fib Special Activity Group Sustainability

Agnieszka Bigaj-van Vliet
(convener TG.SAG.2)

Stufib meeting
Delft, 11/10/2023

TNO innovation for life

Sustainable polices

Sustainable policies and legislation provide the **framework and incentives needed to transition toward a more sustainable future:**

Policies :

- help to **coordinate global efforts** to address environmental challenges
- help to **inform and engage citizens**, encouraging them to make more sustainable choices
- motivate industry to assess and mitigate their environmental and social risks, **fostering responsible business practices**

1984 R. Goodland publishes "**Integration of Economy and Ecology: An Outlook for the Eighties"**. Univ. of Stockholm Press, Stockholm

1984 H. Daly & R. Costanza hold Stockholm Symposium "**Integrating Ecology and Economics**"

1987 Sustainable development defined through **UN Bruntland Report**

2000 **Millenium Development Goals**

2001 **Aarhus Convention** increases public awareness and involvement in environmental matters

2005 **Kyoto Protocol** sets binding emission reduction targets of 7% between 2008-2012 and 18% between 2013 to 2020 compared to 1990 levels

2015 **Paris Climate Agreement** limits global warming to well below 2°C compared to pre-industrial levels (1880)

2016 **Sustainable Development Goals** identify 17 objectives of "blueprint for peace and prosperity for people and the planet now and into the future"

2021 **Glasgow Climate Pactis** is the first climate agreement explicitly planning to reduce global coal usage

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- **define targets for future developments**

2030
EU emissions reduction by 55%
EU all new buildings zero-emissions and solar installations
NL 50% reduction in raw material consumption
NL all public tenders circular

2034
EU 25% existing non-residential buildings zero-emissions

2050
global warming below 2°C and towards 1.5°C
EU climate neutral
EU 100% circular
EU all buildings net-zero
NL all homes renovated
NL a waste-free economy
NL 100% climate-neutral

Sustainable polices

Sustainable policies and legislation provide the **framework and incentives needed to transition toward a more sustainable future:**

Standardization :

- establish **consistent criteria** for products, services, and processes
- help to **guide and enforce environmentally responsible practices**
- provide consumers with **confidence in products and services**
- drive innovation by **challenging industries** to improve their practices

2010 **ISO 26000 Social Responsibility**

2015 **ISO 9001 Quality Management System**

2015 **ISO 14001 Environmental Management System**

2015 **ISO 45001 Occupational Health & Safety**

2016 **ISO 37101 Sustainable development in Communities**

2016 **ISO 37001 Anti-Bribery Management System**

2016 **ISO 37001 Energy Management System**

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2017	**ISO 20400 Sustainable Procurement**

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- **provides a structured framework for organizations and businesses to follow when acquiring goods and services**
- ***fib* must be prepared to lead the change in the structural concrete community**

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2017 **ISO 20400 Sustainable Procurement**

2023 ***fib* Model Code for Structural Concrete**

Ongoing fib activities on sustainability enhancement

STAGE			Supplier	Designer	Builder	Owner
Product Stage	A1	Raw material supply				
	A2	Transport				
	A3	Manufacturing				
Construction Stage	A4	Transport				
	A5	Construction-Installation process				
Use Stage	B1	Use installed products				
	B2	Maintenance				
	B3	Repair				
	B4	Replacement				
	B5	Refurbishment				
	B6	Operational energy use				
	B7	Operational water use				
End of life Stage	C1	Deconstruction				
	C2	Transport				
	C3	Waste processing for reuse, recovery or/and recycling				
	C4	Disposal				
	D	Reuse, recovery, recycling and remanufacturing		New Cycle		

	Item	COM/TG
Material	Concrete	4 / 2.11
	Re-bar	5.2
	Prestressing steels & systems	5.3
	FRP / Textile Reinforced Concrete	5.1 / 2.10
	SFR	4.1 / 4.2
	EPDs	7.5
Structure (Design)	Optimum Concrete Mixture	4 / 4.8
	Structural Sustainability	1.5
Structure (Execution)	Precast	6
	Equipment & Transportation	1.7
	Accessories (Bridge)	1.1
	Accelerated construction	1.7
Conservation	Durability	8
Intervention	Interventions works	3.4
Demolition	Deconstruction	1.7 / 6 / 7
Next Cycle	Reuse & Recycling / RCA	4.7

