

Neo Cement Board

Designing a sustainable fiber reinforced cement boards with waste incorporating value perceptions and visual preferences of architects

Reaching net zero emissions globally in 2050 is a critical and formidable goal.

As climate change intensifies, the race to reduce emissions, consumption, and waste is running. In response, interest in sustainability is growing. Reaching net zero emissions is now set as crucial goal to achieve globally. By industry, building sector emits 16% of GHG emission except emission counted in material sector, and is one of the most responsible sectors. The need to foster investments in this area is urgent.

Cement and concrete production have contributed to high environmental impact.

Especially, environmental impact on cement -the raw material of concrete used in structures - has become an urgent issue. Currently, the world's annual cement production is over 4 billion tons, which also accounts for about 8% of the world's CO2 emissions^[1]. In addition, the construction and civil engineering fields account for 16% of the total green house gas (GHG) emissions, which is more than the amount of GHG produced by air traffic such as airplanes*. In response to this problem, the Global Cement and Concrete Association announced the goal of achieving carbon neutrality by 2050^[2]. There is a growing need for research to achieve this goal. In Japan, cement production emits approximately 41.47 million tons of CO2 per year,^[3] and Japan ranks 7th in the world in terms of cement consumption per capita. Worldwide, 30 billion tonnes of concrete is used each year. On a per capita basis, that is 3 times as much as 40 years ago — and the demand for concrete is growing more steeply than that for steel or wood. In addition to being an essential principle of a Circular Economy approach, systems-based thinking has been argued as necessary in order to achieve net-zero green house gas emissions in the cement industry (Miller et al., 2021).

[1] SWI swissinfo.ch (2021, March 22). “小国スイスはCO2排出国” CO2大量排出のセメント産業、環境負荷を減らせるか, <https://www.swissinfo.ch/jpn/%E3%82%BB%E3%83%A1%E3%83%B3%E3%83%88-%E7%92%B0%E5%A2%83%E8%B2%A0%E8%8D%B7-co2-%E6%B0%97%E5%80%99%E5%A4%89%E5%8B%95-%E3%82%B3%E3%83%B3%E3%82%AF%E3%83%AA%E3%83%BC%E3%83%88/46463288>, 2022-10-16

* IPCC Working Group III contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change

[2] Global Cement and Concrete Association (2019, September 1). *Concrete – the world’s most widely used material – targets carbon neutral future*. Industry outlines ‘2050 climate ambition’ to tackle global challenge, <https://gccassociation.org/news/concrete-the-worlds-most-widely-used-material-targets-carbon-neutral-future/>, 2022-10-16

[3] 経済産業省 資源エネルギー庁 (2021, Dec 15), “コンクリート・セメントで脱炭素社会を築く！？技術革新で資源もCO2も循環させる”,

https://www.enecho.meti.go.jp/about/special/johoteikyo/concrete_cement.html, 2022-10-16

Cement Board

(Vinylon fiber reinforced cement boards have high water and frost resistance and tensile strength)

