaces in the harbour basin in front of the Brewhouse Site while at the same time continuing the trajectories of Vester Voldgade and especially Langebrogade. However, the panel was not convinced by the layout of the bridge deck with the cycle path laid out as a freely shaped element in the surface. The architectural consistency appears unresolved.

The assessment panel noted the entrant's good intention of reducing the number of bridge piers to the two piers that support the opening spans, but also found that an implication of this design is regrettably a relatively large cross-section and a consequent minimal height clearance.

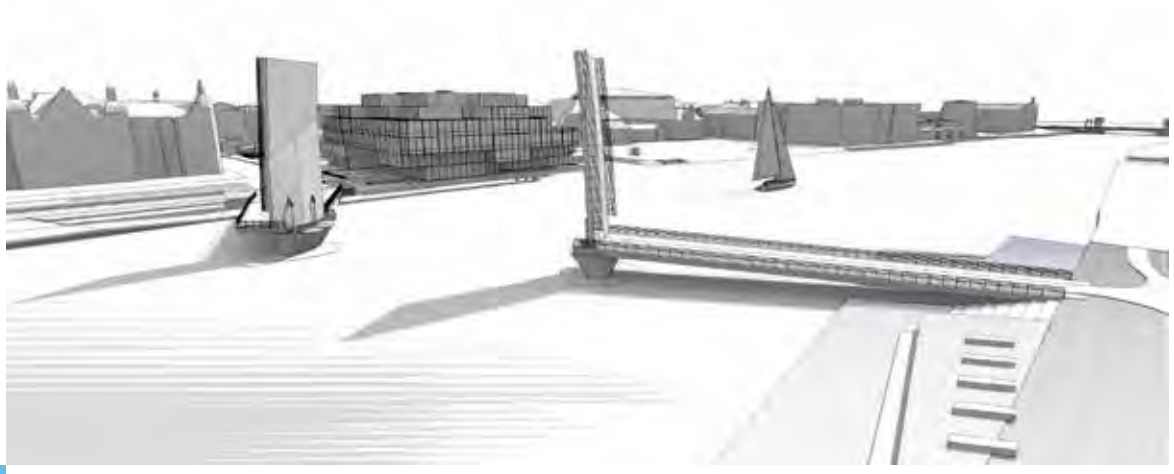
The panel looked favourably on the entrant's proposals for spaces for rest and relaxation along the waterfront. However, the descriptions of the new idiom that is to create an open unobstructed space for cyclists and pedestrians is not adequately illustrated relative to the serious problems that will occur where flows of pedestrians and cyclists cross.

Furthermore, the assessment panel found the two abutments too complex for the site and the context. In addition, the abutments are not included in the cost estimate and are thus 'options' that will add to the budget set aside for the project.

Those are the reasons why this entry was not selected for participation in the negotiated procedure.