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objectives

1. a comprehensive database of environmental impact data for concrete structures.
2. a reliable methodological approach to support designers in quantifying the environmental impact of concrete structure projects.
3. best practices for different innovative solutions, for various structures, market conditions and geographical areas
4. consistent basis for performance-based design of sustainable structures in a life cycle perspective
5. best tools and knowledge to guide the decision-making process towards optimal structural solutions

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structure

TG.SAG.1 fib Database

Convener: Costantino Menna (University of Naples, Italy)

TG.SAG.2 Sustainable Concrete Structures

Convener: Agnieszka Bigaj-van Vliet (TNO, Netherlands)

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structure

TG.SAG.1 fib Database

Convener: Costantino Menna (University of Naples, Italy)

The TG.SAG.1 aims to establish a **comprehensive database of environmental impact data for structural materials used in concrete structures**.

The TG.SAG.1 will prioritize data related to the **construction stage**, but it will also develop a strategy to manage data from the **operational and maintenance stages**, as well as the **dismission stage**.

The TG.SAG.1 will source this data from **manufacturers, designers, associations, and other institutions**.

The data platform will be **continuously maintained** by collecting new data and updating existing data, with a focus on different lifecycle stages in different geographical areas.

TG.SAG.1: *fib* Database

Workplan

- Improving the data within available environmental data platforms (e.g., Building Transparency - EC3) to reflect other geographies and technologies (especially for concrete-like products), but also construction methods and different types of structures other than buildings.
- Define strategies and approaches to transfer environmental performance data into structural design projects and/or assessment methodologies at the structure level.
- Leveraging existing data in available platforms (e.g., EC3) to support fib's mission and activities.
- Consider the inclusion in EC3 of data other than EPDs.
- Consider development and deployment of benchmarks (localised to reflect the context, e.g., compliance to local building codes).
- Examples and case studies

TG.SAG.1: *fib* Database

To **kickstart** TG.SAG.1, three distinct groups are formed:

- Operational Group : This group will consist of enthusiastic individuals, potentially including young Ph.D. students or researchers, who are capable of actively engaging in content production.
- Reviewing Group : We need a dedicated team to support the operational Group and rigorously review materials, ensuring the highest quality standards are maintained.
- Engagement Group : This group will comprise members who are willing to actively participate in discussions, mainly via mail, and attend periodic meetings, providing valuable insights and input.

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Sustainability

structure

TG.SAG.2 Sustainable Concrete Structures

Convener: Agnieszka Bigaj-van Vliet (TNO, Netherlands)

The TG.SAG.2 will evaluate **current best practices and innovative structural solutions in terms of environmental impact**, fit for various market conditions and geographical areas.

The TG.SAG.2 will work on **consistent implementation of the safety philosophy for structural design across a wide range of innovative solutions** (beyond the scope of Model Code 2020).

The TG.SAG.2 will elaborate the objectives and methodologies for a **multi-criteria decision-making** aimed at **sustainability-oriented optimization of design**.

The TG.SAG.2 will formulate principles for an **equivalent performance approach to structural design with innovative (material) solutions** and establish basis for operational **provisions for performance evaluation supported by material and structural testing of innovative solutions**.

Multiple approaches are feasible & necessary to produce and used concrete sustainably

- Reductions in emissions > 80% (i.e. target for 2ºC global warming prevention) , 100% circularity & a waste-free concrete construction sector can be achieved by combining various scenarios

