Waterproofing Systems in Japan

By Kyoji Tanaka and Hiroyuki Miyauchi

INTRODUCTION

Waterproofing technology has been slowly changing in Japan. Such changes include not only performance improvements, but also changes caused by social influence. This paper outlines four topics on such changes in Japan.

REROOFING

Overview

The volume of reroofing compared with that of new structures in Japan has been increasing, accounting for one third of the total. Although there are many types of reroofing, the basic concepts for public buildings are recommended in the guidelines book[1] published by the Ministry of Land, Infrastructure, and Transport as shown in *Tables 1A*, *1B*, and *1C*.

Existing waterproofing membranes primarily include built-up, sheet-applied, and fluid-applied membranes. Built-up membranes applied in Japan are mostly covered with a protective concrete layer, and substrates for reroofing are therefore concrete layers rather than waterproofing membranes.

Whether or not the existing waterproofing membrane is removed depends heavily on its condition. From a practical standpoint, however, what tends to be preferred is an overlay system in which the existing waterproofing membrane is left as it is,

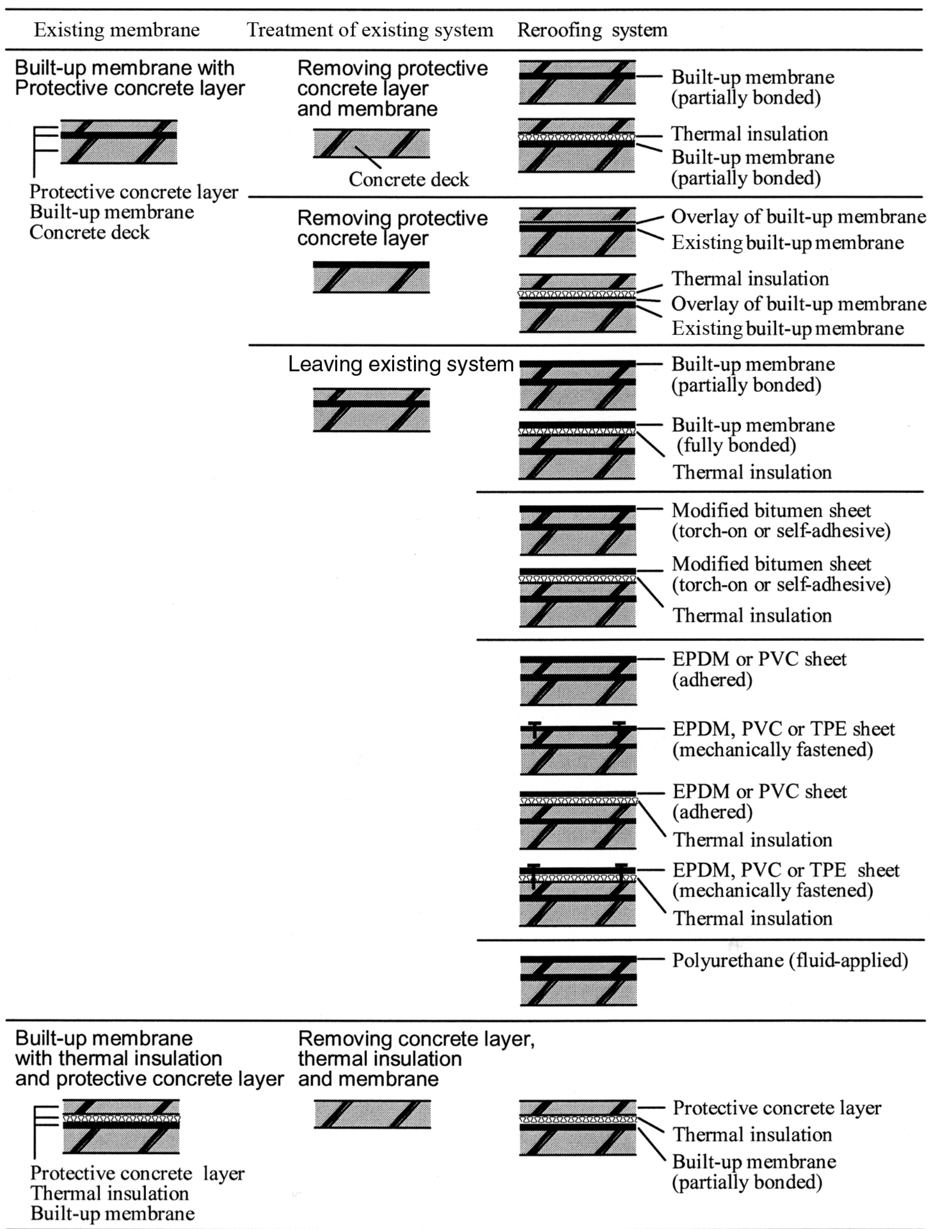


Table 1A – Reroofing for built-up membranes with protective concrete layers (from Guidelines for Supervising Works for Public Buildings, *Ministry of Land, Infrastructure, and Transport, Japan).*

