Innovative Water Reclamation Technology

Water reclamation is of significant importance to any country and/or region facing the constraint of water availability. Other than the traditional sources of water like surface water and groundwater, alternative sources such as seawater and treated effluent from domestic sewage treatment works have been exploited to augment the water supply for both potable and non-potable usages. Water reclamation has been practised in several countries for decades now and has been proven to be a viable option technologically and from the societal standpoint.

Advanced technologies like membrane filtration, Granular Activated Carbon adsorption, Ultra-Violet disinfection and advanced oxidation have been adopted to form a treatment scheme with multi-barriers to address contaminants, which might potentially be of concern to consumers.

Although it is technologically possible to produce reclaimed water with quality at a standard that surpasses all current quality requirements for potable use, it is nevertheless desirable to continue focus R&D.

Minor in Urban Environmental Engineering Programme

Leveraging on the success of the Specialization in Environmental Engineering launched in 1997 and upon the request of the students, the Department of Civil Engineering will launch the Minor in Urban Environmental Engineering Programme in July 2001. This programme is to provide a broad-based education in urban related environmental science and technology to prepare our students to undertake important and challenging tasks to protect our natural environment and to facilitate the infrastructure development on an environmentally friendly and sustainable platform. Any engineering undergraduate student who has successfully completed CE2142 Municipal Wastewater Engineering or an equivalent module (approved by the Head of Civil Engineering) is eligible to apply for the Minor in Urban Environmental Engineering Programme. A student from other faculties who has not taken CE2142 or an equivalent module will be required to complete CE2142 before applying for the Minor in Urban Environmental Engineering Programme. The CE2142 taken by a non-engineering student may be counted towards the requirement of the programme.

The programme will begin in Semester 1 of the Academic Year 2001/2002 i.e. July 2001. There are 30 places available per year for this Minor Programme.

For further information please contact Dr Hu Jiangyong, Tel: 874 4540.
effort to develop cost-effective reclamation technologies. This is to further improve reliability and adequacy of the reclamation technology where conventional wastewater treatment could face pressure from both regulatory bodies and the public. The Water & Biotreatment Group (WBG) at the Department of Civil Engineering, NUS, has been actively conducting R&D in water reclamation since the late 1980s.

Leveraging on the success of water and wastewater treatment technologies developed over the past decade, WBG has developed several versions of membrane-based water reclamation systems that are capable of delivering product water suitable for high value reuse applications. The membrane sequencing batch reactor and membrane ultra-compact biofilm reactor are two examples of membrane-based water reclamation systems developed by WBG. Membranes (Microfiltration, Ultrafiltration, and so on) can be added to biological treatment systems aiming for an enhanced effluent quality for industry reuse. These systems have small footprints but high loading capacities. It is noteworthy that these water reclamation systems are able to support a high level of biomass concentration within the reactor systems that in turn provides a much better performance than that of conventional biotreatment systems. In addition, the membrane-based systems can achieve an exceptionally high degree of solids-liquid separation-unmatchable by any conventional sedimentation facility. The results obtained thus far have conclusively confirmed that these water reclamation systems are capable of producing high quality product water from domestic sewage. WBG has devoted considerable effort to understanding the process fundamentals and developing appropriate design and operating protocols for these water reclamation systems. With appropriate design and operating protocols, the product water produced by these water reclamation systems with proper polishing post-treatment processes, would be able to consistently surpass all current quality requirements for even indirect potable reuse. WBG continues R&D to develop appropriate protocols to further enhance microbial safety, biological stability, and public health safety of the reclaimed water. All these efforts are to safeguard the quality of the product water to meet or surpass the required standard imposed for its intended usage. Water reclamation R&D is one of the focal areas of the newly established Centre for Water Research hosted by the Department of Civil Engineering.

Contact persons: Prof Ng Wun Jern, Tel: 874 2142, Assoc Prof Ong Say Leong, Tel: 874 2890, Dr Hu Jiangyong, Tel: 874 4540, Dr Song Lianfa, Tel: 874 8796.

