Let's make concrete with desert sand !

Tokyo Gakugei University Senior high school

Introduction

● The world is facing a **sand shortage**:
- **River sand**, essential for concrete, is in short supply.
- **Desert and ocean sand** are unsuitable for direct use.
- **Sand mafia activity** affects the supply chain.
- **Desert countries** are importing sand, posing future risks to construction.

● **Solution?**

Using **desert sand** could help address the material shortage!

Objectives

1. Compare the **advantages and disadvantages** of desert sand and river sand in concrete.
2. Conduct **durability tests** on concrete made with desert sand.
3. Based on these results, propose **next-generation concrete** as an **environmental solution** to the current sand shortage.

Methodology

1. Concrete Production Methods:

(1) **Standard Method:** Commonly used concrete mix
- **Mix ratio:** Sand: Cement: Water: Gravel
  = 60ml : 60ml : 30ml : 60ml
- Mixed and dried.

(2) **Sakai Method:** Concrete using desert sand
- **Mix ratio:** Sand: Ethanol: Potassium hydroxide
  = 4g : 15ml : 2g
- Mixed, placed in a reaction vessel, and heated at **600° C for 20 minutes** (heating stopped based on the mixture's condition).

2. Durability Tests:

Dried concrete was tested for durability based on these criteria:

① **Water Immersion Test:**
- How long the concrete stays intact after 1 week in water.

② **Hammer Test:**
- Number of hammer strikes from a height of **30cm** until the concrete breaks.

③ **Load Test:**
- Number of **500ml PET bottles** hung one by one until the concrete breaks.

Results

1. Standard Concrete Durability Test (1):
- **Materials tested:** River sand, quartz sand, vermiculite
- Results were inconsistent due to irregular sample shapes and lack of averaging.
- Test (2) was conducted with corrected samples.

Table.1

(Water immersion)	first	second
river	15	11
quartz	2	3

Table.2

(Fall)	first	second
river	15	4
quartz	2	23

Fig.1 Fig.2 Fig.3 Fig.4 Fig.5 Fig.6

2. Standard Concrete Durability Test (2):
- **Materials tested:** River sand, desert sand
- **Hammer Test:** Desert sand showed higher durability.
- **Load Test:** River sand performed better.

Table3

(Hammer)	first	second	third	forth	Average
river	5	3	2	3	3.25
desert	6	8	7	7	7

Table.4

(Water immersion)	first	second	third	forth	Average
river	Unchanged				
desert	Unchanged				

Table.5

(Load-bearing)	first	second	third	forth	Average
river	not countable				
desert	7△	8△	7△	7△	7.25△

3. Sakai Method Concrete Durability Test (1):
- **Materials tested:** River sand, quartz sand, vermiculite
- After heating, the samples melted, making testing impossible.

Test (2) was conducted with adjusted conditions.

Fig.7 Fig.8 Fig.9 Fig.10 Fig.11 Fig.12

4. Sakai Method Concrete Durability Test (2):
- **Materials tested:** River sand, sea sand, desert sand, vermiculite
- Resulting samples were small, providing only qualitative data.

Fig.13 Fig.14 Fig.15 Fig.16

Discussion

- Did **particle size** cause the vermiculite to crumble?
- In the **submersion test**, drying for over **28 days** likely prevented any change.
- In the **load test**, slightly larger and coarser river sand may be more effective than fine desert sand.
- **Melting** might have been caused by **deliquescence** from potassium hydroxide.
- **Sakai method concrete** has limitations for small-scale production.

Future Prospect

- To assess **practical use**, create models and conduct experiments.
- Create **simple, durable designs** and support **poverty-stricken desert areas** through **technical cooperation**.

References & Corporation

- SDGs MAGAGINE (2022). *Sand is the second most exhaustible resource after water. Is the fight over it caused by something close to home?*
- Sakai Laboratory, University of Tokyo (2022). *Development of next-generation concrete by directly bonding sand together*
- Nikkei Tech (2021). *A cement-free hardened body created by bonding desert sand together*

- Collaboration –
Associate Professor Yuya Sakai, Sakai Laboratory, Institute of Industrial Science, University of Tokyo