The background of the image is a dark, high-contrast photograph of a microchip. The intricate circuitry of the chip is visible as a complex network of light-colored lines and rectangular pads. In the lower right corner, a portion of a golden-colored compass rose is visible, adding a traditional navigational element to the modern technological theme.

TECH

Brazil's first chip was developed by students and professors in USP's electrical engineering department

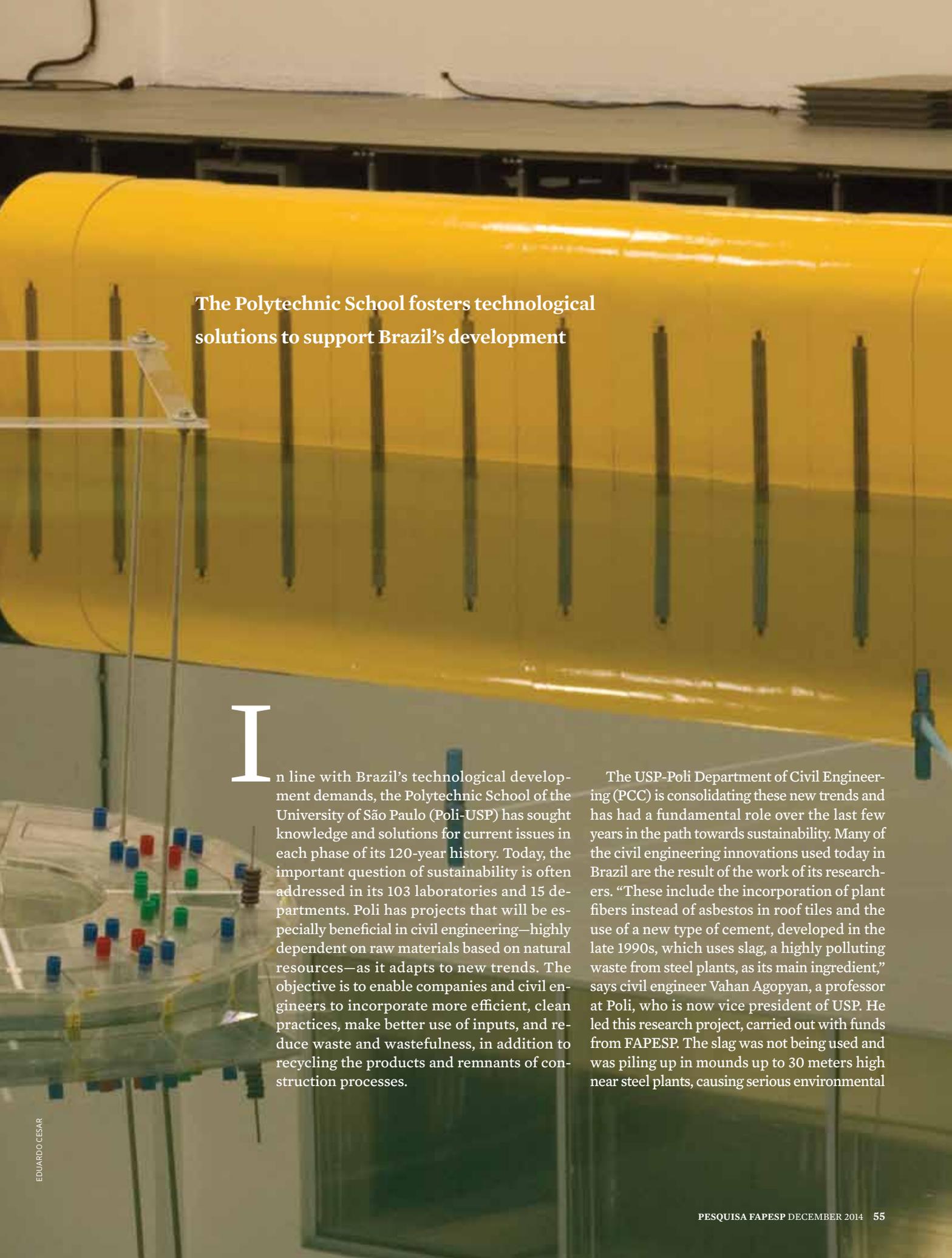
NOLOGY

ENGINEERING

Foundations of Knowledge

Evanildo da Silveira and Marcos de Oliveira

Naval engineering: tank reproduces
ocean conditions on a smaller scale
for platform and ship tests



The Polytechnic School fosters technological solutions to support Brazil's development

In line with Brazil's technological development demands, the Polytechnic School of the University of São Paulo (Poli-USP) has sought knowledge and solutions for current issues in each phase of its 120-year history. Today, the important question of sustainability is often addressed in its 103 laboratories and 15 departments. Poli has projects that will be especially beneficial in civil engineering—highly dependent on raw materials based on natural resources—as it adapts to new trends. The objective is to enable companies and civil engineers to incorporate more efficient, clean practices, make better use of inputs, and reduce waste and wastefulness, in addition to recycling the products and remnants of construction processes.