Research Highlights

Intelligent Road Maintenance Scheduling and Monitoring System

This project proposes to establish a prototype intelligent road maintenance management system that serves two main functions: (1) intelligent scheduling; and (2) real-time monitoring of road maintenance activities that involve closure of traffic lanes. Scheduling of activities involving lane closure should minimize traffic delay at network level. This project proposes to use genetic algorithm, coupled with a traffic simulation model to estimate the impacts of each scheduling solution on traffic delay at network level. When works are being carried out, real-time monitoring of these activities is important in reporting the progress of work, expected completion time, updated location of lane closure, and traffic congestion level. This part of the project aims to develop a real-time video-mapping and communications system, so as to enable transmission of road maintenance data and GPS encoded video information between the work site and a control centre. A sum of S$102,900 has been granted by the NUS (R-264-000-116-112) to Dr Cheu Ruey Long (Principal Investigator), Assoc Prof Chan Weng Tat, Dr Lee Der Horng and Prof Fwa Tien Fang.

Virus Removal by Membrane Filtration

Membrane processes are the emerging technologies in water and wastewater treatment. These processes use synthetic films that act as a barrier to certain substances found in water and the disinfection of water and effluents using membrane is of growing interests. Central to this application is the ability of the various membrane processes to remove virus. Previous works have shown that the use of ultrafiltration (UF), nanofiltration (NF) and reverse osmosis (RO) provided certain removal of virus. In view of this, it is desirable to conduct a systematic study to evaluate the performance of membrane technology for pathogens removal. In particular, the long term performance of the membrane in removal of virus under Singapore weather conditions will be of value to the local industry. It is also useful to study the inactivation of virus from reclaimed water during storage. Greater reduction could be expected under higher ambient temperature prevailing in Singapore.

This research project will investigate the issues concerning: (i) the performance characteristics of membrane technology for bacteria phage MS2 removal, (ii) the inactivation of virus during storage under
Emeritus Professor S L Lee Installed as ASCE Honorary Member

Emeritus Professor Lee Seng Lip was honoured by the American Society of Civil Engineers (ASCE) on 21 Oct 2000 “for his contributions to civil engineering research and teaching in structural and geotechnical engineering, for his publications numbering over 500, and for his work with students in the United States and in Southeast Asia” by installing him as an honorary member. He is one of the 158 individuals currently holding this status. Since 1853, the year the category was created by ASCE, only 458 individuals have been made honorary members.

Emeritus Professor Lee’s pioneering research has covered a wide spectrum, beginning with his early work in structural stability, plasticity and dynamics, and plate and shell structures. His later research addressed topics in structural engineering, geotechnical engineering, and construction technology. These efforts have contributed greatly to the current understanding of deep excavation support systems, land reclamation, soil improvement with particular reference to prefabricated vertical drain and up-down construction of tall buildings with deep basement.

During his academic career, Professor Lee has directed the studies of more than 50 doctoral students, many of whom have gone on to become illustrious engineers in academia, government, and private practice. He has authored more than 500 technical papers and has served as a structural or geotechnical engineering consultant on more than 100 construction projects around the world.

Professor Lee received a doctorate in 1953 and a Distinguished Engineering Alumnus Award in 1991 from the University of California at Berkeley. He began his teaching career in 1955 as an assistant professor in the civil engineering department at Northwestern University, attained the rank of full professor in 1960 and left Northwestern in 1968 to become a professor and head of the division of structural engineering and mechanics at the Asian Institute of Technology, in Bangkok, Thailand. In 1975, Professor Lee was appointed a professor and head of the civil engineering department at the University of Singapore. As an emeritus professor of the university since 1989, he has continued to supervise the work of graduate students.

MOU with Cornell University

In December 2000, the Department of Civil Engineering signed a Memorandum of Understanding with Cornell University on a Disaster Research and Mitigation (DRM) programme. The signatories from NUS were Prof Ng Wun Jern, Dean of Engineering, and Prof T F Fwa, the Head of Department of Civil Engineering from NUS and Prof John Hopcroft, Dean, College of Engineering, and Prof John Abel, Director, School of Civil and Environmental Engineering from Cornell University. The MOU establishes a basis for cooperation to carry out training, research and development activities in the field of Disaster Research and Mitigation. The collaboration will be initiated through the following research projects:

1. Development of wave and surge model under extreme wind conditions
2. Assessment of seismic hazard for buildings in Singapore
3. Urban GIS to support the risk assessment of flooding

To carry out the above projects, the Meteorological Service Singapore is funding $200,000, while NUS is contributing $180,000. Assoc Prof T Balendra is serving as the co-ordinator to this NUS-Cornell programme.
Internationally well-known authority in the investigation of soil behaviour and in centrifuge modelling. He has worked on many different soils including soft and stiff clays, carbonate and quartz sand, saprolites and tills. He is the author of three widely used textbooks on soil mechanics and foundation engineering. He has also advised industry and acted as expert on diverse problems. Nearly 100 participants attended Prof Atkinson’s lecture on “Non-linear Soil Stiffness in Routine Design.”