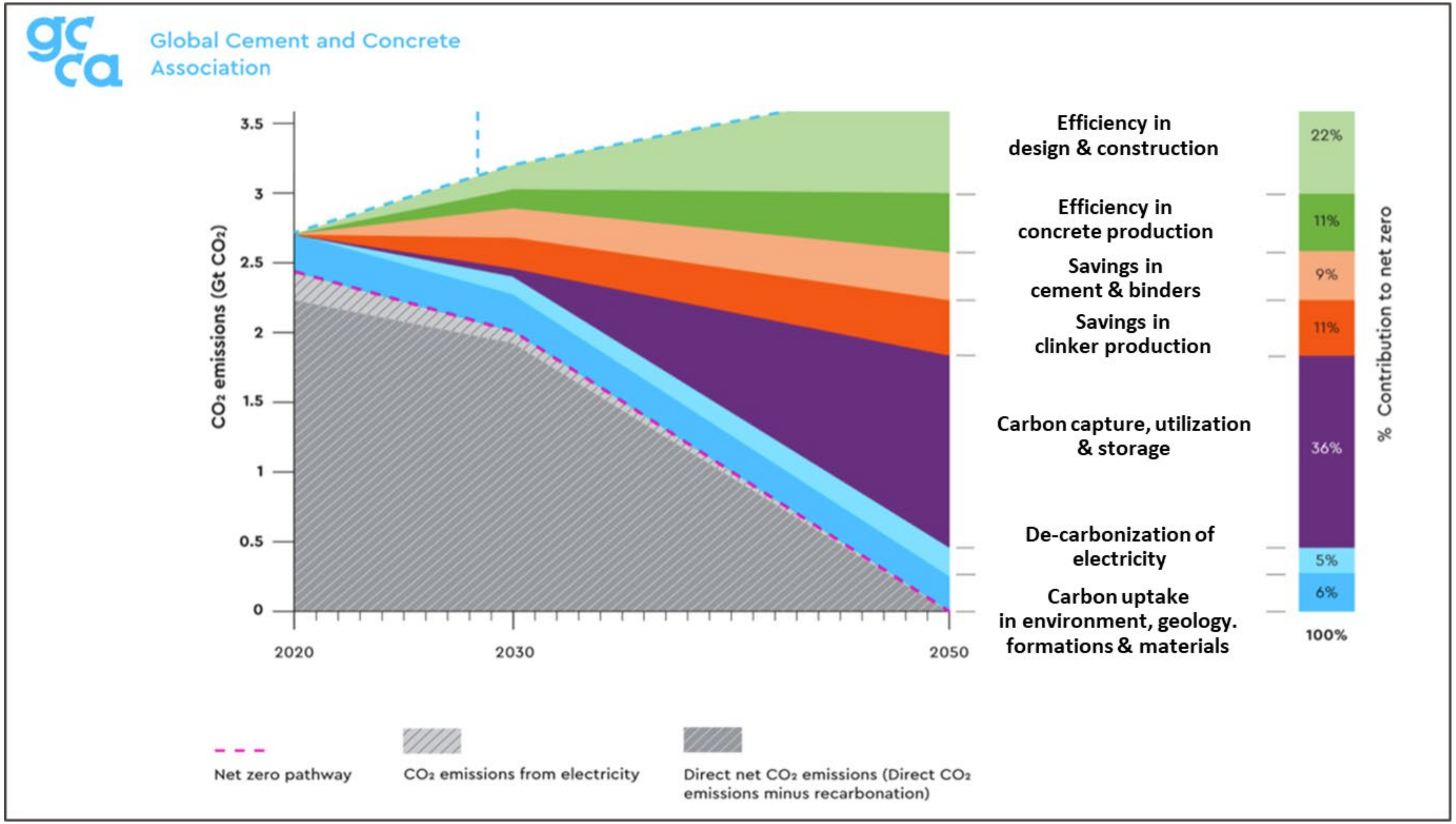
Reduce CO_2 from clinker production → Reduce clinker in cement → Reduce cement in concrete → Reduce concrete in structures → More efficient (re)use of existing structures

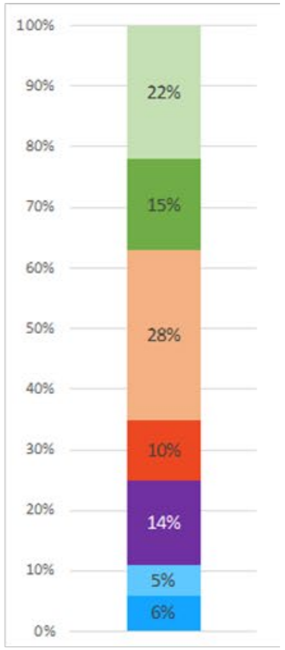
TG.SAG.2: Sustainable Concrete Structures

