DESIGN

In Praise of Retrofit

RAMBOLL

EDITION NO. 5
JULY 2023

“Every existing building has the right to be heard.”

A Ramboll publication

Capella Resort, Singapore (Foster + Partners | DP Architects)
Existing pre-war buildings were retained and underwent extensive repairs for cracked floors, corroded reinforcement, rising damp, termite-infested timber. All remedial work was performed with utmost care to reinstate the past glory of the building fabric, including repointing the brickwork with soft mortar and replacing damaged timber elements. Underpinning was also performed on certain sections of the shallow foundation. The project won a conservation award, which was well deserved.

Schwanthalerstrasse 55-57 Munich (UNStudio)
The refurbishment and extension of these 1913-1915 buildings in Franz Marc Quartier in the inner city of Munich is an example of successful transformation from old industrial and logistic spaces to commercial and office use, giving the neighbourhood 12000 m² of real estate with a modern and lively twist.

Photo credit: UNStudio

In praise of retrofit

Over 95% of the buildings we will have by 2030 are already built!

This percentage will probably hover around 80% or more in a time horizon up to 2050.

In any reasonable time projection into the future, the vast majority of our buildings and neighbourhoods and infrastructure and cities are already built.

These are built to standards which fall well below what would now be environmentally acceptable. It is therefore imperative that we focus on greening the existing and working with what is already built in order to make these sustainable and environmentally in tune with our 1.5 degrees and other aspirations.

The ideas of retrofit, refurbishment and alterations to existing stock of our built environment assets ought to receive more attention from us. We ought to develop skills, knowledge and teams to be able to meaningfully contribute to these efforts.

Greening the existing may take the literal form of enhancing the conditions of an existing building, or be in the form of adding new buildings and nodes to our neighbourhoods and cities which are not inward looking but are generously giving back to the neighbourhood. We need to be regenerative.

Of engineers and trees

Statistics on the contribution of the construction industry to Green House gas emissions are aplenty. The industry is “burdened” with contributing around 39% of the total GHG emissions. While the origin of this figure is debatable, in that the vast majority of this has been “imported” from the energy sector, it is nonetheless imperative to appreciate the embodied carbon figures in construction. The structural frame of a typical 40-storey highrise building in reinforced concrete can have an embodied carbon footprint of around 300 kg/m^2 of the built area. The actual number varies widely, depending on the external factors (location, seismicity, prevailing wind, usage and Live Load allowance, etc), and on the various stages within the overall life cycle of a building, but the figure remains high when compared with other GHG-generating activities we engage with. Demolishing an existing building and replacing this with a new building tantamount to emitting such additional GHG-es for the new build. The environmental impact of the demolish-rebuild development model, therefore, is similar to cutting trees which absorb greenhouse gases. Demolishing a large building, can have similarly adverse environmental impact to setting vast swathes of forest in fire. Forest fires conjure up justifiably negative images in one’s mind; whereas demolishing existing buildings seem to have been somewhat “normalized” in our minds and our built environment and construction industry.

This erroneous mindframe must change.

DESIGN Life

In assessing viability and implications of retaining an existing structure, it is imperative to have accurate visibility on the residual life of the existing structure.

Residual life is the balance of the overall design life of a structure. Buildings are designed and built to specified levels of performance. Such performance levels are implicit or explicit in the codes of practice to which the buildings are designed.