The USP-Poli Department of Civil Engineering (PCC) is consolidating these new trends and has had a fundamental role over the last few years in the path towards sustainability. Many of the civil engineering innovations used today in Brazil are the result of the work of its researchers. “These include the incorporation of plant fibers instead of asbestos in roof tiles and the use of a new type of cement, developed in the late 1990s, which uses slag, a highly polluting waste from steel plants, as its main ingredient,” says civil engineer Vahan Agopyan, a professor at Poli, who is now vice president of USP. He led this research project, carried out with funds from FAPESP. The slag was not being used and was piling up in mounds up to 30 meters high near steel plants, causing serious environmental

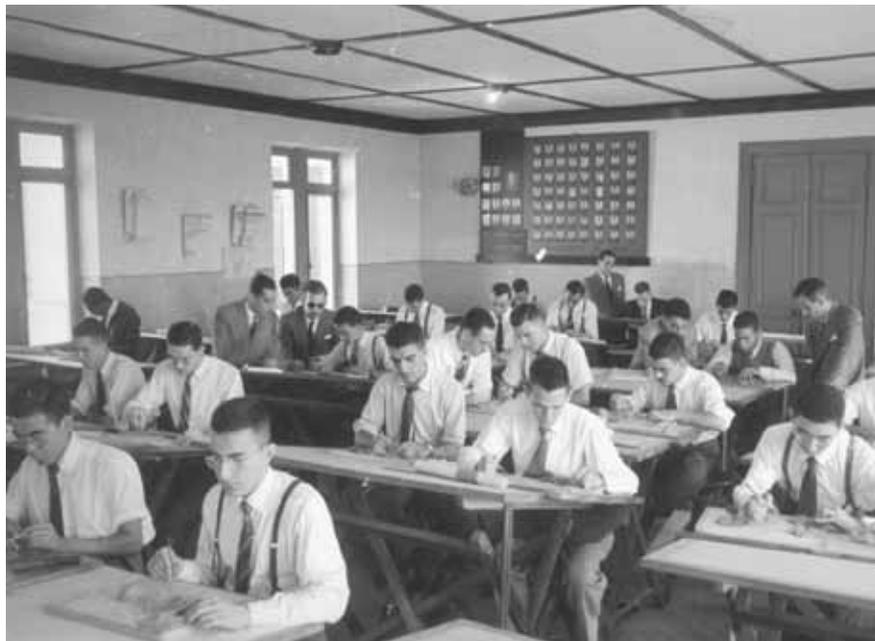
problems. Today, this type of cement is widely used in construction. “Over time, its manufacture has used up the slag that had accumulated throughout Brazil,” he says. “The incorporation of this material into cement was already being done in other countries, but we carried out a study in order to understand the chemical aspects and operation of the mixture of cement with slag.”

The origin of this new attitude towards sustainability in civil engineering goes back many years. According to Agopyan, it dates from the start of the 1970s. “At that time there was a change in approach, from an empirical view of construction to a scientific one,” he says. “From that point on, foreign books began to introduce us to a scientific view of materials. When I did my PhD at King’s College in London, from 1979 to 1982, I was one of the first Brazilians to study with professors who had this scientific approach.”

The first and main result of this change in approach was that engineers came to understand building materials. “We started to study how concrete works, for example. This allowed us to increase its resistance from 20 megapascals (MPa) to as much as 120 MPa [Pascal is the standard unit for pressure and stress and is equal to the force of 1 Newton (N) applied uniformly on a surface measuring 1 m²], and enables the construction of tall buildings, like we see in São Paulo. This landmark transformation occurred in parallel worldwide.” What changes are the materials and the raw inputs used in each country. “Among current research topics is the study of the optimization of concrete production in order to reduce the consumption of cement,” says Agopyan.

Teaching and research in civil engineering led Poli to the top spot in the ranking of Brazilian universities published by the newspaper *Folha de S.Paulo* in 2014. The civil engineering department was one of the first established in the Polytechnic School by the founder and first dean Antonio Francisco de Paula Souza, who taught classes on the strength of materials and the stability of structures to the first class of civil engineering students in 1894, one year after the department was founded. Poli was incorporated into USP in 1934, the year in which the university was founded.

Three other engineering departments at Poli came in first in their categories in



Drafting boards, T-squares, pencils and compasses, civil engineering before computers and without a scientific view of materials, an approach that would become common after the 1970s

the 2014 *Folha* ranking due to their tradition and research excellence. In addition to civil engineering, electrical, mechanical and chemical engineering were each ranked in first place in their respective fields. In total, in the seven engineering fields listed in the ranking, Poli was first in four and second in another two, environmental engineering and production engineering. Poli does not have a program in the seventh category, control and automation.

ELECTRONIC SYSTEMS

In electrical engineering, more precisely in the Department of Electronic Systems Engineering (PSI), there is a large variety of projects underway, such as the cardio-chip (a chip to monitor heart signals), an electronic circuit that can help the deaf hear, software for low-cost mobile phones, virtual reality infrastructure for the Navy, and a 3D cinema system with integrated chair movements.

