Waste not... when making new roads

The Science of Surfaces is a four-part weekly science series that looks at the surfaces we walk on so often but know so little about. In this third part, we look at the material used to make our roads anti-skid. Next week, we look at sand.

By Maria Almenoar

WASTE from steel factories is what keeps a tight grip on car tyres in wet weather conditions.

Road pavers have found that steel slag, or a by-product from making steel, provides a better anti-skid property than conventional materials such as granite.

Increasingly, the Land Transport Authority (LTA), which oversees road paving, is adding recycled or waste materials into Singapore's roads.

The aim is to increase the composition of these recycled materials in roads to 70 per cent, up from the current 25 per cent.

LTA's acting manager for road infrastructure management, Mr Yoong Chin Chong, said: "In the old days, all four layers of the road were made from granite stone but nowadays, we are looking at using recycled material which can do the same or even a better job."

Recycled materials minimise Singapore's dependence on imports from neighbours Indonesia and Malaysia, reduce the rate at which landfills pile up and save the authorities millions of dollars.

Steel slag is one waste material, for example, that is being used in the top layer of roads, called the asphalt wearing course.

Different sizes of granite stones and steel slag are heated at about 170 deg C to remove any moisture before being mixed with a dark sticky liquid called bitumen, or what is commonly known to motorists as tar.

The steel slag with its grooves gives the road surface a honeycomb texture and makes melding with the bitumen easier and, in turn, the surface stronger.

The use of steel slag also helps to reduce the price of the top layer, which with the quality of the granite aggregate being used is now about the same as that for the bottom layers – about $11 per sq m – despite being about one-sixth the thickness.

On the top two layers, the LTA is testing the use of some of the "old roads" or roads dug up during resurfacing.

"Old road" surfaces are processed into reclaimed asphalt, which is then crushed and screened into various sizes.

Said pavement specialist Kelvin Lee from Samwoh Corporation, one of the four asphalt production factories in Singapore: "The field test results of using asphalt with the reclaimed asphalt pavement have been encouraging and we envisage that it will be approved for usage in the near future."

For the bottom two layers, which need to be between 200mm and 300mm thick, the LTA is testing using processed incinerated waste from landfills.

This is made up of mostly discarded household items and contains mainly silica, glass, ceramic and metal.

The waste is exposed to weather for three months to dry before it is screened to remove unwanted materials.

It is then sieved to the required sizes before being treated by chemicals.

Already, for the bottom two layers, the LTA uses discarded blocks of concrete from construction sites when, for example, buildings are demolished.

The steel reinforcement rods are removed and the concrete is treated before it is used as road-building material.

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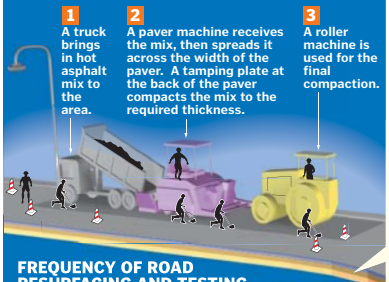
Smooth drives

Roads are generally made of four layers. These layers vary in thickness depending on how heavily the roads are used. All roads also checked and resurfaced regularly.

HOW ROADS ARE RESURFACED



MATERIALS THAT GO INTO A ROAD

Asphalt wearing course: Comprises bitumen and aggregates of granite stone, 19mm and below in size. Steel slag is also used.

Asphalt base course: Comprises bitumen and aggregates of stone sized 25mm and below.

Road base: Comprises aggregates of stone sized 38mm and below

Sub-base: Comprises aggregates of stone sized 75mm and below. Crushed concrete (derived from demolished concrete structures) and milled asphalt waste (derived from asphalt road maintenance) can be used here.

FREQUENCY OF ROAD RESURFACING AND TESTING

- Expressways resurfaced **EVERY THREE TO FIVE YEARS**
- Major roads resurfaced **EVERY FIVE TO 10 YEARS**
- Minor and residential roads: Inspected **EVERY TWO MONTHS** and affected stretches resurfaced as needed.
- Typically, minor roads are resurfaced **EVERY 10 TO 20 YEARS** and residential roads **EVERY 30 TO 40 YEARS**.

DIFFERENT ROAD, DIFFERENT THICKNESS

(Figures in mm)

	Express-way	Major arterial	Primary access	Local access
Asphalt wearing course	50	50	40	25
Asphalt base course	120	120	90	75
Base course	250	250	200	200
Sub-course	300	300	300	200
Total	720	720	630	500

HOW ROADS ARE TESTED

Road Profilometer

It measures road profile parameters ,such as the longitudinal and transverse road profile. Results are used to determine the road riding quality.

Testing Time: Mostly during day

Speed: Normal traffic speed

Scrim Machine

Measures wet-road skid resistance values. The machine moves at a speed that simulates usual vehicle movement

Testing Time: Mostly during the day

Speed: 50kmh

Deflectograph

Measures road deflections and evaluates the lifespan of the road

Testing Time: Mostly during the night

Speed: 2.5kmh

Source: LTA

GRAPHICS: TIEN CHUNG PING PHOTOS: LTA

Silk so strong you can turn it into bullet-proof vests

By Grace Chua

DR WILLY Tan will soon run Singapore's only silkworm farm – and he is doing it for the good of science.