Inner walls

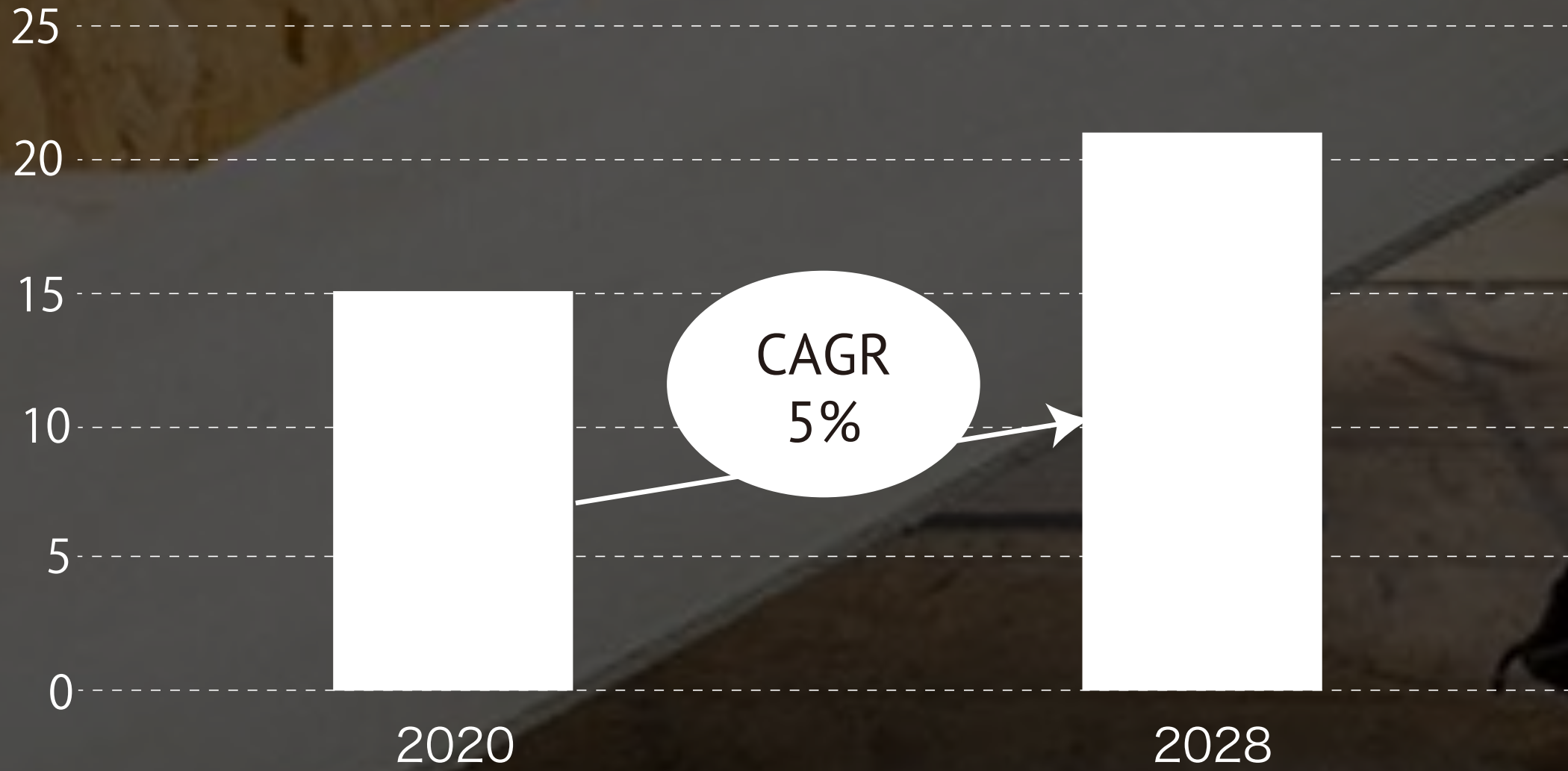
Outer walls

Floor

Rooftiles

- 1. Higher demand for thin boards combined with insulation used for energy efficiency
- 2. Trend of renovation

Growth of global cement board market (Billion US \$)

