ISSMGE HTC PROJECT SESSION AT 14TH ANZ CONFERENCE ON GEOMECHANICS

EDUCATION OF THE NEXT GENERATION OF GEOTECHNICAL AND ENGINEERING GEOLOGY PROFESSIONALS IN AUSTRALIA AND NEW ZEALAND

Outcomes and actions from session held at the 14th Australia and New Zealand Conference on Geomechanics, Cairns, 3rd July 2023

Background

The Heritage Time Capsule is an initiative from the ISSMGE for which detailed information can be found at https://www.issmge.org/the-society/time-capsule. Current content includes contributions from member societies, technical committees, past-presidents and corporate associates.

The contribution from Australia to the Heritage Time Capsule project was the 50th Anniversary book (https://australiangeomechanics.org/downloads/50th-anniversary-book/). It was the opinion of some colleagues that the book did not sufficiently highlight the contribution of academics to the geomechanics profession in Australia. Related conversations about current challenges in education and industry skill deficiencies led to consideration of the topic of geo-education and future needs. The intent was to understand perspectives from different stakeholders and start the process of formulating a plan and actions to improve the situation. The invitation was extended to colleagues in New Zealand, considering common issues and challenges.

Introduction

This session explored the topic of the education and training of the next generation of geotechnical professionals along with the current state of geotechnical engineering and engineering geology programs in Australia and New Zealand universities. A panel was formed consisting of a young professional, an industry representative and an academic from both Australia and New Zealand.

The initial objectives were to cover the following main three topics.

- Education and training of the next generation of geotechnical professionals.
- How does the industry manage the resource planning and development?
- The young professional's experience in the industry and how it relates to their university education.

An introduction to the session was delivered by Graham Scholey, ISSMGE Vice President for Australasia. Prof David Airey moderated the session and set the scene. The panellists included:

- Academia: Liam Wotherspoon (NZ) and Negin Yousefpour (AU).
- Young professional: Christoph Kraus (NZ) and Xue Le (AU).
- Industry representative: Eleni Gkeli (NZ) and Jason Surjadinata (AU).

Overall coordination was carried out by Golnaz Alipour. There were approximately 50 attendees at the session.

Setting the scene

The initial objective of this session was to capture how well universities were preparing geotechnical professionals for their career in Australia and New Zealand. Following several discussions between the organising team and panel members, it was decided to focus on the future rather than capturing the past.

To start with, the group explored the effectiveness of education and training from the perspectives of academics and professionals at different stages of their careers.

A fundamental question was posed to frame the discussion:

Is geotechnical engineering / engineering geology education and training meeting the needs of graduates and the industry?

This session explored the thoughts of various stakeholders and the responsibilities across academia and industry, with a view to providing input into a plan to tackle issues that are raised.

The role of universities has been debated for many years but in summary the general aims are to:

- prepare students for life professionally and personally.
- provide education more than instruction.
- guide students on ways they can build new knowledge.
- provide skills that the industry can build upon.
- equip students with forward thinking skills.

It is worth asking if that model is still a reality today with changing behaviour and external pressures. Points related to this are raised in the following sections.

Examples of what people are meant to know after leaving university were explored, with focus on engineering and (engineering) geology programs. These include:

- ASCE's Civil Engineering Body of Knowledge. Presents some foundational skills and others to be covered by mentoring in industry.
- Australian Institute of Geoscientists (AIG) provides advice on knowledge and careers for geologists, but limited detail is

provided for Engineering Geology, it is 1 among 12 other sub-disciplines.

- Professional BOKS (Body of Knowledge and Skill) from New Zealand provides an indication of expectations of geotechnical professionals. The expectations are similar for both geotechnical engineers and engineering geologists, with one clear difference being that chartered geotechnical engineers are expected to cover design aspects and earthquake engineering.

It was noted that the ISSMGE technical committee TC-306: Geo-engineering Education is mainly focused on education in universities and all members of the committee are academics. What happens when graduates enter the workforce is not within the remit of the committee, which could be a potential issue.

Views from academia

Liam Wotherspoon presented a summary of situation in New Zealand. The current offerings are:

- Geology and Engineering Geology:
  - BSc or BSc(Hons) (Earth Science or equivalent) at five universities.
  - Post-graduate with focus on Engineering Geology: one active and one on hold.
- Civil Engineering:
  - BE(Hons) offered at three universities.
  - 800 hours of industry work experience required to complete civil engineering degree.

There is always a discussion between the balance of technical and soft skills with a fact that technical content will be lost if adding more soft skills content.

