



# Dam Safety

## Using ROV to inspect and repair storm-damaged dams

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### Project Overview

This project combines dam inspection and repair functions by forming a cavity at the underwater crack and injecting resin to seal it. Our research objective is to verify that this approach can effectively and efficiently perform post-disaster inspection and repair of dams.

We have successfully developed a fully operational system that not only supports routine dam monitoring, but also performs efficient and stable inspection and repair in complex underwater environments, providing a scalable, fast, and low-cost solution for dam repair.

### Background & Rationale

**Storm Response:**  
SeaPerch 2026 focuses on storm response. Flood surges and debris impacts can easily cause physical damage to dam structures, leading to potential structural risks.

**Hidden Risk:**  
If tiny cracks are not repaired in time, they can rapidly expand and lead to dam failure. Great things are often brought down by tiny dangers. Protecting downstream safety admits no delay.

**Technology Vision:**  
Utilizing underwater robotic technology to achieve efficient, precise health diagnosis and on-site repair of damaged dam structures, reducing manual risks and costs.

### Approach

**High-Definition Waterproof Camera:**  
Enables real-time transmission of underwater footage to accurately locate cracks and provide a visual reference for subsequent repairs.

**Underwater Robotic Platform:**  
Serves as a stable carrier for all inspection and repair equipment, utilizing motor thrust to ensure precise positioning and operational stability during underwater missions.

**Sealing and Injection Repair System:**  
A sealing enclosure combined with rapid-hardening sulphoaluminate cement creates a dry cavity to isolate water interference; specialized syringes then inject resin/cement into the cracks to ensure effective restoration..

### Our Path From Problem to Solution

The main challenges of our design are primarily focused on (1) which material is suitable for dam repair, (2) how to make a waterless space, (3) how to fill the crack with the selected material

(1) To determine which material to use for dam repair, we conducted experiments on the properties of different materials.

Test Results	Cement	Underwater Adhesive Sealant	502 Instant Adhesive
Initial Drying in Dry Air	30min	30min	30s
Complete Drying in Dry Air	12h	24h	24h
Can it set/harden underwater?	×	✓	✓
Initial Drying Underwater	\	Immediately	15s
Complete Drying Underwater	\	24h	24h

After comparison, we selected **rapid hardening sulphoaluminate cement** as the final repair material.

