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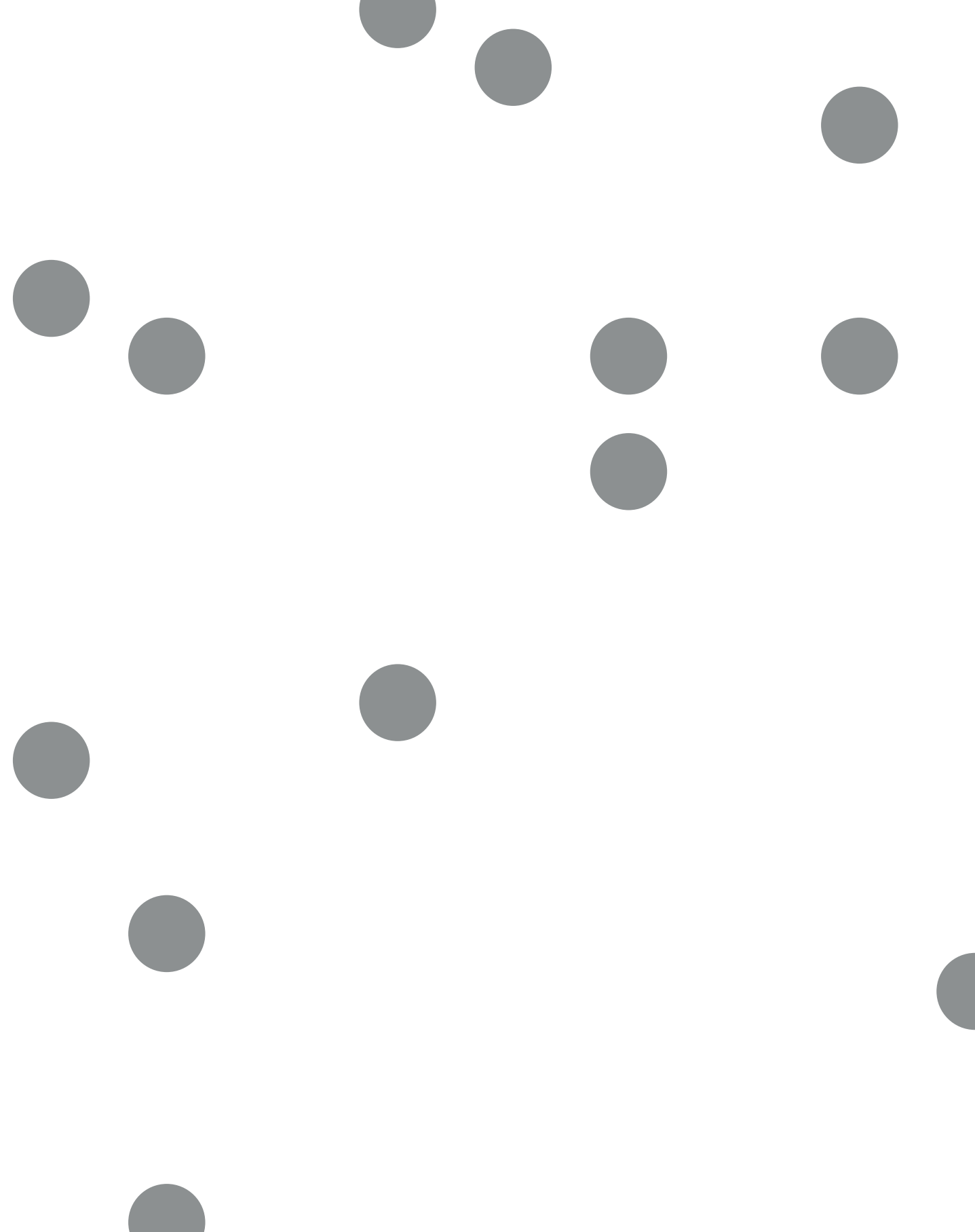
# SILLO

New facade for north Copenhagen

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# THE SILLO

New facade for north Copenhagen





## Preface

The Silo is part of the transformation of Copenhagen's North Harbour, a vast post-industrial development that is creating a new city district. Designed by COBE with clients Klaus Kastbjerg and NRE Denmark, this former grain storage facility, the largest industrial building in the area, has been reinvented as 'The Silo', housing residential apartments and public functions.

We wanted to retain the spirit of the original silo as much as possible, both in terms of its monolithic exterior and majestic concrete interior, by simply draping it with a new overcoat. The aim was to transform it from the inside out in such a way that its new inhabitants and the surrounding urban life would highlight the structure's identity and heritage. Hence the use of batch galvanized steel for the facade, which patinates in a raw way and retains the original harbour character and material feel, lending a roughness and raw beauty to the area, as in its industrial past.

COBE has been pleased to cooperate with the European General Galvanizers Association and Isabelle Priest to publish this project report following the The Silo's success in the 2018 Global Galvanizing Awards.

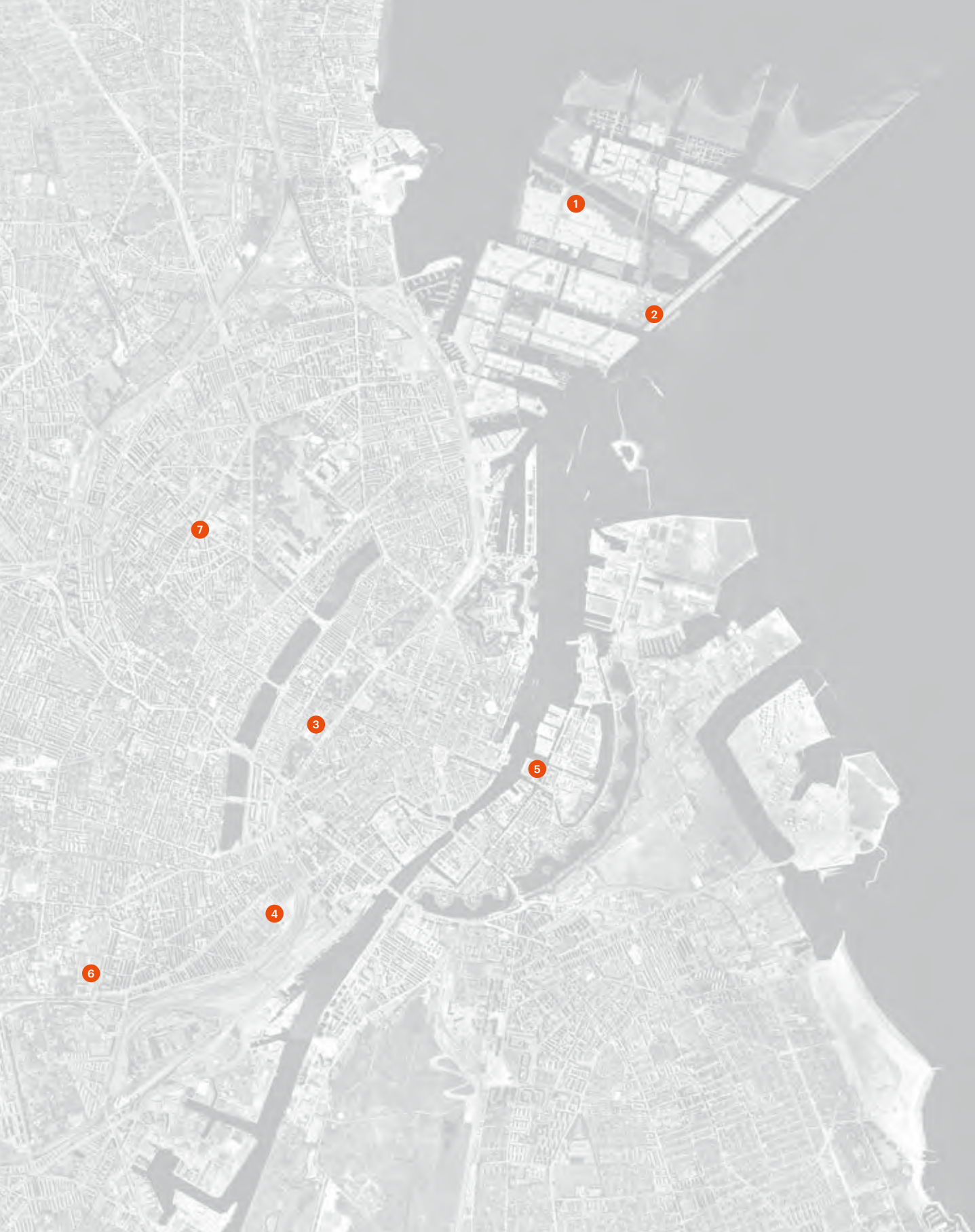
Dan Stubbergaard, Founder and Architect, COBE



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This is a PDF version of a printed publication. The page numbering in this version differs from the printed publication as some pages have been deleted for clarity and ease of printing. For a copy of the printed publication, contact your national galvanizers association or visit [www.egga.com](http://www.egga.com).