Curriculum design and courses scope is influenced by BOKS for geotechnical engineering and engineering geology.

There is collaboration and development in place reflected in the items listed below, but more can be done:

- Academic involvement in professional societies and consulting projects.
- Guest lectures and industry project partners.
- Advisory groups and degree review processes.

Another challenge is that students are working more in industry during their degrees. Feedback from students has suggested that this may be to the detriment of their university preparation; as soon as they start working in consultancy, there is less desire to learn more and just passing becomes important. In relation to this issue, the following was mentioned:

- Hours increase as degree progresses.
- How much does this distract from degree completion and comprehension?
- How much does this impact on personal development?
- May also translates to small domestic enrolments in engineering Master's.

Assessments and passing grade requirements were also discussed. Universities have shifted towards more of a business than a house of learning. How does this impact on what can be set as the minimum standard is an important question.

Negin Yousefpour first touched-based on the general academic pathways for geotechnical engineers in Australia which starts with an undergraduate degree (general bachelor's degree, choosing a major in the last year, 3rd year, or a civil engineering degree), followed by a master's degree in geotechnical engineering or an undergraduate + graduate degree package with specialisation in geotechnical engineering (3+2 yrs). It was emphasised that only a few universities have specialised master's degree in geotechnical engineering, such as UNSW, and in specialisation courses, only a limited number of core geotechnical subjects are offered in most universities (3-4). It was also noted that Engineers Australia provides accreditation of programs for degrees in Australia. The universities would like to see a return in investment (sufficient numbers of students registering) if they invest in developing master's degrees in geotechnical engineering, given the significant efforts and budget that this process requires.

In addition, Negin discussed the issue of production of geo-engineers in Australia with reference to EA (2019) as summarised in Figure 1.

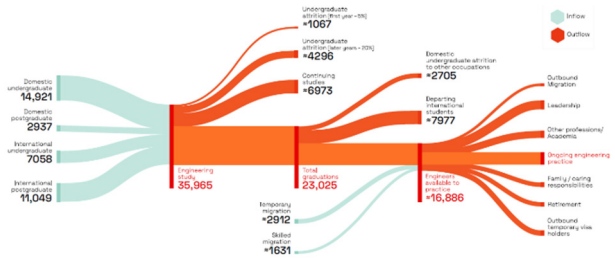

Figure 1. Inflows and outflows of professional engineers (EA, 2019).

It is shocking that a very low percentage progresses to on-going engineering work (<25%).

One of the main issues is increasing recruitment of students to have more engineers at the downstream by increasing the number of graduates.

To achieve that, careers in geotechnical engineering should be more appealing to attract more students. This may involve advertising campaigns, creation of new or more appealing programs and increasing the quantity and content of learning in geotechnical engineering. Another

challenge is the preparation of students for real industry work and the following was discussed:

- Industry experience for academics it's a good thing.
- Decrease the gap between what is taught and what is known as "best practice" - A two-way avenue.
- Industry to engage in academic research.
- Academics to engage industry experts in teaching.
- Three to four subjects are not enough to cover the fundamentals.
- Encouraging post-graduate studies.

Reference was also made to the challenge of retention of engineers, especially women in practice (numbers have dropped to half 1-4 years after graduation). The situation is critical, as summarised in Figure 2.

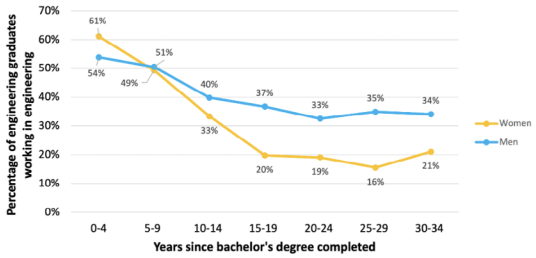

Figure 2. Retention in Engineering by gender 2019 (Society of Women Engineers).

Improving retention is fundamental and effort should be placed on maintaining the workforce (in particular women), provide more diversity and inclusion training, provide support and fulfilling industry careers for all, especially women who are widely underrepresented in the engineering fields, in particular geotechnical engineering.

In addition, the potential impacts of artificial intelligence to the future of geotechnical engineering careers was discussed and the importance of including data science/AI/ML-related knowledge in undergraduate and graduate level courses.

Views from young professionals

Christoph Kraus completed a survey in New Zealand of over 50 young geotechnical professionals who studied at different universities and polytechnics. About half of the respondents studied geology and/or engineering geology, while the other half studied civil and/or geotechnical engineering. The respondents' years of experience could be divided into 3 roughly even groups of <2 years, 2-5 years and 5-10 years.