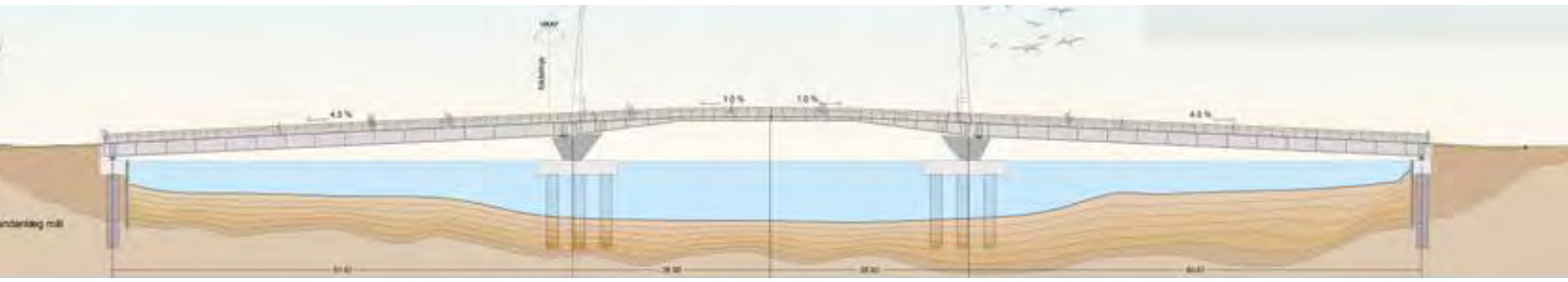


Bridge when closed and open



Plan

Longitudinal section

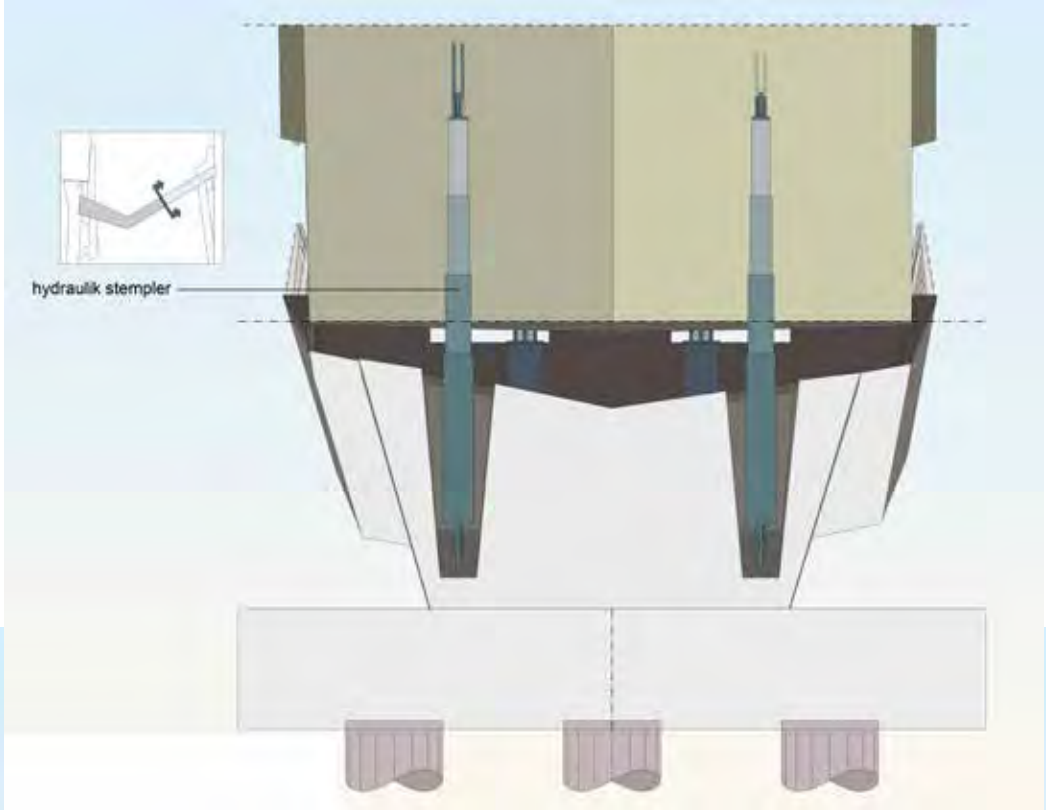


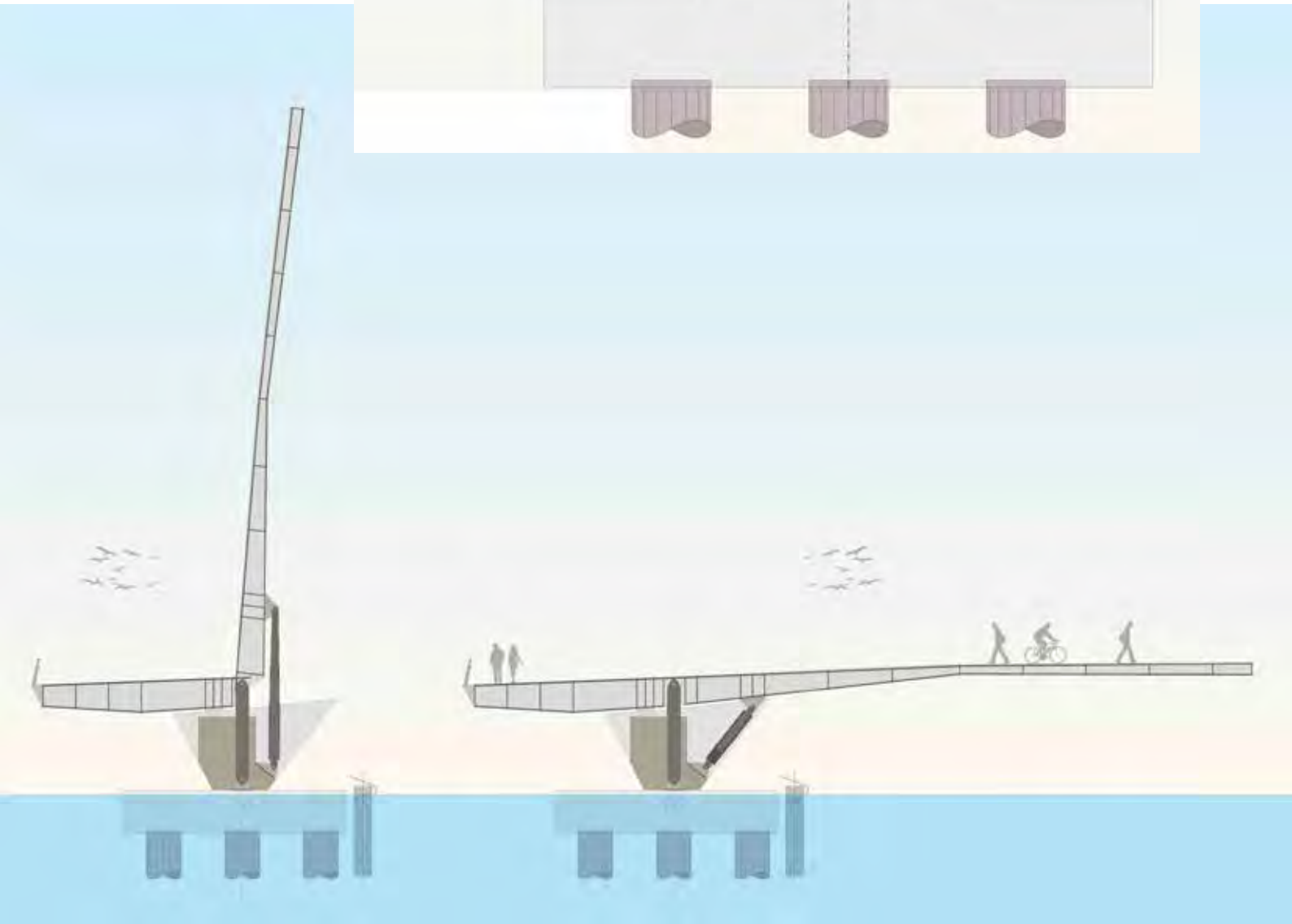
Western bridge abutment

Eastern bridge abutment

Visualisation of evening scenery

Structural design





ENTRY 5 / 13113 PARTICIPANT STAGE 1

TEAM **TRACTEBEL ENGINEERING**

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GENERAL REMARKS STAGE 1

Using the phrase 'a boat is the best vantage point', this entry defines itself. It is 'a bridge that provides many new spectacular possibilities' and 'shows the sky and the horizon'.

In the words of the entrant, this bridge 'does not offer the shortest distance between the quays on either side; instead it is a pleasant cycle and pedestrian route'. Conceptually, the bridge proposed is exceptional: it features two spans that open by rotating on individual supports, whereby the desired navigation passage is obtained.