Mix ratio of cement for dam repair



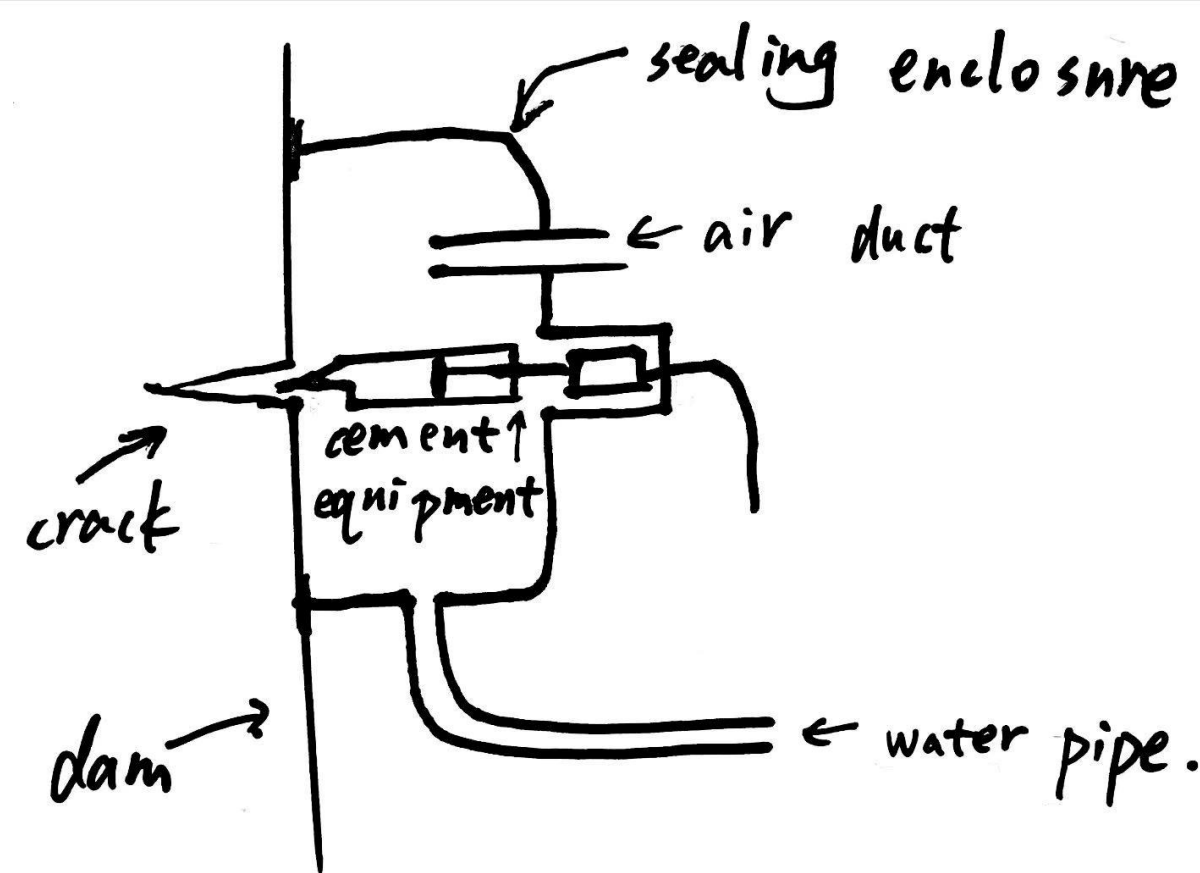
1 part water to 6 parts dry cement



Mixed cement

Finally, the cement we produced features fast-drying, high strength, easy adhesion, and good plasticity.

(2) Because the cement material cannot set underwater, we need to use a sealing enclosure to create a dry cavity.