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## Copenhagen's regeneration

Copenhagen is a rapidly changing city. On average, since the mid 2000s, 1000 new people have come to live in the Danish capital every month. In 2015, it was even more by almost 50 percentage points, with 78,510 additional arrivals into the wider urban area.<sup>1</sup> According to the latest figures from the government's statistical service, 793,501 people now live in the city itself, and as a result of growing urbanization the figure is only expected to rise: to 882,201 by 2030 and to 952,267 by 2045<sup>2</sup>.

Copenhagen is also a city that has also seen its fortunes change. Favourable tax regimes for foreign workers have encouraged an influx from overseas, as well as investment and regional bases for international companies. And as budget airlines have transformed the skies, Copenhagen – along with places such as Lisbon and Prague – has emerged from being a second tier European capital that fewer people visited, passed through or spoke of, into sparkling destinations in its own right.

Copenhagen has become known in particular for its continent-wide cultural impact on food, design, architecture, planning, social welfare and reform. Between 2009 and 2016, it saw an 8.1% increase in travellers, one of the largest rises for any city in Europe<sup>3</sup> – and, as with its inhabitants, ever increasing numbers are expected, adding to pressures on accommodation, facilities, public space and infrastructure. Buying and renting housing in Copenhagen is expensive. All this means that, although the recent population boom has only just restored levels to 20th century peaks, after 20 years of decline from the mid 1970s, there's now a housing shortage.<sup>4</sup>

The depopulation of the countryside is a growing political issue. People who would have traditionally moved to the suburbs, such as those with young families, are staying put and retirees are moving back into city centres. To the Danish, this represents an increasing crush. Thrown together in a short space of time, these issues present a logistical headache for this famously organized and careful nation.

However, whereas some countries might bury their heads in the sand in the face of such monumental and conflicted challenges, or over promise and under deliver, Copenhagen is taking a proactive approach by restructuring the city in

### Copenhagen city map

- 1 Nordhavn
- 2 Cruise ship terminal
- 3 Nørreport
- 4 Meatpacking District
- 5 Paper Island
- 6 Valby
- 7 Nørrebo

preparation and developing multiple new inner city districts through an extensive agenda of building works stretching to the year 2060. The transformation of the former Meatpacking District, for example, into a foodie and creative hub is one of Europe's recent urban regeneration success stories. Meanwhile, Carlsberg's former 33-hectare production site in Valby is set to become a neighbourhood of 10,000 inhabitants by 2025. To a masterplan by Danish architectural firm Entasis, 3000 apartments will be slotted into and between the historical buildings and follies that characterized the brewery site as a whimsical urban playground. Nine new residential towers will forever change Copenhagen's typically low-rise skyline – the tallest at 120m.

While this particular site is being redeveloped by Carlsberg Byen, a conglomerate of five private companies, many of the city's largest development sites are on former publicly owned land along the waterfront. These have been rezoned for residential and commercial use and transferred to the Copenhagen City and Port Development Corporation, which is now managing their regeneration. The organization was started by former mayor Jens Kramer Mikkelsen during his tenure from 1989 to 2004 to help turn around the city's decline at a time when unemployment was 17.5%. However, the corporation remains 95% owned by the city, the remainder by the nation, allowing its profits to be reinvested in the city, including for the establishment of a metro system.

Cycle for 10 minutes north of Copenhagen's city centre and you will soon find yourself in one of these new developing districts. Here in Nordhavn, meaning north harbour, construction dust clouds the air and temporary portable buildings are stacked up beside makeshift car parks filled with contractor vehicles. Dozens of small cranes are lifting windows into position, helped by truck-mounted boom lifts on the ground. A new metro line passes overhead, the odd cyclist makes their way through on sketched cycle lanes. Hoardings illustrated with enticing visions of the future encircle the many plots yet to be commenced, interspersed by wharfs bristling in the clear water. Today every vacant square metre of the city is being remade for housing. Trucks rattle by transporting fresh supplies or removing waste. In the distance, past the playful international school designed by CF Møller, the working container port continues – for now.

Copenhagen's strategy over the coming decades is to relocate



Exterior of Copenhagen International School, Nordhavn, designed by CF Møller (2017).

Exterior of Copenhagen Terminal Building, Nordhavn, designed by Christensen & Co Architects (2014).







Interior of COBE's office in a converted warehouse, Nordhavn.

its historical industrial areas, which have traditionally buffered the city centre's relationship with the sea, and reallocate them for more profitable and urgent use. The logic is twofold: first to create new residential, social and commercial districts close to the centre to help solve the bulging population issue while giving people convenience. And second, to relocate heavy industrial functions further away from where people live to reduce the overall exposure to noise and air pollution. Whereas the city previously turned its back on the waterfront, now it is being exploited as its best asset. This second aim is part of a progressive and conscientious city-wide focus on sustainability in preparation for Copenhagen to become the world's first carbon neutral capital by 2025.

Like the majority of other sites within the remit of the Copenhagen City and Port Development Corporation, including Paper Island, Nordhavn is one of these post-industrial landscapes, but at 2km<sup>2</sup> it is by far the biggest. The area developed as a port in the 19<sup>th</sup> century and greatly expanded into the Øresund Strait that separates Denmark from Sweden in the post-war period through progressive projects that reclaimed land from the sea, turning it into a vast peninsular.

The industrial harbour visible in the distance has itself already been reduced and relocated north onto more reclaimed land created using soil from the establishment of the metro system in the early 2000s. The cruise ship terminal was moved there too, into a series of buildings designed by Christensen & Co Architects along a 1200m-long pier.

Towards the middle of this busy landscape, in the last row of historical warehouse buildings, COBE – the area's masterplanner – has just converted a mid-century warehouse into its new office. The practice was jointly appointed with Sleth + Polyform by the municipality after an open competition in 2008 to address the future of Nordhavn and how it would look.





'One man's trash is another man's treasure' graffito in the Nørrebro district of Copenhagen.

## COBE's background

COBE's vision for the area was for a mixed urban district bordered on three sides by water and intersected by it. New canals connecting existing wharfs will give the feel of a city of islets, with people having maximum access to the waterfront. Excavations are underway, as is a new wooden promenade skimming the water's surface that will allow residents to lounge alongside it, as well as jump in and swim. In all, the Nordhavn masterplan will provide housing for 40,000 inhabitants as well as workspace for another 40,000, interwoven with public squares, pocket parks, green corridors and cultural, leisure and retail facilities with a lot of public realm at ground level to keep the area animated at night. Cars are being deprioritised in favour of collective parking lots and street layouts are designed to be longwinded for drivers but quick for pedestrians and cyclists, as well as easily accessible by public transport. The majority of the site will be built or rebuilt in the process.

The practice, which now employs 150 people, was founded in Copenhagen in 2006 by Dan Stubbergaard to have an emphasis on creating social interaction at three scales – architecture, public space and urban planning. Its work encourages an all-encompassing urban landscape involving practical, economical and environmental considerations and comes out of particularly Danish ways of urban thinking that focus on recreation, comfort, bikes and public transport. At its project to redevelop the public space around Copenhagen's main transport hub Nørreport, the firm employed its 'urban living room' concept to intertwine public and private space in exciting ways for the enjoyment of inhabitants and visitors. Meanwhile its 2015 Frederiksvej Kindergarten lays out 1700m<sup>2</sup> of nursery space as a miniature village for children across multiple buildings.