Tropical condition, and (iii) the long-term performance characteristics of membrane technology for MS2 removal. The results obtained should be useful to the local water industry. A sum of S$79,827 (R-264-000-122-112) has been granted by the NUS.

Contact Person: Dr Hu Jiangyong, Tel: 8744540

Application of Concentration Techniques to Reclaimed Water

A standard protocol for water concentration has been developed via laboratory-scale study and it will be verified under site condition in separate studies under the Water Quality Programme, hosted by the Centre for Water Research, Department of Civil Engineering, National University of Singapore. The water concentration technique will be tested, refined and applied via a pilot-plant water concentration operation to concentrate organics, if any, in reclaimed water as well as surface water. The concentrates produced will be used for health effect assessment at the Department of Civil Engineering, National University of Singapore.

This research would provide an excellent opportunity for NUS to build up expertise on water concentration which is of vital importance to water reclamation R&D. The NUS has provided a grant of S$127,500 (R-264-000-122-112).

Contact Person: Dr Hu Jiangyong, Tel: 8744540

Water Reclamation from Secondary Effluent with Membrane Processes

Membrane technology is a new and innovative process for advanced wastewater treatment that has a great potential to become a predominant measure in water reclamation. However, as an emerging technology, many aspects of membrane process remain largely unknown and need great efforts to explore further. The main objectives of this project are (1) to study the feasibility and efficiency of different membranes in water reclamation according to different water quality goals, (2) to investigate fouling mechanisms on different membranes under various operating conditions, and (3) to develop effective pretreatment methods to prevent or minimize membrane fouling. The successful completion of this project will enhance our knowledge on membrane technology and contribute substantially to the national commitment on water reclamation.

The research team consists of Drs Song Lianfa and Hu Jiangyong. Membrane based water quality enhancement R&D is one of the focal areas of the Center for Water Research hosted by the Department of Civil Engineering. National University of Singapore has provided a grant of $120,000 (R-264-000-110-112).

Contact Person: Dr Song Lianfa, Tel: 8748796

Soil Nailing in Singapore: A numerical and experimental investigation

The current research work on soil nailing (a form of earth reinforcement), seeks to assess the working mechanisms in local tropical soil condition. This technique has great potential in stabilising deep vertical excavations, slopes, tunnels and slope remediation. The project involves two full-scale field instrumentation of large soil nail application; the first is the ACS Barker Road Contiguous Bored Pile wall reinforced with soil nailing, and the second is a large cut slope at Bukit Batok stabilised with soil nailing. With the field data obtained, FEM analysis will be made in 3D and 2D to provide insight into the internal working mechanisms of nail inclusions. The challenges ahead are to arrive at a cost-effective method for design of soil nails, and to produce a technique for non-destructive testing of soil nails in practice.

The research team consists of Assoc Prof Tan Siew Ann, Dr Dasari Ganeswara Rao and Prof KY Yong. A sum of $49,000 has been granted by NUS (R-264-000-112-112).

Contact Person: Tan Siew Ann, Tel: 874 2278
The HEW team won “Gold Award”

The Wits Team, HEW, from the Hydraulic and Environmental Division of the Department of Civil Engineering participated in the PS 21 ExCel Convention 2000 held from 18th to 27th October 2000 at the Ministry of the Environment. The Public Sector WITs Convention is held every year to recognise the efforts of Ministries/Statutory Boards and staff who have contributed significantly to the improvement in the Civil Service by participating actively in WITs programme. The theme for this year’s convention is “ExCELe rate through Innovation” Its main thrust is to encourage innovation and creativity in the public sector. The HEW team won a “Gold Award” in the Static Display Category and was also one of the top three teams out of 46 teams that took part in the Convention. At the NUS 2000 Quality Service Day, the HEW team was commended with a trophy and a “Special Commendation Award” of $2000.

The HEW was formed in July 1999 and comprises one Professional Officer and eleven Laboratory Officers from the Hydraulics and Environmental Laboratories. The HEW team submitted their first completed project “Reducing the High Consumption of Water in the Chemical Oxygen Demand (COD) Refluxing Apparatus”. The COD test involves an acid oxidation of the organic waste by potassium dichromate. Usually, running portable water is used to cool the condenser and the heated water is discharged into the drain. By collecting the heated water in a fiberglass tank and recycling it, the team was able to save 427,680 litres of water or about $1308 per year for the Faculty of Engineering.