Aim 1 : Prepare the State-of-the-Art inventory on innovative solutions aimed at identifying the current "best practices" and innovative structural solutions that enhance sustainability of concrete structures (both in terms of environmental impact, life cycle costs and social (incl. structural) performance)

Scope of SotA report to be formulated based on

- the relevance of the solutions for the practice,
- the potential impact they may generate,
- the feasibility of gathering a group of experts willing to provide their well-documented cases

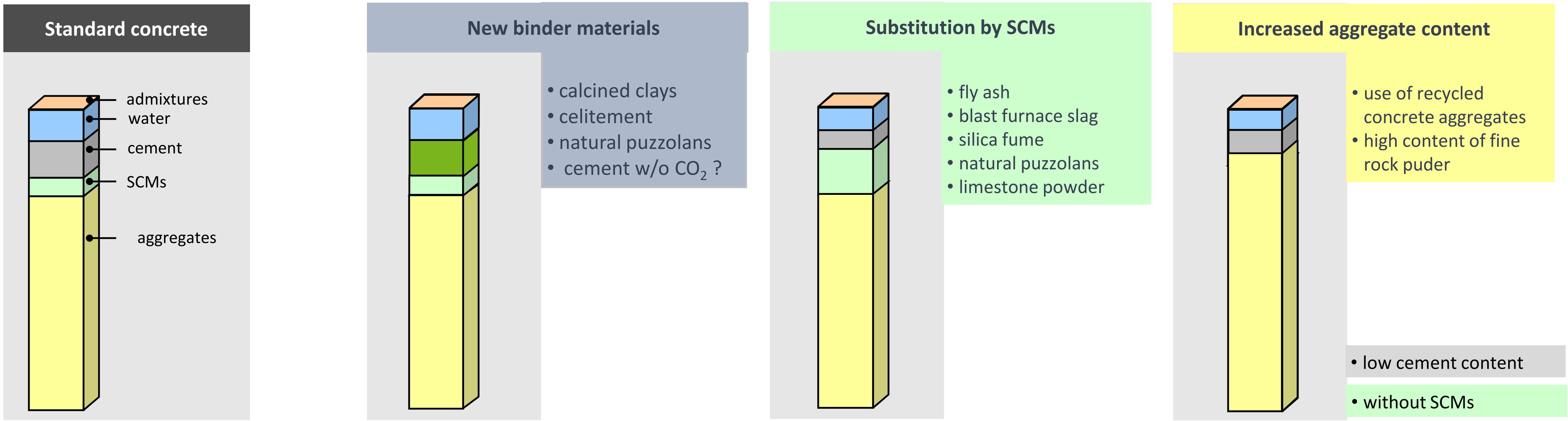




source: K. Scrivener, *Drivers for CO2 reductions*, LC3-project (Limestone Calcinated Clay Cement) EPFL, 2023

Creating know-how : Substitution

Substitution involves replacing materials with a high environmental impact with alternatives of lower impact and equivalent or superior performance, with the aim of minimizing the use of materials that harm the environment.



source: H.S. Müller, *Green concretes – approaches, properties and challenges*, Workshop on fib Model Code 2020, Rome, 2022

Identifying State-of-the-Art innovative solutions

- **Lifespan Extension:** Efficient use through sustainable management, maintenance, renovation, and adaptation of existing structures.
- **Reuse & recycling:** Circular use of materials and components from existing objects, CDW and other residual streams .
- **Substitution:** Replacement of materials with a higher environmental impact with materials with a lower impact and the same or better performance
- **Dematerialization:** Material reduction through smart design, for example, design optimization and materials with better performance.
- **Sustainable Production and Construction Processes:** Efficient energy and water use; the use of sustainable transportation and renewable energy .
- **CO_2 capture :** Direct CO_2 capture, storage, and reuse;
- **CO_2 uptake (sequestration):** CO_2 uptake in the environment (terrestrial sequestration), geological formations (geological sequestration), or in materials used in construction (industrial sequestration).