Two main questions were asked and a range of responses were received as summarised below.

- *What parts of their tertiary education have NZ YGPs found particularly useful and applicable for their work in the industry?*
  - Most respondents noted the following:
    - First principles, fundamentals and core subjects/courses.
    - Field courses and mapping (especially for geologists).
    - Postgraduate study (some noted the courses offered at postgraduate level were very useful, and that postgraduate study helped with developing technical writing skills).
    - Engineering geology papers.

    Some respondents also noted:
    - Developing problem solving skills and critical thinking.
    - Some non-engineering or non-geology skills and courses (e.g. project management).
    - Exposure to software used in industry.
    - Group projects and practical exercises.
- *Where do New Zealand Young Geotechnical Professionals (YGP) see the gaps between what is taught in universities and the skills they need in industry?*
  - There is generally a consensus among YGPs that more overlap between engineering and geology is needed at university.
  - Teaching of engineering geology.
  - Many engineers noted there needs to be more field work at university.
  - Education about software development, theory, and best practice use.
  - Teaching of the building code, guidelines, standards, and common industry practices.
  - More collaboration between university and industry (which could be facilitated by NZGS and AGS).

Feedback from YGPs from Australia was obtained by phone interviews by Xue Le. The sample covered graduates from several universities in Australia, with working experience between one and five years, based in consulting firms and/or contractors, and with the highest level of tertiary education ranging from bachelor's to PhD degrees.

- The Australian YGP respondents identified the following gaps between what is taught in universities and skills required in work:
- No/limited training in engineering geology, particularly local geology.
- Design methods taught in universities being too theoretical.
- No/limited field trips and visit to construction sites.
- Limited knowledge about constructability in geotechnical projects.
- Insufficient exposure to relevant standards and guidelines.
- Promotion of AGS. Many graduates were only aware of Engineers Australia during their studies, but only learned about AGS after graduation.

On both countries the respondents were asked to rank how well they think the education has prepared them for working. While limitations of the surveys and interviews are acknowledged, it is reported that the average marks were 3.5 and 3.3 out of 5, for New Zealand and Australia, respectively.

Views from Industry

Eleni Gkeli interviewed senior practitioners from several companies (from major multi-disciplinary companies to small practitioners) and asked three questions:

- How does industry support the training and development of geo-professionals?
- How does university education relate to industry practice?
- What can we do better?

Broadly speaking, two types of professional training were identified: internal and external training.

Internal training may include:

- On the job training.
- Formal graduate programs (2-3 years long). This covers general skills and aim that graduates enter the workforce smoothly. This appears to be a sought-after criterion for graduates to join a company to begin their careers.
- Less or more formal geotechnical training programs. Mainly to ensure a consistent way of doing things within the organisation but also as an offer of professional development.
- Professional development plans for employees and developing professional groups.
- Mentoring framework.
- Internal conferences.
- Internships.
- Internal guidance documents.

External training:

- New Zealand Geotechnical Society training courses, seminars, webinars, etc.
- Guidance documents by technical societies.
- Engineering New Zealand training courses and resources.
- External conferences.
- Other external training and resources (e.g., online modules, software training, etc).

Figure 3 summarises the reliance on internal training. Bigger organisations generally offer all types of training. Medium size companies also offer a variety of in-house training but less formal, and small companies rely less on in-house training.

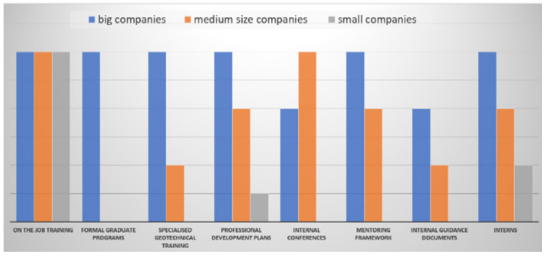

Figure 3. Reliance on in-house training.

The situation changes dramatically in relation to external training, as summarised in the figure below. Smaller firms rely strongly on external resources.

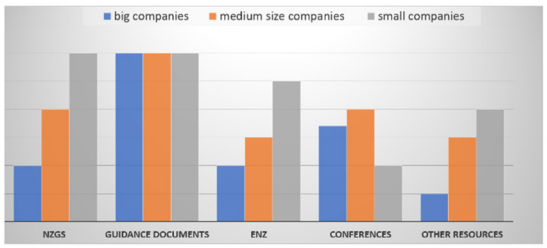

Figure 4. Reliance on external training.

