ROBOT SYSTEM FOR REMOVING ASBESTOS SPRAYED ON BEAMS

Mitsunori Arai* and Haruo Hoshino

Advanced Research Department R&D Institute, Takenaka Corp, Chiba, Japan
** Corresponding author (arai.mitsunori@takenaka.co.jp)*

ABSTRACT: At this time in Japan, buildings built about 40 to 50 years ago are aging, and demands for demolition or renewal are increasing. Asbestos materials were used in many parts, and for many purposes in these buildings. But now, using asbestos and asbestos containing materials is prohibited by law, because its toxicity has been confirmed around the world. Therefore all trace of asbestos must be removed safety and properly in advance of demolishing or renewing any old building. Works to scrape asbestos by human workers are very hard and dangerous. The workers have to wear protective suits and full facepiece powered air purifying respirator, and the working space must be completely isolated in order to prevent the leak of any asbestos fibers.

We have developed a robot system for removing asbestos sprayed on steel beams or elsewhere to reduce manual work. This research and development was started in 2007, and the system has been evolved gradually through many experiments in our laboratory. The most recent robot system consists of a multi-DOF manipulator mounted on a vehicle with a lifting platform, vacuum suction unit, and manipulator control unit. The tool for scraping asbestos is a rotary wire brush, which is driven by a strong electric motor, and is set on the end of the manipulator. The scraped and ground asbestos is automatically sucked into a special bag by air.

We have tested this robot system on an actual demolition site. As a result, we have confirmed the practical problems and evaluated the efficiency.

Keywords: *Sprayed Asbestos, Robot System, Test On Site*

1. INTRODUCTION

Asbestos was used in a lot of buildings, for many purposes, from 1950's to 2000's in Japan. In recent years, the toxicity of asbestos has been widely recognized around the world. Today, it is prohibited to use asbestos in any industrial field by low. We must remove all asbestos firstly before reforming or demolishing the old buildings. Removal of asbestos is very hard, tough and dangerous for workers. It is also very expensive, because the workers have to wear protective suits and full facepiece powered air purifying respirator. The work space must be isolated and covered with polyethylene sheets in order to prevent the leak of asbestos. The work space is very hot, and it is hotter in the suites. Especially in summer, laborers can work for only one or two hours within the suits and the clothes and polyethylene sheets can be used only once. And these cause high cost. All of this means it is very expensive process.

To counter these problems, we developed a robot system for removing asbestos sprayed on steel beams in order to reduce the hard and dangerous manual work. We tested and checked the movement of robot and packing equipment in our laboratory firstly, and as a next step we tried operating them on an actual demolition site.

This research and development was conducted from 2007 to 2009 under a grant from NEDO (New Energy and Industrial Technology Development Organization, Japan).