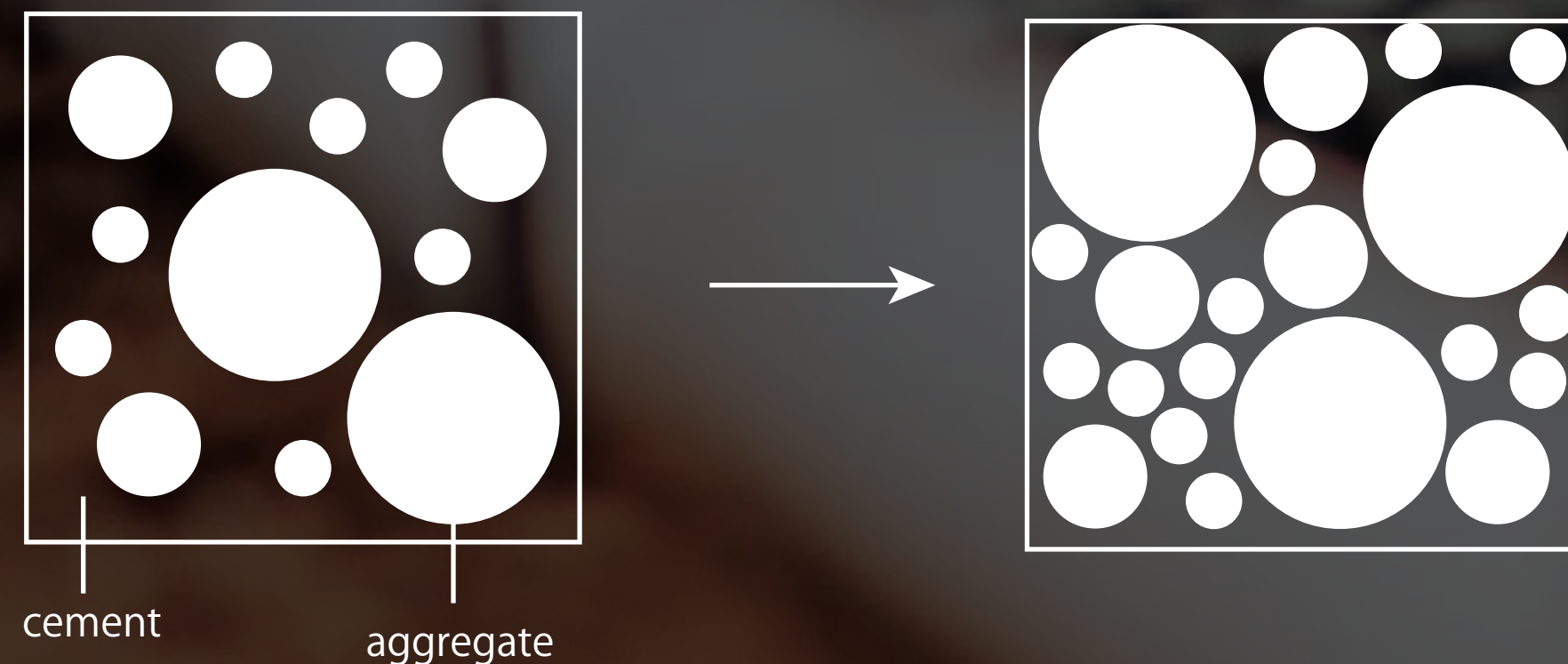


On material scale

Light impact material

For environmental consideration, renovate and build new buildings with fewer resources. Reduce cement, steel, and chemicals that emit large amounts of GHGs in particular.

(i.e.) Reduction of cement content in concrete



On social scale

Social acceptance

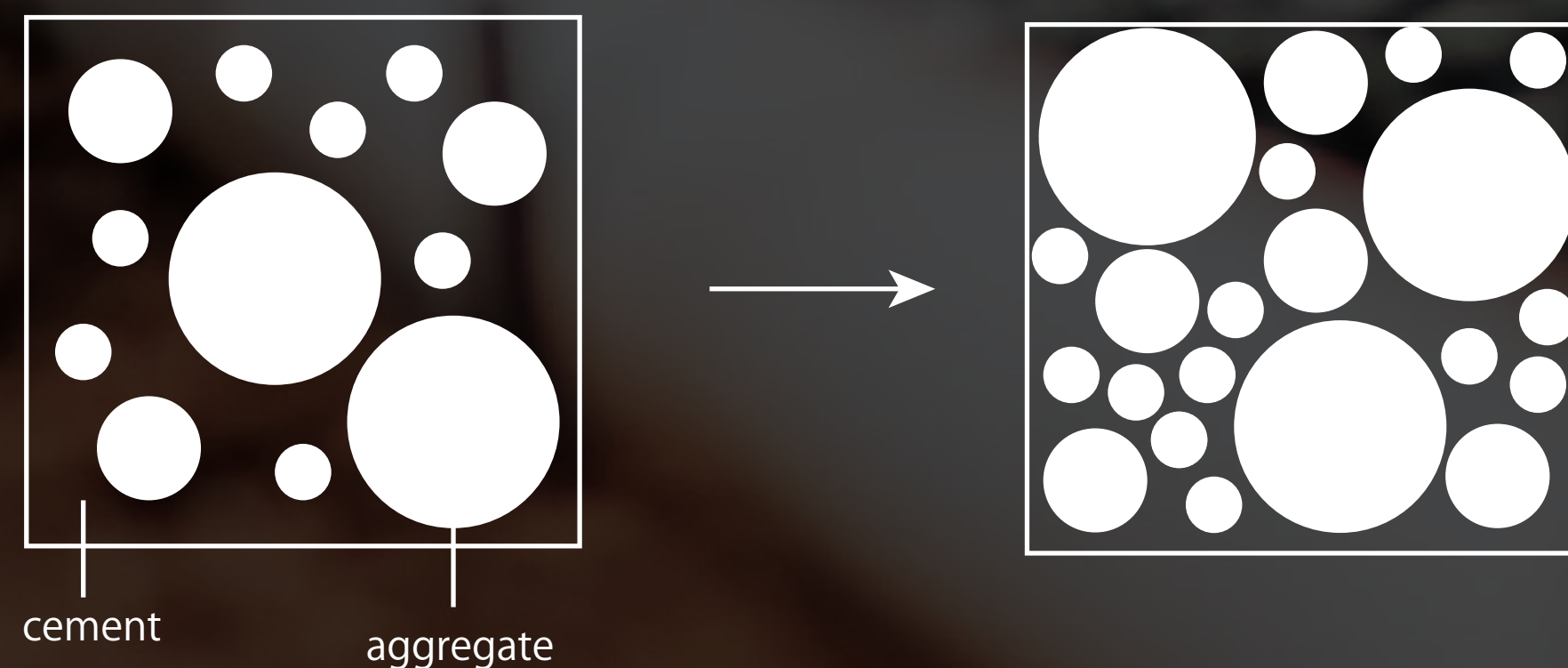
Practitioners' decision-making is not purely matter of hard (i.e. technical, economic, environmental) considerations. The social, legal and political aspects have been relatively neglected. Cultural and social aspects including clients' and the public's perceptions of Circular Economy innovations are important.