Combined with a desire to comply with the required gradient of 45‰ and to align the bridge structures with the top level of the quays, this layout results in a bridge so long that it takes up more space than is available and conflicts with the requirements set out in the competition brief concerning the line of the bridge.

The relatively sharp angles between the bridge and the quay at both sides of the harbour basin and the orthogonal bend at the middle of the bridge not only make traffic difficult, especially for cyclists, but also communicates difficult accessibility to bridge users. In this connection the assessment panel discussed safety in relation to the design of the road barrier and the open wedge between the quay and the bridge that is created when the bridge opens. The panel looked favourably upon the simple strength of the concept and the well prepared and detailed design presented in this entry, but considered the organisation of spaces and the bridge line too problematic.

LAND INSTALLATIONS

The bridge spans the harbour basin between the two quays and lands at the current terrain level. Thus the waterfronts are kept free of obstacles, open passage is created along the harbour basin and the two spaces to the east and west retain their characteristics. The panel was favourable to this idea which provides full accessibility for cyclists and pedestrians both across and along the waterfront promenades. Howe-

Location plan

”Conceptually, the bridge proposed is exceptional: it features two spans that open by rotating on individual supports, whereby the desired navigation passage is obtained.

ver, this potential is also the weakness of the proposed design, as it is not compellingly utilised. The abutments appear relatively random and do not specifically meet the requirements of the competition brief for the location of the bridge in relation to the historical axis and traffic flows. The boomerang shape of the bridge make passage of the bridge unnecessarily long, which is particularly true of access via the Langebrogade street, and the sharp corners on the dual-direction cycle path are difficult to negotiate for cyclists.

A classic urban space is created on the quay at the eastern abutment. Different types of distinctive trees similar to those on the ramparts will be planted in this space, and an urban space that attractively becomes part of the identity of the site is thus created.

PEDESTRIAN AND CYCLE TRAFFIC

Cyclists and pedestrians are separated by a 60 cm high steel beam on the bridge, which ensures a high level of traffic safety for both groups of road users. The dual-direction cycle path is located on the southern side of the bridge where it causes a minimum of conflicts between pedestrians and cyclists at the western end of the harbour space, as the vast majority of pedestrians will be heading north or towards Vester Voldgade. The line of the bridge with its sharp bend at the middle and the oblique lines of the abutments on the quays will present challenges to the flows of cyclists. The 3.8 metre wide pedestrian area is wider than stated in the competition brief and provides good conditions for pedestrians.

The entire bridge must be vacated for it to open, which may be very time-consuming and mean that cyclists and pedestrians will have to wait on the quays. They will be held back at the waiting areas by road barriers whenever the bridge is about to open. The road barriers are not illustrated in the entry.

BRIDGE TECHNOLOGY

The entry features an unconventional but technically simple five-span bridge across the harbour basin with two almost identical rotating spans cantilevered above the navigation passage.

The bridge superstructure is a central closed box girder on which two cantilevered bridge decks are installed. The decks are installed on each side of the box girder, which means that the girder will be visible on the bridge decks and serve to physically separate cyclists and pedestrians. The height of the box girder varies along the length of the bridge deck, from 0.7 metres where the two bridge decks meet to about 3.0 metres above the outermost supports at the navigation passage. The total cross-section width varies between 8.5 m and 9.5 m.

The opening of the spans will be done by means of a horizontal hydraulic cylinder fixed to the quay and the bridge deck. The cylinder makes it possible to rotate the bridge spans around a 'pivot pier' whose only purpose is to keep the bridge span in place when the bridge opens. Pumps and other technical devices needed for the cylinders are located in a plant room on the quay, close to the cylinders.

Each bridge span is supported by two curved horizontal steel 'rails' where the bridge deck rests on a frame structure with pairs of wheel bogies running along the 'rail'. The supports rest on circular (steel) piles. The pivot pier and the counterhold for the hydraulic piston are made of concrete. The entry contains no description of corrosion protection (paint and coating). Likewise, there is no description of self-excited vibration, but it is stated that this matter has been investigated and that there will be no problem complying with the requirements formulated.