The results indicate that reliance on external training increases as the company size decreases. This is considered normal (less resources at smaller companies) and do not represent advocacy for major companies. This highlights the importance of courses run by professional societies (like NZGS and AGS).

Internal training and conferences are positive as they create engagement and improve good culture within the organisations. This makes the profession more attractive.

At the same time, it appears that support to attend external events has decreased in recent years.

There is a severe shortage of geotechnical professionals in New Zealand and companies must compete strongly for a limited pool of graduates. This reduces the competition between candidates and their appetite to upskill.

In relation to the second question of university education versus industry practice, generally there seems to be a disconnect. Some observations in relation to this are summarised below:

- The question of practicality of university education and how connected it is to industry practice.

- General consensus that fresh graduates may not have adequate practical skills to immediately be able to apply in the job and carry out basic geotechnical engineering tasks.
- Lack of consistency in engineering degree programs, with universities having different focus areas.
- People would like to see more postgraduate theses and research work connected to industry practice.
- It is not clear whether education is aligned with technological developments and innovation in the profession.
- Limited offer of postgraduate courses in engineering geology in the ANZ region is a major concern for the profession. This gap puts more pressure on the industry to develop geologists to do geology for engineering.

While industry is doing their bit, it can do better:

- Connection of professional development with construction.
- Encourage secondments in consultancies.
- Retention or return of professionals seeking OE.
- Advocate for geo-profession in schools and universities.
- Investment on training and development.

NZGS can also do better but it is noted that it is already working on some of those initiatives:

- Re-activation of evening presentations and meetings – local branches.
- Training on basic principles and practice, oriented to graduates.
- Online training.
- Guidance documents.
- Training connected to construction.

To complement the views from industry, Jason Surjadinata presented his perspective from his role in a multidisciplinary internal consultancy within a major construction company, with a purpose of managing risk and providing value engineering.

He highlighted that it may not be clear how a geo-professional may look like and what the term "industry needs" mean. Current path and career progression seem to be based primarily on years of experience rather than specific skills. There is no consistent framework among different companies.

Some key questions from an industry perspective:

- Where are we heading as an industry?
  - Reactive vs proactive (strict vs more flexible system).
  - Quantity vs quality.
  - Long vs short views.
  - Soft vs technical skills (need to prioritise one set?).
- Is there a road map to get there?
  - Years of experience.
  - Skillset matrix.
  - Business vs technical (is it possible to merge some skills?).
- What is required to get there?
  - (Postgrad) Academic vs industry training (or both are required?).
  - Relevant experience (how to provide it).
  - Key skillsets.

Discussion contributions

A summary of the main comments from the open floor discussion is presented below. These have been reviewed by the contributors and are reproduced with their authorisation.

Prof Ellen Rathje
The University of Texas at Austin, USA

It was a very illuminating session to hear all the different perspectives. Something that seems to be different in the USA is the expectation of what a bachelor's degree awardee will know of geotechnical engineering. In the USA, a large percentage (90 to 95%) of the people working in geotechnical engineering consulting have a master's degree. Some of the items that were listed as topics that a BSc graduate should know, probably would not be applicable to BSc graduates in the USA.

In the USA, we also struggle to get people into Civil Engineering to start with. The situation varies among universities. At the University of Texas, it helps that students are admitted directly into Civil Engineering (in contrast to general engineering programs), so we are not competing with other engineering disciplines after the students arrive. Once in Civil Engineering, we still must attract them to geotechnical engineering. There is an effort to introduce geotechnical engineering in as many courses as possible. This is an attempt to integrate geotechnical engineering broadly in the curriculum.

She highlighted the importance of introducing geotechnical engineering to first year students. Reference was made to the teaching by A/Prof Krishna Kumar who uses failure case histories in his courses, where the unknown cause of the failure is a murder mystery that the entire class must solve. Creates excitement in students with the murder mystery concept.

Liam Wotherspoon noted that in New Zealand, most students enrol in general engineering programs and the situation becomes a popularity contest to fight out for students to choose civil engineering.

Jason Surjadinata emphasised the importance of graduates to, as a minimum, being able to understand the fundamentals. For example, clarity about one-dimensional consolidation theory and effective stress

concept, but not necessarily being able to carry out a complex analysis. Fundamentals are important and is very hard to help or teach someone without them having this understanding.