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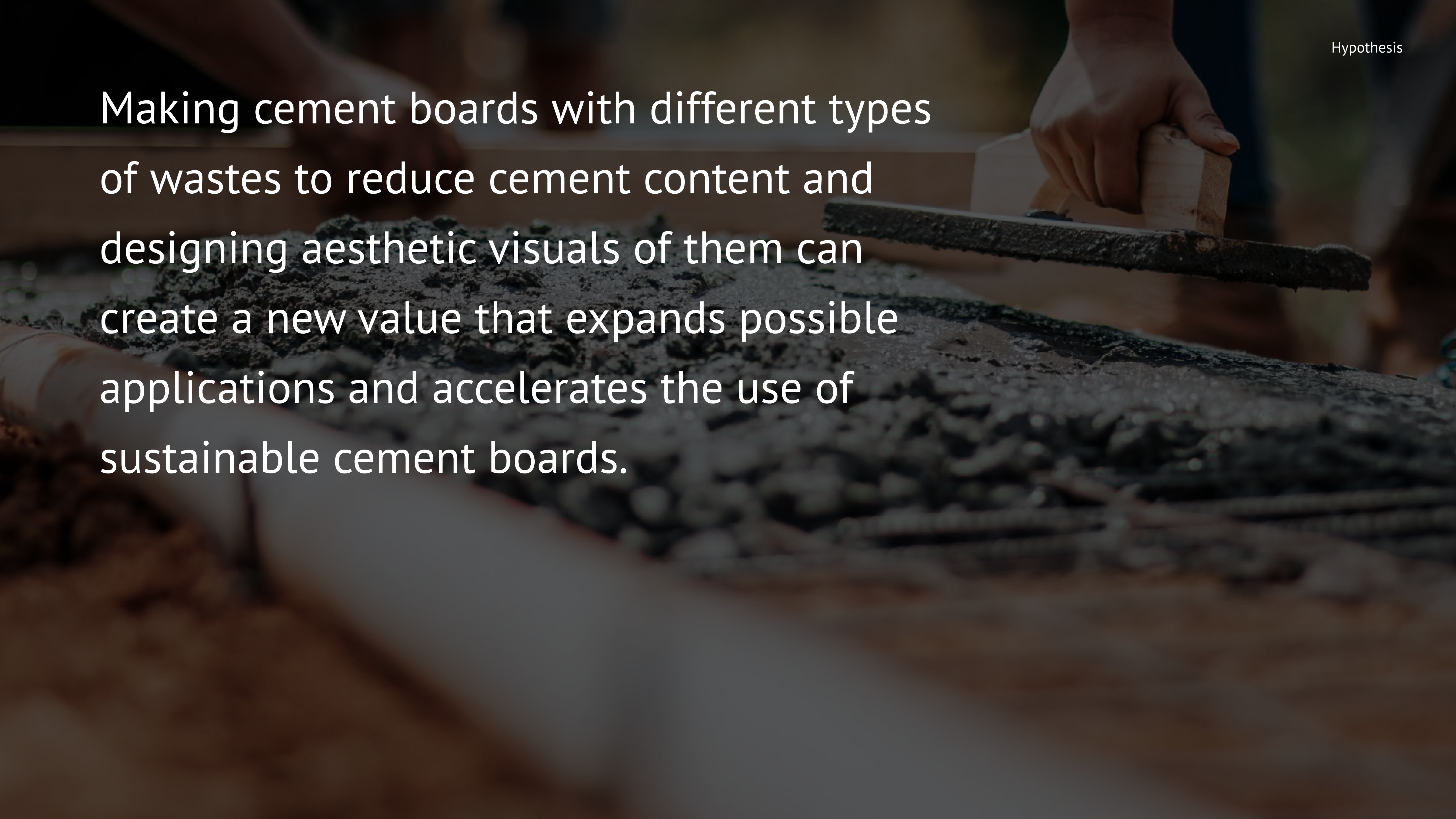
高炉セメントB種（高炉水砕スラグ）を実験で使用

- 比率は重量比で60%（24%分を普通ポルトランドセメント代替とする）
- 身近な廃棄物を骨材ほかで利用
 - 外観の変化による建材としての可能性の広がり
 - 消費者の環境貢献欲求を満たす

Designing sustainable cement boards utilizing waste as a resource incorporating architects' preferences and value perceptions