The entry contains no detailed description of foundation principles, but the foundations illustrated appear to be hollow steel piles founded in the limestone.

Railings are illustrated as vertical sceptres and horizontal stainless steel elements (steel profiles and wires).

The bridge elements will be sailed to the site and lifted in place once the supports and abutments have been completed.

The assessment panel looked favourably upon the simple strength of the concept and the well prepared and detailed design presented in this entry, but considered the organisation of spaces and the bridge line too problematic.

OPERATION AND MAINTENANCE

The primary costs relating to future operation and maintenance of the bridge illustrated in this entry will be associated with the following overall elements: Machinery for the operation of the opening bridge spans, surface treatment, bridge deck surfacing.

The proposed solution with a single simple hydraulic cylinder for each moving span combined with a closed plant room on the quay will be a good basis for optimal operation and maintenance of the machinery. The rolling support with rails should be executed with a strong focus on subsequent maintenance. The rails should have a replaceable top layer, preferably of stainless steel. Similarly, the wheels should be robust and roll on closed bearings to keep maintenance to a minimum.

The assessment panel recommends corrosion protection (and believes the entrant has had such protection in mind). The protection should be in the form of surface treatment of exterior surfaces and hermetic sealing of the box girders, as this would provide a good basis for optimal maintenance. A high-class paint system of corrosion class C5-M should be used, preferably after priming with a metal spray. Such protection would increase construction costs but also ensure a maximum lifetime of the surface treatment.

The deck surfacing should be a type-approved resin with an anticipated lifetime of about twenty years.

ASSESSMENT OF BRIDGE TECHNOLOGY

The technical solution proposed is interesting. It ensures that the requirements applying to the bridge opening are met in a simple way.

The structural principles proposed for the bridge superstructure are simple and well known. The central box girder will be subject to torsion and extensive anti-torsion bracing is likely to be necessary on the inside of the girder. The structural heights indicated in the entry seem realistic, but a thorough analysis of the bridge dynamics is required. It should be noted that the assessment panel did not find the cross-section design suitable for possible installation of tuned mass dampers if such dampers are deemed necessary. The bridge will be highly sensitive to subsidence of its supports, and a strong focus on tolerances is necessary. The design of the steel frames with the wheel bogies must allow both vertical and horizontal adjustment. It is also necessary to ensure that all supports, including the pivot piers, are well protected against ship collision loads.

The assessment panel would have liked to see a description of joints/connections between the two bridge spans and between the bridge spans and the edge of the quay, as both places must be able to cope with horizontal variations (primarily caused by temperature variations). The principles for draining the bridge are unclear and should be further described.

COSTS

The cost estimate submitted is very rough and contains no quantities or unit prices, which made it difficult for the assessment panel to assess it.

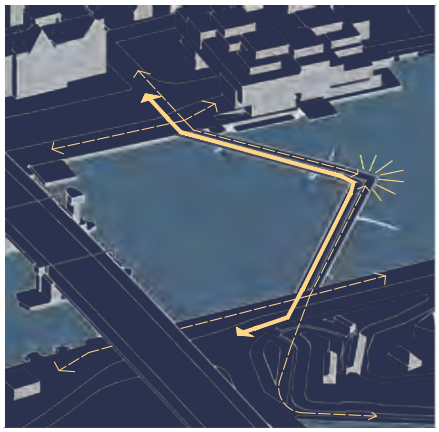
CONCLUSION

The assessment panel looked favourably upon the simple strength and careful consideration and detailing that characterise this entry, but also considered the proposed 'space organisation' and bridge line too problematic.

