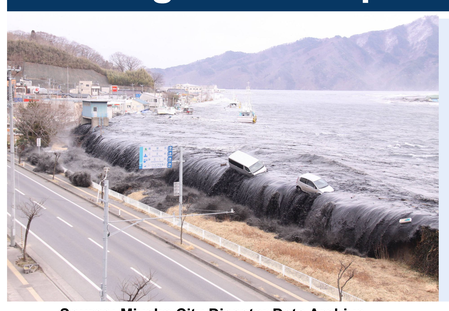
Basic Study of Evaluation Indicators for the Purpose of Disseminating Floating Devices in Tsunami Disasters.

Seto Shuji[1] , Akinori Kitamura, Madoka Nagano, Sonoko Suzuki, Tatsuhiko Miyasaka, Fumihiko Imamura[2]

1: Akita University, in charge of preparation for establishment of new faculty/ Comprehensive Research Center for Regional Disaster Prevention and Mitigation.
2: Division of Tsunami Engineering, International Research Institute of Disaster Science, Tohoku University.

1. Background/Purpose



Source: Miyako City Disaster Data Archive, Miyako Asu

Tens of thousands of people are expected to be killed by tsunamis in the Nankai Trough and the Japan Trench and Kuril Islands Trench earthquakes, which are currently feared.

In order to protect the lives of each and every person, it is necessary to consider new measures in addition to the current evacuation methods and to promote their widespread use.

After the Great East Japan Earthquake, various floating devices such as tsunami lifeboats and tsunami shelters have been proposed.

Therefore, this study aims to develop an index that enables comparative evaluation of tsunami evacuation devices and to promote the diffusion of new devices.

2. issues related to tsunami evacuation measures

Re-organize issues related to horizontal and vertical evacuation → Clarify complementary issues

Issues related to horizontal evacuation

time constraint

In areas where the time between earthquake occurrence and tsunami arrival is short, there may be insufficient time to travel to a safe location, and this problem is particularly acute in coastal and low-lying areas.

geographical restriction

In areas with steep terrain and complex street structures, evacuation routes to safe higher ground or inland areas are limited. In areas near cul-de-sacs and cliffs, there are few options for evacuation routes, making evacuation difficult.

physical restraints

For the elderly, people with disabilities, and people with infants and toddlers, traveling long distances is a great burden, requiring more time for evacuation and increasing the risk of being caught in a tsunami.

Issues related to vertical evacuation

spatial restriction

In areas with many low-rise buildings, there are few buildings of sufficient height, making it difficult to secure a safe vertical evacuation site.

structural constraint

When buildings are damaged by earthquakes, the safety of vertical evacuation sites is threatened. Evacuation to buildings with inadequate earthquake resistance may create new risks.

continuous constraint

Insufficient stockpiles (food, water, blankets, etc.) to stay for a certain period of time at vertical evacuation sites. It will be difficult to stay for a long period of time under the condition that lifelines are disrupted.

constraints on the capacity of

Lack of evacuation buildings with sufficient capacity in densely populated areas. It will be difficult to safely accommodate residents who need to evacuate.

Common Challenges

Lack of crisis awareness and effectiveness

Delayed and inappropriate evacuation behavior due to lack of crisis awareness of tsunami. Confusion during evacuation due to lack of training.

Insufficient means of information transmission

Tsunami warnings and evacuation instructions are not disseminated due to communication problems caused by earthquakes, and appropriate information is not conveyed to evacuees.