2. OVERVIEW OF THE ROBOT SYSTEM

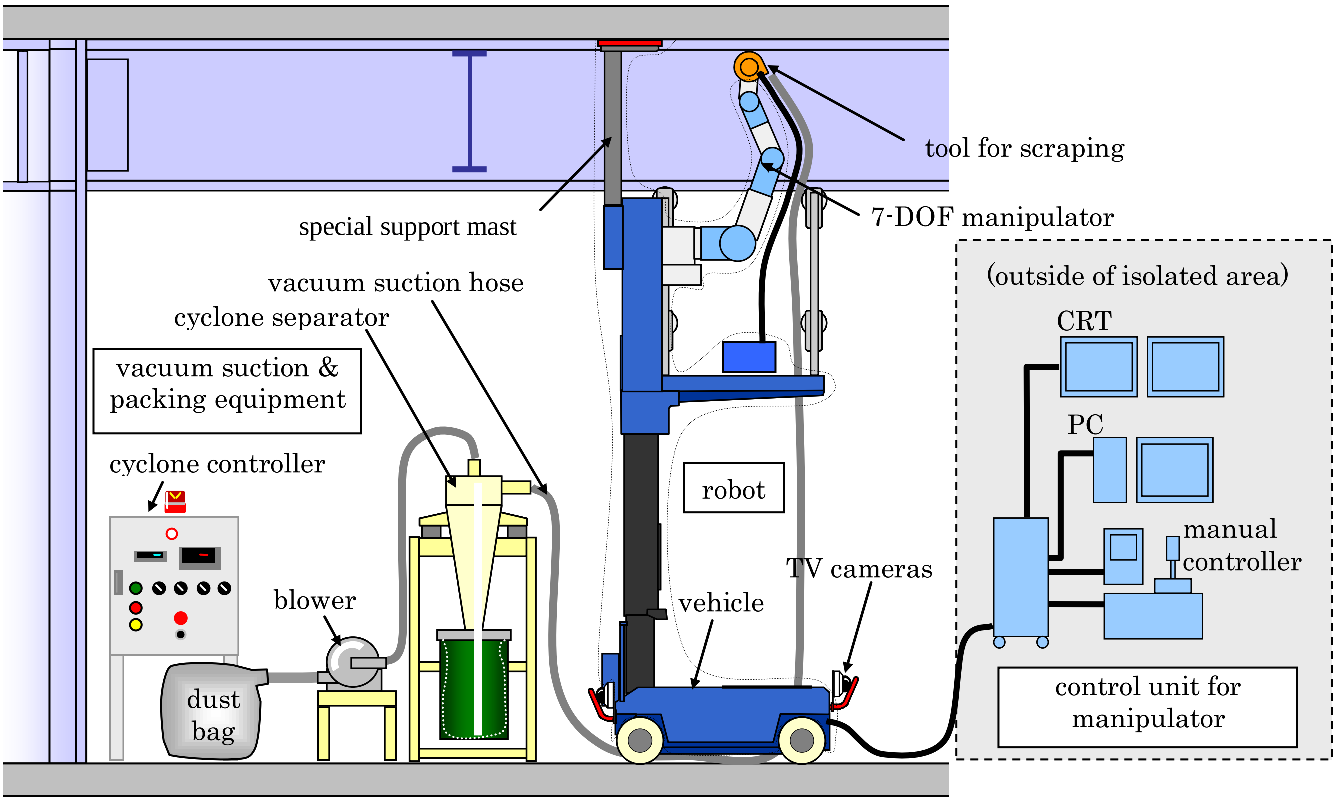

Fig. 1 Overview of the robot system

This robot system was developed to reduce the amount of work carried out by human workers for the removal of asbestos. This robot system has the following several advantages.

1) efficiency and performance are equal to or superior to manual removal

2) by reducing the volume of stripped asbestos, the cost of disposal also can be reduced (the disposal cost of asbestos is proportional to the volume rather than mass, now in Japan).

3) every component of this system is manually portable and can be transported in a standard elevator.

The most recent robot system consists of "robot", "vacuum suction and packing equipment" and "control unit" as shown in figure 1.

3. ROBOT

The robot consists of a manipulator, a vehicle mount aerial work platform, a tool, and cameras. The manipulator has 7-degrees of freedom (DOF) and is the latest one on the market. Its maximum moving width is 1100mm and maximum capacity to load is 20kgf in strength. It holds a removing tool on the end of its 7th

Fig. 2 Photo of Robot witout covering

arm, and is mounted on the mast of vehicle in the horizontal position. This vehicle has a special support mast that was added to withstand the reaction force of the actions of the manipulator, and is controlled by a manual controller.

This robot is connected to the control unit by power cables and signal cables, and can be controlled from the control unit. Between the tool and the manipulator arm, a pressure force sensor is specially incorporated. To feedback this sensor signal to the control unit, the manipulator can correct the slightest error in accuracy.

3.1 TOOLS FOR REMOVING ASBESTOS

We tested many kinds of tools for the effective removal of asbestos in our laboratory at an early stage of development. Those were a vibrating scraper, a rotary cutting edge, a rotary rubber brush, and other kinds of tools