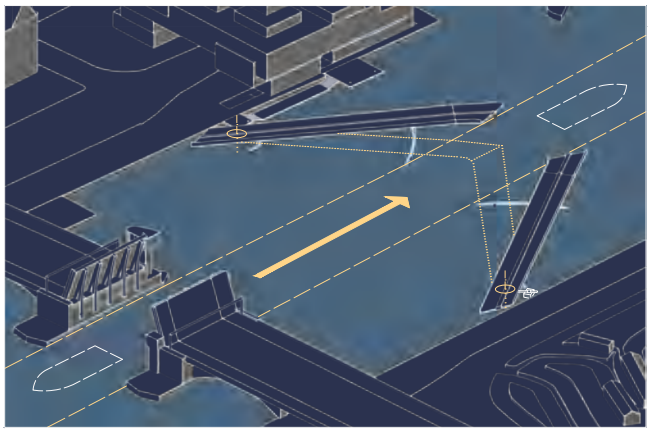
The abutments seem random and do not specifically meet the requirements set out in the competition brief concerning the location of the bridge in relation to the historical axis and the traffic flows at the site. The boomerang shape of the bridge makes the passage of the bridge unnecessarily long, especially as far as access via the Langebrogade street is concerned, and the sharp corners of the dual-direction cycle path will be difficult to negotiate for cyclists.

The entire bridge will have to be vacated before the bridge can open, which may be very time-consuming and will mean that cyclists and pedestrians will have to wait on the quays.

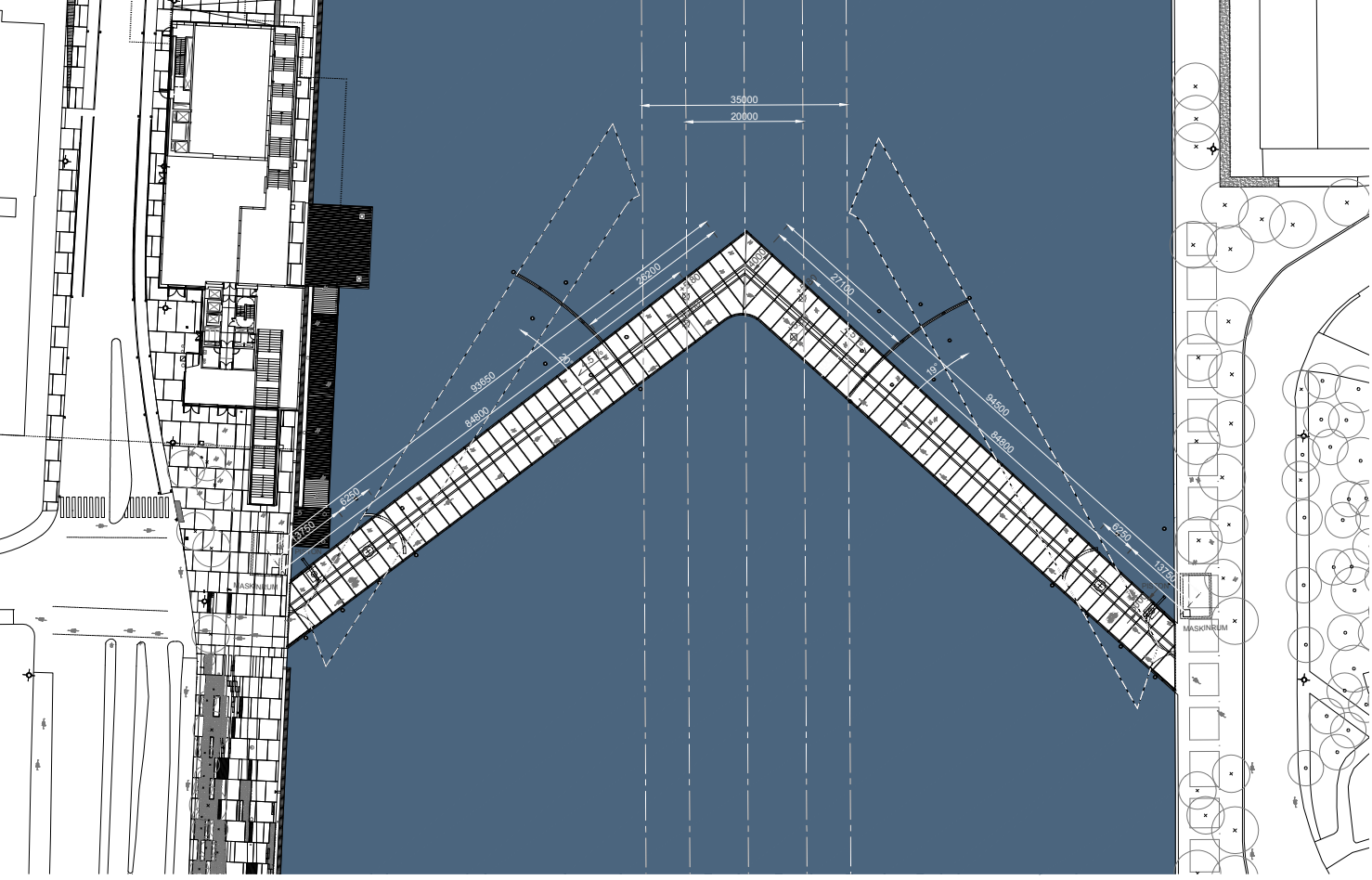
For these reasons, this entry was not selected for participation in the negotiated procedure.