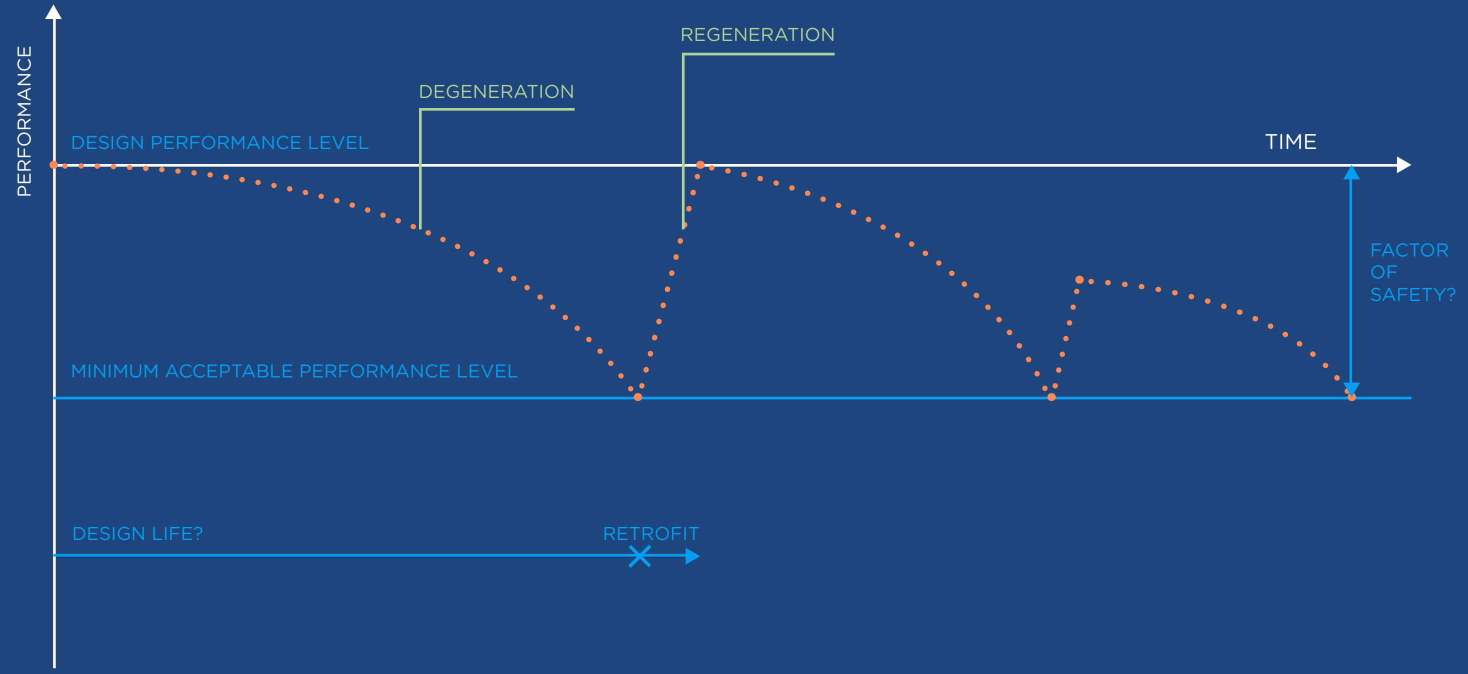
Such Design levels of performance continue to deteriorate as the building ages. Such deterioration continues until such time as the level of performance reaches the minimum acceptable level of performance.

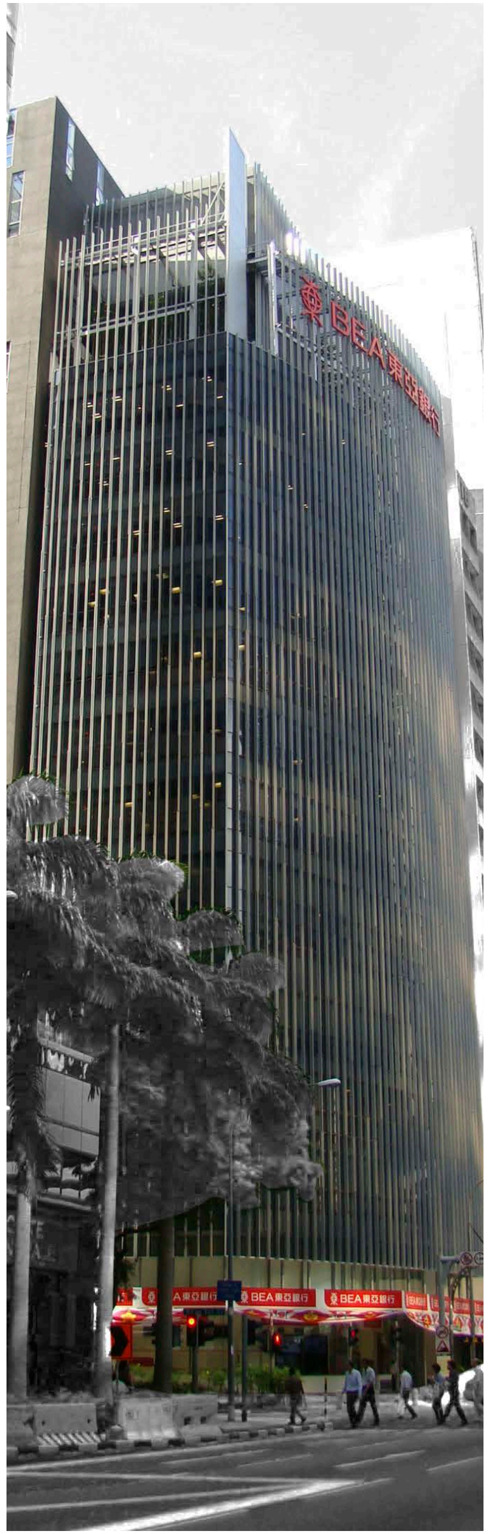
The time that it takes for the design level of performance to reach the minimum acceptable level of performance is called the "design life" of a building.