Identifying State-of-the-Art innovative solutions

- **Lifespan Extension:** Efficient use through sustainable management, maintenance, renovation, and adaptation of existing structures (e.g. low-impact repairs (SMA), …)
- **Reuse & recycling:** Circular use of materials and components from existing objects, CDW and other residual streams (e.g. reuse of reclaimed elements and structural parts for buildings & bridges, RCA/RAC, …)
- **Substitution:** Replacement of materials with a higher environmental impact with materials with a lower impact and the same or better performance (e.g. LC3, alkali activated fly ash, alkali activated fine fractions, …)
- **Dematerialization:** Material reduction through smart design, for example, design optimization and materials with better performance (e.g. use of UHPC, use of FRP & carbon reinforcement, …)
- **Sustainable Production and Construction Processes:** Efficient energy and water use; the use of sustainable transportation and renewable energy (e.g. modular construction, prefabricated construction, industrial flexible demountable construction (IFDC), …)
- **CO_2 capture :** Direct CO_2 capture, storage, and reuse;
- **CO_2 uptake (sequestration):** CO_2 uptake in the environment (terrestrial sequestration), geological formations (geological sequestration), or in materials used in construction (industrial sequestration).

In the current safety philosophy, environmental objectives are subordinate to economic interests.

How large is the deviation from an optimal sustainable decision when designing using the current safety philosophy method?
Is the adjustment of reliability requirements necessary for sustainable constructions with reused elements?

