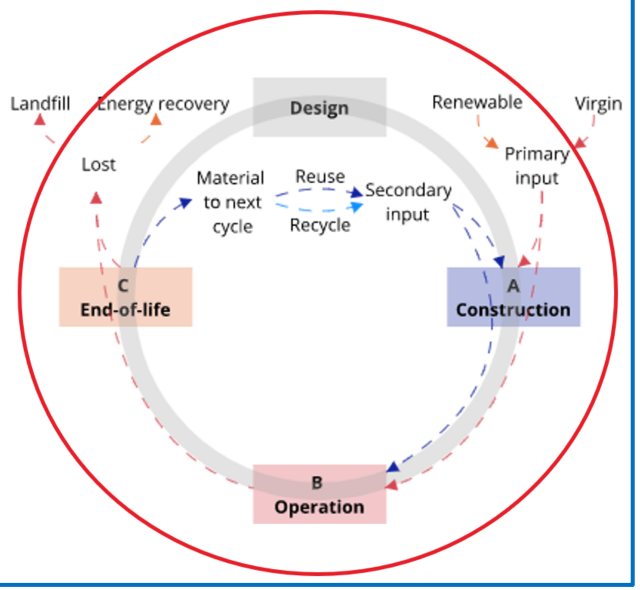
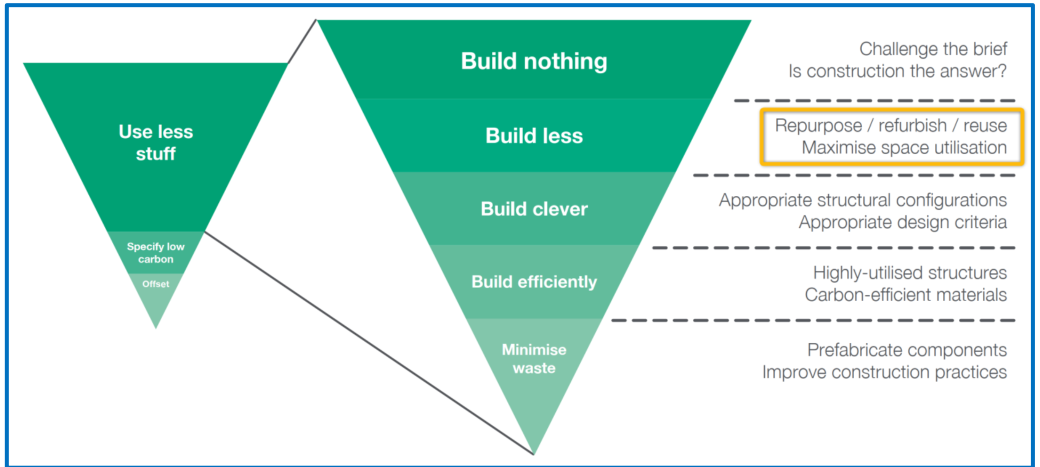