However, COBE's way of working is always to start by scrutinizing what already exists in an area – its urban, social, cultural and architectural context – as well as listening to its future users. As described in the practice's recent book *Our Urban Living Room*, another area of its work revolves around the maxim 'One man's trash is another man's treasure', which Stubbergaard saw inscribed on the gable end of a building in the district of Nørrebro.<sup>5</sup>

Consequently, at Nordhavn, with the industrial history of

Denmark slowly disappearing and being replaced all over the city, the practice has sought to keep as many of the old port buildings as possible in the new masterplan. Learning from the failed major European redevelopment projects of the 1950s and 60s that swept away swathes of city in favour of a completely new architecture in a completely new, zoned urban plan, the agenda emphasizes the importance of preserving former iterations of the city and the architectural heritage of the industrial age. The goal is to give regeneration areas a feeling of continuity and connection to the older city, rather than places that need to struggle to build an identity from nothing. Warehouses, customs buildings, offices and terminals have been scheduled for redeployment – against the wishes of many of the land’s original owners who would have preferred them to be demolished.

One such building was a 59m tall, 13 storey concrete grain silo, formerly owned by Danish agricultural cooperative DLG. It ceased use in the 2000s and had become derelict by 2008 – its machinery abandoned and its silos filled not with grain but pigeon muck building up over time. Together with its ‘little sister’ grain silo attached by high-level lean steel bridge behind, and a separate double circular-plan silo on the opposite side of the wharf pier, COBE identified these buildings as possible landmarks for the area that could continue the existing urban grain. In a future district nearly all built from scratch, they would stand taller than the majority of upcoming development around and thread together past with present.

‘We wanted to keep some of the history and soul of the area,’ explains Caroline Nagel, project director and architect at COBE who worked on The Silo, as it has become known, since the beginning. ‘Nordhavn will be a mix of existing structures which previously had another meaning but are transformed.’

Opposite: The DLG silo and its ‘little sister’ silo perpendicular to it viewed before conversion from the opposite side of the wharf.

Next page: The two silos were very similar in construction, made of concrete and connected by a high level bridge.





HYADRIKKER MØLK



'What does Molr drink?' asks  
the graffito on the DLG silo  
before conversion.





## The Silo building history

In 1958, when the DLG silo was built by engineering firm LBT, Konsulterande ingenjörer och arkitekter, its purpose would have been to hold as much wheat as possible in the 16 clean, dry and secure vertical storage tubes behind its cold, blind concrete walls. Freight vehicles would have funnelled off grain at the base. In a part of the city not visited by most people, it would have stood with its six-storey office in a watery landscape of oil storage tanks, gas cylinders and dockside gantries. All around cargo ships would have been importing and exporting goods across the globe – the port is a gateway to the Baltic States in particular. Within that view, the DLG silo wouldn't have been considered a thing of beauty but of pure engineering.

By the time of COBE's masterplan in 2008, however, the mood had changed. Architectural photography duo Hilla and Bernd Becher had enchanted architects since the mid 1960s, showing how 'pure engineering' or 'form follows function' could have such a variety of guises. Their vertical, front-on, stripped back, stated 'objective' approach to photographically cataloguing and categorizing everything from water towers and blast furnaces to gas tanks preserved the memory of industrial structures and transformed them into art.<sup>6</sup> No serious industrial regeneration project could be drawn up without reference to the Bechers' work, which had already saved the Zollverein Coal Mine Industrial Complex in Essen, Germany, from demolition in the 1990s.<sup>7</sup>

The DLG silo, likewise, had become something of an icon on the Copenhagen skyline. It was one of the city's tallest buildings and a representation of its diminished industry – in an area that awaited its fate. The building had also earned a cherished place in Copenhageners' hearts for the huge black inscription that had mysteriously appeared on it some decades before, 'HVADRIKKER MØLR', meaning 'What does Mølr drink?', with its amusing echoes of 'øl' (beer).

With no consensus on to what extent the late industrial building complexes deserved to be preserved as historical landmarks and identity markers, or how, it would have been easier and more economically attractive to demolish the silos as part of the masterplan. Yet, contrary to initial beliefs that they would be a burden on future development, when it came to the Phase 1



Opposite: DLG's silo has been cloaked with a galvanized steel facade ready for its new life in the mixed use neighbourhood that is emerging all around it.

Nordhavn plots being split up and sold to private developers, they were the first to be snapped up. The circular one, one of the first projects to complete in the new district, was bought by NCC and redesigned by Danish practice Design Group Architects into 12,000m<sup>2</sup> of commercial space in 2014 to a design that evokes MVRDV's Frøsilø (2005), elsewhere in the city. Praxis Arkitekter turned the 'little sister' silo into housing in 2017.

Unionkul, a development company directed by Klaus Kastbjerg, a long acquaintance of Stubbergaard, bought the 'big brother' DLG silo. Kastbjerg has built a career on transforming former industrial land bought relatively cheaply, and together the companies are also working on another of Copenhagen City and Port Development Corporation's regeneration areas, Paper Island. In 2013, Kastbjerg invited COBE to develop ideas for the DLG building, which at the time had been designated in the local plan as having a possible public function, such as a climbing centre, in order to make use of the unusual honeycomb-like grid structure inside. Only the highest northern-most part on the edge of the wharf, the 13-storey machine tower, was intended for housing.

However, by the time COBE looked again at the building, alongside five others it is designing in the Nordhavn masterplan, an opportunity to change the local plan had emerged. Instead, it proposed sandwiching housing between public functions at the top and bottom: a gallery on the ground floor with an exhibition about the development programme for the district, and a public restaurant and bar with 360° views on the 17<sup>th</sup> floor.

COBE's dilemma, however, was how to transform the silo into a new urban anchor point that would function as high-end contemporary housing while confessing to and retaining the building's original solid, yet elegant and slim, robust closed character. After all, for his new apartments the client wanted big windows with big views and balconies with glass balustrades as well as all the necessary thermal comfort. For inspiration, the architect looked at many converted structures, including Ricardo Bofill's Factory in Barcelona (1973) that transformed an old cement plant with 30 silos and vast machine rooms into a house and studio.

Ultimately, COBE decided that the way to capture the spirit of the building and most effectively disseminate its architectural heritage was to keep the spaces inside as close as possible to

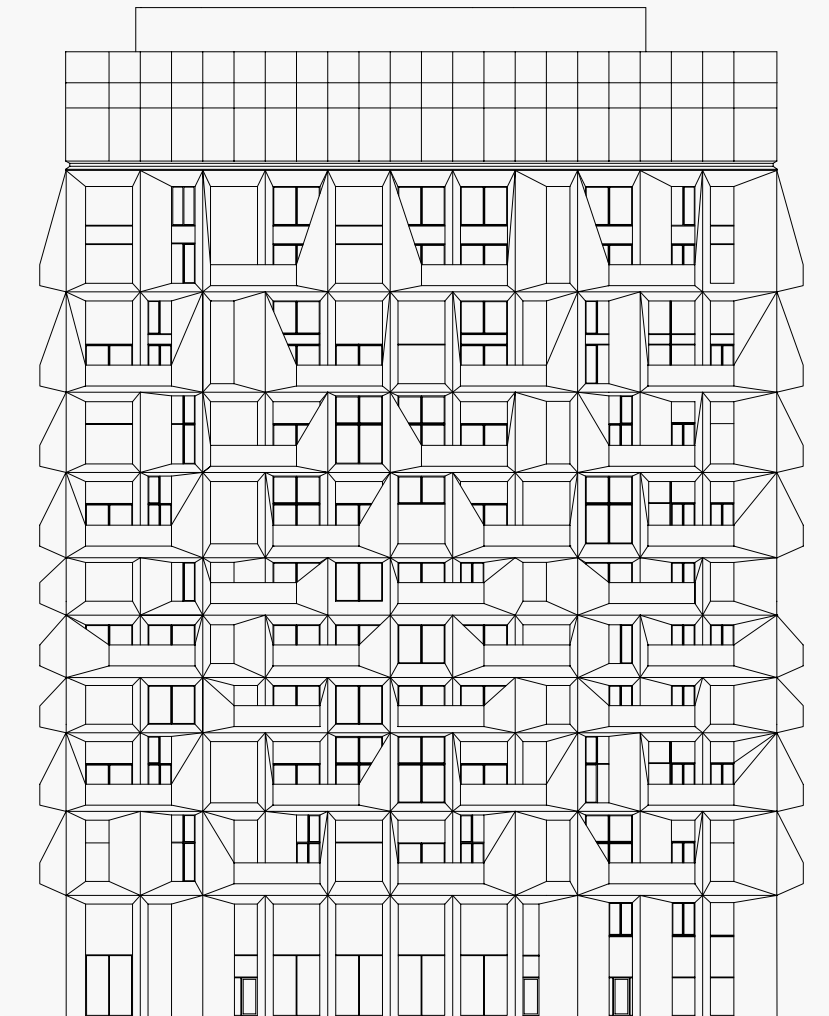
La Fabrica, Barcelona, designed by Ricardo Bofill Taller de Arquitectura (started 1973). The project transformed an existing factory into a house and architectural studio.