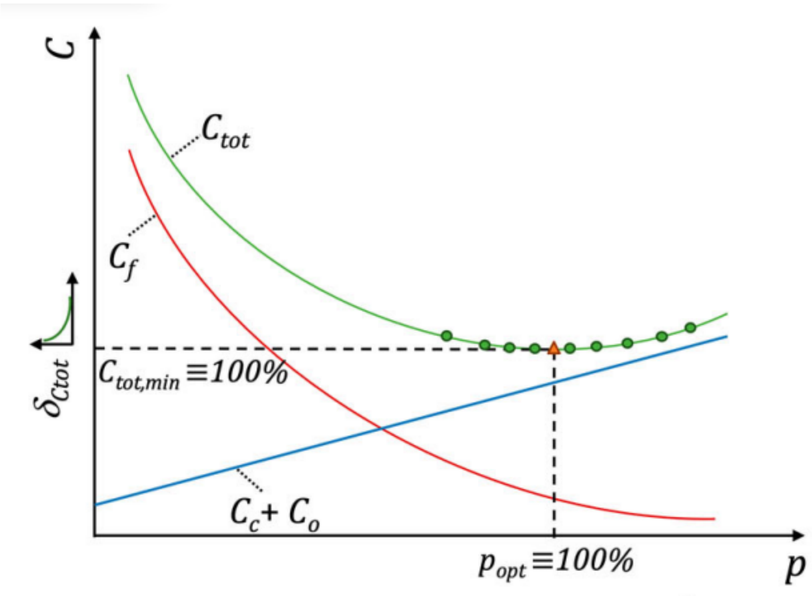


Illustration of cost optimisation principle

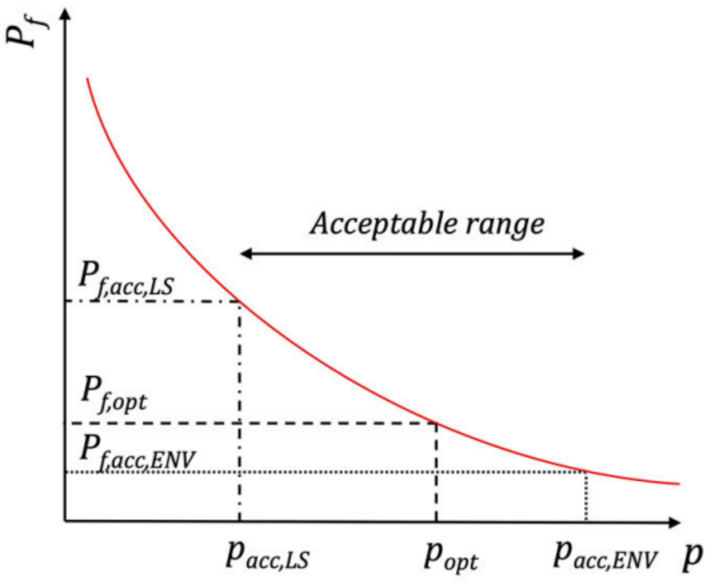


Illustration of relationship between failure probability (P_f) and acceptable range for p_{opt} limited by life safety ($p_{acc,LS}$) and environmental impact ($p_{acc,ENV}$) requirements

R. Hingorani, J. Köhler (2023), *Towards optimised decisions for resource and carbon-efficient structural design*, Civil Engineering and Environmental Systems, 2023, DOI: 10.1080/10286608.2023.2198767

TG.SAG.2: Sustainable Concrete Structures

Aim 2 : Reliability requirements are indented as a criterion for decisions regarding new structures (e.g. the dimensioning of the structural members) and existing structures (e.g. the design of strengthening measures or the disapproval of the structure). The reliability requirements and verification formats given in the codes of the future shall be based on consideration of economic cost optimization, criteria for human safety and environmental impact.

TG will develop a **framework for assessing optimal and acceptable reliability requirements taking into account also the environmental impact.**

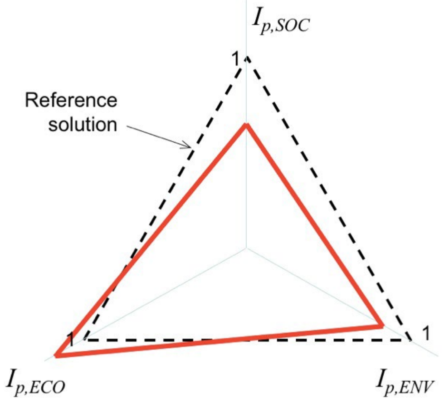
TG will propose a calibration framework for the **derivation of optimal partial factors in terms of lifecycle costs and environmental impact**. In addition, this TG will **formulate needs for amendments to the currently used partial factors for loads and material resistances** based on the application of the proposed calibration framework to the selected benchmark cases.

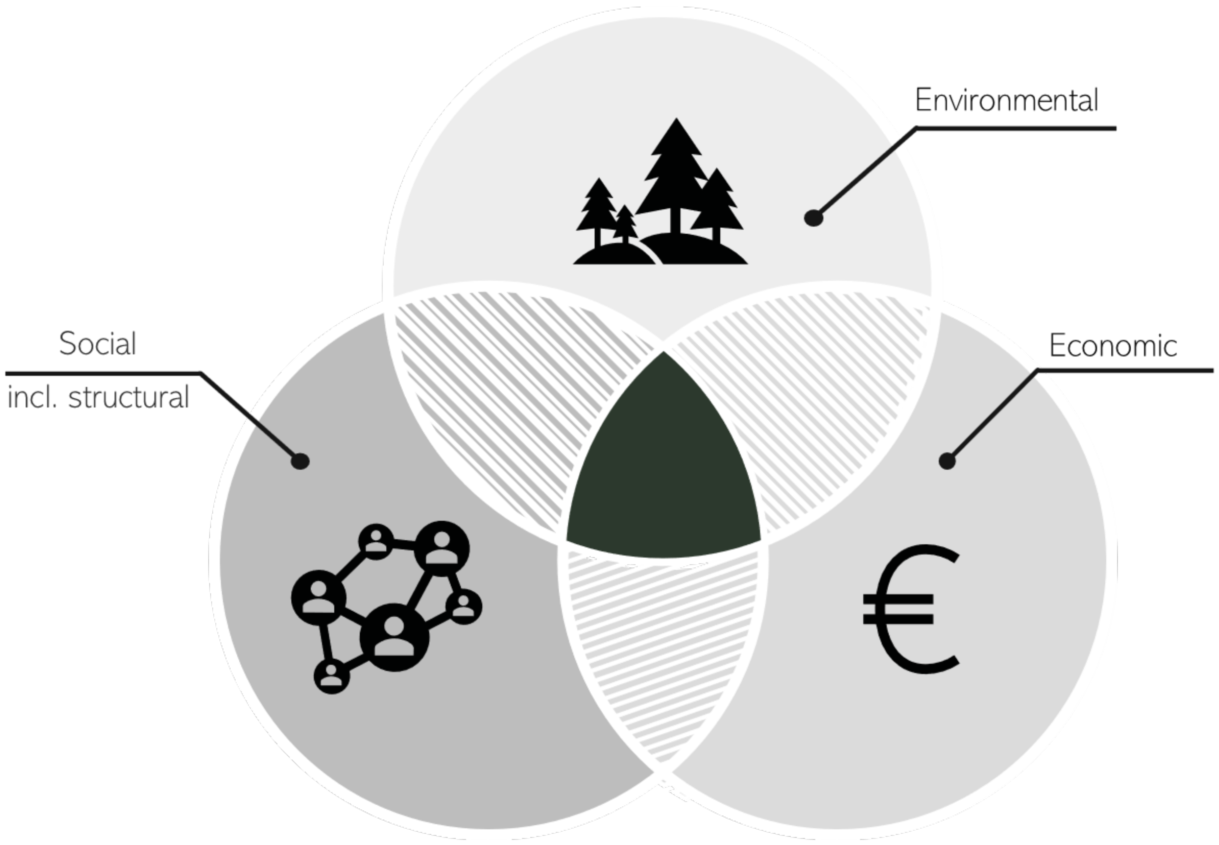
Multidimensional context of sustainable growth