ARUP EFLA

29. október 2022

Brýr í hringrásarhagkerfi

Rannsóknarráðstefna Vegagerðarinnar

Magnús Arason, EFLA

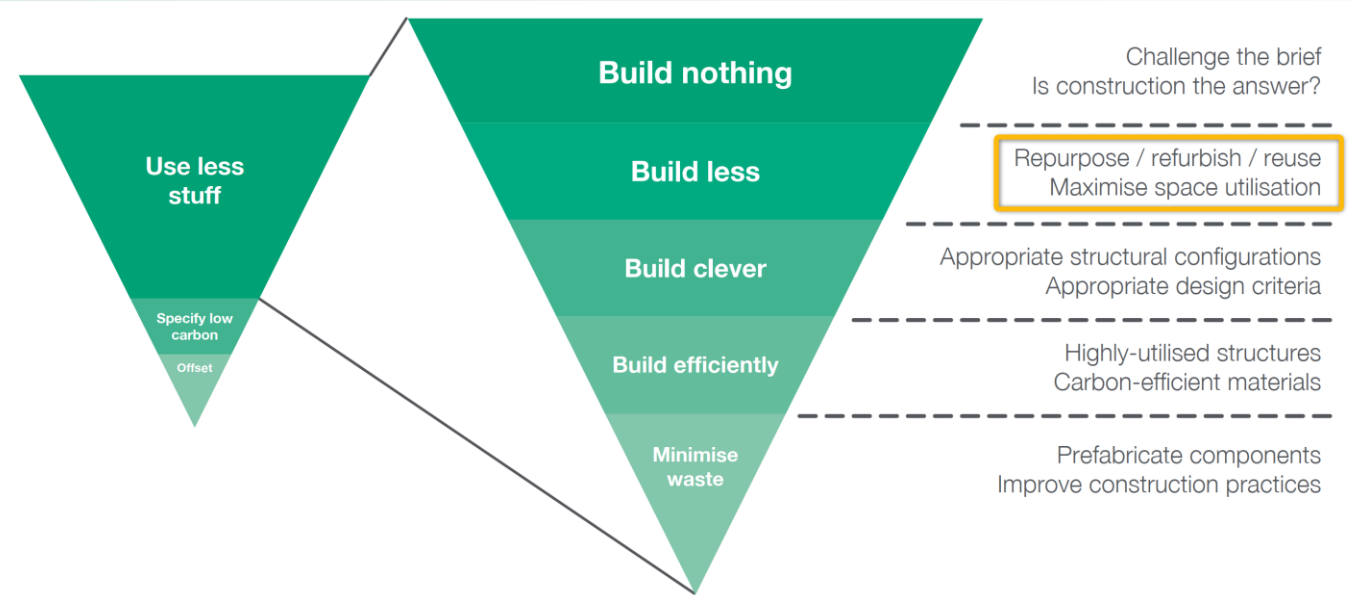
Rannsóknarverkefni

- Framhaldsstyrkur 2022
- Samstarf við Arup í Hollandi
- Deiling á þekkingu og vinnustofur
- Hollendingar mjög framarlega í hringrásarhagkerfinu

Verkefni - Yfirlit

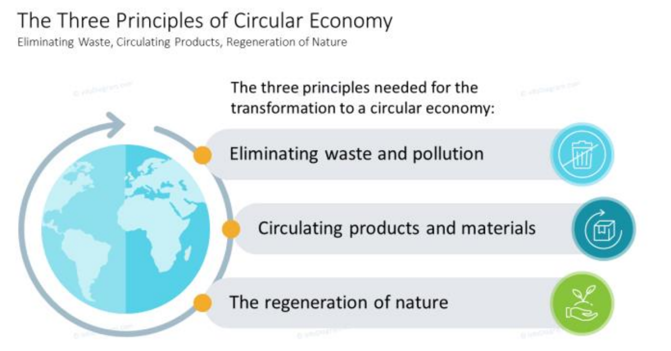
- Bakgrunnur
- Markmið
- Hollensk nálgun í hringrásarhagkerfum
- Mat og samanburður á hringrásareiginleikum tveggja brúa
- Aðgerðaáætlun

Bakgrunnur



- Það er áríðandi að auka sjálfbærni í byggingariðnaðinum
- Brýr engin undantekning
- Hringrásarhagkerfi getur verið þar öflugt verkfæri

Hringrásarhagkerfi



- Ellen MacArthur Foundation
- Þrjú meginviðmið hringrásarhagkerfa
  1. Hætta úrgangsmyndun og mengun (Eliminate waste and pollution)
  2. Halda efnum í notkun (Circulate products and materials)
  3. Endurnæra náttúruna (Regenerate nature)
- Viðmið 1 og 2 er unnt að heimfæra á brýr
  - Mæla hringrásareiginleika
  - Hanna með hringrásarkerfi í huga (Circular design)

Markmið þessa verkefnis

- **Aukin sjálfbærni í brúarverkefnum**
  - Sækja þekkingu til þeirra sem standa okkur framar nú
  - Sýna fram á hvernig meta má hringrásareiginleika
  - Benda á aðgerðir

Hollensk nálgun

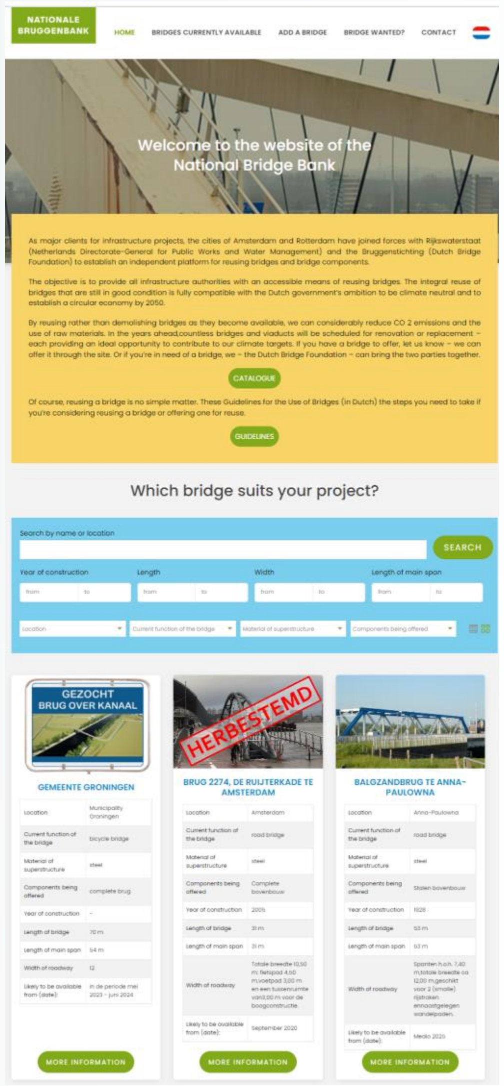
- Til að uppfylla skuldbindingu Parísarsáttmálans ætlar Holland að
  - Að vera „completely circular“ árið 2050
  - Neysla hráefna (jarðefni, málmar, jarðefnaeldsneyti) helminguð á árabilinu 2016 - 2030
- Rijkswaterstaat (framkvæmdaaðili innviðaráðuneytisins) vinnur eftir þrem lykilmarkmiðum:
  - Verndun auðlinda
  - Verndun og endurheimt umhverfislegra gæða
  - Varðveisla og sköpun verðgildis
- Unnið eftir Platform CB’23 (Circular construction 2023)