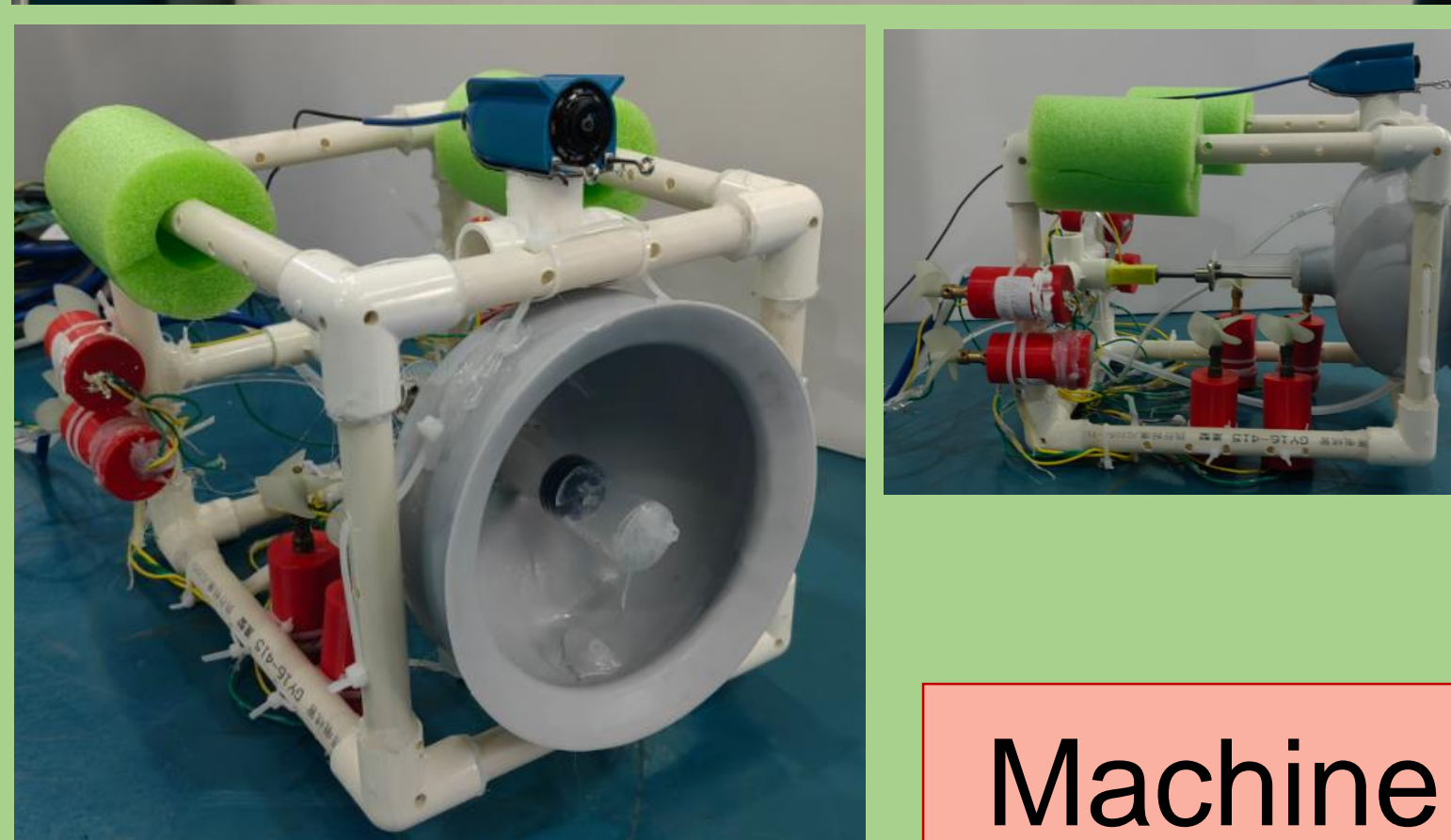


We design a lid, and press the lid onto the surface of the dam tightly. There is an airtight space. we pump air in it, and the water flows out.

We chose a **rubber lid**, and press it on the glass, made a air pipe on the top and a water pipe at the bottom. The picture shows the water is flowing out.



(3) we use a 30-ml syringe as the cement injection tool. The power of injection come from a N20 DC motor which has a threaded shaft. The syringe piston is secured to a flange nut, when the motor runs, the flange nut rotates, causing the piston moves forward, then the cement go into the crack.