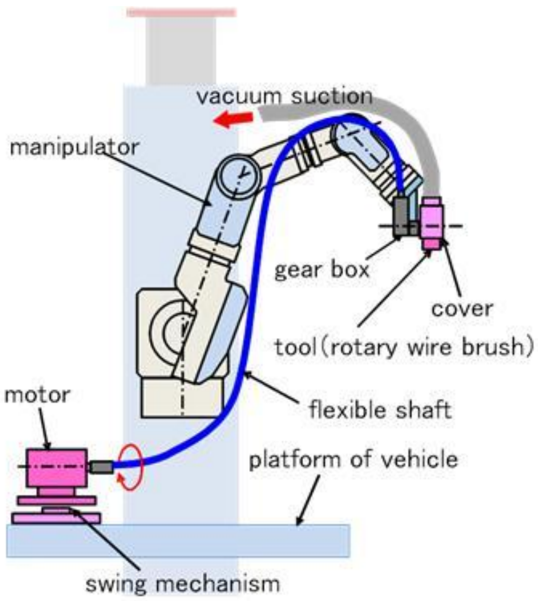

Fig.3 Transport the torque from motor to tool

Fig. 4 Rotary steel wire brush

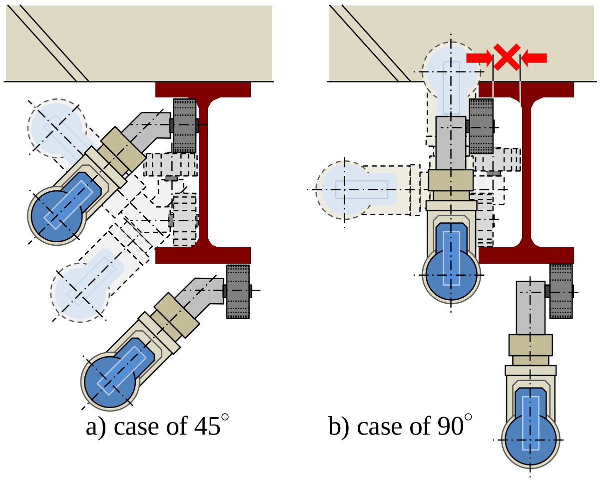

Fig. 5 Comparison of movement area

commonly used. As a result, we finally decided that the best tool is a rotary steel wire brush, because it can efficiently scrape any type of hard asbestos and is able to finish the job without leaving any trace of asbestos. The torque of the rotary wire brush is transmitted by a flexible shaft from a powerful motor anchored to the platform in order to get strong torque level.

The tool is held at 45° inclination to the axis of the robot arm to reduce any blind spot in the moving range (shown in Fig.5).

The volume of asbestos removed and crushed into powder by this wire brush is much less than that of asbestos scraped as blocks. It is very useful to decrease the costs of final disposal.

4. VACUUM SUCTION AND PACKING EQUIPMENT, AND CONTROL UNIT

The asbestos scraped by this robot is carried through the tube by vacuum suction air to the cyclone separator, and asbestos are separated from air. Afterward asbestos is packed into a special bag. These operations are performed automatically by the machine. The operators only need to replace the bag when it is full.

The manipulator moves following to the predetermined programs and it cannot move unless programmed to do so. The control unit memorizes the programs and sends control signals to the manipulator. This unit can be located outside of the isolated area.

5. EXPERIMENT ON A DEMOLITION SITE

We experimented with this robot system in an actual demolition site in 2009. We removed asbestos that had been sprayed on steel beams approximately 15m^2 in area. It took 9days. We understood the total time needed for the transform, sending in and reassembling of this robot system through decomposing it in the laboratory. All units set in the isolated area must be covered with non-woven fabrics, and these covers have to be removed before the units are dismantled when works are finished.

The surface of the floor of the isolated area must be covered with a double layer of polyethylene sheets as prescribed by Japanese standards but the sheets must be fitted tightly so as not hamper the tires of vehicle as they move over the sheets. We drew center lines on the sheets to mark the movement of the aerial work platform.

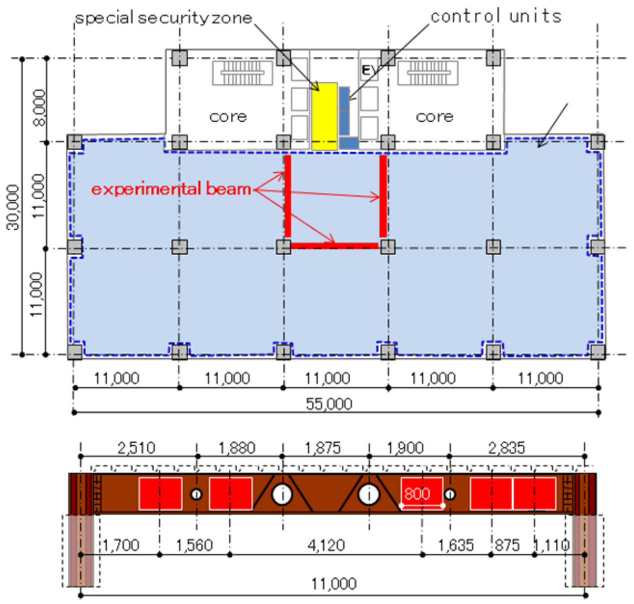

Fig. 6 One of the plans of experiments & a sample of the beam

5.1 CONTROL PROGRAMS FOR SITE TEST

We created the programs to run the manipulator accordingly by deciding the location to install the robot as well as the distance for the manipulator to move in one pass. This was done by carrying out a site investigation in advance. As the steel beams have some stiffeners and openings as shown in figure.6, we selected the parts which would be easiest for the removal of asbestos. We selected a scraping area 50mm in width (=width of brush), 800mm in length as one action of the manipulator, and planned to repeat the action once because the asbestos was so thick. The speed to move along the surface was set at 50mm/sec for complete removal because this was the first experiment at an actual site. Six main programs were made for remove the asbestos sprayed on the beams for one setting of the robot.