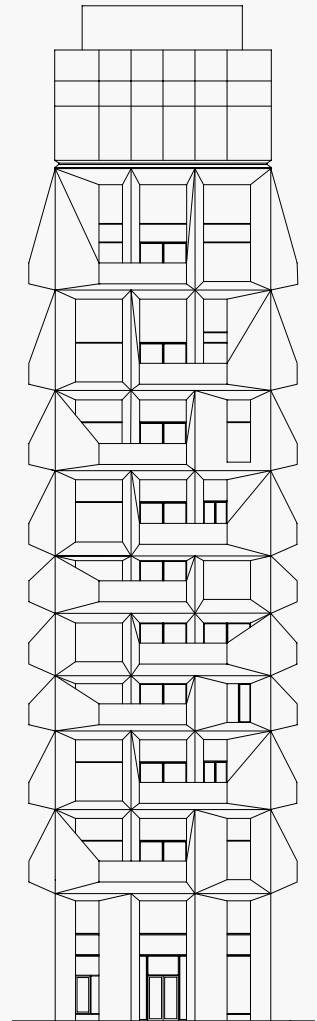
their original state, tall and concrete, because the same kinds of spaces would never be built now. On the exterior, however, the idea emerged to give the building a new thermal cloak or climate screen skin that would integrate the balconies to appear as one element and look as closed as the concrete had behind. There wasn't a single moment of inspiration, but once COBE realised the facing material needed to be flexible and lightweight to do that, the project architects quickly came to metal and galvanized steel, for which The Silo has become a tour de force.

Opposite: The galvanized steel cladding wraps around the projecting balconies, enveloping the building in a single skin that is reminiscent of the silo's previous robust and solid character.

East elevation



North elevation







## The Silo exterior

Walking through the developing neighbourhood of Nordhavn today, the three silos stand complete and above construction taking place at their feet. The old mix of ancillary industrial buildings in between – loading bays, depots, mechanical plants – has been swept away, introducing a network of new streets, passages and city blocks. The high-level bridge that joined the two perpendicular silos is gone. Progressing from Copenhagen's city centre, new trees are flourishing, buildings are beginning to sparkle, construction sites dwindle the further one goes. Individual three-storey houses give way to low-rise apartment blocks with communal entrances – stepping up again for The Silo and its former little sister, which are not so similar any more. Urban variation comes in the form of cantilevered balconies, deep loggias, stippled rendering, brown brick, charcoal and black. Almost every block has been designed by a different architect, while still adhering to a strict language of 90° angles and pared back facades.

The Silo, with its sharp triangular wind-protecting wings to its many terraces and squat levels interspersed by tall ones, breaks the rhythm of this otherwise orthogonal urban pattern. The final building has been stretched in all directions in proportion to its original form so it is hardly noticeable. The once-protruding tower is levelled off horizontally with another layer of apartments, its precast concrete panels hidden behind its shimmering, changing, galvanized steel facade. Like Herzog and de Meuron's Tate Modern in a former London power station, a glass box housing the restaurant on top reflects the changing sky during the day and becomes a lantern at night.

From a distance, the building appears light against lower, dark development – as forecast in the city plan. The shadows cast by its angular multifaceted facade are so crisp that the building looks as much like a blown up rendered drawing in real life as it does in photographs – even when not in the sun. Colourful reflections from the wharf to the north and buildings around create a psychedelic complex of overlapping shadows that add character to the surface. The facade has a continuously changing crystalline urban effect that contrasts with the matt all around. Its original monumental appearance lives on. Get closer, and the variations become more profound. Patterns of perforations in the protective balcony wind shields and balustrades play a flickering game from transparency to opacity. The patina of the building's surface glistens.

Opposite: Aerial view of The Silo, taller than its neighbours and lighter in appearance.

Next page: The light effects across the new galvanized steel facade changes in tone and luminosity throughout the day and night, picking up the fluctuating effects of the sky, weather and water – from bristling white to dusty iridescent pink.







## The Silo interior

Inside is a labyrinth of gargantuan Piranesi-esque concrete spaces laid out to a 4.5m grid. The original structure is significantly intact. Individual silo cylinders have been cut through, the tower enveloped and brought into the larger body of the building, its 13 floor levels pulled through to divide the former granary tanks. Each ceiling height, dependent on the previous machinery on each floor of the tower, is preserved, resulting in enormous variation from 3.5m to 8m. New mezzanines have been inserted in the cathedral-like heights to create duplex apartments. On the ground floor, the exhibition space and communal apartment entrances retain many of the silo's industrial contraptions. As with the Nordhavn plan itself, COBE's approach has been to demolish as little as possible.

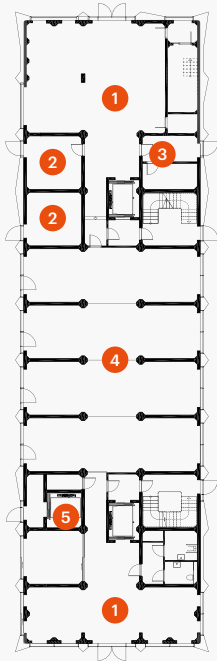
Above, nearly all of the 42 apartments are unique, varying in size from 80m<sup>2</sup> to 200m<sup>2</sup>, with a maximum of three to a floor. Apartments at the north and south ends have three external sides. Rooms divide comfortably between the 4.5m square grid. Acoustic insulation is concealed in special new cast floors and white plaster ceilings. Windows and glazing are set onto the building's original exterior, so when viewed from the inside openings appear frameless. Not discernible from the exterior, terraces project a huge 2m and are at least 8m long, adding a minimum extra 16m<sup>2</sup> to the living area.

Potential buyers could choose between bare apartments to fit out themselves, or subscribe to a package of finishing options offered by Union Kul, resulting in a cacophony of styles visible through the windows. An additional three apartments were interior designed by COBE too. In those a concrete fetish reigns, continuing the architectural language of Jens Casper and Petra Petersson's 2003 conversion of the Reichsbahn bunker in Berlin into a home and public gallery. The aggregate in the exposed cut-through concrete walls sparkles like terrazzo. At DKR 22 million (€3 million), these are some of the most illustrious and unusual homes marketed in the whole of Copenhagen – attractive to those emerging types of Copenhagener with changing fortunes, from Denmark or overseas.

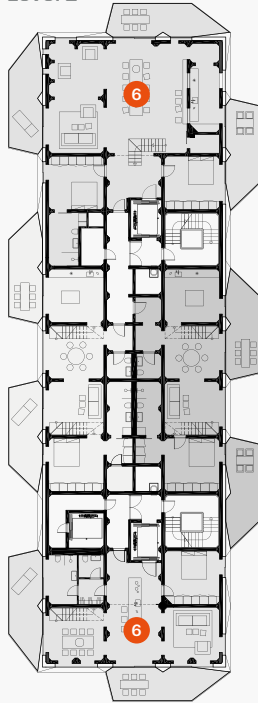
Opposite: Reclad on the exterior, inside the 42 apartments expose their original concrete structure to create cathedral-like spaces.