To complement the issue

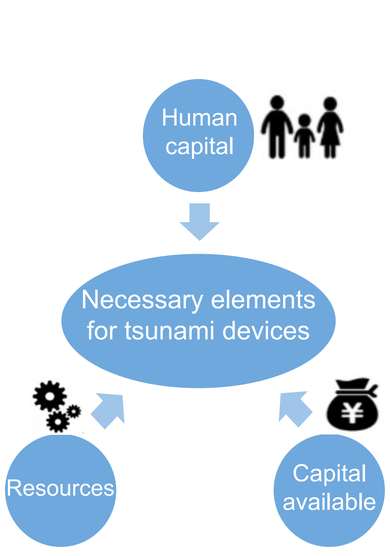
Tsunami evacuation support device

Focus on the use of

3. evaluation index (necessary elements) of tsunami evacuation support devices and evaluation of existing devices

Identification of key elements for tsunami evacuation support from the viewpoint of "Human capital, Resources, and Capital available" → Clarification of key elements for the purpose of dissemination by comparing and evaluating existing devices

Study of evaluation indicators (necessary elements) for tsunami evacuation support devices



point of view	(data) item	Contents
Human Capital	Education and Training	Easy to use for education and training on usage
	degree of recognition	Many people have seen, heard, and know
	Simplicity of operation	Easy to use and operate by anyone, regardless of the user
	Regulations and Certifications	Compliance with national and international regulations, certifications, etc.
Resources	Material strength	Withstands strong impacts and collisions with sharp debris
	Heat resistance, fire resistance	Resistant to heat and fire, and does not burn easily
	Flood Prevention	Highly sealed to prevent water from entering the interior
	ensuring buoyancy	Maintains floating on the water without submerging
	stability	Resistant to overturning and maintains constant orientation
	Measures to be taken in case of damage/breakage	Installation of duplex construction and buoyancy aids
	temperature control	Can maintain a certain degree of constant internal temperature.
	oxygen supply	Underwater evacuation does not interfere with breathing
	Rapidity of deployment and use	Immediate availability in case of emergency
	Ease of storage and transportation	Space-saving design allows for storage and transportation
Capital available	productivity	Supply is possible according to demand by establishing a production line.
	Installation Cost	Pricing available to individuals and households
	Maintenance and management costs	Low cost for periodic inspection and maintenance

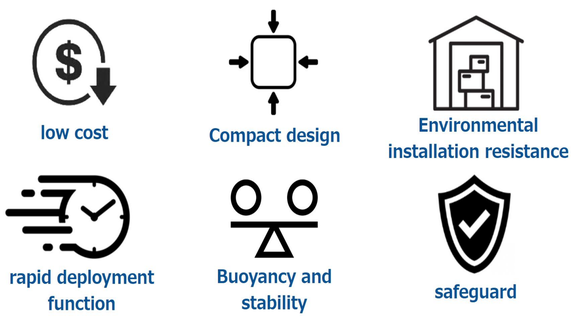
Evaluation of existing tsunami evacuation support devices (positioning)

point of view	(data) item	life jacket	tsunami shelter	tsunami evacuation tower
Human Capital	Education and Training	○	○	○
	degree of recognition	○	▲	○
	Simplicity of operation	✖	○	○
	Regulations and Certifications	○	✖	○
Resources	Material strength	✖	○	○
	Heat resistance, fire resistance	✖	○	○
	Flood Prevention	✖	○	not subject to evaluation
	ensuring buoyancy	▲	○	not subject to evaluation
	stability	✖	○	not subject to evaluation
	Measures to be taken in case of damage/breakage	✖	○	not subject to evaluation
	temperature control	✖	○	not subject to evaluation
	oxygen supply	▲	○	not subject to evaluation
	Rapidity of deployment and use	○	▲	not subject to evaluation
	Ease of storage and transportation	○	▲	not subject to evaluation
Capital available	productivity	○	✖	✖
	Installation Cost	○	✖	✖
	Maintenance and management costs	○	✖	✖

Legend: "○" meets all conditions, "▲" meets some conditions, "✖" does not meet any conditions

Existing devices are biased toward advantages and disadvantages. Difficult to implement in society

For the purpose of dissemination (=social implementation), the The following elements must be met



4. International Life Saving Appliances Code (LSA Code) under the Safety of Life at Sea Convention (SOLAS Convention)

The LSA code in the SOLAS Convention has commonalities with the elements required for tsunami evacuation support → LSA code-compliant products are used as tsunami evacuation support devices

What is the SOLAS Convention? (Ministry of Land, Infrastructure, Transport and Tourism, 2001)

An international convention enacted in 1914 in response to the sinking of the Titanic in 1912 **that stipulates safety standards for ships and the installation of life-saving appliances**, it is one of the most important international regulations to regulate ship safety in accordance with global standards and to prevent loss of life due to maritime accidents.