because disposal of the removed membrane is not easy in Japan. Service life of 10 to 20 years is expected for most overlay systems of existing membranes.

Commonly adopted membrane systems for reroofing

Overlaying with mechanically-fastened, sheet-applied membrane systems and polyurethane, fluid-applied membrane systems has been increasingly preferred from the standpoint of waterproofing existing membranes. PVC sheeting is mostly used for the mechanically fastened, sheet-applied membrane systems. Another reroofing technique is overlaying with a urethane membrane having a thickness of about 3 mm. Special ventilating/buffer sheeting is mostly applied underneath for ventilating and alleviating the effects of cracks in the substrate.

Unfortunately, some of these systems were damaged by the No. 18 typhoon that attacked the coast along the Sea of Japan in 2004. Improvement in wind resistance has been made to these systems, and wind-resistant design methods have also been actively reviewed.

As reroofing work is expected to continue to increase more than new roofing, specifications for reroofing are being actively developed by roofing manufacturers for all waterproofing membrane systems.

Existing membrane	Treatment of existing system	Reroofing system
Built-up membrane Built-up membrane Concrete deck	Removing built-up membrane	Built-up membrane (partially bonded)
		Built-up membrane (fully bonded) Thermal insulation
		Modified bitumen sheet (torch-on or self-adhesive)
		Modified bitumen sheet (torch-on or self-adhesive)
	Leaving existing built-up membrane	Overlay of built-up membrane (fully bonded) Existing built-up membrane
		Built-up membrane Thermal insulation
		Overlay of modified bitumen sheet (torch-on or self-adhesive) Existing built-up membrane
		Modified bitumen sheet (torch-on or self-adhesive) Thermal insulation
		Overlay of EPDM, PVC or TPE sheet (mechanically fastened) Existing built-up membrane
		EPDM, PVC or TPE sheet (mechanically fastened) Thermal insulation

Table 1B – Reroofing for self-finished, built-up membrane.

Existing membrane	Treatment of existing system	Reroofing system
Sheet-applied membrane EPDM or PVC sheet-applied membrane Concrete deck	Removal of applied membrane	EPDM or PVC sheet
		EPDM or PVC sheet Thermal insulation
	Leaving existing built-up membrane	Overlay of EPDM or PVC sheet (adhered) Existing EPDM or PVC sheet
		Overlay of EPDM, PVC or TPE sheet (mechanically fastened) Existing EPDM or PVC sheet
		EPDM or PVC sheet (adhered) Thermal insulation
		EPDM, PVC or TPE sheet (mechanically fastened) Thermal insulation
Polyurethane fluid-applied membrane	Leaving existing membrane	Overlay of polyurethane fluid-applied membrane Existing polyurethane membrane

Table 1C – Reroofing for sheet-applied membrane and polyurethane, fluid-applied membrane.

LONG-LIFE WATERPROOFING MEMBRANES

Overview

Waterproofing membranes with a target lifespan of around 10 years have been developed, as a 10-year guarantee has long been standard business practice. In 1999, the government formulated a new law promoting construction of high-quality houses, which went into effect in 2000. This was a government measure, primarily to promote the supply of high-quality and long-warranty houses.

Along with main structures, this law covers waterproofing of roofs and exterior walls that are the important building elements for preventing rainwater ingress to be subject to defect liability for 10 years. In other words, contractors were held legally liable for guaranteeing waterproofing for 10 years. A legal guarantee has different implications from business practices, imposing greater responsibility on the contractor in regard to waterproofing. This law also enabled, as an exception, the extension of the warranty period up to 20 years in home-acquisition contracts. It had a strong impact on the durability of waterproofing membranes, which had been set around 10 years by social consensus, bringing about a breakthrough in their lifespan extension.

Longer building lifespans have also been desired from the standpoint of recent movement toward global environmental protection. (The average lifespan of Japanese buildings has conventionally been less than half those of buildings in Europe and the U.S.) The extension of waterproofing membrane lifespans has been in demand as a natural consequence.