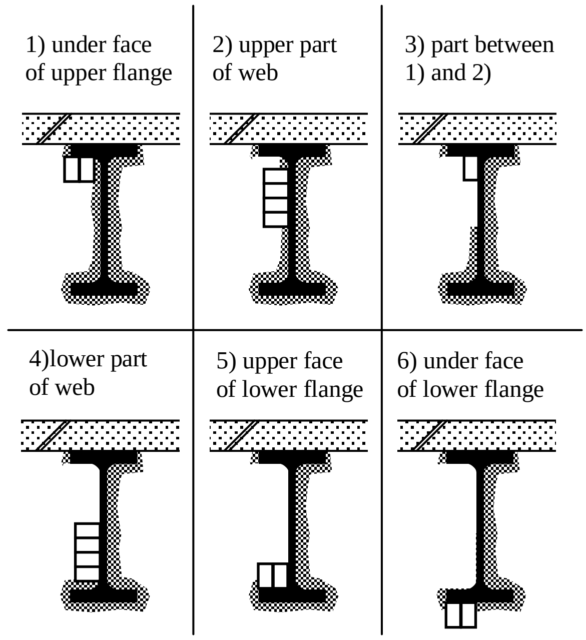

Fig.7 Scraping range of each program

6. RESULTS

The total removal time was 1,290minutes (not including the time to assemble and disassemble the equipment) and the total area of the 13 places where the removal was carried out was 15.19m^2. The removal work was finished in very good quality.

In this case, the sprayed asbestos had weak adhesion to the steel beams and thickness was greater than we expected. As we used a rotary brush for scraping thick asbestos we needed to repeat the actions again and again for the complete removal. The rotary brush can scrape thick asbestos little by little. If a hand scraper is used (e.g. a tool made of thin, flat metal plate and a handle), it may be more effective because the chunks of asbestos can be removed in a single operation.

Such extended operating revealed new problems trouble in durability. These problems were the disconnecting of the flexible shaft, burst of the dust bag, and corruption of the brush cover. We recognized them as new problems to be solved.

Fig. 8 Finished under surface of beam

Fig. 9 Finished surface of the web and flanges

6.1 REMOVAL SPEED & EFFICIENCY

The working time (1290 minutes) included several downtimes due to machine failure. The speed was 0.86m2/h that was obtained from dividing the entire area for the removal of asbestos by the time without periods of downtime. Furthermore, the total time includes the time to set the robot into the exact position. The average speed is 1.31m^2/h calculated from the time without the set up time. This is only about half the speed of manual removal. This is because the thickness of the sprayed asbestos was so great that the scraping must be repeat three or more times in many cases. The best data is 2.38m^2/h in speed, and recorded in the situation that the scraping was completed by only two processes. This is as fast as the speed of manual scraping.

7. CONCLUSION

Based on our previous estimates, in order to be cost effective, the removing speed of this robot system needs to be more than 4 times as fast as that of manual workers. But we unfortunately have not been able to achieve this on this field test.

The moving speed of the manipulator along a beam was set at only 50mm/sec for complete removal because this was the first examination on an actual site. A maximum speed of 100mm/sec was only achieved in laboratory experiments. It may not be difficult to accelerate the action of manipulator. We planned for the tool to operate only on the forward path, under the condition that during the manipulator’s return to the next starting point, the tool was not working. It should be able to allow the manipulator work on this return path by some remodeling to the control programs.

A rotary wire brush was selected for scraping hardened solidified asbestos, but the actual asbestos we encountered was soft. The tool could not work well in this situation. In other cases where the asbestos is hard and the efficiency by manual workers is low, it should perform well enough.

We believe we will be able to reduce the costs and to increase the efficiency more than the present system by taking these remodeling measures or applying the robot to specific situations.

Finally, I will show some photos of experiment on the actual demolition site.

Fig. 10 The robot is delivered to the site by a standard elevator

Fig.11　Covering with nonwoven fabric

Fig. 12　Wrapping with polyethylene sheets

Fig. 13　The robot is working

Fig. 14　Scraping asbestos on the flange

Fig. 15　Scraped asbestos go into powder

Fig. 16　Control unit & monitoring with TV cameras

REFERENCES

[1] Haruo Hoshino, Keiju Kamoto, Masahiro Sugata et al., "Development of Closed type High performance Robot for Processing of Sprayed Asbestos Materials", 10th Symposium of Construction Robotics in Japan (SCR), September 2,2008

[2] Keiju Kamoto, Haruo Hoshino, Seiichi Takeuchi et al., "Development of Closed Removing Robot System of Sprayed Asbestos Materials", 17th Construction Robot Symposium in Japan, March 13, 2008

[3] Mitsunori Arai, Hoshino Haruo et al., "Development of Closed type Robot for Removing and Recollection of Sprayed Asbestos Materials on Steel Beams", 12th Symposium of Construction Robotics in Japan (SCR), September 7,2010