Mat á hringrásareiginleikum

- Viðmið Platform CB’23 fyrir tvö af lykilmarkiðmunum:
  - Material Circularity Indicator (MCI) - Verndun auðlinda
  - Environmental Cost Indicator (ECI) - Verndun umhverfis
- Sýnidæmi, Mjølan göngu- og hjólabrúin

Endurnýting brúa

- Rijkswaterstaat, Amsterdam og Rotterdam hafa sett upp sameiginlegan brúabanka
- Heldur utan um brýr sem til stendur að fjarlægja
- Góð reynsla hingað til



Mjølan göngu- og hjólabrúin, Noregi

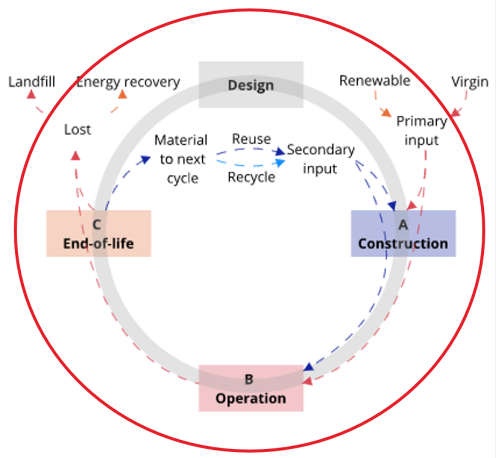
- Mo i Rana í Noregi
- Brú hönnuð á EFLU 2017-18
- Byggð 2019
- Forhönnun á stálbitabrú og eftirspenntri steyptri brú
- Gefur færi á að bera valkostina saman m.t.t. hringrásareiginleika
  - MCI
  - ECI

Stálbitabrú (Mjølan) og eftirspennt steypt brú (Breiðholtsbraut)

Mjølan brú, magntölur

Material	Component	Producer EPD	Quantity steel bridge	Quantity concrete bridge	Unit
Hollow steel section	Piles	Mannesmann	20,5	20,5	tonne
Concrete B45 SV Standard	Piles	Sunnfjord Betong	32	32	m3
Reinforcement steel	Piles	Kamstål AS	6	6	tonne
Lumber formwork	Pile caps	Moelven AS	14	14	m3
Reinforcement steel	Pile caps	Kamstål AS	14	14	tonne
Concrete B45 SV Standard	Pile caps	Sunnfjord Betong	124	124	m3
Hollow steel section	Piers	Mannesmann	9,3	9,3	tonne
Metallic zinc rich Epoxy primer	Piers	International Interzinc	110	110	m2
Polyuerthane topcoat	Piers	International Interthane	60	60	m2
Reinforcement steel	Piers	Kamstål AS		7	tonne
Concrete B45 SV Standard	Piers	Sunnfjord Betong		7	m3
Hot rolled stainless steel plates	Superstructure	Norsk stål	15,5		tonne
Hot rolled mild steel plates	Superstructure	SSAB	48		tonne
Hollow steel section	Superstructure	Mannesmann	31		tonne
Metallic zinc rich Epoxy primer	Superstructure	International Interzinc	900		m2
Polyuerthane topcoat	Superstructure	International Interthane	1100		m2
Reinforcement steel	Superstructure	Kamstål AS		31	tonne
Lumber formwork	Superstructure	Moelven AS		40	m3
Concrete B45 SV Standard	Superstructure	Sunnfjord Betong		153	m3
Permanent Strand Anchor	Superstructure	Dywidag		6	tonne
Hot rolled stainless steel tubes	Superstr. parapet	Outokumpu	4,8	4,8	tonne
Wire mesh (stainless steel)	Superstr. parapet	Outokumpu	0,2	0,2	tonne
Asphalt	Superstr. surfacing	Vandle (NCC)	32	32	tonne
Epoxy-based coating	Superstr. surfacing	Drizoro	320	320	m2

Material Circularity Indicator (MCI)



- Notaður með hliðsjón af markmiði um Verndun auðlinda
- 0 < MCI < 1 (1 = 100% circular, ekkert nýtt hráefni, enginn úrgangur)
- Fyrir allt efni sem notað er í brú er magn flokkað
  - Bygging
    - Primary Renewable
    - Primary Virgin
    - Secondary Reused
    - Secondary Recycled
  - Lok líftíma
    - Reusable
    - Recyclable
    - Energy recovery
    - Landfill