Long-life waterproofing membranes

Waterproofing membranes claiming 30-year guarantees have appeared on the waterproofing market. Such a long-term guarantee is based on the improvement of materials and specifications as a matter of course. However, guarantees cannot be realized without the combination of various rules. These include work limited to roofing contractors having a certain level of skill and the contractor and material manufacturer jointly purchasing an insurance policy so that building owners are protected even in the case of bankruptcy of the contractor. Though the high price has so far hampered the spread of such long-life waterproofing membranes, they will gain importance in the coming years.

WATERPROOFING MEMBRANES FOR GREEN ROOFS

Overview

Japan has previously had so-called “green roofs,” in which the waterproofing membrane was covered with a protective concrete layer to receive soil for planting. Such a system has posed little risk of damage from plant-root penetration. This has enabled architects to design gardens with large trees without fear of root penetration. But the resulting additional load is so great that the building is required to be structurally robust, eventually incurring large cost. Such green roofs have therefore been scarce for ordinary buildings.

On the other hand, a new green roof system has been rapidly spreading in Japan. It is a system for growing primarily lawns and grasses on a relatively thin layer of lightweight soil to reduce the weight of the system. The wider implementation of this system is expected to mitigate the severe heat island phenomenon in cities, preventing urban flooding by temporary stormwater retention in the soil layer, and enhancing the quality of urban life.

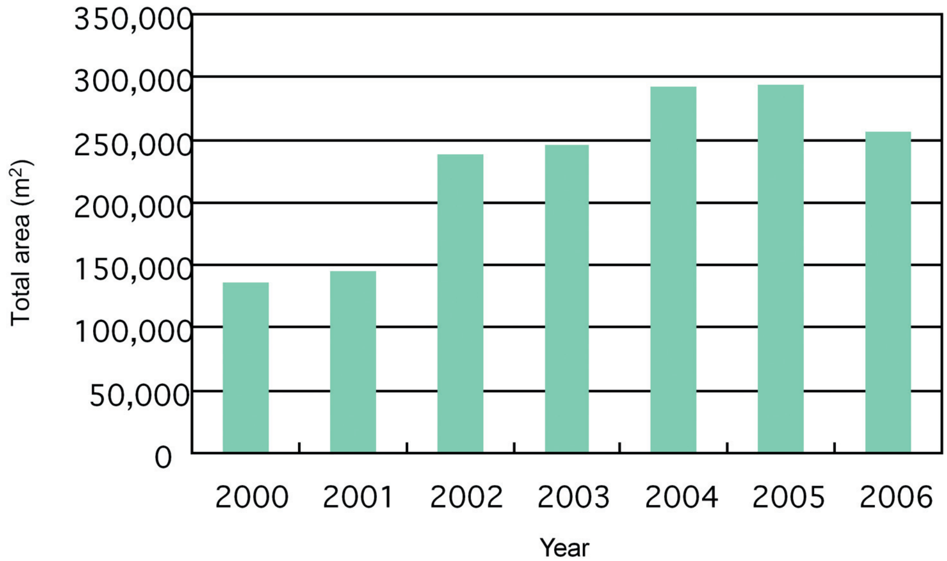


Figure 1 – Increase of green roofs in Japan.[2]

With this as a background, municipal governments legally and financially support the spread of these systems. Examples are Tokyo and Osaka, which have made it mandatory to plant on at least 20 percent of the roof area of newly constructed and reconstructed buildings. Some cities offer subsidies for green roofs. As a result, the green roof area has been increasing every year, as shown in *Figure 1*, exceeding 200,000 m^2 in 2004.[2]