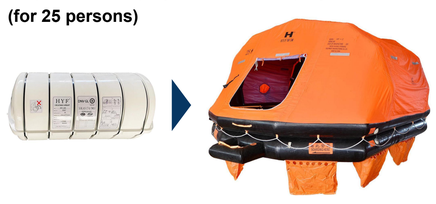
Western ships, especially those that sail internationally, **are required to have evacuation equipment installed to** ensure the safe evacuation of crew and passengers in the event of an emergency.

Requirements for life-saving equipment (extracted from SOLAS Annex related documents LSA Code)

(data) item	Requirements and Specifications
capacity	Can accommodate the expected number of people (6 to 150)
Expansion method	Automatic and manual inflation with compressed gas
stability	Self-righting structure that returns to original position even after reversal Ballast bags (water bags) ensure stability
Materials and Durability	Weather-resistant, abrasion-resistant, and corrosion-resistant materials Resistant to ultraviolet rays, seawater, oil and grease
Equipment and Furnishings	Drinking water, emergency food, signal equipment, first aid supplies Rainwater collection systems and nighttime lighting fixtures
Protective structure	Canopy to protect from wind, rain and waves Designed for use in cold climates
buoyancy	Maintains buoyancy even at full load Structure that does not sink even if flooded
Deployment speed and storage	Inflates and ready to use in less than 1 minute Compact and easy to store
Operating temperature range	Operates normally in a temperature range of -30°C to 65°C
Inspection and Maintenance	Designed for periodic inspections With expiration date and inspection label

inflatable life raft

Shape before deployment, when deployed (for 25 persons)



(Source: Metex Corporation)

Example of rack stacking (Source: RFD Japan K.K.)

Benefits of LSA Code Compliance

low cost
Unit price per person: Within the 100,000 yen price range, so that customers can consider purchasing the product without feeling an excessive burden, contributing to the promotion of the product.

All-weather
Designed for use in cold climates and at night, it can be adapted to various regional characteristics and weather conditions, contributing to improved survival rates.

Compact design/supports outdoor installation
Since the equipment is designed to be installed on ships, it is space-saving and can be installed and stored even in harsh environments.

Rapidly available
Automatic inflating system enables simple and quick use in an emergency, contributing to shorter evacuation time.

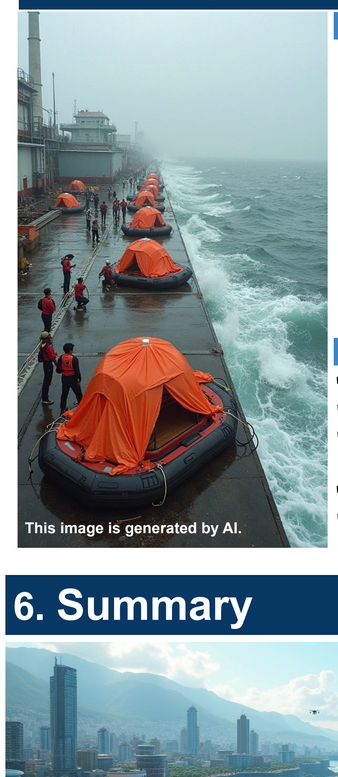
High buoyancy and stability
Utilizes marine life raft technology to ensure stable buoyancy even in high waves and strong currents.

multi-person capacity
Designed to accommodate families and neighbors, contributing to overall community viability

5. Possibility of "Inflatable Life Raft" as a Tsunami Evacuation Support Device

Inflatable life raft" is expected to be used as a tsunami evacuation support device.