Mjølan brú MCI input

	A. Protection of material resources								
	Input				Output				MCI
	A Construction				C End-of-life				
	Primary		Secondary		Next cycle		Lost		
Material	Renewable	Virgin	Reused	Recycled	Reusable	Recyclable	Energy recovery	Landfill	
Hollow steel section	0,00	0,80	0,00	0,2	0,05	0,92	0,00	0,03	0,63
Concrete B45 SV Standard	0,00	0,97	0,00	0,03	0,00	0,58	0,00	0,42	0,35
Reinforcement steel	0,00	0,13	0,00	0,87	0,00	0,97	0,00	0,03	0,88
Lumber formwork	1,00	0,00	0,00	0,00	0,00	0,05	0,94	0,01	0,54
Metallic zinc rich Epoxy primer	0,00	1,00	0,00	0,00	0,00	0,00	0,00	1,00	0,12
Polyuerthane topcoat	0,00	1,00	0,00	0,00	0,00	0,00	0,00	1,00	0,14
Hot rolled stainless steel plates	0,00	0,29	0,00	0,71	0,00	0,95	0,00	0,05	0,81
Hot rolled mild steel plates	0,00	0,96	0,00	0,04	0,00	0,98	0,00	0,02	0,53
Permanent Strand Anchor	0,00	0,87	0,00	0,13	0,00	0,97	0,00	0,03	0,60
Hot rolled stainless steel tubes	0,00	0,29	0,00	0,71	0,84	0,11	0,00	0,05	0,83
Wire mesh (stainless steel)	0,00	0,28	0,00	0,725	0,00	0,92	0,00	0,08	0,80
Asphalt	0,00	0,68	0,00	0,32	0,00	1,00	0,00	0,00	0,69
Epoxy-based coating	0,00	1,00	0,00	0,00	0,00	0,00	0,00	1,00	0,29

MCI samanburður

Indicator	Description	Steel footbridge	Concrete footbridge
1. QUANTITY OF USED MATERIAL (INPUT)		**700 ton**	**1050 ton**
1.1 Quantity of primary material	Use of material produced from primary resources	85.0%	87.5%
1.2 Quantity of secondary material	Use of material from previous use or residual from other system		
	1.2.1 Quantity of secondary material reused	0.0%	0.0%
	1.2.2 Quantity of secondary material recycled	15.0%	12.5 %

Indicator	Description	Steel footbridge	Concrete footbridge
2. QUANTITY OF MATERIAL AVAILABLE FOR NEXT CYCLE (OUTPUT)		**200 ton**	**350 ton**
2.1 Quantity of material for reuse	Extend to which reuse of material is a realistic next cycle scenario	1.0%	0.5%
1.2 Quantity of material for recycling	Extend to which recycling of material is a realistic next cycle scenario	71.3%	64.4%
3. QUANTITY OF LOST MATERIAL (OUTPUT)		**500 ton**	**700 ton**
3.1 Quantity of material for energy recovery	Extend to which burning of material for energy recovery is the most realistic end-of-life scenario	0.9%	2.4%
3.2 Quantity of material going to landfill	Extend to which the loss of material to landfill is the most realistic end-of-life scenario	26.8%	32.7%

- The Arup Circular Economy Dashboard notað við framsetningu niðurstaða
- Lítill munur á brúnum tveim, ekki ýkja hátt skor

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Environmental Cost Indicator (ECI)

Umhverfiskostnaður

- Notaður með hliðsjón af markmiði um Verndun umhverfislegra gæða
- Byggður á staðlinum EN15804 (Sustainability of construction works)
- Notar „skuggaverðgildi“ á umhverfisáhrif
  - Nýttur við samanburð tilboða í alútboðum
  - Nýttur sem þröskuldur í mati á gildi tilboða
- Nátengdur vistferilsgreiningum (LCA):
  - Byggir á sömu gögnum, einkum Environment Product Declarations
  - Metur út frá sömu umhverfisáhrifum

Environmental Cost Indicator (ECI)

Umhverfiskostnaður

- Umhverfisáhrif metin í verkefninu með þessi einingarverð[1]:

ENVIRONMENTAL IMPACT CATEGORY	UNIT	WEIGHING FACTOR OR SHADOW PRICE [€/KG EQUIVALENT]
Global warming potential	kg CO_2e	0,05
Ozone layer depletion	kg CFC11e	30
Acidification	kg SO_2e	4
Eutrophication	kg PO_4e	9
Photochemical oxidant creation, smog	kg C_2H_4e	2
Depletion of abiotic resources	kg Sbe	0,16