Recently increasing green roof systems

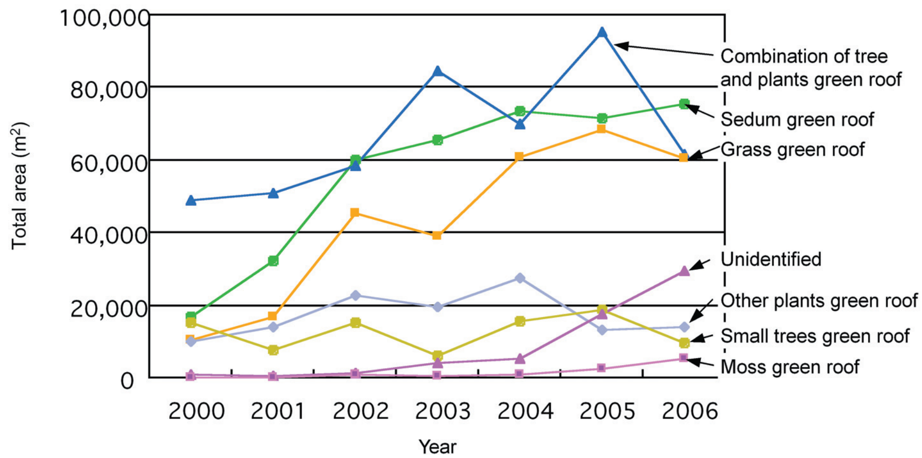
Structural reinforcement has to be simultaneously considered in most cases when planning a green roof, particularly on an existing building. In earthquake-prone Japan, an increase in the load of the roof floor can lead to a structurally unsafe condition. For this reason, lightweight greening systems have been preferred.

The core technology from which various techniques for lightweight green systems have been introduced has come mostly from Europe. *Figure 2* shows the trend of plants used for this purpose, where lawn grass and sedum are by far the most widely used, presumably due to the background problem of live loading. Sedum in particular is planted because of its low demand for water and ease of maintenance. Some may not choose this plant, however, as it may be only partially green, resulting in a view slightly different from the green roof image that the average Japanese has had.

Root-penetration resistance test methods

With no protective concrete layer, root penetration through the waterproofing membrane is of concern for these lightweight greening systems. Root-penetration resistance is therefore one of the important performance considerations of membranes for green roofing. Though there has been an excellent test method developed in

Figure 2 – Trend in variety of green roofs.[2]



Germany referred to as the FLL procedure,[3] it is not applicable directly to Japanese systems, since the test plants are not common in Japan and the climate is different. For this reason, the Architectural Institute of Japan (AIJ) organized a research team to investigate a test method and completed it in July 2005.

The AIJ method is as follows: Apply a waterproofing membrane to an inner container made of punched metal sheeting. Plant trees (*alnus firma* and *machilus thunbergii*) and grasses (*Sasa veitchii* and *Zoysia japonica Steud.*) in the container. Place the inner container in an outer container with soil. The sides of the outer container can be detached for trees as shown in *Photo 1*, and pulled off for grasses as shown in *Photo 2*. This setup facilitates root penetration through the waterproofing membrane and enables regular observation of the state of penetration. The AIJ method has just been established with service test data being accumulated using various waterproofing systems for green roofs.

DAMAGE TO WATERPROOFING MEMBRANES CAUSED BY A TYPHOON

Overview

Japan is attacked by typhoons from late summer to autumn every year. Though most strong typhoons take similar routes, Typhoon No. 18 that lashed Japan from September 6 to 8, 2004, passed through cities that had been relatively unaffected by strong storms, causing severe damage to waterproofing membranes in these areas.

Damage investigation and results

The AIJ promptly set up an investigation team to examine the damage to roof membranes by sending questionnaires to roofing manufacturers' associations, waterproofing contractors' associations, general contractors' associations, and building caretakers. The response from 63 parties revealed that the damage mainly consisted of separation and blow-off of waterproofing membranes from the substrate, most of which are supposed to have started from roof edges or poor application areas. *Table 2* gives the detailed description and probable causes of damage to waterproofing membranes.

Lessons were learned from the damage investigation. Achievable improvements in current technology include the following: securing the design quality (specifying appropriate detail design for parapets, eaves, etc., and selecting an adequate type and number of fasteners for mechanically fastened membranes), assuring the application quality, and performing regular maintenance.

Improvements requiring technology development in the future include the following: improvement in the bond strength with the substrate and improvement in the strength of sheet materials.

It is also pointed out that a more appropriate method of evaluating wind resistance of membrane systems should be established. A research committee for the wind resistance of waterproofing membranes has already been organized in AIJ and has been conducting an investigation into the behavior of membranes through wind-tunnel testing.

Photo 1 – Root-penetration test for trees. (One side panel is removed for inspection of root penetration.)

Photo 2 – Root-penetration test for plants. (An inside container is dug up for inspection of root penetration.)