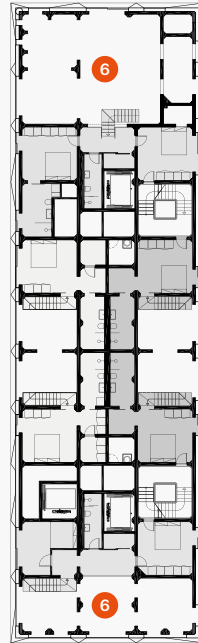
Level 0



Level 2



Level 3



- 1 Lobby area
- 2 Waste
- 3 Fire alarm unit
- 4 Exhibition space
- 5 Restaurant elevator
- 6 Maisonette
- 7 Restaurant

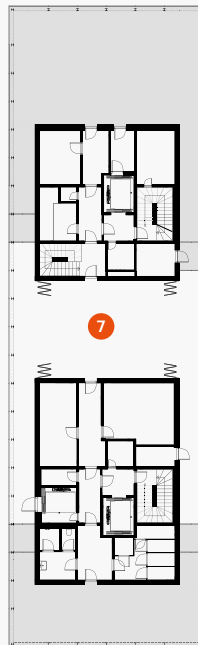
Level 13



Level 14



Roof level restaurant



Opposite: Glazing frames are attached to the external surface to give unobstructed, seemingly windowless openings.

Next page: Perforations in the galvanized balcony balustrades filter patterns of light into the apartments while preserving privacy and the solidity of the building's appearance from the outside.







## Cladding and galvanizing

For the cladding itself, COBE searched for an ‘honest’, ‘lively’ material that would resonate with the industrial heritage of Nordhavn and carry The Silo’s existing spatial qualities. It wanted to recreate a single material envelope that could adapt with projections and facets – folding in and out to integrate the deep terraces. Although COBE had not used batch galvanized steel in this way before, the choice was inspired by Andreas Fuhrmann Gabrielle Hächler Architects’ architect’s and artist’s house, Zurich, Switzerland, as well as Carmody Groarke’s artist’s workshop in London (2012), both of which use it in a much simpler manner. Perforations in the steel cladding designed in advance by the architect allow big views out of apartments but also retain privacy for residents within. They add an extra texture too – each perforated panel is ever so slightly different from the next.

The decision to use batch galvanized steel (to EN ISO 1461) was not, however, straightforward. Given the surrounding sea air, exposed position and risk of physical damage to any coating, corrosion was an issue from the start. The client and contractor, NRE Denmark, wanted to use aluminium instead, perceiving it to be cheaper and easier to install. To inform the decision process, the client commissioned analysis from the Force Institute, a private organization in Denmark that carries out research into building materials, to study and investigate the advantages and disadvantages of both materials in their various forms – durability, required coatings, possible fixings and cost. It also compared plain steel sheet with batch galvanized steel, pre-galvanized plates, aluminium plates and aluminium treated with various coatings to have a galvanized look.

It was consequently necessary to convince the client that the aesthetic benefits of batch galvanized steel would be far superior in outcome to aluminium. Working with the facade contractor Skandinaviska Glassytem, who came on board after the initial sketch design, COBE and the team made study trips all over Denmark to show the client galvanized steel in action, including to the all-clad Technical School at Roskilde completed in 2013, again by Christensen & Co, as well as example facades made from aluminium. In 2015, they also set up a 1:1 prototype of the cladding options to help the decision process, which is also part



Architect’s and artist’s house, Zurich, Switzerland, designed by Andreas Fuhrmann Gabrielle Hächler Architects (2003). The building is entirely clad in galvanized steel plates.

Artist’s studio, King’s Cross, London, designed by Carmody Groarke. The building is clad with galvanized steel.





Perforations in the balcony  
surrounds create transparency  
and lightness.





Opposite: The choice of galvanized steel has allowed a multi-faceted facade with angular geometries and sharp connections and joints.

of the requirements to get planning permission for tall buildings in Copenhagen. The prototype facade, which also looked at possible glazing frame colours and the possible dimensions between rainscreen panels, tested the various material options to compare them aesthetically, one set against the other over a six-month period. It was shown to the client and contractor as well as the city council representatives.

In the end, the final decision to adopt the batch galvanized steel cladding came down to the material's more interesting, playful and lively character as well as comparative cost and the Force Institute's advice on life expectancy.

'We put a lot of energy into making aluminium plates look like galvanized steel,' says Haris Kapsis, the project manager at Skandinaviska who worked on the project from detail design. 'Ultimately, aluminium was more expensive because it wasn't a simple plate; the different coatings added to the price.'

The research carried out by the Force Institute also concluded that the life expectancy of batch galvanized steel could be achieved by careful selection of the base steel to ensure a slightly thicker coating. A steel with a specified minimum silicon content to achieve at least 100 microns of galvanized coating was used for the 3mm thick facade plates. It also determined that, if even longer life was required, the galvanized facade panels could be removed and re-galvanized at a later point in the building's life. Batch galvanized steel was also preferred instead of pre-galvanized sheets to avoid exposed steel edges from cutting that would corrode.

The batch galvanized steel material choice was supported by Copenhagen's municipality too – an important factor in determining the outcome – because it liked the fact that from a sustainability perspective, it could be refurbished in future if necessary.

From that point it was Skandinaviska Glassystem's job to work out how the facade could be manufactured and realised. The company was founded in Sweden in 1994 and specializes in facades, usually for new build projects. In dialogue with the client, main contractor and architect, it ultimately settled on complete off-site manufacture, using expertise gained on other projects.

'It was a struggle to get the project through,' comments Caroline Nagel, project architect at COBE. 'Collaboration was really important. It wouldn't have happened without Haris.'

## Structure design

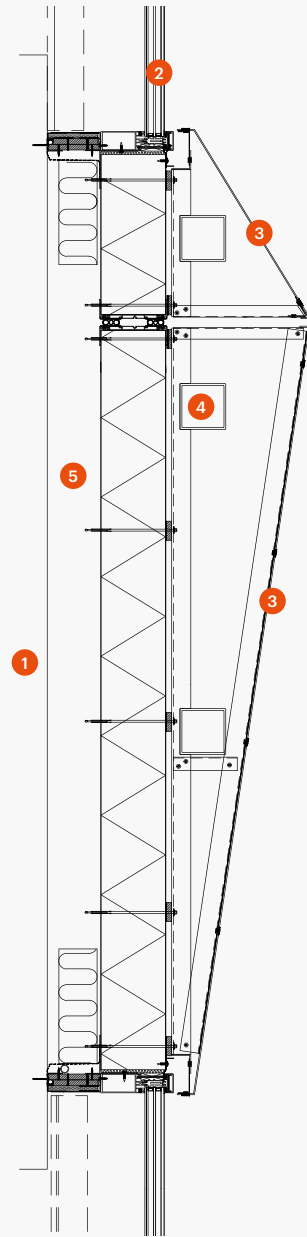
During five months of intensive pre-design, Skandinaviska divided COBE's design into 256 equal-width facade units that would echo the Silo's original internal 4.5m grid on the new external skin and be suitable for prefabrication. Everything was designed and prepared in advance to fit on the back of a truck for transportation to site. Skandinaviska worked out how the facade units would be composed, be specified and attach to the building. When it came to aesthetic choices, however, that was done in conjunction with COBE.

Despite the 4.5m-wide grid, this process was an enormous amount of work. Nearly all the modules are unique in the other axes, according to the varying floor heights and fenestration/balcony configurations – left and right. The perforations were another consideration to account for at this time as they too had to be finalised in advance of manufacture. The units were also designed to be as thin as possible to keep the building's elegant and slim proportions. Usually climate screens added onto the exterior of existing buildings might require a depth of 400mm, excluding any balconies, but Skandinaviska Glassystem used a sandwich element to reduce the thickness to 270mm.