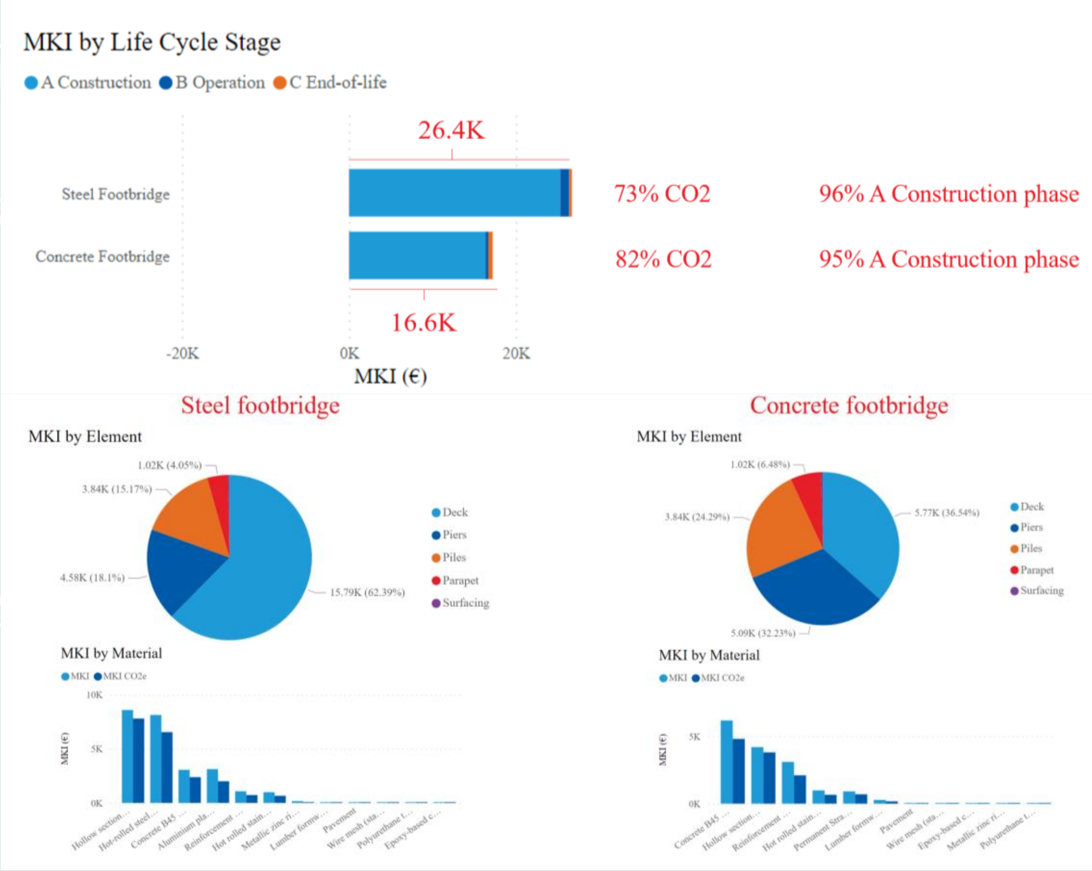
1: Dutch Nationale Mileudatabase

Umhverfiskostnaður efna í Mjølan brú

Material	Producer EPD	A ECI Total	A ECI CO2e	B ECI Total	B ECI CO2e	C ECI Total	C ECI CO2e	D ECI Total	D ECI CO2e	Service life (years)
		B. Protection of environmental boundaries								
		ECI								
		A Construction		B Operation		C End-of-life		D End-of-life benefits		
Hollow steel section	Mannesmann	141,00	128,00	0,00	0,00	0,00	0,34	-89,00	-81,00	100
Concrete B45 SV Standard	Sunnfjord Betong	19,57	15,24	0,00	0,00	0,64	0,33	-1,80	-1,52	100
Reinforcement steel	Kamstål AS	53,55	36,34	0,00	0,00	0,07	0,04	-2,00	-1,44	100
Lumber formwork	Moelven AS	5,15	3,18	0,00	0,00	3,73	3,20	-21,51	-19,20	100
Metallic zinc rich Epoxy primer	International Interzinc	0,16	0,07	0,66	2,62	0,00	0,00	0,00	0,00	20
Polyuerthane topcoat	International Interthane	0,04	0,02	0,15	0,08	0,00	0,00	0,00	0,00	20
Hot rolled stainless steel plates	Norsk stål	201,00	129,00	0,00	0,00	7,00	3,59	-63,00	-37,70	100
Hot rolled mild steel plates	SSAB	169,00	136,00	0,00	0,00	0,00	0,16	-90,00	-74,00	100
Permanent Strand Anchor	Dywidag	152,23	116,06	0,00	0,00	0,26	0,14	-14,32	-10,28	100
Hot rolled stainless steel tubes	Outokumpu	205,61	137,00	0,00	0,00	0,17	0,12	-94,13	-59,50	100
Wire mesh (stainless steel)	Outokumpu	184,30	170,10	184,30	170,10	0,13	0,08	-83,34	-54,90	50
Asphalt	Vandle (NCC)	1,33	1,15	5,30	4,60	1,45	1,30	-3,03	-2,50	20
Epoxy-based coating	Drizoro	0,09	0,09	0,19	0,18	0,00	0,00	0,00	0,00	40

Kostnaður í €/einingu

Samanburður á umhverfiskostnaði



- The Arup Circular Economy Dashboard notað við framsetningu niðurstaða
- Umhverfiskostnaður metinn hærri við stálbrúna
- Munurinn myndi minnka ef D-fasinn væri tekinn með
- Einingarverð sem notuð eru virka full lág, útreiknaður umhverfiskostnaður er aðeins um 1,5% af byggingarkostnaði brúarinnar => ólíklegur til að hafa úrslitaáhrif við val á brúargerð

Indicator	Description	Steel footbridge	Concrete footbridge
4. ENVIRONMENTAL IMPACT			
4. Total	Total of environmental impact on combination of environmental impact categories	26.4K € (A-C) 14.8K € (A-D)	16.6K € (A-C) 11.5K € (A-D)
4.1 Climate change	Extend to which the material contributes to global warming	21.1K € (A-C)	13.0K € (A-C)