The roadmap through the design life of a building is also traceable. This will enable us to determine how much residual life is left in each building at anytime within the design life. This information will be a key driver in determining the viability and relevance of retaining an existing building and incorporating same in a new development.

A variety of engineering techniques, methods and tools are available to determine the health of an existing building, design life of same, and the residual life.

The irony is that for every environmental and development problems we face, there is a viable and workable solution. We have the knowledge, the skill and the techniques of dealing with existing buildings. What we lack, at times, is the courage and the policies that are needed to save our buildings and, with it, life on this planet.





Left to Right
55 Market Street (AR+D Architects)
137 Market Street (Teh Joo Heng Architects)
Bank of East Asia (Teh Joo Heng Architects)

Major refurbishment, retrofit, additions and alterations to non-conservation reinforced and prestressed concrete framed buildings in downtown Singapore.
Load replacement technique was used in most of these projects to enhance height and floor area without major strengthening to the foundation and to existing walls and columns.

Photo credit (Left to Right)
AR+D Architects
Jeremy San
Teh Joo Heng

"For every environmental and development problems we face, there is a viable and workable solution. We have the knowledge, the skills and the techniques of dealing with existing buildings. What we lack, at times, is the courage and the policies that are needed to save our buildings and, with it, the life on this planet"

Hossein Rezai-Jorabi
Global Design Director,
Ramboll

Utilisation of existing buildings

Of all the roadmaps towards environmental congruency, the **“build nothing”** route is evidently analogous with zero-harm scenario.

If we must build, then we must do so Regeneratively.

(see Regenerative Worldview in Edition 4.)

Of all the roadmaps towards environmental congruency, the "build nothing" route is evidently analogous with zero-harm scenario. While this is practically impossible to achieve in a situation where we are in need of more buildings to respond to development needs of our growing societies, this may well be possible in the arena of existing buildings where embodied carbons have already been expended to build them. It should be possible to stay close to a “build nothing” scenario by keeping existing buildings which have a reasonable residual design lives. Furthermore, the ideal of “build nothing” may also be achievable by higher utilization of existing buildings.

Current anecdotal evidence points to most genre of our existing buildings being used under 30% of the times! Office buildings, for example, tend to be used around 8 hours in 24 hours. Adding the weekends and other holidays when our office buildings remain idle and unused, reduces the utilization ratio of this genre of our buildings to way below 30%. It is imperative that, through clever future planning, and by utilizing technology in our “Smart Buildings”, we make better and more use of what we have in order to reduce pressure on the demand for building more, with all the deleterious effects that come with more and more buildings.

Kirstine Seligmanns Skole, Denmark (Ramboll)
This project has a school, kindergarten and a neighbouring housing development. The housing developement was partly demolished to build a brand new two-storey building with teaching spaces. This includes a roof terrace and a large `learning staircase’. The structure is strengthened, the facade renovated, the roof replaced, and all internal walls and floors have been rebuilt.

Photo credit: Ulrik Tofte

IPCC, Sufficiency and Efficiency

IPCC's latest report in 2022 rightly identifies **retention of existing buildings as the most Preferred model** in the developed world.

Efficiency,

is the most suitable and least destructive model. This relies on design and scientific techniques of optimization, minimization of material usage, efficient design processes, and all that will ensure the best material usage for various components of each development. Efficiency, therefore, is highly dependent on design and analysis tools, as well as on technology to ensure that best forms, shapes and material usage is found through complex multi-objective optimization methods. The approach applies to architecture, massing, built area, natural ventilation, form, shape, structure, servicing, interiors, etc; all to ensure that the sum of embodied and operational "carbon" (read "greenhouse gas") is targeted towards zero or better over a reasonable period.

Sufficiency,

in simple terms, refers to "building what is sufficient". This is in contrast to the wasteful extravagance which has crept into our built environment under the guise of comfort and delight! At a most basic level, ceiling heights which have been continuously going up, primarily in response to demand for "perceived luxury", ought to be controlled. On structural frames, design live load allowances have been going up over the past 50 years, not in response to a deficiency in previously lower live load allowances, but in response to marketing campaigns which presents higher load allowances as a positive attribute rather than the waste that they actually result in having structures which are stronger than ever need to be! The upshot of such wasteful demands on much higher floor-to-floor heights and live load allowances in our buildings is that most existing buildings which have been performing satisfactorily for many years, fall short of the newly normalized and "deemed acceptable" limits.

