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## Singapore Universities Set to Dig Deep for Expansion

By CALVIN YANG

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SINGAPORE — At universities in land-strapped Singapore, students may one day borrow books from an underground library, attend lectures in a subterranean auditorium or even swim in an Olympic-size swimming pool below sea level.

Two of the city's public universities, Nanyang Technological University and the National University of Singapore, have completed preliminary studies on developing the space beneath their campuses for lecture theaters, laboratories, sports facilities and performance halls. A third school, Singapore Management University, has already constructed a basement-level space linking its main above-ground buildings.

At N.T.U., a group of researchers has spent the past year gathering available data on the university's surface topography and subsurface geology.

The preliminary survey, completed late last month, found that the campus, which is in western Singapore, offers opportunities for underground space development. Extensive investigations indicated that rock strata 20 to 30 meters, or 66 to 98 feet, below the surface, are suited for cavern construction with spans as wide as 20 meters wide.

"In the long term, the university may need to go underground" to accommodate projected increases in the student population, said Zhao Zhiye, one of four researchers who worked on the study.

The study, which started in July 2012, could be used as a supplement to the university's ambitious 15-year strategic plan to develop the 200-hectare, or 500-acre, campus. The plan, unveiled in 2011, proposed infrastructure like outdoor spaces, interdisciplinary buildings, and a campus-wide network of pedestrian walkways and cycling lanes.

"It may not be at this particular moment, but if in 10 years' time we run out of space, going underground is a good option," said Mr. Zhao, an associate professor at the university's School of Civil and Environmental Engineering and interim director at the Nanyang Center for Underground Space.

The researchers have also proposed preliminary designs for a four-story underground learning complex and a three-story underground sports hall.

Designed for both learning and socializing, the learning complex — a group of interconnected caverns — would include the university's main library, a museum, study rooms, cafeterias and conference halls. The sports hall, beneath the existing university



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sports complex, would house basketball, badminton and table tennis courts, swimming pools and spectator stands.

“At this moment, from a concept point of view, we are looking at how much space we can create below the university campus if we really want to utilize the underground space,” said Mr. Zhao. “At a reasonable depth, there is enough space to accommodate various facilities, if there is a need in the future.”

According to the local media, National University of Singapore has also identified areas on its Kent Ridge campus, in the western part of the island, for underground development to house classrooms, sports halls, laboratories and libraries. In an e-mail last month responding to questions, the university described the reported study, completed last year, as preliminary.

While N.T.U. and N.U.S. continue to survey their underground potential, Singapore Management University, a business school, began using the space below its campus in 2005, building a one-level basement concourse to link its five main buildings and the mass transit system’s nearby Bras Basah train station.

“As in any city location, especially in dense urbanized locations like our university’s campus, the presence of existing underground utility services, including transit lines, were challenges the university had to overcome,” Loke Mun Sing, director of the university’s campus development, said in an e-mail.

The 19,000-square-meter, or 205,000-square-foot, air-conditioned concourse also houses facilities and amenities including offices, retail outlets, courtyards, a medical clinic and the university gymnasium.

The universities are not alone in going underground. Other big subterranean facilities and projects include the Jurong Rock Caverns oil bunker and a proposed underground science city, as well as an underground ammunition depot completed in 2008. Expressways, transit lines, underground drainage systems and utility tunnels have become an integral part of the city’s urban landscape.

Zhao Jian, professor of rock mechanics and tunneling at the École Polytechnique Fédérale de Lausanne, in Switzerland, who also worked on the N.T.U. study, said he expected the universities to move quickly to realize their underground potential.

“With the pressure on space, it will probably take place soon,” he said.