Dr Kim de Graaf
The University of Waikato, New Zealand

Discussed the situation of graduates being part-time in jobs during the course of their studies and the effects on their grades. She suggested assistance from industry is needed to put value back into achieving First-Class Honours degrees. This should be a minimum requirement to get a good geotechnical job and, at the moment, the students are not seeing they need to study toward this.

Challenge industry to start funding research and guide research on what is important for industry. Universities are struggling for support and funds are required to pay postgraduate students, mainly international, as local students prefer to take a job.

The short duration of programs and requirements of Washington Accord for accreditation makes it complex to accommodate the many concepts that need to be taught. Agreement that a Master's degree could be the solution.

Negin Yousepour commented on the challenges in Australia to get industry funding research and mentioned that more needs to be done to highlight that benefits from research will outweigh the investment.

Prof Ian Moore
Queen's University, Canada

What a great session, really enjoyed the presentations. I do not have many answers but will make some observations. In Canada, some graduates get jobs and integrate into the community, enjoy it and stay; some others are turned off from the profession after a few years on a drill rig (e.g., miserable extreme weather) and it is something that some companies in Canada need to address.

In Canada, there is no prescriptive accreditation system in terms of a given number of hours of specific subjects (e.g., structures, hydrology, etc.). The system refers to hours of design, engineering science, etc. For example, there are 16 civil engineering programs in the province of Ontario and each program is different. Industry will look for preferred candidates from a program where the specific discipline they need is strong. This facilitates putting together teams requiring different skillsets.

Summer work is preferable for students to get money and experience, rather than try to get income working part-time during the study period. However, there is a strong culture of providing additional positions during the summer for students (this is not a strong part of work culture in Australia – since there are many work activities that continue all year that are dormant in the Canadian winter).

In Canada there is a challenge to get companies to send young professionals to specialised conferences, including to the annual geotechnical conference organised by the Canadian Geotechnical Society. That can be a transformative experience and will contribute to better retention.

Dr Brendan Scott
The University of Adelaide, Australia

In line with the previous contribution, it is understood that the average age of attendees at ANZ2023 is a bit higher than we would like. He mentioned that the quadrennial ISSMGE conference and the corresponding conference for young professionals are coupled. This does not occur in the ANZ region. Not a criticism but something to look at. Consideration could also be given to running a workshop aimed towards young professionals at the main conference.

Issue of the retention within the profession and the drop of women in engineering is shocking and there is a definite need to attract more women to the profession. Targeting students in lower secondary and upper primary schooling years is important, before potentially irreversible decisions are made regarding STEM subject selections. When he goes to schools to promote engineering, he is asked a lot of questions. Ten years ago, the questions used to be around earning potential and job security. Today's students are different and question what we do on a daily basis and how we can impact society. Professional societies like the AGS and Engineers Australia need to help answer those questions so there is a better and broader understanding of what we do.

Ioannis Antonopoulos
Technical Director, Stantec, New Zealand

Highlighted a double tug of war with conflicting incentives, at least in New Zealand. The first one is that students pay for tuition fees and then the shorter the academic period and the closer the profession comes to them, it is easier as they are out of debt faster.

The second tug of war is the significant shortage of geo-professionals and there is a big incentive for industry to attract professionals as fast as possible, regardless of whether they have all the knowledge required. He supports the opinion of Prof Rathje in the sense than in Europe most people following a geotechnical career have at least a master's degree.

It is a conundrum that is going to cycle itself in the next 10 to 15 years and reverse. At the moment, there is a lot of pressure on senior people with knowledge and a lot of young people coming into industry without the knowledge. There is a high attrition rate, a lot of stress and not enough time for mentoring.

Need to find a way in between.

Mark Orr
Principal Engineering Geologist, Advisian, Australia

Mentioned an example from South Africa that may be considered to attract people into geotechnical education. In the second year of university (BSc in engineering geology), he obtained a bursary from the Geological Survey that paid for both tuition and provided a living allowance. This arrangement is mutually beneficial as it guarantees the student a job following graduation whilst also providing the employer with a graduate. Similar incentives could be considered.

Jason Surjadinata commented that a challenge is to demonstrate a return on such investments, to make them practicable (i.e., present the business case for hard-nose account type decision-maker).

Ann Williams
Technical Fellow, Beca, New Zealand

Highlighted changes during the pandemic period. Prior to Covid there was an excess of strong graduates, and it was easy to filter the pool for selection purposes. Student learning seems to have suffered through Covid and it has also been difficult to recruit from overseas during that period. These factors have combined to grow competition for graduates in the industry and these have exacerbated some of the concerns raised by prior speakers.