... sustainability as an inherently multidimensional issue where the environmental, social, and economic factors involved are mutually incommensurable ...

source : *The appraisal of sustainability: Some problems and possible responses*
A. Stirling, The International Journal of Justice and Sustainability, 1999

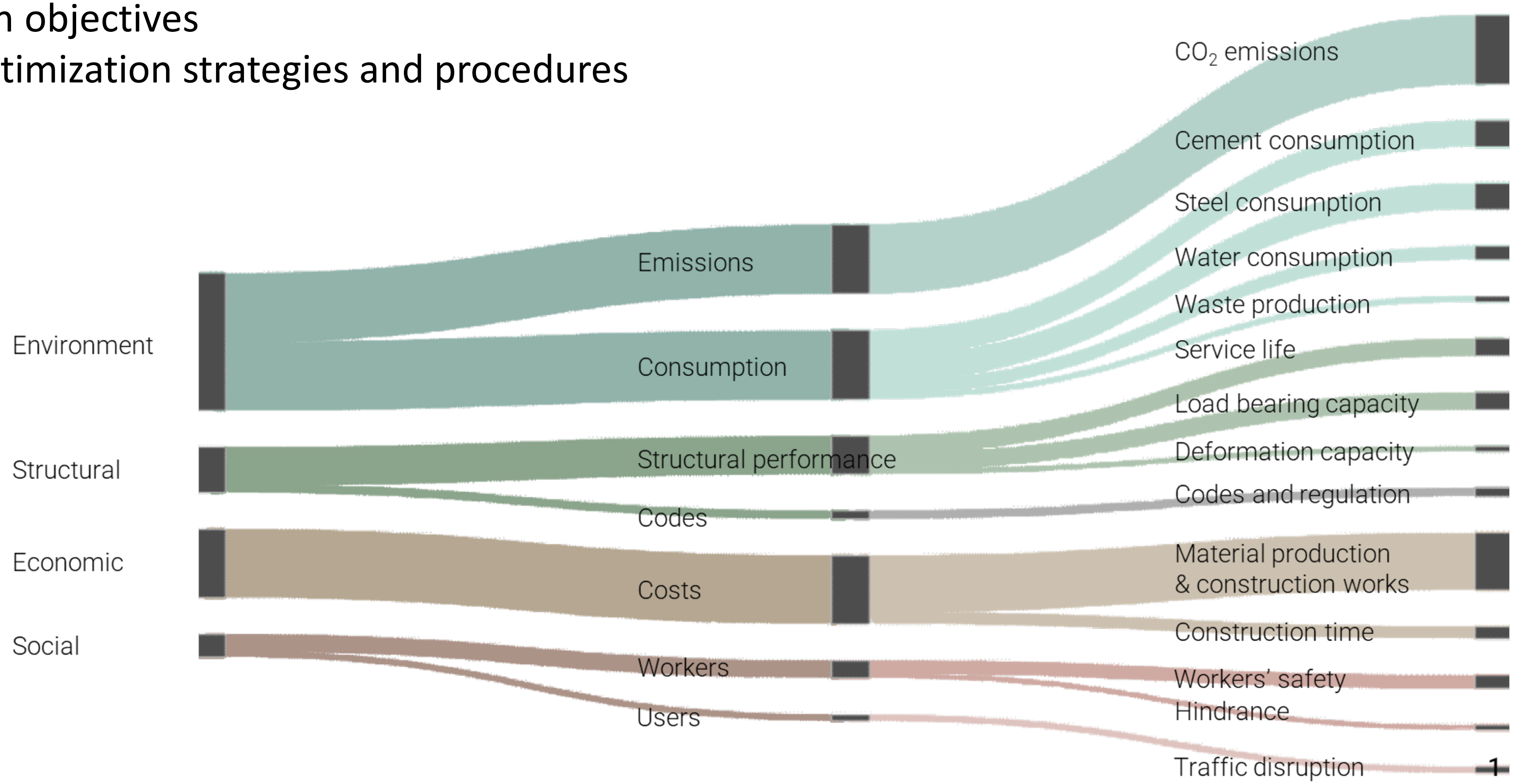
Sustainability assessment involves parallel evaluation of three pillars of sustainability, and thus creation of the holistic appraisal on entire performance quality supporting decision making during life cycle