Use as secondary evacuation means and emergency evacuation means



Proposed and Assumed Usage Scenes

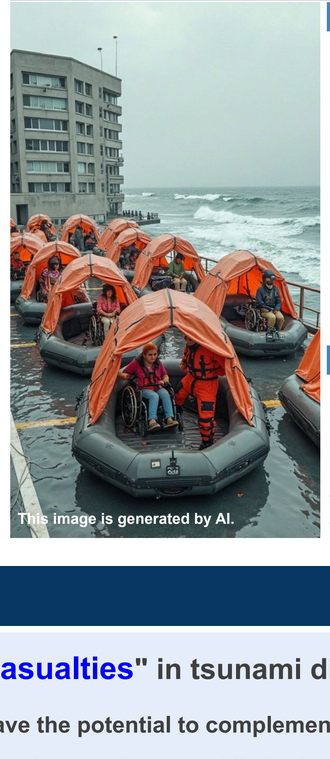
(1) Installation at **tsunami evacuation sites**
(e.g., **high ground, buildings designated for tsunami evacuation, tsunami evacuation towers**, etc.)
- Tsunami damage beyond expectations
- The capacity of the evacuation site exceeds its capacity limit.
- Difficulty in mid- to long-term stay after evacuation

(2) Installation in **premises or buildings of port facilities, factories, fishing ports, etc.**
- No time delay between tsunami occurrence and evacuation
- No tsunami shelter in the neighborhood
- Difficulty in durability of shelters

Expected Effects

- ✔ **Provide secondary means of evacuation from** unexpected situations
- ✔ Ensure worker safety (**corporate disaster prevention measures**)
- ✔ Can be **handled at a lower cost than** building or renovating tsunami evacuation facilities
- ✔ **Providing emotional security** by having a means of final evacuation
- ✔ Easier to **foster disaster prevention awareness** during normal times through drills, etc.

Use as a means of evacuation for persons requiring evacuation in the event of a disaster



Proposed and Assumed Usage Scenes

(1) Installation in facilities to **accommodate persons requiring evacuation assistance in the event of a disaster**
(e.g., hospitals, schools, kindergartens, nursing homes)
- Difficulty in evacuating alone due to the need to be accompanied by a leader, companion, or medical equipment.

(2) Installation in **places where an unspecified number of people gather**
(e.g., visitor attraction facilities, tourist attractions, public facilities)
- Not familiar with the area and do not know the evacuation sites in the vicinity
- Environment difficult to control during tsunami evacuation

Expected Effects

- ✔ Consideration for **people requiring evacuation in case of disaster, tourists**, etc.
- ✔ Risk response to areas where **tsunamis are expected to reach in a short period of time**
- ✔ **Low installation costs** and flexible operation
- ✔ **Simplified usage procedures for** any user

Example of social implementation in Japan (Shimizu Ward, Shizuoka Prefecture)

La Nassica Miho no Matsubara, a three-story, tsunami-evacuation building for the elderly in Shimizu Ward, Shizuoka City, is located approximately 800 m from the coast. 5 life rafts with a capacity of 25 people were installed on the roof in preparation for a 10 m tsunami in 2023, which exceeded expectations. Drills including local residents are held every year (Yomiuri Shimbun, 2024).

Demonstration of automatic inflation at the facility, which completes deployment in less than a minute (Source: Metex Corporation).

6. Summary

Toward the goal of "zero casualties" in tsunami disasters

(1) LSA code-compliant devices have the potential to complement the challenges of current tsunami evacuation measures.

Understanding the performance (characteristics and limitations) of each device may lead to more optimal tsunami disaster prevention and mitigation measures for each region.

(2) The existing technologies and products have the potential to make a significant contribution to "tsunami countermeasures," even if they are in seemingly different industries/industries from those involved in tsunami disaster prevention/mitigation.

It is necessary to continue to improve the system through technological innovation and social implementation, and to promote efforts to establish a tsunami evacuation system that can be used by everyone.