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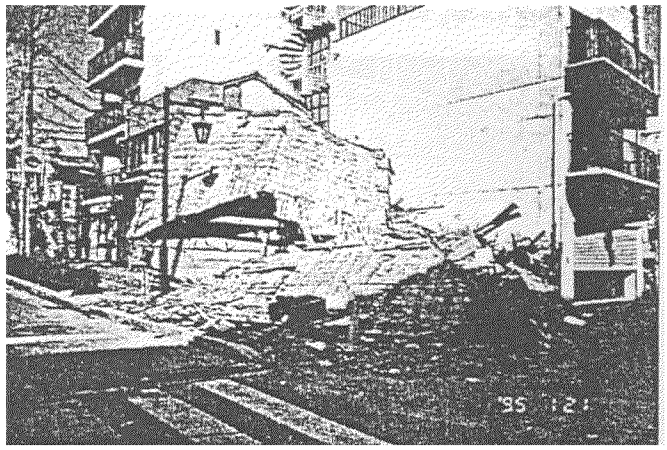
④ Often was the case that cutting beams and pillars risked total collapse, so work had to precede under the constant fear of cave-in.

⑤ When it was discovered that someone was trapped alive under a collapsed building, rescuers worked to dig him out before the building went ablaze because burning ashes were flying about. The air was filled with smoke which made rescue efforts as excruciating as death itself.

⑥ Broken walls spewed dust into the air. This dust irritated eyes and the throat, and relief had to be sought by washing. It was also extremely hard to cut through the bamboo coverings on earthen walls.



Fully collapsed wooden home

(5) Light gauge steel buildings

① The collapsed building was much more complicated than a wooden building. Rescuers had to work with the danger of secondary disaster.

② It was a repetition of removing concrete rubble, cutting steel and removing wood. We had to rotate tools between engine cutters, heavy-duty equipment, chain saws, etc., which required time.

③ It was necessary to crawl through rubble to cut the steel frame. It was strenuous work and there was constant fear of aftershocks.

④ Even after removing floor boards and floor cement, it took time to cut through cast-on slabs.

⑤ Because the structure collapsed in some places and not in others, it was never certain which way it might collapse again. It was necessary to brace the building, which took considerable time.

5. Rescue Activities in Earthquake Disasters

In this earthquakes, rescue squads saved the lives of many people, but heavy-duty equipment could not be used. Here following are described the basic procedures and precautions of rescue operations using simple tools. These procedures were followed by fire-fighters and local residents involved in rescue efforts. This should give you idea of what sort of rescue equipment is needed.

(1) Collect information and determine whether someone needs rescuing or not.

① Are the inhabitants of a collapsed home in need of help?
② Can the inhabitants lead a normal life?

(2) Call out to inhabitants and check their well-being. Calm those trapped inside.

① If the inhabitants can talk, determine their location, nearby situation, state of injury and the number of other persons trapped.
② If the inhabitants cannot talk, instruct them to tap on something in order to locate where they are.

(3) Examine how to rescue them.

① Select the safest and most effective way to rescue the trapped persons, taking into consideration the surrounding situation and the state of building collapse.
② If there is no way to enter the rubble, strip away obstructions a safe distance from where people are trapped.

(4) Precautions in rescue work

① Assign responsibilities and carry out work under the instructions of a leader.
② Deploy someone to ensure safety in the surrounding area. This person should prevent secondary disaster and prepare fire extinguishers, buckets of water, etc.
③ Be careful not to subject those trapped to excessive load.
④ Use what equipment can be found nearby.
⑤ Remove nails, tin sheets and any other obstructions to rescue work at as early a stage as possible.
⑥ Take necessary measures to prevent secondary collapse under aftershocks or when supports are removed.
⑦ Pile up removed members away from the rescue site.
⑧ Get the help of a physician where possible.

(5) Other

① Get the help of persons nearby.
② Keep persons trapped inside calm and informed on rescue progress.
③ If rescue is difficult, ask person nearby to help.
④ Protect persons trapped inside against dust by covering their face with a towel.
⑤ Take any post-rescue emergency action necessary including transport to hospitals, etc.

The above information has been compiled into the following 10 items.

6. Basics of Search and Rescue Operations

(1) Before trying to rescue persons trapped inside collapsed buildings, seek the help of persons nearby. Continually check the well-being of the trapped persons and rescuers throughout the rescue operation.

(2) Call out from the center of a collapsed building to verify if anyone is trapped inside or not.

(3) Keep fire extinguishers and buckets of water nearby because you never know when or how fire will break out. It is also important to shut off gas valves and circuit breakers of the collapsed building.

(4) Save first those whose life is threatened most. If multiple persons need rescuing, save those which are easiest to rescue first. In a life-endangering situation, such as severe blood loss, perform first-aid while proceeding with the rescue operation.

(5) When someone is trapped underneath something, do not pull. Remove the object and visually check the situation first.

(6) Before cutting or removing pillars or other members, brace overhead parts with wood at safe intervals and anchor with rope, so as to prevent collapse.

(7) Allow only experienced persons handle dangerous equipment such as chain saws.

(8) Transport rescued persons immediately to a hospital.

(9) Fill out the time, place and details of rescue on the rescued person's hospital card.

(10) Continually talk to injured persons and keep them calm. Regularly check their status.