Identifying methodologies for **decision-making process towards sustainable structural solutions for design, execution and life cycle management including interventions,** optimized in terms of environmental impact, economic and social performance, and satisfying structural and functional performance requirements

- optimization objectives
- effective optimization strategies and procedures



TG.SAG.2: Sustainable Concrete Structures

Aim 3 : Identifying the approaches to guide the decision-making process towards optimal structural solutions, including objectives and methodologies for a multi-criteria decision-making process for sustainability-oriented optimization of engineering decisions throughout the life cycle of concrete structures.

- What are the key objectives and methodologies for a multi-criteria decision-making process aimed at achieving sustainable structural solutions through sustainability-oriented optimization of design, construction, conservation, etc.?
- How can particular aspects of sustainability (e.g. circularity) be handled in the multi-criteria decision-making process?
- What are the state-of-the-art approaches to the multi-criteria decision-making process (case studies)?
- What are the effective strategies and procedures to ensure that decision-making at various design stages supports the successful accomplishment of these objectives?
- How to account for (large) uncertainties in a multi-criteria decision-making process?

TG.SAG.2: Sustainable Concrete Structures

Aim 4 : Development and implementation of performance based approaches in a practical / operational format

- principles of equivalent performance approach for structural design with innovative (material) solutions

- framework for performance evaluation based on material and structural testing of innovative solutions

- guidelines for the green regeneration of the concrete heritage structures:
  - methodology for the sustainable implementation of the conservation and reuse of the modern and contemporary concrete architecture to the international professional audience in the construction and renovation sector, offering a practical instrument for an innovative and applicable form of heritage regeneration

- and other issues to be considered in due time

SAG outcomes

1. fib Platform of environmental impact inventory data for members on our website
2. fib Bulletin on the best practices
3. Recommendations for implementation of safety philosophy
4. fib Bulletin on optimization strategies
5. Recommendations and practical guidelines for implementation of performance-based and sustainability-oriented design, construction, maintenance and rehabilitation approaches

SAG Timeline

- Phase I (2023 - mid 2024): first version of the outcomes of both the TGs
- Phase II (mid 2024 - 2025): update version of the outcomes of both TGs
- Phase III (2026 -): Uptake of the knowledge in *fib* Model Code

- October 16th, TG.SAG.2 meeting in DELFT