We are demolishing buildings that are now seen as not "marketable" due to their lower, yet perfectly functioning, floor-to-floor heights!

This needs to change

Concepts like "delight" and luxury, ought to be complimented with "understanding" and "thriving".

The Lighthouse,
United Kingdom, (Ramboll)
Located in the heart of King's Cross and dating back to 1875-1895, the Lighthouse building is a local landmark. It was left derelict for many years until developers; UK Real Estate, took the bold decision to redevelop the Grade II listed building that was on Historic England's Buildings at Risk Register.

The building now features an additional storey-and-a-half, conserved and repaired masonry façade and the restored timber lighthouse, ensuring its great character was retained and its long term viability secured.

Photo credit: Daniel Shearing

Hard Limits on Embodied Carbon

It is imperative that we now limit the embodied carbon of all our buildings, and to continue to reduce this limit over the next decade or so, such that we can reach a limit which can be readily offset with operationally "Carbon Negative" systems in our buildings within a short period leading to 2030 or 2035. It is suggested that a basic embodied carbon per square meter of built floor area of about 300 kg is a reasonable and achievable limit for residential buildings of up to 10-storey in places with mild wind speeds and no seismic activities. This is proposed to be taken as an upper bound number for the assessed embodied carbon (excluding operational carbon emissions) per square meter of the built area. In the Nordics, for example, many low-rise buildings record emission levels of much lower than this limit. The recommendations provided here are intended for the global construction industry, and for buildings at the upper limit of 1 to 10-storeys. For a building with a floor area of about 10,000m^2, this will add up to an overall embodied carbon of 3,000,000 kg of CO2e. In the way of a simple comparison, this is the amount of carbon sequestered by over 135,000 referenced trees in one year.

The limit of 300kg/m^2 ought to be reduced by 10% on a year-on-year basis till 2025, then further reduced by 8% year-on-year till 2030. This will reduce the overall embodied carbon to less than 150kg/m^2 of the built floor area. Upward adjustments to the 300kg/m^2 limit can be made for taller buildings, and for buildings with higher live load demand, or those in highly seismic zones, etc, but adherence to the hard limit and the reduction journey imposed would reduce the embodied carbon down to 150kg/m^2. By 2030, it should be possible to defray such numbers with negative operational carbon to achieve net-zero carbon status within as short as 3 to 5 years.

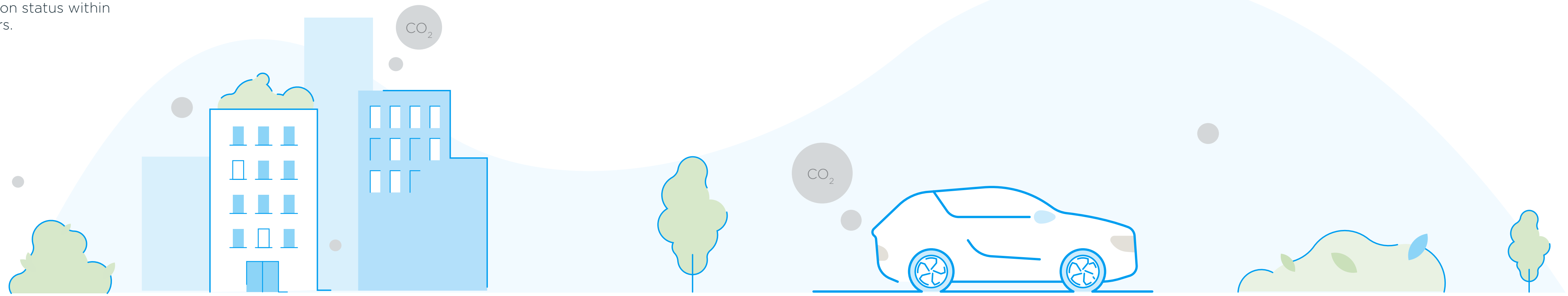
By then, as the energy sector continues to decarbonise, the embodied carbon numbers will progressively reduce too. The combined effect of reduced embodied carbon and net positive operational carbon will help accelerate the journey towards full decarbonisation in the built environment industry.

A future edition of Ramboll DESIGN publication will be dedicated to the important topic of decarbonization to net zero, which is one of our four strategic unifying themes.