Family Get-together at Pasir Ris

The occasion on January 13th was a Family Get-together for the Department’s academic and non-academic staff. After several rounds of the social committee’s meetings, with some hesitation over the unprecedented inclement weather the committee decided to choose the above date.

The day started with some volunteers and members of the committee making a pre-cursor preparation for the get together by going to the site a few hours ahead. They were later joined by the rest, some of whom hopped into the bus provided from the campus for the function. As the participants approached the venue, Pasir Ris Park, a picturesque site adjoining the North East coast beach, a certain amount of anxiety surfaced when the blue sky gave way to black clouds. Many of the bus riders to the site experienced several rounds of drizzle during the 45-minute ride.

As the staff got together family after family, the drizzle became a mild shower for a while. The kids and their parents were worried; but not for long as the magician decided to clear the sky of clouds. He enthralled the crowd by making balloon-animals: octopi, dogs, cats, monkeys and others – a feat staff could not do, as they were not blowing the balloons with ‘stomachs’. For about an hour the magician performed many tricks and cajoled to get volunteers who were handsomely rewarded for being spontaneous. The sky cleared afterwards to see a treasure hunt, ping-pong and a game of fire fighting on candles with water pistols.

The BBQ buffet dinner was ready by 6 pm. The chef had prepared in the adjacent shed all the cooked and BBQed food, and everyone was ready to have a sumptuous meal, not sitting by the side of the table, but sitting with the family members of the staff, on mats and benches in the park. Others were standing and enjoying. There was plenty of food, as some staff forgot to come and others consumed only a little. Followed immediately after the dinner was a lucky draw for the staff. Many had real luck on that day – including the weather, which cleared up after the BBQ. Many stayed behind to have a stroll until the bus turned up to pick them up. It was interesting to watch how the staffs automatically helped one another in a family circle, how they laughed and enjoyed.
Prof Fwa Tien Fang and Assoc Prof Tan Siew Ann, Harry received the IES Engineering Achievement Award 2000 on 29 October 2000 in recognition of their outstanding engineering contribution to road industry through their research in “Field and laboratory permeameters for nondestructive assessment of expressway drainage mix asphalt pavements”. Their work has resulted in two patents, the first on the laboratory permeameter was granted on 16 Jan 2001 with Certificate of Grant of Patent, Singapore P-No. 67286.


Assoc Prof Koh Chan Ghee was invited to participate in the US-Japan Workshop on Nonlinear System Identification and Structural Health Monitoring held at the University of Southern California, 20-21 October 2000.

Dr Lee Der Horng has been invited to be a Member of the International Advisory Panel of the First Symposium of Green Transport, organized by W. Alton Jones Foundation (USA) and the Ministry of Construction (China), held in Beijing, China, from Nov 25 to 29, 2000.

Assoc Prof M.A. Mansur has been invited to be the Chairman of IFS Committee on Housing and Terrestrial Structures: IFS-40 by the International Ferrocement Society.

Professor P Paramasivam presented a keynote lecture on Durability of 32 year-old Reinforced Concrete Piles Exposed to Marine Environment (co-authored CTE Lim and KCG Ong) in the International Conference On High Performance Concrete-Workability, Strength, and Durability in Hongkong and Shenzhen 10-17 December 2000.

Professor N E Shanmugam was invited as a Visiting Professor by the Department of Civil and Environmental Engineering, University of New South Wales, Sydney where he spent two weeks from 10 Dec to 24 Dec 2000. He delivered two seminars to the Munro Centre and to the Australian Institute of Steel Construction.

Professor N E Shanmugam delivered an Invited Lecture on "Behaviour of Cold-Formed Steel Angle and Channel Sections" at the First International Conference on Structural Stability and Dynamics held in Taipei, Taiwan during 7-9 December 2000.

Professor N E Shanmugam has been elected as Member of the Executive Committee of the Association for International Cooperation and Research in Steel-Concrete Composite Structures (ASCCS).

Assoc Prof Tan Kiang Hwee has been invited to be a member of the International Scientific Committee of the Second International Conference on Durability of FRP Composites for Construction (CDCC 2002), to be held in Montreal, Canada, May 29-31, 2002.