The size and placement of the openings were decided in consultation with engineering company Norconsult for the first phase of the project prior to planning submission. Whereas previously there were only a handful of slit windows on the northern tower, to make the building habitable the engineer used a device to detect where the existing iron reinforcement in the concrete structure was located in order to determine where best to make larger openings that would avoid the iron as much as possible. At the same time, the contractor had to calibrate the dimension and depth of each facade module to account for a 100-150mm torque at the top of the building that had been discovered during the initial 3D scan of the building. Skandinaviska had to make fine adjustments to each panel to ensure it would be straight.

'There were a lot of challenges,' explains Nagel. 'We were all drawing with 90° angles, but the building was slightly twisting.'

Skandinaviska had also previously done fire testing for another similar project. In terms of The Silo's design, the risk was felt



Above: Module detail

- 1 Existing concrete wall
- 2 Triple glazing – can be opened
- 3 Galvanized steel facade
- 4 Galvanized steel RHS (100x100mm)
- 5 Insulation panel

The galvanized steel is a full building envelope material, including for the balcony soffits.



The connections between cladding panels are barely visible.

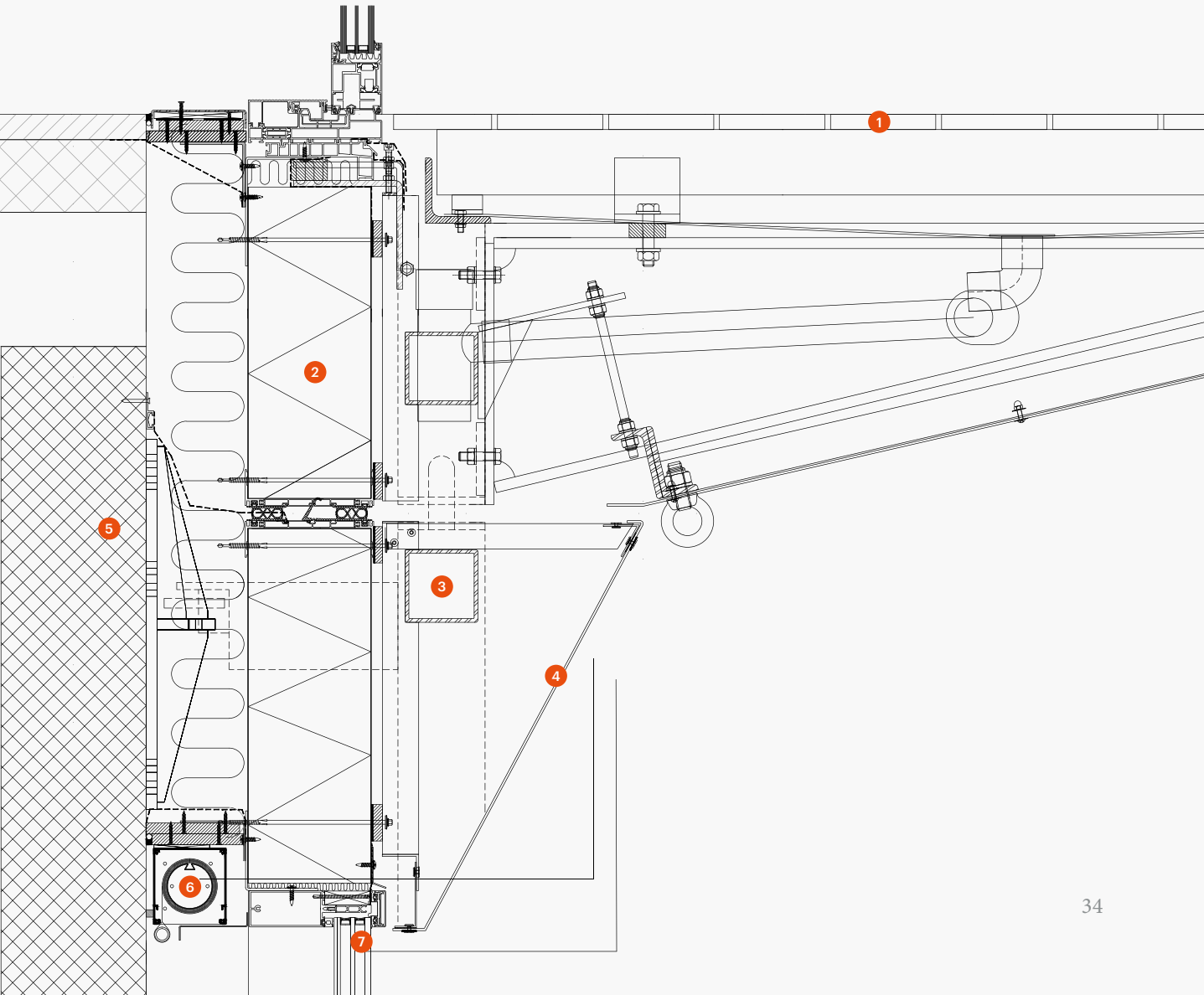


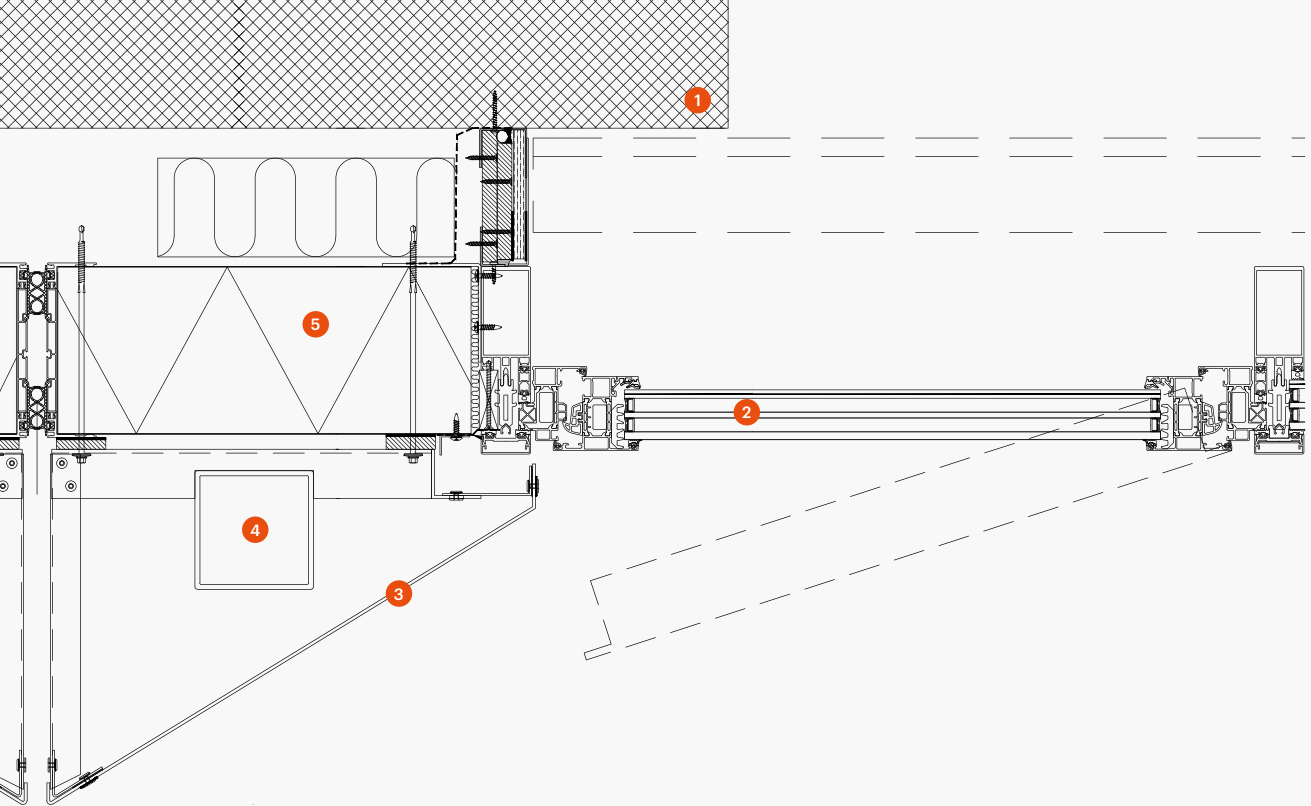
**Below: Facade section detail**

- 1 Hard wood plank
- 2 Wall insulation panel
- 3 Galvanized steel RHS
- 4 Galvanized steel facade
- 5 Concrete wall
- 6 Integrated blind
- 7 Triple-glazed window

minimal because the client chose to construct the new over-cladding skin from A-class materials with their own integral fire-proof properties. The insulation was also designed to be completely covered and boxed in, reducing risk of flames being able to catch it. The various components of each facade unit were also designed to be fixed together mechanically with screws, bolts and rivets rather than plastic brackets or glue, which melt.