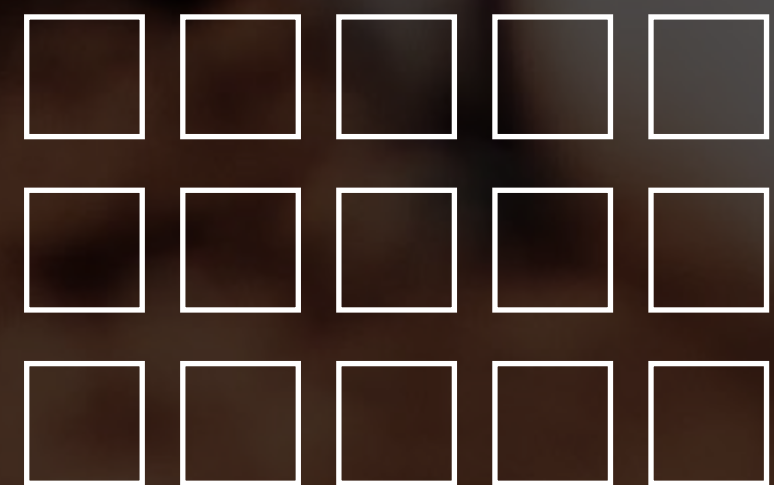
* Decision-makers who design buildings and understand social and legal aspects as well as technical, economical and environmental aspects



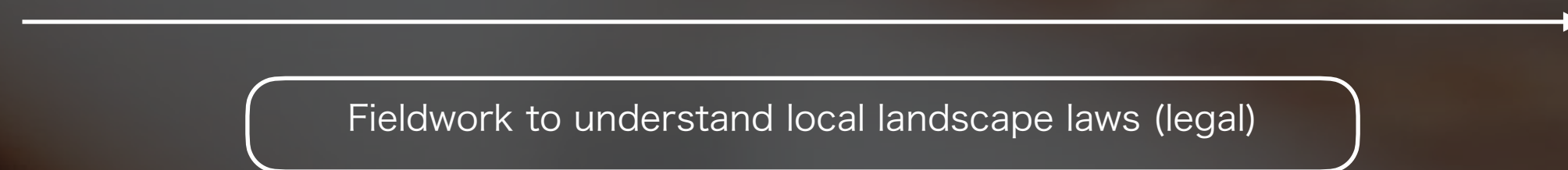
A close-up photograph showing a person's hands using a wooden tool to smooth a layer of grey cement or concrete on a surface. The background is blurred, showing more of the construction site.

Making cement boards with different types of wastes to reduce cement content and designing aesthetic visuals of them can create a new value that expands possible applications and accelerates the use of sustainable cement boards.

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Prototyping small cement board tiles with different types of wastes



Possible applications

- Inner walls
- Outer walls
- Floor
- Rooftiles
- ?

Possible factors

- Visual
- Social
- Economical
- Economical
- Environmental

Interviews to 10 architects using prototypes to understand preferences and value perception on cement boards including aesthetics rating