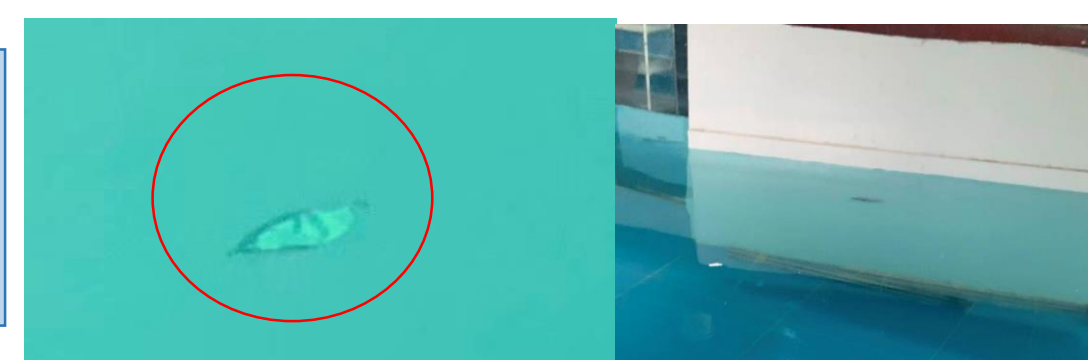
Pictures of the final

Machine design

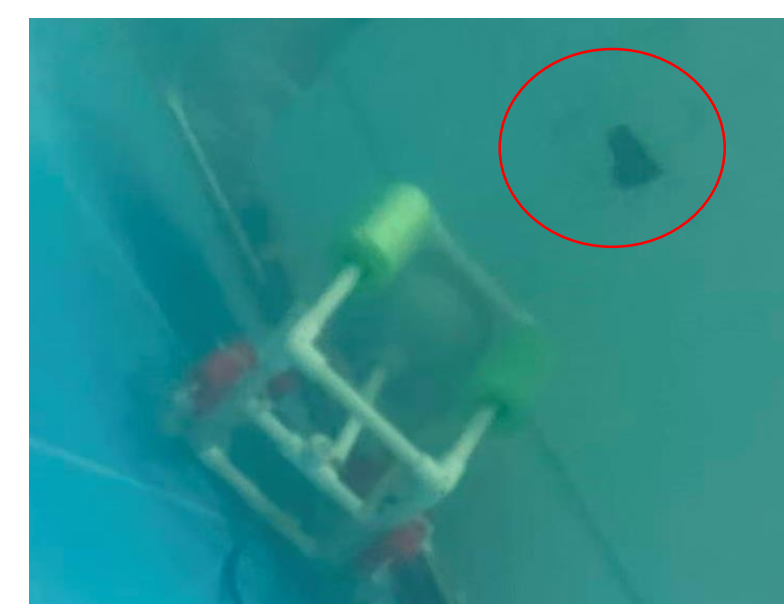
### Machine testing

We design a test to simulate the progress of filling the cement into the crack.

First, we dug a hole about 7 cm long and 1 cm wide on a board to simulate a damaged dam.



Second, the ROV find the crack by its camera, and we control the rove moves near the crack



Third, we control the ROV adjust the position and press on the "dam", pump air in the space to make a waterless space