In terms of durability, the Force Institute conducted research into how long the galvanized steel facade would last. Although the facade contractor's initial estimate of 50 years is likely to be achieved, the final building has been rated with a 25 to 35-year lifespan as it was postulated that on the northernmost elevation there could be a zinc corrosion rate of 4-5 microns





Above: Balcony plan detail

- 1 Existing concrete wall
- 2 Triple-glazed window
- 3 Galvanized steel cladding
- 4 Steel rectangular hollow section
- 5 Wall insulation panel

per year because of prevailing salt-laden winds. It is, however, COBE and Skandinaviska's expectation that in 25 years' time the galvanized steel will still have the same protective quality as it did on completion. If one side alters in appearance more than another it wouldn't be visible at once and only the patina would have changed over time which would not indicate a reduction in protection. Nevertheless, as Kapsis explains: 'In theory all the plates can be individually removed, stripped and re-galvanized.'

Once all the initial research and projections into the materials were complete, Skandinaviska broke down the larger 256 facade modules further into their constituent parts. These were split up to have them ordered, pre-cut and manufactured from multiple suppliers for assembly – steels, bolts, rivets, insulation, galvanized steel rainscreen panels. Regarding the galvanized steel rainscreen panels, the metal was purchased as a 1.37m-wide coil. This determined the maximum width of each plate which were then distributed across the facade units into triangular pieces for later assembly. The panels were designed to suit the 6m length of the supplier's galvanizing bath, resulting in a total of 4737 individual galvanized steel elements across the building – the biggest of which is 3258mm by 1360mm.

Opposite: The flooring for the balconies was the only aspect of the external envelope that was not prefabricated. Rather it was fitted on site so pieces of timber could bridge multiple cladding panels.











THE  
SILO

HYATT RIVER MOUNTAIN

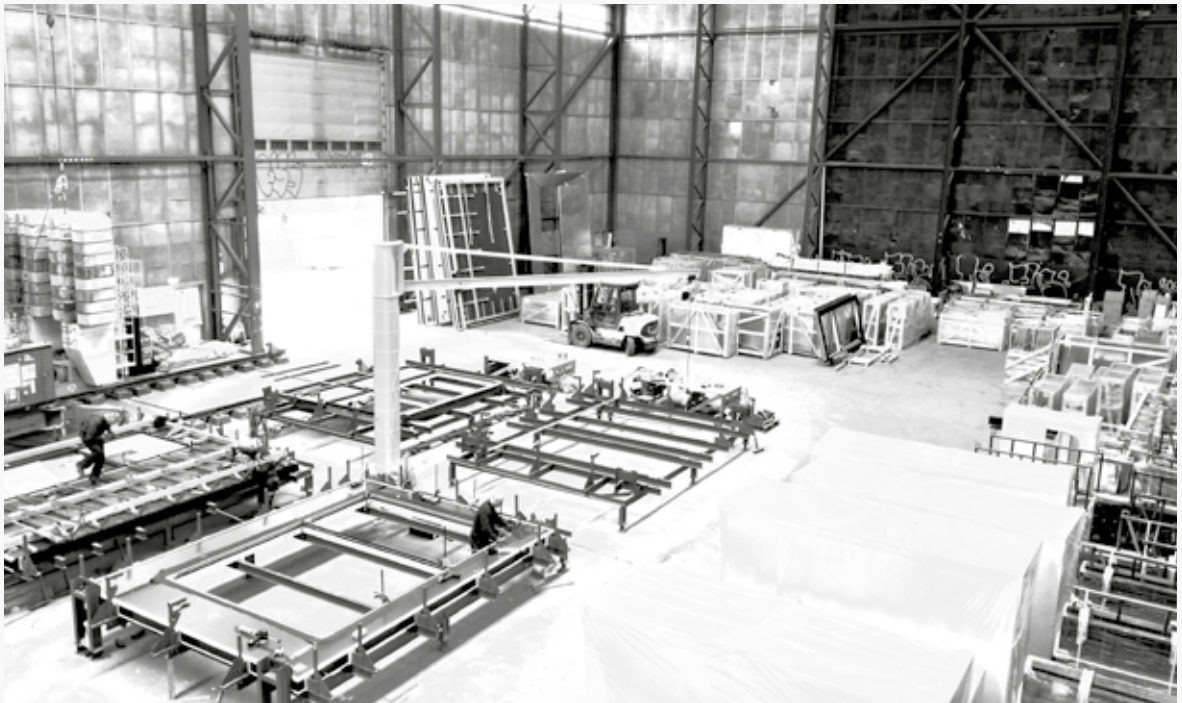
## Production and installation

Previous page: Construction workers fitting the prefabricated facade panels into place on the existing concrete shell.

Opposite: Panels were fitted from the bottom upwards while the ground floor gallery was already open.

Below: Skandinaviska Glassystem's facade panel assembly factory where pieces were developed using pre-manufactured elements from scratch.

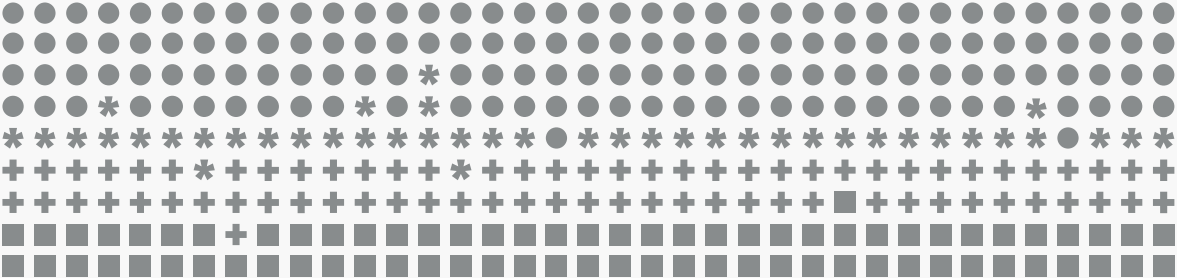
In 2016 the project started on site. Although the idea was to preserve as much of the original building and structure as possible, more than 200 new openings were made into the concrete on site, between 3m and 6m tall. Internally, the former storage tubes were opened to each other to create the new rooms as well, amounting to the removal of around 50% of all concrete surfaces. Reinforcement iron rods that were exposed or cut through in the process were protected from fire with transparent lacquer. At the same time, the remainder of the 13th storey was filled horizontally using concrete precast panels – all while having to work around the exhibition on the ground floor which was already open. A steel structure was then added on top to attach the restaurant glazing, for which a second engineering firm Balslev was responsible. Working up the building on site, 120-130kg steel brackets from which to hang the panels were then bolted into the concrete structure one by one. Each panel is supported by hanging on two half brackets to form a grid.





Hot dip galvanizing of batches of fabricated steel provides a thick, durable zinc coating that is metallurgically bonded to the steel.

Schematic section through typical hot dip galvanized coating



● Pure Zinc \* 6% Fe + 10% Fe ■ Base Steel

The new facade shines above the Nordhavn skyline. Its light-shade effects are rather mesmerizing too.







Opposite: COBE selected galvanized steel for its textured, light-catching character.

Meanwhile, from May 2016 Skandinaviska began full production of the 256 facade modules in a warehouse 2km away from The Silo site. The warehouse was rented specifically and designed to simplify and speed up the assembly process with a manufacturing line of four benches, four to five people allocated to each. The company made its own set angle moulds, so components could be accurately and quickly slotted together, as well as building an example 4.5m-tall unit to agree the standard of manufacture.