MEMBRANES	DAMAGES	AGE OF DAMAGED MEMBRANE	SUBSTRATES	CAUSES
Built-up membrane (fully or partially bonded)	• Tear of membrane • Blow-off of membrane	Mostly over 10 years	• Cast-in-place, reinforced concrete deck	• Poor design for strong wind • Degradation of membrane
Modified bitumen sheet (torch-on system)	• Blow-off of membrane • Separation of membrane from deck	Within 3 years	• Cast-in-place reinforced concrete deck • Autoclaved, aerated, concrete panel deck	• Poor design for strong wind • Poor application
EPDM sheet-applied (adhered or mechanically fastened)	• Blow-off of membrane • Wrinkles caused by sheet separation from deck	Over 10 years for half of the membrane and within 10 years for the other half	• Old existing membrane • Cast-in-place, reinforced concrete deck • Autoclaved, aerated, concrete panel deck	• Poor design for strong wind • Poor application • Degradation of adhesives
PVC sheet-applied (mechanically fastened)	• Puncture of membrane by flying debris • Tear of membrane • Blow-off of membrane • Looseness between fastener and substrate	Mostly within 10 years	• Old, existing membrane • Cast-in-place, reinforced concrete deck • Steel deck	• Poor design for strong wind • Poor application • Improper design of detail • Flying debris
TPE sheet-applied (mechanically fastened)	• Puncture of membrane by flying debris	Mostly within 20 years	• Steel deck • Old existing membrane	• Flying debris
Polyurethane, fluid-applied membrane (partially bonded)	• Blow-off of membrane • Separation of membrane from substrate	1 to 16 years	• Cast-in-place, reinforced concrete deck • Autoclaved, aerated, concrete panel	• Poor application • Existence of blistering

Table 2 – Damage of membranes by typhoon.

AFTERWORD

Since its boom in the late 1980s to early 1990s, Japan's construction has moderated. The momentum toward long and careful use of buildings has been growing in concert with the global movement toward environmental protection. In these circumstances, the waterproofing industry has been acting to technically support the movement. This is the situation at present, whatever the future may bring.

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3) *Procedure for Investigating Resistance to Root Penetration at Green-Roof Sites*, FLL Work Party, "Root-Penetration" team, January 2002.

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~ PIMA Celebrates 20th Anniversary ~

For 20 years, the Polyisocyanurate Insulation Manufacturers Association (PIMA) has served as the unified voice of the rigid polyiso industry. PIMA's members, who first came together in 1987, include a synergistic partnership of polyiso manufacturers and industry suppliers.

Upon being formed, the association faced a critical environmental issue – an international phase-out of chlorofluorocarbons (CFCs), which were implicated in the accelerated depletion of ozone in the earth's stratosphere. PIMA provided valuable guidance to Congress and the Environmental Protection Agency (EPA) in implementing the highly successful provisions of the Montreal Protocol. In 2003, the polyiso industry converted to zero ozone depleting blowing agents. The early transition resulted in an award by the Sustainable Building Industry Council.

Some of PIMA's proudest accomplishments include:

- Primary mover in the enactment of the Energy Policy Act 2005, providing federal tax incentives for energy-efficient homes and commercial buildings.
- Founding member of the Building Codes Assistance Project, to achieve state energy code enhancements that are critical to actual building performance.
- Service on the Secretary of Energy's Federal Energy Advisory Committee and chairmanship of the Alliance to Save Energy's Task Force on Federal Energy Productivity.
- Adoption of the "Beyond the Code" marketing campaign to increase awareness about the return on investment for buildings that exceed existing energy code requirements. This included the successful support for the first increase in 18 years for ASHRAE R-value requirements, the nation's consensus standards for minimal energy performance of commercial buildings.
- Created the voluntary Quality Mark program, enabling polyiso manufacturers to obtain third-party certification for the LTTR values of the permeable-faced, polyiso roof insulation they produce. Polyiso is the only highly thermal product with this certification program.
- Working with groups such as the Sustainable Building Industries Council, NCRA, BOMA, RCI, CSI, and AIA, developed new ASTM standards for polyiso and jointly sponsored the new roof energy assessment Web-based EnergyWise® calculator.
- Working with the National Association of State Fire Marshals, ensured that rigorous testing is required before code acceptance of new under-deck fire standards.
- Early partner in EPA's Energy Star Buildings and Homes program, as well as the subsequent Home Resealing Program.
- Advocate for enhanced state energy codes and other government policies that motivate building owners and contractors to heighten building-envelope performance. Testifying frequently regarding funding of federal energy efficiency programs, PIMA has strongly supported legislative policy to encourage federal tax incentives for energy-efficient commercial buildings.