Hugleiðingar

- Rýni gefur tækifæri á endurmati á hönnun nú þegar ný viðmið eru að koma fram
- Það er ekkert efni í brúnum sem endurnýtt er beint, og aðeins fremur lítill hluti úr endurunnu efni
- Notkun á endurnýttu og endurunnu efni hækkar MCI og lækkar ECI
- Áskorun að endurnýta sveigð steypt burðarvirki
- Í Noregi er verið að setja kröfur á það nú að endurnýtingar- og endurvinnslumöguleikar burðarvirkja séu skrásettir í hönnun

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Aðgerðaáætlun

Key focus point	Circular Economy Design Strategies 1-10
Build Nothing	01. Refuse unnecessary new construction
Efficiently used assets	02. Increase intensity of use
Long-term value	03. Design for Longevity 04. Design for Adaptability 05. Design for Disassembly
Efficient use of materials	06. Refuse unnecessary components 07. Increase material efficiency 08. Reduce the use of virgin materials
The right materials	09. Reduce the use of carbon intensive materials 10. Design out hazardous/pollutant materials

- **‘Circular Design Framework for Bridges‘** skrásett í rannsóknarverkefninu - hönnunaraðgerðir
- Byggt á Circular Buildings Toolkit sem Arup hefur þróað
- 10 atriða hönnunarnálgun hringrásarhagkerfa
- Nokkrar aðgerðir fyrir hvert atriði
- Flokkun aðgerða í 1, 2 og 3
    1. Aðgerðir sem ætti að leggja áherslu á hérlendis nú
    2. Aðgerðir sem hægt er að undirbyggja nú og bæta við síðar
    3. Aðgerðir sem ekki tengjast brúarhönnun beint