From there, the first step was to set up the primary structure, a batch galvanized steel frame pre-manufactured in Denmark by CSK Steel. The insulation, pre-cut Kingspan foam 170mm panels, was then filled into this frame. Skandinaviska chose a higher quality insulation to ensure the final panels would be as narrow as possible. The secondary structure, which is made of stainless steel, to support the balconies, wind shield panels and cladding was then attached to the steel frame, using stainless steel bolts and rivets.

Once the secondary structure had been built, all the finishing details, including electrical sockets and drainage, were installed before the galvanized steel cladding panels were fixed encasing the modules. As for the other parts of the unit, the steel for the rainscreen panels was pre-manufactured in advance. They were cut to size and stamped with the perforation patterns by UAB Vytrolma in Utena, Lithuania. From there the panels were sent for galvanizing. Each plate was subsequently dipped in the bath of molten zinc for five to six minutes to pick up a layer of at least 100 microns of metallurgically bonded coating. In some places the thickness was as high as 120/130 microns. On the recommendation of Force, the galvanized coating was spot checked twice daily to ensure the correct minimum coating as the specification exceeded the normal requirements of EN ISO 1461. These completed panels were delivered to the assembly plant in Copenhagen and attached to the secondary structure. At this point, Schueco system windows supplied by KGC Latvia were added to the units.

From there, assembled panels were delivered to site by lorry according to a schedule that worked up the facade in an anti-clockwise direction. Once on site, the units were hung onto the prepared steel brackets using a crane with help from a trolley lift and two support climbers, sealing against surrounding modules



on contact, creating a watertight exoskeleton elevation. After being secured and adjusted into position, Fermacell plates and grilles were installed on site to create a continuous level between inside and out. The timber terrace floor was also laid at this stage to enable it to have a continuous effect across multi-unit balconies.

In all, Skandinaviska produced 3.5 units per day, completing The Silo's entire assembly process by January 2017 – an incredibly quick turnaround for such a large and complex building project with so many bespoke constituent parts. In only eight months, the building's structure was transformed from being suitable for keeping grain cool to one that was thermally comfortable for human habitation.

Opposite: The Silo stands tall and elegant above the new development of Nordhavn.



## Conclusion

On a micro scale, what COBE and Skandinaviska Glassystem have achieved is to find new innovative approaches for over-cladding existing buildings safely, efficiently and rather cleverly. Established building materials, such as galvanized steel, are used in previously unseen ways that respond appropriately to the exposed context, opening it to new architectural ideas and methods of working. The manufacturing process learned here will advance construction too.

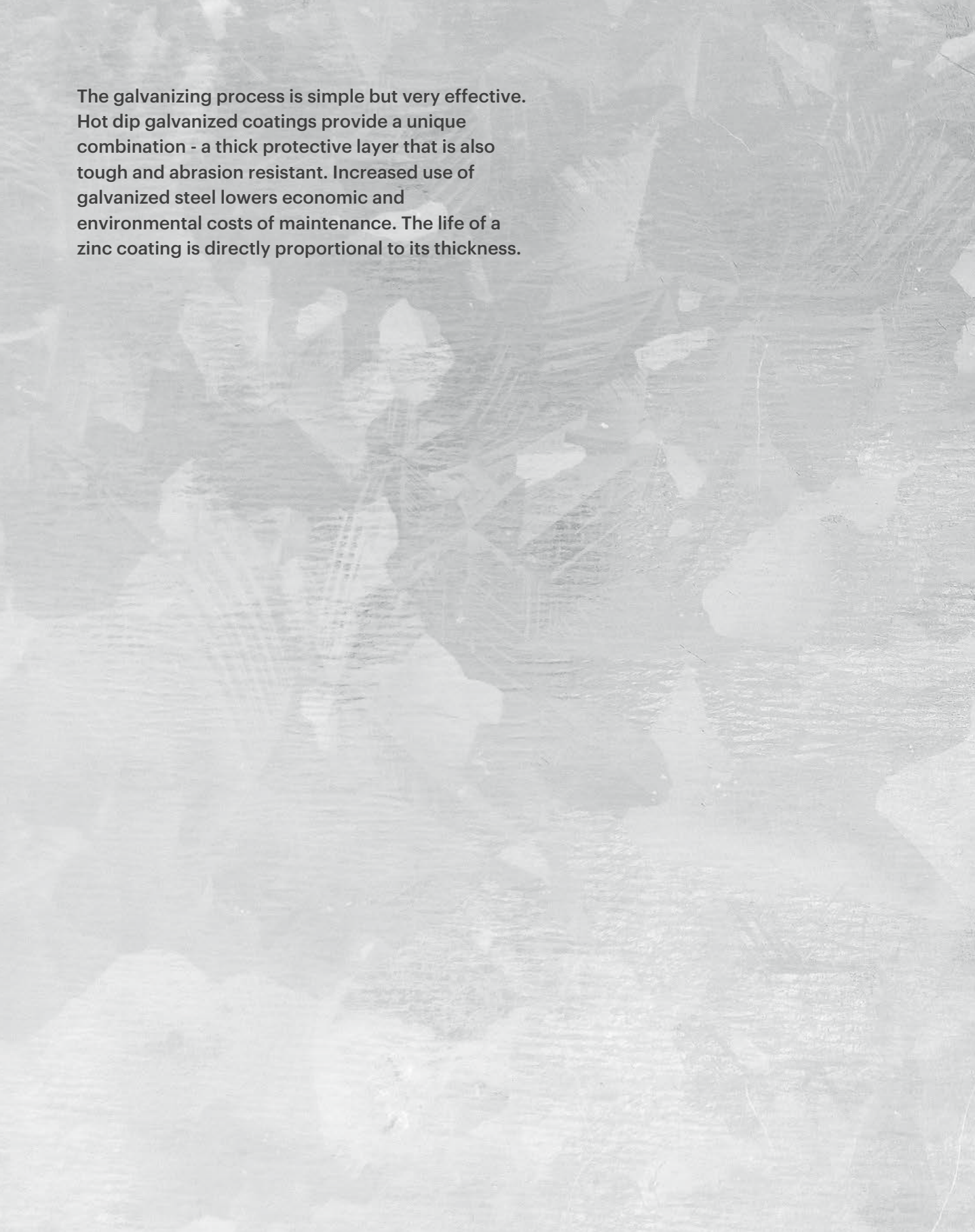
At a macro scale, however, what The Silo achieves is far more significant. On one level, by creating 42 new apartments, the redevelopment goes some way towards alleviating the housing shortage in Copenhagen, as well as offering the market spaces with enormous individuality, character and variation. They are raw, tough yet elegant and contemporary, which is desirable in a city growing in terms of both population and fortunes.

More important, however, is the project's contribution to sustainability: by reusing an existing redundant structure and giving it a new protective coat, all the embodied energy in its original 1950s concrete is given a second life. This was an enormous risk for the client, who may well have been able to disregard the silo and build something more economical in its place instead. Without Klaus Kastbjerg's commitment to the authenticity of a place and belief in reuse, The Silo would never have happened, and the future of the building could have remained uncertain.

Instead, The Silo's reinvention serves a far greater and long-term function. By learning from the large 20th century housing developments and retaining key existing buildings, it helps to create an identity for the completely new residential and commercial district of Nordhavn that otherwise might struggle to find one. It creates a pleasant, grounded place to live and work that feels part of and is connected to the older centre and longer history. In an area that is starting to come to life, The Silo is a new lesson in not overwriting everything. The social ramifications for the people who end up living there are possibly incalculable. By wrapping a new skin around the old while respecting the scale and volumes of the original, it preserves the memory and importance of the industrial age in Copenhagen, Denmark and Europe. Other countries struggling with loss of a national identity issues could learn from this approach.

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The galvanizing process is simple but very effective. Hot dip galvanized coatings provide a unique combination - a thick protective layer that is also tough and abrasion resistant. Increased use of galvanized steel lowers economic and environmental costs of maintenance. The life of a zinc coating is directly proportional to its thickness.

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This book could not have been published without the contribution of these creative and enthusiastic people:

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## Colophon

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