In relation to retention, the industry has become very aggressive and competitive. Retention might be improved if we drive a culture of collaboration with one another.

Darren Paul
Technical Director, WSP

Presented a hypothetical case of deciding if it was necessary to have an engineering geology master's course in Australia. Assume a professional society can provide seed funding for that. Is that possible from a university point of view? What impact would it have?

David Airey mentioned that one challenge is to have integrated engineering and geology programs at the same university and that many universities have downsized their geology schools.

In response to the points raised by Darren Paul, Prof Nasser Khalili mentioned that UNSW is setting up a master's course in engineering geology – a comment which was met with applause from the audience!

Tony Miner
Director, A.S. Miner Geotechnical

He referred to an example of industry professionals putting together a one-week engineering geology block course for geologists (mainly mining engineers) at the then University of Ballarat (now Federation University) in 2013. The course offered an introduction to mainly mining students of the opportunities that Engineering Geology offered as an alternative to mining. In particular, many of those students were not wanting to commit to a life in more remote mining areas and that Engineering Geology workplaces offered them the opportunity to work in cities which was attractive from a lifestyle point of view for this generation. It included theory and field work and was very successful. Students valued industry teaching and the case highlights that can be done.

Could universities look at sharing resources and run such type of mobile courses with industry support?

Closure notes and initial action plan

Based on the thoughts and comments raised during this session some key points emerge:

- What is the problem?
  - There are insufficient suitably trained professionals in the industry.
  - Limited attractiveness of a career as a geotechnical professional? Geotechnical engineering does not seem to be the most attractive choice among different options in civil engineering programs. On the geology side, the focus in Australia has been on mining, but current students are not interested in this traditional field. Rather than pivoting to environmental and engineering geology student numbers in geology have dropped dramatically.
  - It is noted that many students are doing double-degrees, mainly combined with commerce. Immediate experiences after graduation are quite different and many choose the commerce career.
- What can universities do?
  - Specialist undergraduate degrees.
  - Specialist Master's degrees (requiring Master's for Professional Registration may be an option to make those programs viable).
  - Micro-credentials (more short courses).
  - Increase industry-related content in universities (more teachers with industry experience). It was noted that a considerable amount of research topics is not driven by industry needs.
- What can industry do?
  - Formalise mentoring/training programmes.
  - Increase engagement with universities across curriculum, teaching, proposing student projects and research topics and career promotion, amongst others.
  - Promotion and recognition.
  - Support STEM initiatives.

The intention is for this conversation to continue and to develop a vision, mission, and some strategic goals with achievable actions against each of the goals. Both the Australian Geomechanics Society and the New Zealand Geotechnical Society are supportive of these activities, with additional sessions at a regional and chapter level being developed to

bring in a local flavour and enrich the discussion.

AGS and NZGS are planning the following short to medium term activities:

- Disseminate the discussion and conclusions of this session in the AGS and NZGS publications.
- Engage with Engineers Australia and Engineering New Zealand to inform the wider engineering community about this initiative and seek collaboration, especially for STEM initiatives.
- Hold similar panel discussions sessions in the AGS Branches and NZGS local branches to collect more feedback and different perspectives from the industry.
- Continue the discussion sessions in the upcoming local and national Geotechnical Conferences and Symposia in Australia and New Zealand and the 2028 ANZ Conference in Christchurch.
- Continue publishing the results of these discussions in the ISSMGE Heritage Time Capsule project.

More events and initiatives may be developed from the ongoing discussion. The panel intends to continue this work and informing the geotechnical communities in both countries about the outcomes.

This clearly requires participation from a wide range of stakeholders and those interested in contributing can get in contact with Golnaz Alipour, Lecturer at Macquarie University (golnaz.alipour@mq.edu.au). The core group meets on a monthly basis and we would like to have increased participation. If you are interested, please also contact Golnaz Alipour.

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- Panellists: Eleni Gkeli, Liam Wotherspoon and Christoph Kraus from New Zealand; Negin Yousefpour, Xue Le and Jason Surjadinata (Australia).
- HTC ANZ session advisors: Rolando Orense, David Airey, Sukumar Pathmanandavel and Hugo Acosta-Martinez.

The support from the ISSMGE executive is also acknowledged.

Figure 5. Session introduction by Graham Scholey. Panellists (l-r): Liam Wotherspoon, Negin Yousefpour, Christoph Kraus, Xue Le, Eleni Gkeli and Jason Surjadinata.