Version 0.1: 23.10.2022

Circular Design Framework

Bridges

Key focus point	CE Design Strategies 1-10	Description		Design Actions	#	Suggested follow-up
Build Nothing	01. Refuse unnecessary new construction	Early decisions on design and program of a project yield massive impact on the following construction, operation, refurbishment and second life reuse phases. Consideration of environmental, social and economic value at project outset against the clients strategic objectives is a key task. It should be determined if new construction presents the most efficient solutions to meet the client need. This strategy aims at rethinking the need for new transport, energy and water assets by reassessing the **necessity of new construction** for the envisioned objectives. Potentially other measures can be taken to fullfil or reduce the client need. If not, then assess if an existing asset can be used instead of new build.	1.1	Establish a modal shift in the mobility need so that lesser roads are needed to meet the demand for mobility.	3	Not for bridge designers specifically but the brief can be influenced
			1.2	Reuse, renovate or repurpose existing assets instead of building new. Doing more with what we already have.	3	
			1.3	Link requirement for new infrastructure to areal plannning strategies for transport and traffic that are based on optimisation of environmental, social and economic performance	3	
Efficiently used assets	02. Increase intensity of use	Maximising the **intensity of use** of assets is fundamental to minimise overall resource consumption. Increasing utilisation of infrastructure assets is a fundamental principle and the accomodation of various functions of an asset must be included into the construction programme early on. Existing assets can be adapted to increase their utility. For roads and streets bus lanes can be used to replace car capacity and space can be created to include active mobility. This strategy aims at the reduction of upfront resource consumption by maximizing the intensity of use of transport, water and energy assets. Optimized utilization can be achieved through the exploration of the "Space sharing" and "multi-use" concepts The future utilization potential is explored under "Design for Adaptability".	2.1	Increase the multi-use mobility potential of bridges. Allowing for other future use than what the original design is intended for. For example include different loading schemes into the design.	1	**Include in a circular design strategy checklist, checklist to be drafted in follow-up to the Bridges in a circular economy research**
			2.2	Create the general physical conditions to enable multi-use mobility. For example create an obstacle free road surface to accomodate various mobility functions (closely linked with 04 Design for Adaptability).	1	
Long-term value	03. Design for Longevity	This strategy aims at maximizing the value of the asset and it's component over time, optimising **value retention and value recovery potential**. At asset level, it aims at delivering the required function, as well as designing and selecting durable products that can stand the test of time. Durable products and components can be adapted to changing needs over time and extend the service life of an asset and reduce cost. At end of functional asset life durable products and components will have residual value and can be reused in the future. A long life cycle of products and components is directly linked to its design, as the design sets the baseline for an element's quality, maintenance need, necessity for repair, adaptability and residual value when removed.	3.1	Design beautiful and social. Design for timeless architecture that local communities will love and care for a long time.	2	Bridge engineers to advocate inclusion of architects in prominent projects
			3.2	Design for future climate adaptability so that it retains its functionality, performance and value, despite more extreme climate conditions.	2	Include in design checklist, and CEEQUAL certification of larger projects
			3.3	Use fewer unique and project-specific bridge elements.	1	**Include in a checklist**
			3.4	Investigate Product As-a-Service or Leasing schemes for components expected to have a short or medium service life in the project. Within these schemes the durability of the product is generally higher than when you only buy the product. Linked to LCC.	2	Influence the brief to increase awareness of such scheme in procurement
			3.5	Select durable and low maintenance materials for the load bearing structure.	1	**Include in a checklist**
			3.6	Select easy to replace alternatives for components with low service life (compared to main structure) like joints, bearings and parapets.	1	**Include in a checklist**
			3.7	Make use of Life-Cycle Cost Assessment (LCCA) as design assessment tool, and make this a requirement in all bridge design processes.	1	**Support IRCA in defining methodology for LCCA and set the mandate**
			3.8	Select durable and low maintenance materials for non-load bearing components such as parapets, bearings, utilities and joints	1	**Include in a checklist**
	04. Design for Adaptability	This strategy aims at enabling the **adaptability potential** during the use stage. Functional requirements change and it is important that assets have the ability to adapt to new functions to retain their value. It considers three design principles for adaptability: versatility, convertibility and expandability, which are in turn related to the required level of system changes adaptations.	4.1	Increase expandability: Allow for substantial changes by preparing for modifications to the load bearing structure. Include analysis of possible future bridge widening or lengthening and configure the structure such that both can be accommodated without extensive demolition. Applies to 4.2 and 4.3 also.	2	Identify which bridge/project types would benefit from this additional analysis and include in checklists accordingly
			4.2	Increase convertibility: Allow for substantial changes in use by preparing for modifications to the surface layout.	2	
			4.3	Increase versatility: Allow minor changes to the exterior of bridges like railings and edge details	2	
			4.4	Increase access to services, enabling easy repair and replacement.	2	
			4.5	Develop and issue a Manual for adaption with sufficient asset information (e.g. digital twin and Material Passports)	1	**Include in as-built BIM models that are used by owners in-service**
	05. Design for Disassembly	This strategy aims at enabling the **disassembly potential** at end of service life. The design life of some components in assets outlast the service life. It is of importance to design upfront for the disassembly of components in order to recover residual value at end of service life. Seven design principles for disassembly are considered. Following ISO 20887 these principles are; ease of access, independence, avoidance of unnecessary treatments and finishes, supporting re-use (circular economy) business models, simplicity, standardization and safety of disassembly.	5.1	Develop reversible connections between layers of different life span	2	Draw on international experience and with IRCA identify an opportunity to build a reversible bridge in Iceland
			5.2	Allow good access to reversible connections	2	
			5.3	Develop reversible connections between components with different functionality. Dutch circular bridge example, funded by Rijkswaterstaat.	2	
			5.4	Develop and issue a Manual for disassembly Document with sufficient asset information (e.g. Digital twin and Material Passports)	1	**Include in as-built BIM models that are used by owners in-service**
Efficient use of materials	06. Refuse unnecessary components	This strategy aims at meeting the project requirements with **minimal material consumption** . At all levels, it fosters simple design approaches, thoughtfully considering the real need of components and materials. It aims at questioning if certain components can be refused without compromising the ability for the project to function at the desired performance level.	6.1	Refuse redundancy in clearance envelope and overestimated user growth predictions	1	**Include in a checklist**
			6.2	Refuse the use of solely aesthetical design elements like edge elements	1	**Include in a checklist**
			6.3	Avoid components where at all possible, for example integral bridges reducing the need of joints and bearings where justifiable.	1	**Include in a checklist**
	07. Increase material efficiency	This strategy aims at meeting the project requirements with minimal material consumption. At all levels, it aims for an **efficient use of materials** at a maximum level of performance. It looks at avoiding inefficient designs (unbalanced cut and fill) and selecting efficient systems and forms. It also looks at the use of high-performance products and materials and advance engineering methodologies.	7.1	Select material efficient structural forms and techniques that suit the span and function.	1	**Include in a checklist**
			7.2	Reduce dimensions of the bridge structure components through selection of high strength materials	1	**Include in a checklist**
			7.3	Use advanced engineering practices to improve material efficiency of the bridge structure. Optimise all components of new structure to a utilisation close to 1.0 over the length and width of the bridge	1	**Include in a checklist**
			7.4	Reduce material waste at production and construction through off-site prefabrication of the bridge structure.	2	Work with other stakeholders and researchers in introducing pre-fab to bridge design where appropriate
	08. Reduce the use of virgin materials	This strategy aims at the prevention of **virgin abiotic material** consumption and promotion of secondary products and materials. At all levels, it aims to promote the use of reused products and recycled materials as well as promoting the use of renewable and biobased materials. And the prevention of virgin construction materials and critical raw materials in transport, water and energy. This strategy helps to mitigates potential risks imposed by scarce materials and material dependency.	8.1	Use reused components in the main structure. To enable this develop an open-source database of available components based on material passports sourced from digital twins	2	Work with the industry to set-up a register of useable components from decommissioned bridges
			8.2	Use concrete and steel with high recycled content	1	**Legislate and work with CO_2 targets**
			8.3	Use timber (or other biobased products)instead of traditional non-renewable structural materials. See here an example https://www.nordic.ca/en/projects/structures/mistissini-bridge	2	Monitor experience of recent timber bridges in Iceland
			8.4	Increase re-use of components for the railing and barriers	2	Work with the industry to set-up a register of useable components from decommissioned bridges
			8.5	Reduce the use of critical raw materials. See more info here https://www.crmalliance.eu/critical-raw-materials	2	Include in a checklist
The right materials	09. Reduce the use of carbon intensive materials	In the construction industry, embodied carbon (upfront carbon) has a significant impact on the climate crisis. As upfront carbon immediately cuts into our remaining carbon budget to stay below the globally agreed 2°C temperature rise by 2050. Other strategies already look at reducing material demand, now and in the future. This strategy aims at reducing the use of **carbon intense materials**. It prioritizes products and components which use reused products, recycled materials, renewable and biobased materials and suppliers that use clean energy in their manufacturing processes.	9.1	Keep track of the embodied carbon footprint of superstructure and substructure and set a target which is below the regionally recommended thresholds	1	**Legislate and work with CO_2 targets**
			9.2	Use concrete products with cement replacers, instead of traditional concrete	1	
			9.3	Use Engineered timber (or other biobased) products, instead of traditional carbon intensive materials like concrete and steel	2	Monitor experience of recent timber bridges in Iceland
			9.4	Alway consider use of reinforced soil solutions to retain soil in vertical walls instead of traditional carbon intensive materials	1	**Include in a checklist**
			9.5	Design for digital information management and provide sufficient information for LCA	1	**Include in as-built BIM models that are used by owners in-service**
	10. Design out hazardous/pollutant materials	This strategy aims at preventing the use of materials that have a negative impact on the **planetary boundaries** other than the Global Warming Potential that is covered by strategy 09. It focusses on the environmental impact categories covered in international LCA guidelines. Additionally, this strategy aims at preventing the use of materials that have a negative impact on the health and wellbeing of local communities and users. Materials which pose a potential risk to human health are likely to prevent the reusability of materials and components in the future, thus impeding on the value retention potential.	10.1	Make sure that materials and products are not on the 'Living Building Challenge (LBC) Red List'. See more info here https://living-future.org/lbc/red-list/	2	Include in a checklist
			10.2	Use on-site electric equipment to reduce the use of fossil fuel driven machines on site, so in turn this reduces the impact of nitrogen, smog and particulate matter emissions in the area.	2	Include in LCA
			10.3	Keep track of all environmental impacts during design through detailed LCA and set an ambitious target for the overall project (all layers, including realistic functional and service lives of components)	1	**IRCA to make LCA a mandatory requirement in bridge design**