More than 40 years ago, when the PSI had a different name, it was responsible for developing the first integrated circuits, better known as chips, and even the first Brazilian computer, named “Ugly Duckling,” under the coordination of Professor Antônio Hélio Guerra Vieira. Electrical engineer João Antônio Zuffo, who earned his undergraduate degree from Poli in 1963 as member of the third class

of students in the field, knows the story well, since he was a part of it. Today, he has retired from his professor position, but still works full-time. “In 1960, the Electrical Engineering Department was established with two options, electronic and electrical engineering,” he recalls. “In 1962 and 1963 I had a FAPESP scholarship, as a student.” Shortly thereafter, in the late 1960s and early 1970s, the Microelectronics Laboratory (LME) and Digital Systems Laboratory (LSD) were founded and, later, in 1975, the Integrated Systems Laboratory (LSI) was established. All three still exist. Before that, in 1971, Zuffo developed the first Brazilian chip. “It was as fast as the quickest chips at the time, but was never produced industrially, although it was viable,” he says.

The year 1972 marked PSI’s triumph, with the construction of the Ugly Duckling. Its development started with the professors in the electrical engineering program. A workshop was set up and the team itself manufactured the components and the integrated circuits for the computer’s memory, which reached 8 bits. The device was presented to the public in July 1972. “Neither the chip nor the duckling went into production because, at the time, there was no industry. The investment needed was very high and would have had to come from a company,” says Zuffo.

In the specific case of LSI, the initial objective was stronger development of graduate research, on the same level as the most advanced research in the world. “When we made our chip, it was only 12 years after the first had been made in the United States,” recalls Zuffo. “Not many countries were doing this. Not even Japan had a microelectronics industry then.” The first virtual reality projects and parallel data processing occurred on LSI workbenches. “In the latter case, the result was a super microcomputer later manufactured by Itautec,” he says.

The Brazilian digital TV system, which is spreading throughout Latin America, contains important contributions made by LSI, principally those allowing the signal to be picked up by mobile phones and other mobile devices. The Digital Cave is not as widespread, but its scientific importance could be even greater. It is a room with projection from five sides—four walls plus the ceiling—controlled by a parallel supercomputer developed by the laboratory’s researchers. It can hold up to six people, who can interact with the simulated world via computer. But it is not just a curiosity. Its applications extend to several fields of research, such as engineering, medicine, astronomy, astrophysics, biology and chemistry and even entertainment, such as games, photorealistic visualizations and interactive movies.

Simulations in the numerical tank are essential to pre-salt exploration

Poli’s adaptation to Brazil’s recent demands is visible in oil exploration in deep and ultra-deep waters, such as in pre-salt exploration. The partnership between the Poli-USP Department of Naval and Ocean Engineering (PNV) and Petrobras is contributing to the success of exploration in the waters off the states of Rio de Janeiro and São Paulo. The development of the Numerical Test Tank (TPN) in 2002 and the inauguration of the physical tank in 2009, called the Hydrodynamic Calibrator

(CH)—similar to an ultra-sophisticated swimming pool

measuring 14 m (meters) by 14 m with a depth of 4 m, capable of producing waves and other ocean conditions on a smaller scale—were fundamental to Petrobras’ exploration of pre-salt oil, which can be at a depth of 6 km (kilometers), under a layer of at least 3 km of water. One system complements the other and, together,

they can simulate various environmental and operational conditions under which ships and platforms operate. “There are many physical tanks in Norway, the Netherlands and Japan, but there is no laboratory that uses a physical and numerical tank together like the compu-



The Ugly Duckling was the first computer made in Brazil based on a research project. A workshop was set up in the electrical engineering department and students manufactured components

tational cluster we have here. We began with 120 processors and now have almost 2,500,” says Kazuo Nishimoto, who was head of the department from July 2010 to July 2014.

Before starting exploration, every operation is simulated on the TPN computers, some calibrated using the CH, and viewed in a virtual reality room. The TPN is used to simulate things ranging from the anchoring of oil tankers—known as FPSOs (Floating Production, Storage and Offloading)—on the high seas using risers that tie them to the ocean floor, to drilling the salt layer, under which petroleum is found. “Without the TPN and these simulations, pre-salt exploration would be impossible.”

Foreseeing the evolution of offshore oil exploration, Professor Celio Taniguchi, then head of the department, a position he held from 1984 to 1992—before becoming dean of the school from 1994 to 1998—signed a cooperation agreement with the Petrobras Leopoldo Américo Miguez de Mello Research and Development Center (Cenpes) for the development of technology and offshore structures for deep water. “Until then, our department focused on ships,” recalls Nishimoto. “After the agreement with Cenpes, we started working on offshore drilling and oil production platforms, risers for anchoring them and submarine pipelines for transporting oil. That is why, in 1986, the PNV, which until then had been called the Department of Naval Engineering, added “and Ocean” to its name. ■



In 1971, the first chip made in Brazil. As fast as chips manufactured at the time