List of waste

Prototype



Thread



Eggshell



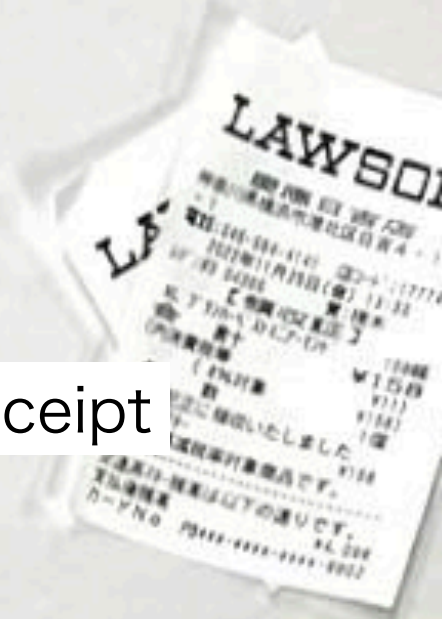
Cigarette



Ocean Plastics



Hair



Receipt



Oyster shell



Crab shell



Ceramics



Sea Glass



Shredded jeans



Fishing net



washi



Sawdust



Peanut shell



Rice husk



Single-waste
Heat pack

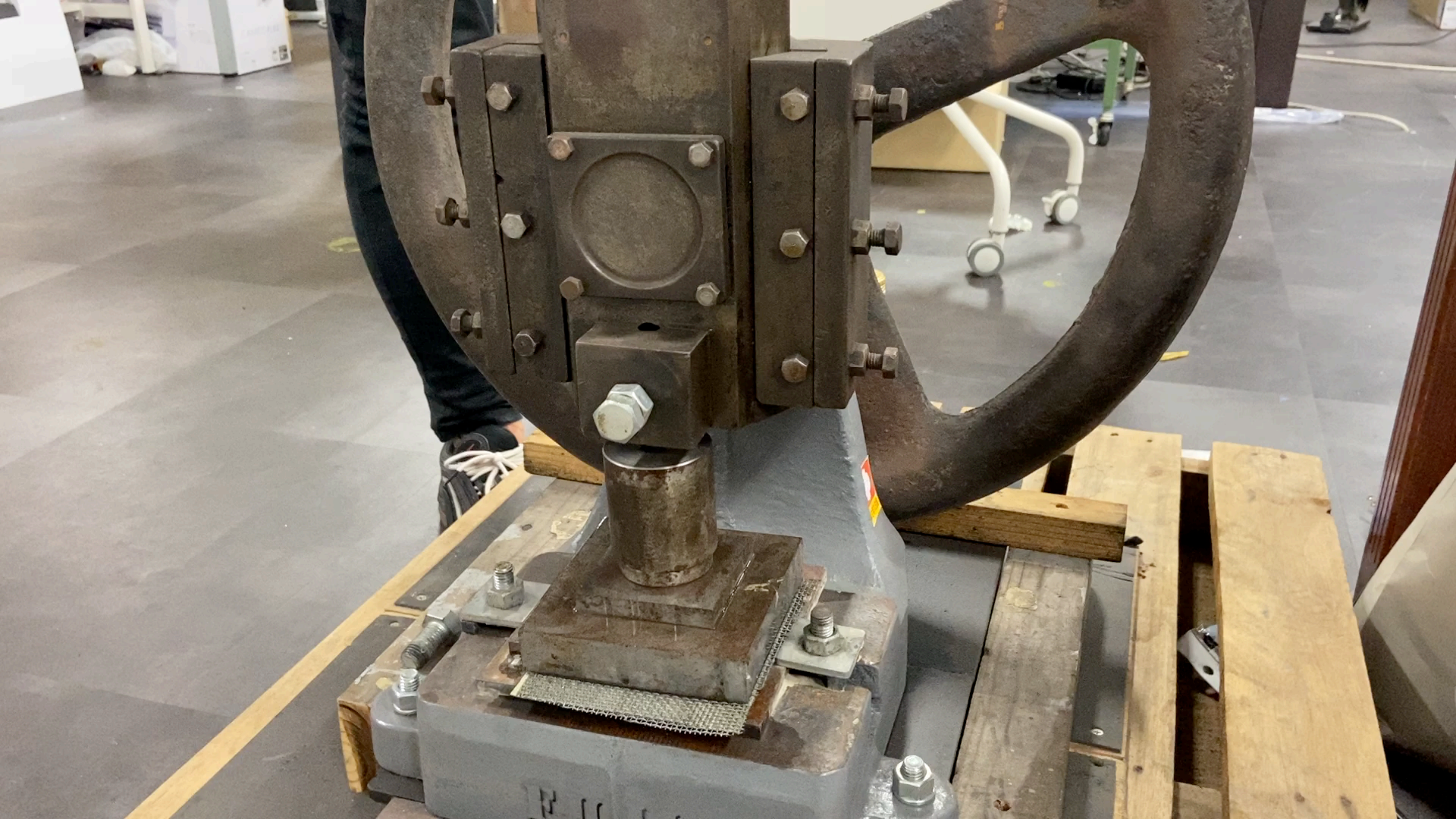
Slug

Loess





cement + fiber + waste mix

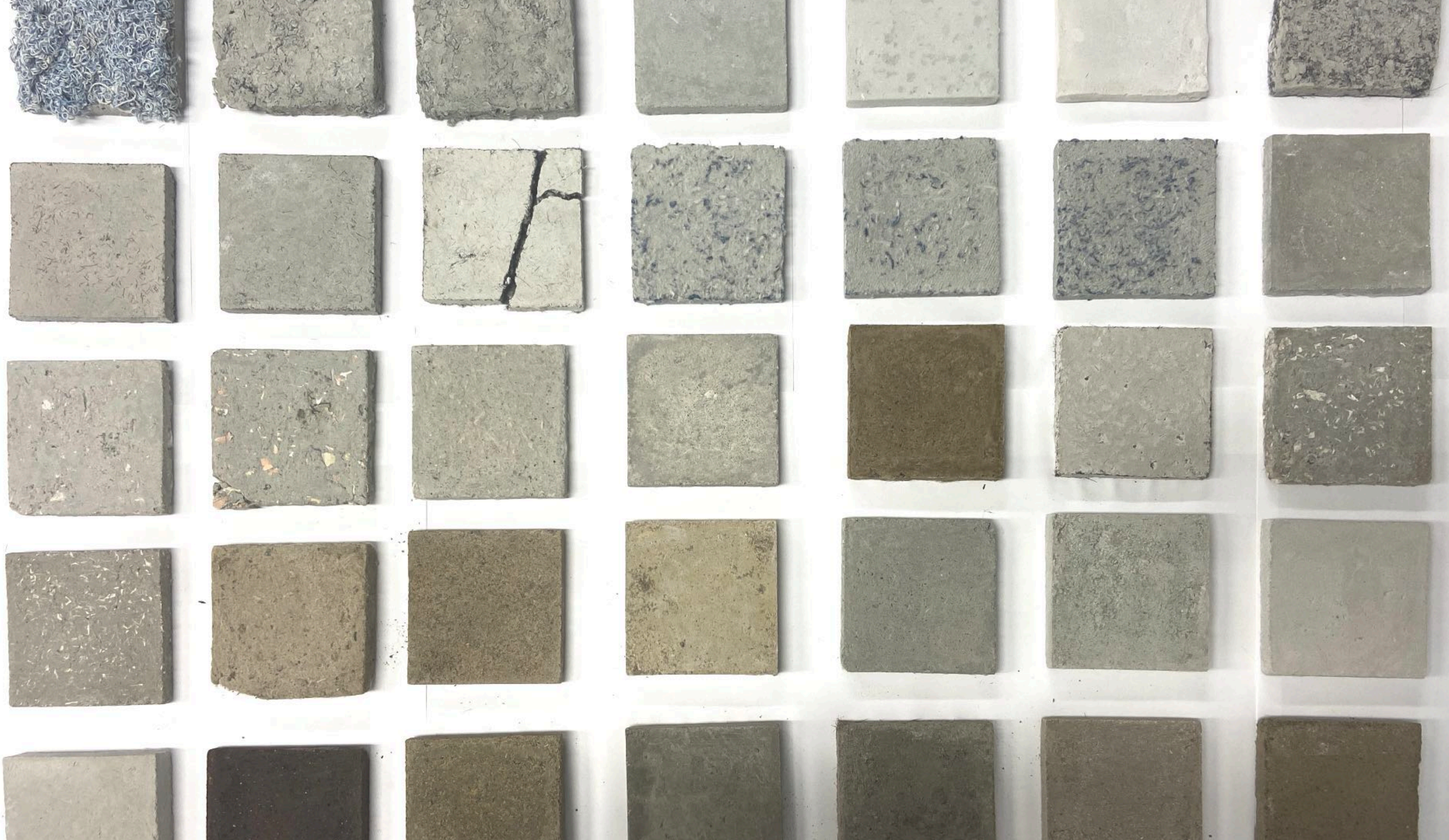




11日 (金曜日)

【第三種郵便物】

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Fly Ash

- Industrial waste from thermal power
- Ash is collected in dust collectors from coal ash generated when pulverized coal is burned in coal-fired power plants
- The use of fly ash as an admixture improves the long-term strength of concrete and densifies the microstructure, resulting in densely compacted concrete



Eggshell

- Industrial waste from processing food companies and residential waste
- Annual production is 2600 million ton in Japan (NHK, 2022) and 8.58 tons globally



Shredded Jeans Waste

- Industrial fashion waste



Hair

- Waste at salons
- general wastes from business activities, and most salons waste them as combustible waste. Otherwise, salons have to pay 3000 to 5000 yen as industrial waste
- Hair used to be used as soil fertilizer, but dyed hair is harmful to soil



Ocean Plastics

- Ocean plastics account for 65.8% of all ocean waste
- Plastics that break down into microplastics (<5mm) is problematic as it's persistent and almost impossible to remove them from the environment where they accumulate.



Crab Shell

- Food Waste from restaurants
- Industrial waste from food processing companies
- Contains high calcium and chitin
- A large amount of crab shells are generated when removing crab meat in food processing company that produces canned goods. Company pays a fee to dispose them



Oyster Shell

- Food waste from restaurants
- Contains high calcium



Cigarettes

- Waste collected at smoking areas and beach
- Approximately 6 trillion cigarettes are manufactured per year.
- More than 90% of these contain plastic filters, which is equivalent to more than one million tons of plastic. Cigarette butts discarded on streets and in gutters are carried through drainage water into rivers and oceans, where they gradually become smaller and smaller and do not decompose, polluting the oceans.