Quantifying Embodied CO_2e

1 ton CO_2 ≈ 5,000 km driven in a car

Grand Hyatt = 20,520 tons reduced embodied CO_{2e} ≈ 102,600,000 km driven in a car ≈ 3640 cars taken off the road for a year



National Design Centre, Singapore, (SCDA Architects)
Existing heritage conservation building was restored, and additions and alterations were made to transform them into the new National Design Centre (NDC).

At the heart of the existing building composition was a central courtyard which in the proposed design was roofed over. The space was internalized and is now the main atrium space in the NDC.

Photo credit: Aaron Pocock Photography

Physical, environmental, historic and cultural aspects of retention

In addition to the physical and environmental aspects of retention hitherto described, the built environment offers historic, cultural and social values too. These can be adversely affected with demolition of a building.

Buildings, the communities and the streets they form, are depositories of collective memories of their past and present inhabitants. Historic events which have taken place in a particular building have been archived in that building. Memories of such historic events live on through fond, or otherwise, memories that continue to exist in people's consciousness. Historic events do not necessarily have to be of general public and general interest, but can be personal experiences of our citizens. Removal of buildings tends to lead to a gradual fading away of such experiences and memories.

A relevant question to raise, therefore, is "Whom do our buildings ultimately belong to?". Parallels to this paradigm are drawn on the agenda of the natural environment. While the Amazon Rainforests happen to be mostly located within the geographic boundaries of Brasil, "Whom do they ultimately belong to?".

Demolition of buildings has been likened to deforestation, "Architectural and Heritage deforestation", that can damage the collective memories and paradigms of a neighbourhood and a city at large. We must protect such historic and social capitals in our cities through preservation of the fabric of our buildings.

Tate Modern

A success story of retention

London's Tate Modern gallery, a Grade II listed structure occupies a former oil-fired power station on the south bank of the River Thames. The gallery opened in 2000 expecting 1.8 million visitors a year. Now, it receives an average of 4.5 million visitors, often topping the charts as the UK's most visited attraction.

Between 2008 and 2016, Tate Modern's existing building underwent three stages of renovation and addition.

Chapter 1

Floor Strengthening

Tate Modern's floors required strengthening for an exhibition which featured heavy art pieces at 23.5kN/m² that were beyond the capacity of the existing structure. The floors were strengthened to achieve a higher load-bearing capacity.

To strengthen the floor, new steel beams were introduced in the plenum space between the upper and lower slabs. By strategically positioning these beams to reduce the span of the upper deck, the floor's localised capacity was increased.

Chapter 2

Redevelopment of the existing Switch House

This phase encompasses the redevelopment of the neighbouring Switch House, aiming for a seamless integration with the main building in both visual and physical aspects.

In the Switch House, the existing steel frame was removed and a new steel frame added to bridge the resulting void between the reinforced concrete tower structure and the new steel columns. This created 18m clear spans to the galleries below.

Both structures are supported on piled foundations to ensure continuity through the two buildings.

Chapter 3

The New Extension

The new building increased Tate Modern's display space by 60% over 11 levels, and provided additional performance and educational spaces, retail areas, cafés and offices. Its form is complex, with an irregular ground plan dictated by the constraints of the site.

Engineering the building was a geometrically complex feat. For the inclined perforated brick façade, an innovative design was developed from first principles.

The Tate Modern, UK

A truly ground-breaking retention, renovation, and addition to an existing building that pushes the boundaries of modern design engineering and building technology.

Engineered by Ramboll UK
Contributing writers: Martin Burden and Eleanor Fox

We enable society's transition to a future that flourishes

Ramboll is a global engineering, architecture and consultancy company founded in Denmark in 1945. Across the world, our 18,000 experts create sustainable solutions.

We combine local experience with a global knowledge base to create sustainable cities and societies, driving positive change for our clients, stakeholders and society. We enable our stakeholders to realise their goals and navigate the transition to a more sustainable future.

We call it:
Bright ideas. Sustainable change.

Kristian August Gate 13, Norway (Mad Arkitekter)
The project successfully incorporated numerous existing structures and materials from its own resources, showcasing a commitment to reuse. Additionally, it utilised various materials sourced from external projects, including concrete slabs, kitchen units, and outdoor steel cladding.

Photo credit: Mad Arkitekter

DESIGN is a periodical publication by the Design Excellence Board (DEB) within the Buildings Market in Ramboll.

The publication promotes and articulates latest ideas on matters relating to design, technology, environment and ethos within the design industry and the built environment, at large. It aims to address key issues facing contemporary design professionals, including our evolving relationship with the natural environment; as well as pressing political and social agendas for the built environment.

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