7. Equipment Needed in Search and Rescue Operations

Search and rescue operations can be categorized as follows.

(1) Rescue operations

Rescue operations aim to rescue persons buried alive underneath dirt and rubble, whose location is known. As aforementioned, in a major disaster, rescue work must be regularly performed under extremely harsh conditions in a battle against time. This requires appropriate decisions and infallible work. The equipment most wanted in rescue work would have the following capabilities and specifications.

① Simple construction

② Small and lightweight enough to be carried by one person

③ Equipment should not carry the risk of explosion or ignition noting the fact that gas is all over the place.

④ Waterproof and dustproof because work may have to be performed underwater

⑤ It should be possible to set the equipment up in unstable places as well.

⑥ It should be possible to attach lighting to the equipment because, even in the daytime, work may have to be performed in dark places.

⑦ The equipment should have a load detecting sensor so as to detect building collapse.

⑧ The equipment should protect the user when crawling through tight spaces.

⑨ The equipment should enable fresh air flow.

(2) Search operations

Search operations are a part of rescue operations and aim at locating missing persons whose whereabouts underneath the rubble is unknown as well as to determine whether those trapped are alive or not. Before carrying out search operations, it is necessary to understand the following characteristics of the disaster site.

① It is necessary to conduct searches from on top of the collapsed building Heavy objects will provoke further collapse or fall through.

② Very often is the case that the disaster site cannot be easily accessed because of fissures, cave-ins or collapsed buildings. Liquefaction of 20 to 30 cm can also make transit difficult.

③ Because of widespread power failure, it is difficult to secure a power supply. It is also hard to see at night.

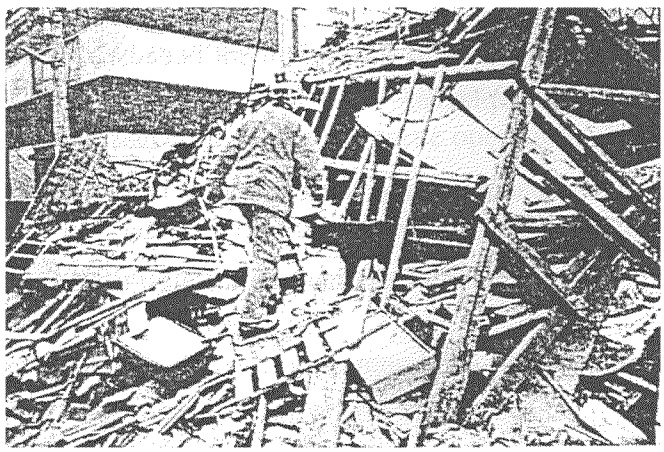
④ Flames and smoke from fires make searching that much more harder.

⑤ Many people may be seriously injured. It is a battle against time.

⑥ Very often is the case that those buried under the rubble can hear rescuers and sounds from outside, but their calls cannot be heard by rescuers. Also, even though a person buried under the rubble can be heard, his/her voice is drowned out by the sound of helicopters, etc.

⑦ Very few persons capable of handling special equipment can be found.

⑧ When multiple searches need to be conducted at the same time, it is difficult to secure equipment and personnel.



Search dog used to search for missing persons

① When search dogs were used to locate missing persons, rescuers had to stay away. The scent of nearby people can throw a search dog off. So, dogs were given instructions from several meters away. Also, noise made it difficult for dogs to concentrate.

② The dogs reacted not only to people but any sort of living things, dead or alive. In fact, one dog found something amongst a bunch of product boxes, but when rescuers moved in, a cat jumped out.

③ Dogs reacted to food as well. In one case, a toppled over refrigerator has spilled some meat out. The dog picked this up, but rescuers found only meat.

④ In collapsed buildings where rubble was piled high, dogs could not pick up the scent of trapped persons. Because rubble was removed as dogs were hunting, the dogs constantly picked up the rescuers scent. So, detection took a long time.

⑤ Dogs could not pick up the scent when the building was totally burned. The body looses all odors when completely burned.

Rescuer giving instructions to a search dog

In a large city, neighbors no little of one another. Other neighborhoods seem far away and it is quite possible that one person does not know a single thing about a family living 10 doors away.

Because of this, search equipment used to detect persons underneath rubble should have the following capabilities and specifications.

① Equipment should enable searching through concrete rubble, steel girders, wood, dirt, etc.

② Equipment should not require a reference plane such as scanning surface to conduct searches.

③ It should be possible to detect missing persons whether conscious or unconscious. If at all possible, it would be better if it could be detected whether the person was alive or not.

④ Searching should be possible without contacting the victim. Remote control would be better.

⑤ It should be possible to use the equipment at night and under all types of weather.

⑥ Lightweight and small enough to carry by hand

⑦ Assembly and setup should be simple. Detection should be high precision and fast.

⑧ Battery drive to enable use of automobile power supplies, etc.

⑨ It should not require a high level of know-how to use or interpret data.

⑩ If at all possible, the equipment should be used on a daily basis and not reserved entirely for emergencies.

As described above, search and rescue operations are a battle against time. You cannot take your time when either searching or rescuing someone. Safety, precision and speed : these are the basics of search and rescue.

We cannot wait for a similar disaster occur. The experiences learned in this disaster must be applied in any sort of situation in which multiple persons require rescuing in an instant. We only hope that the equipment and robots can be developed and made available in time.