Sea Glass

- Ocean waste
- Glass debris discarded in the ocean that has been broken and rubbed by seawater and the seafloor over time



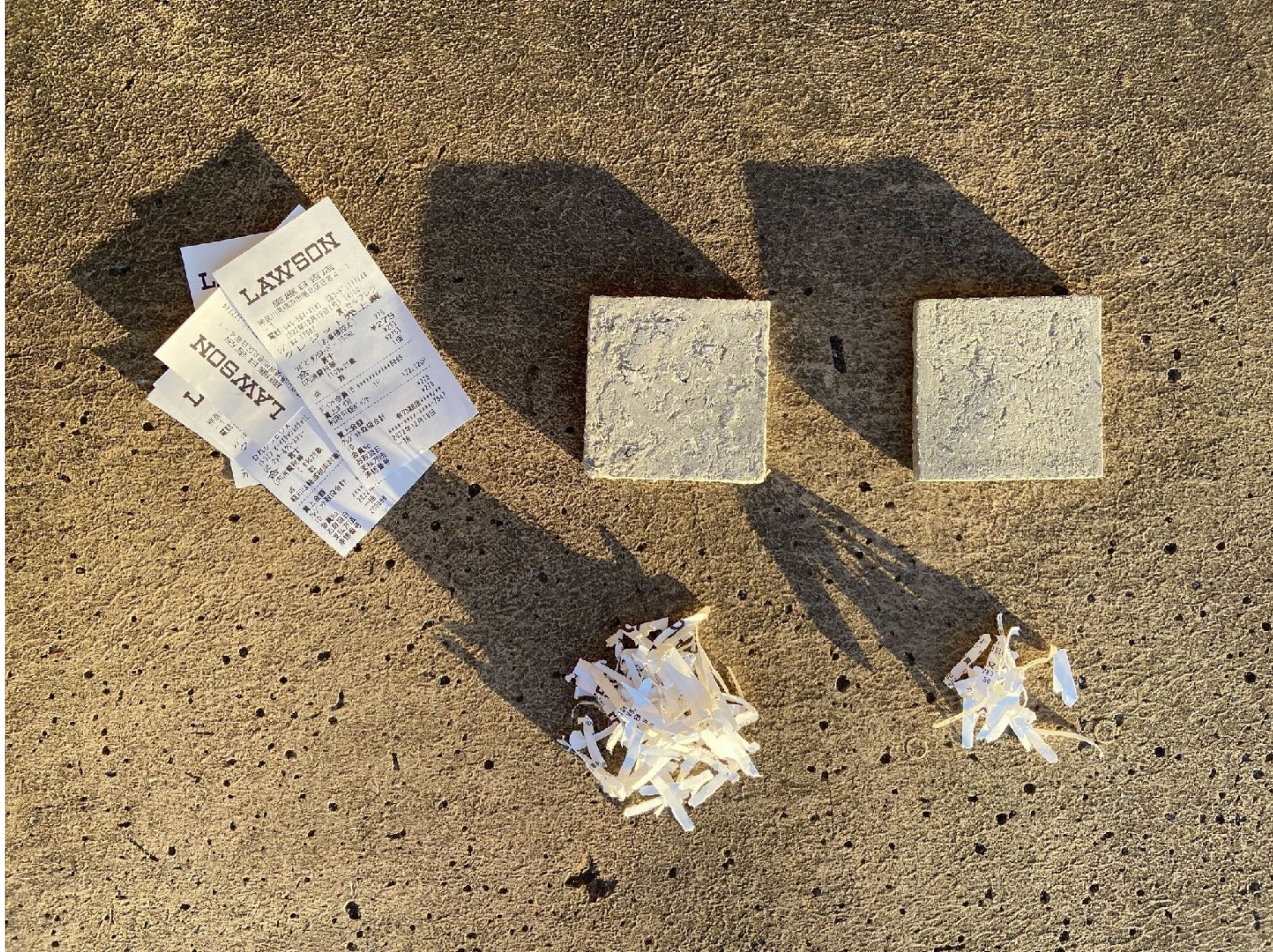
Sea Ceramics

- Ocean waste
- Pottery debris discarded in the ocean that has been broken and rubbed by seawater and the seafloor over time



Receipts

- Waste from stores
- According to an article, an estimated 93% of paper receipts are toxic thermal paper, coated with the chemicals bisphenol A (BPA) or bisphenol S (BPS)



Sawdust

- Industrial waste from construction and wood industry



Disposable Heat pack

- Single-use waste with activated charcoal and iron powder



Social aspect (Design for acceptance)

Aesthetics

Investigating value perceptions and visual preferences through interviews to 10 architects in Japan. Then seek for possible applications and improvements together considering legal aspects linked to landscape.

Environmental aspect (Design for less GHG)

Carbon Savings

Calculating carbon footprint of each cement board prototypes using GABI and Ministry of Environment database

Technical aspect (Design for durability)

Material Property

Testing prototyped fiber cement boards with easy tests at kmd and kuraray lab

1. impact resistance
2. bending (tensile) strength
3. dimensional stability



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