Fourth, control the N20 motor, and the syringe inject the cement into the crack

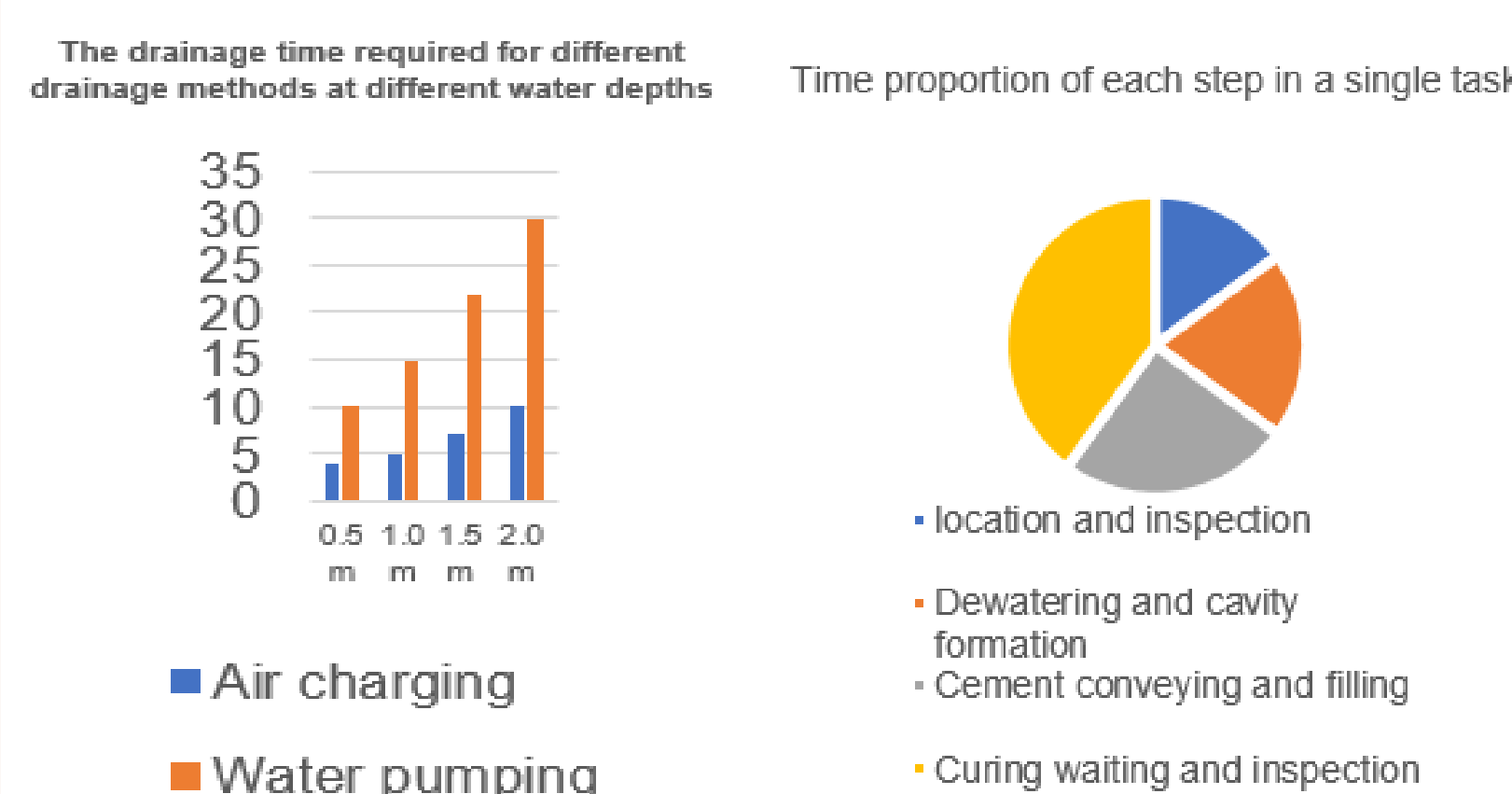


Fifth, wait and test

### Final Result

Test Item	Number of Tests	Success Rate	Notes
Underwater Crack Localization	10	90%	Slightly affected by turbid water, overall positioning accurate
Cavity Formation Stability	8	87.5%	Enclosure angle needs fine-tuning based on crack geometry
cemen Injection and Curing	8	75%	Underwater, it is sometimes difficult to adhere to the wall, requiring several attempts
Overall Repair Success Rate	8	75%	Can be improved to 90%+ with process optimization

After multiple experiments, we summarized the above experimental table based on the experimental data.



### Next Steps

Future Development & Real-World Scalability  
To bridge the gap between our prototype and a commercial-grade dam inspection ROV, we identified the following critical engineering upgrades:

#### 1. High-Torque Propulsion & Stability Challenge

Turbulent post-hurricane waters and heavy payloads demand immense power. Solution: Upgrade to high-torque brushless motors with ducted propellers to increase linear thrust against strong currents and improve maneuverability.

#### 2. Advanced Smart Materials Challenge

Standard cement washes away in active leaks, and some resins are toxic. Solution: Utilize eco-friendly, hyper-hydrophobic polymers and fiber-reinforced cement for rapid underwater curing and superior tensile strength.

#### 3. Anti-Clogging Injection Mechanism Challenge

Materials can solidify prematurely inside the delivery tube during a mission. Solution: Redesign into a modular cartridge system with a tip-mixing nozzle. Add a motorized plunger with auto-retract functions to prevent internal clogging and simplify reloading.

#### 4. Autonomous Station-Keeping Challenge

Manual piloting in murky, post-disaster waters is highly imprecise. Solution: Integrate a sonar sensor with PID control. This enables autonomous "station-keeping" —maintaining a stable position against currents for precise, hands-free injection.

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