Traffic flows

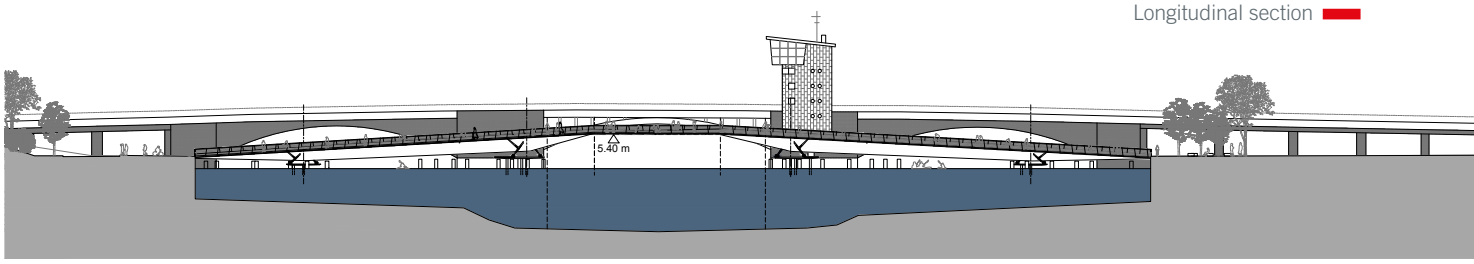


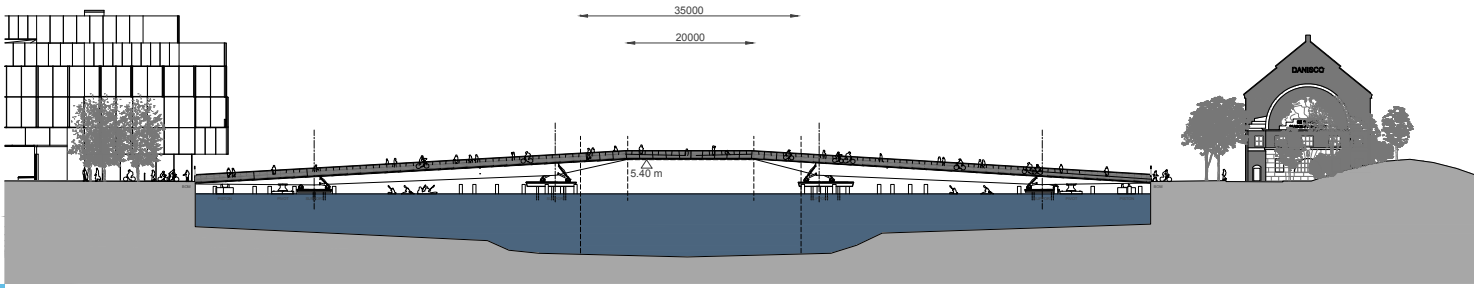
Bridge opening

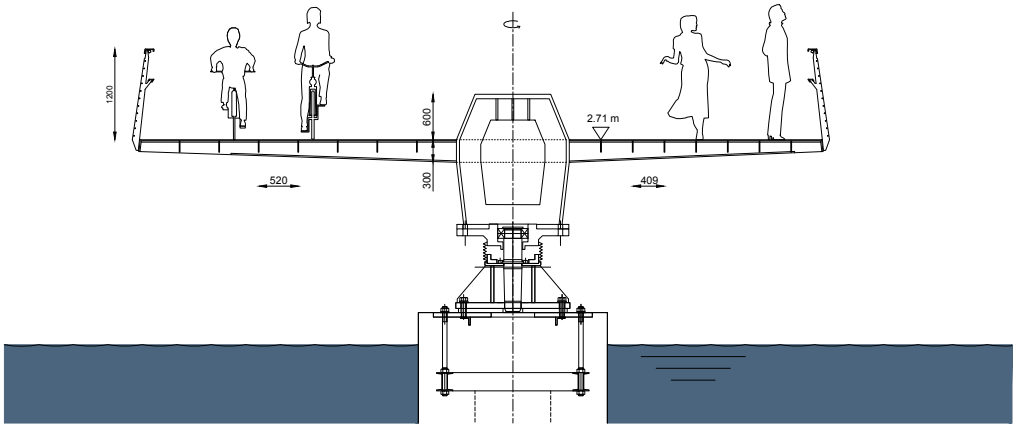


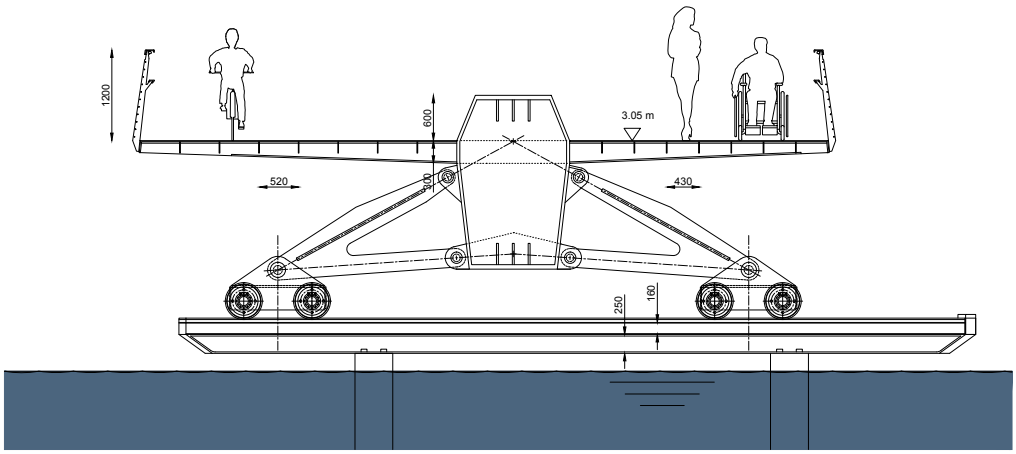
Plan

Longitudinal section






1200
600
300
2.71 m
520
409


1200
600
3.05 m
520
430
250
160

Western bridge abutment

Eastern bridge abutment

ASSESSMENT PANEL'S
SIGNATURES

COMPETITION
The competition was announced and implemented by **Realdania** together with the **City of Copenhagen** and Arkitektkonkurrencer.dk.

ASSESSMENT PANEL REPORT
The assessment panel report is prepared with contributions from:

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Lisbeth Westergaard (independent assessor)
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Realdania

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Illustrations: The participants
Aerial photos: Dragør Luftfoto

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