The Republic Polytechnic researcher is leading a project that coaxes silkworms to spin stronger silk by exposing them to an electric field before they spin.

Defence engineering firm ST Kinetics is interested in turning this tougher silk into stronger ballistic or bullet-proof vests and composite materials.

Before Dr Tan got involved with the silkworm project in 2008, the 37-year-old materials scientist had no experience rearing insects. "I'm not a live animal person – but it's part of the scientific learning curve," he admitted.

At the time, Republic Polytechnic's applied science school was casting about for a project to commercialise.

It approached National University of Singapore (NUS) physics researchers Liu Xiang-Yang and Du Ning, who had filed a patent for the method to make stronger silkworm silk.

Normally, silk proteins are arranged like several bundles of chopsticks, grouped to form a bigger single bundle of chopsticks. The "chopsticks", or protein molecules, are linked with other molecules called beta crystals.

It may be an age-old industry, but (from left) Dr Willy Tan, 37, Dr Liu Xiang-Yang, 49 and Dr Du Ning, 32, are putting a new spin on the way silkworms are raised to coax them to produce stronger silk. ST PHOTO: CHEW SENG KIM

Exposing the silkworm to an electric field before it spins changes the way the crystals are lined up, firming up the "chopstick" links and strengthening the silk strand.

That enhanced strand is 40 per cent stronger than normal silkworm silk and needs two to three times the force before it breaks, putting it on a par with spider silk.

It is also stretchier and lighter than current synthetic fibres such as Kevlar. A Kevlar-reinforced helmet can weigh several kilograms. Enhanced silk helmets could be up to 30 per cent lighter, Dr Tan estimates.

While spider silk is tougher than steel, researchers are trying to find alternatives as it is nearly impossible to mass-produce. For instance, another NUS group is studying the structure of spider silk and trying to replicate it in the laboratory.

Dr Tan's silkworm project is supported by about half a million dollars from a National Research Foundation translational grant, which helps polytechnics shepherd inventions from universities and research institutes along to commercialisation.

At the moment, the enhanced silkworm silk costs about $140 per kg to produce in the lab, but the cost will drop to about $70 per kg when the silkworm farm begins larger-scale production.

The farm, holding 16,000 cocoons in a facility the size of a large classroom, will be up and running by May.

The worms will be ordered from catalogues, from Canada, China and India, housed and bred in incubators here, and fed on a paste made from mulberry leaves.

Tape strips will be pasted along the breeding room's doorways to prevent any getaways.

When the fibres are harvested, they will be used in composite materials, and made into fabric with different weaves whose properties will be studied.

Dr Tan expects the enhanced silk to be ready for commercialisation in about three years' time.

Dr Liu said: "People have been weaving silkworm silk for 7,000 years, and nothing has changed. This could revolutionise the silk industry."

Polys get funding to bring varsity inventions to market

By Victoria Vaughan

GETTING research translated into products for sale is a challenge, but nine inventions have received funding to do just that.

Singapore's five polytechnics will each get a slice of $3.57 million from the National Research Foundation's $25 million Translational Research and Development Grant Scheme to develop nine inventions from the universities to produce devices for the market.

One of the nine projects is the Gap Clearing Wheelchair which will help the disabled to cross the space between platforms and trains, or across drains, safely.

It was invented by Associate Professor Kok Hui John Gerard from the School of Mechanical and Aerospace Engineering, Nanyang Technological University (NTU), and Singapore Polytechnic lecturer Soon Yew Boon has received a grant to take the work forward.

"We are still in the conceptual stage and looking at how we can adapt the prototype for the market," said Mr Soon. "We're not sure if we will build a new wheelchair or make a device that fits to existing wheelchairs, or both."

Mr Soon will work with three others and is already in talks with a wheelchair manufacturer about getting the finished product to the market. The project will take about 18 months.

By 2012, there will be an estimated 4.2 million wheelchair users worldwide.

Dr Ong Fook Rhu, also a lecturer at Singapore Polytechnic, will look to develop the Finger Function Rehabilitation Device. Invented by Associate Professor Teo Chee Leong from the National University of Singapore's engineering department, it is designed to help restore the ability of a stroke patient to grab and pinch.

Stroke is the leading cause of adult neurological disability in Singapore, with more than half of the surviving patients requiring specific rehab.

"The device has five rings for the fingers and thumb and a system moves the hand to help retrain the patient's brain to remember the lost functions," said Dr Ong, who specialises in biochemistry of the hand and foot.

The project is predicted to take about two years and to cost $295,000.

Dr Sun Ling Ling, a lecturer at Temasek Polytechnic, will be developing a portable biosensor stem for early screening of the dengue virus.

"There are some methods for detecting dengue but they are lab-based, require skilled manpower and expensive equipment and take one to three days. Our sensor will take just a couple of hours," said Dr Sun. The biosensor was invented by Prof Tan Ooi Kiang of NTU.

Dr Sun said it was a very exciting opportunity for the polytechnics to be involved in such translational research. "This is the first time there has been such a scheme in Singapore," she said.

The grant comes under the National Framework for Innovation and Enterprise, announced by Prime Minister Lee Hsien Loong in March 2008. It aims to fund around 19 projects each year and the next call for applicants will be in April.