Categorisation of Design Actions:

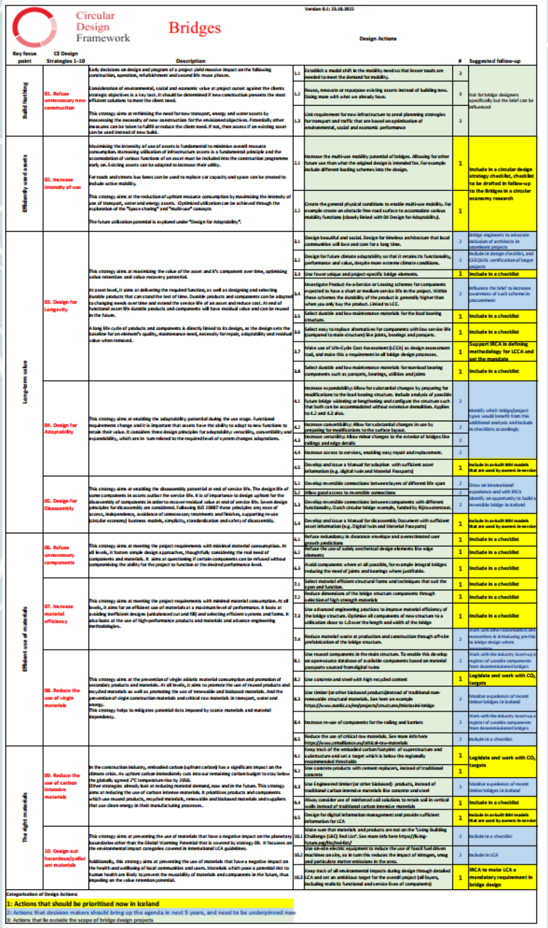
1: Actions that should be prioritised now in Iceland

2: Actions that decision makers should bring up the agenda in next 5 years, and need to be underpinned now

3: Actions that lie outside the scope of bridge design projects

ARUP EFLA

Aðgerðaáætlun



- Aðgerðir sem ætti að leggja áherslu á hérlendis nú
  1. Gátlisti sem styður við hringrásarhugsun í brúarhönnun
     - Skilgreina hvað þarf að uppfylla til að „haka í“ hvert atriði
  2. Gera kröfur um líftímakostnaðargreiningu við samanburð valkosta
  3. Gera góð BIM líkön í hönnun og halda utan um eigindi á borð við efnisgæði, endurnýtingarmöguleika og viðhald – nýtist á rekstrartíma
  4. Gera kröfur um vistferilsgreiningu í hönnun brúa og skilgreina og fylgja eftir markmiðum um kolefnisspor brúarmannvirkja

Samantekt

- Kynnt hefur verið hvernig nálga má brýr í hringrásarhagkerfi
- Studst við almennar skilgreiningar og hollenska aðferðafræði
- Hringrásareiginleikar tveggja brúa hafa verið metnir og bornir saman
- Vinna nýtt við að setja fram aðgerðaráætlun fyrir bætta hringrásarhönnun brúarmannvirkja







Takk fyrir!