Assoc Prof Tan Kiang Hwee has been invited to be a resource person at a Workshop on "Composites for Construction: A Reality", to be held in Capri, Italy, July 20-21, 2001.

Assoc Prof Tan Siew Ann, Harry is invited by IEM, Malaysia to give a Workshop on the "Computational Geotechnical Analysis with PLAXIS", to be held in Kuala Lumpur from 20 to 22 March 2001.

Assoc Prof Wang Chien Ming presented an invited paper entitled "Elastic/Plastic Buckling of Rectangular and Circular Mindlin Plates" at the First International Conference on Structural Stability and Dynamics, held on 7-9 December 2001 at Taipei, Taiwan.

Publications. July - September 2000


Koh, C G, B Hong and C Y Liaw, “Parameter identification of large structural systems in time domain”, J. of Structural Engineering, ASCE, 126(8), 957-963.


Wang, Q and C M Wang, “Optimal placement and size of piezoelectric patch on beams from the controllability perspective”, Smart Materials and Structures, 9, 558-567.


New Appointments
Mr Wang Hui Min, Management Support Officer
Mr Maung Tint Lwin, Research Technician
Dr Yuan Tao, Research Fellow
Ms Dong Ning, Laboratory Officer
Mr Ju Feng, Research Fellow
Mr Cheung Yeung, Professional Officer
Ms Goh Sock Hoon, Lina, Operation Support Officer

Research Engineer
Mr Liu Ding
Mr Pankaj Kumar
Mr Budianto Ontowirjo

Research Scholars
Mr Foong Kok Wai
Ms Huang Wei
Mr Ismail Ibrahim
Ms Jeng Shin-Ting
Ms Koh Mei Ing
Mr Ler Chin Wei
Mr Liu Daizong
Mr Ma Wenteng
Mr Magesh Chandramouli
Mr Ong Seong Yong, Jeremy
Mr Ong Ek Leong, Dominic
Ms Pa Pa Win
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Seminars held. October - December 2000

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Visiting Professor

Professor Zhang Lingmi

Prof Zhang Lingmi, on leave from the Institute of Vibration Engineering, Nanjing University of Aeronautics & Astronautics, has more than 30 years of experience in the Dynamics and Control of Mechanical Structures, since he finished his 5-year undergraduate and 3-year postgraduate study at Northwestern Polytechnic University in Xi’an, China. He spent three years in USA in early 1980’s, as a Post Doctorate Research Associate in the Department of Structures and Mechanics, University of California at Los Angeles, and Research Scientist at the Structural Dynamics Research Laboratory, University of Cincinnati. Prof Zhang’s major research interests are in (1) Structural System Identification; (2) Structural Health Monitoring & Damage Detection; (3) Modal Analysis & Testing; (4) FE Model Updating & Dynamic Design; (5) Vibration Control & Smart Structures. He has published more than 160 technical papers in refereed Journals and Conference Proceedings, 60 of which are in English, and two books on the above topics.

Prof Zhang served as Advisory Board member of the annual International Modal Analysis Conference, and Editorial Board member of an International Journal on Mechanical System & Signal Procession, and 3 Journals published in China. He has been invited to give more than 20 seminars and short courses for the universities and industries in USA, Europe and Japan. He was a Visiting Professor at the Department of Civil Engineering of Kassel University, Germany, Aalborg University, Denmark, Hong Kong Polytechnic University, and Graduate School of Engineering of Doshisha University, Japan, in the past few years.

Errata In the article on AWARDS on Page 3 of the CE Newsletter October 2000 issue, line 2 should read as:

1990 1st IES Innovation Award (Merit) [G P Karunaratne, K Y Yong, S A Tan, T S Tan, S L Lee and A Vijiaratnam].

### Conference/Workshop/Short Course 2001

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<tr>
<td>23 - 24 May 2001</td>
<td>Design and Application of Fibre Reinforced Polymer (FRP) Reinforcement for Concrete Structures</td>
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<td>27 - 29 June 2001</td>
<td>7th International Symposium on Ferrocement and Thin Reinforced Cement Composites</td>
<td>Assoc Prof M A Mansur</td>
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<tr>
<td>29 Jul - 1 Aug 2001</td>
<td>Fifth CANMET/ACI International Conference on Recent Advances in Concrete Technology</td>
<td>Professor P Paramasivam</td>
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<td>16 - 18 Dec 2002</td>
<td>Second International Conference on Structural Stability and Dynamics (ICSSD '02)</td>
<td>Assoc Prof C M Wang</td>
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