



# ICOLD continues its vigorous work programme despite global challenges

In view of the necessity to postpone ICOLD's next live meeting until 2022, a virtual meeting was held from 16 to 19 November. This included a short Symposium (to provide a foretaste of the full Symposium to be held in Marseille in June 2020), several workshops hosted by Technical Committees, and the 89th General Assembly.

In his opening address to the Symposium, ICOLD President Michael Rogers observed that ICOLD needed to meet future challenges relating to dams and reservoirs based on lessons learned from the past, while maintaining a commitment in the present. He summarized four of the most important roles as:

- collaboration and communications between nations in a peaceful and harmonious spirit;
- sharing lessons learned and innovation with benevolence for the common good;
- commitment to the safety of all dams and levees to protect human life, above all things; and,
- continuous and growing accountability for the engineering and operation of infrastructure.

He highlighted the global drivers for future dams and reservoirs as:

- the demand for reliable water and dependable power supplies;
- ageing of dams, with the average age globally being about 60 years, requiring engineers to address life expectancy issues;
- climate change, with operational impacts resulting from changing hydrology;
- a capacity gap, resulting from the retirement of legacy experts; and,
- risk adaptation and tolerance, with the question of what risk is acceptable.

President Rogers stressed that ICOLD was in a position of great responsibility in fulfilling its duty and its mission of achieving "Better dams for a better world, in a better future".

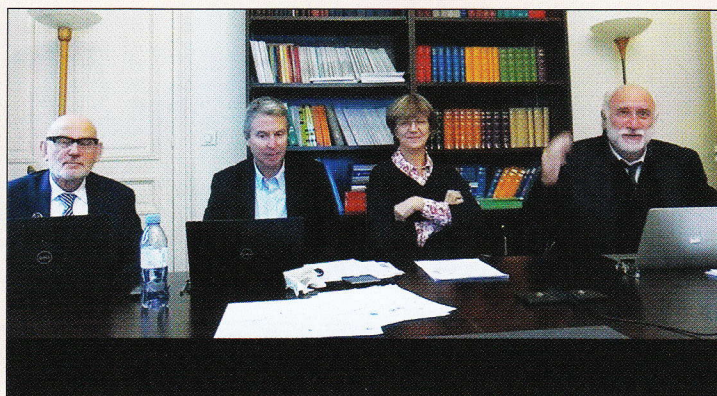
During his introductory message, outlining the scope of the virtual meeting, Secretary-General Michel de Vivo said that despite the lack of in-person meetings, ICOLD was continuing its work, and was "alive and well". Since the last virtual General Assembly, three new member countries had joined, he said: Mongolia, Laos and Kyrgyzstan. There were now 26 Technical

Committees with an increasing number of contributing members. In the current year, 10 new Technical Bulletins were being produced in English and French, and four more were to be approved at this GA.

In his presentation to the Opening Ceremony, Michel Lino, President of the French National Committee (CFBR) drew attention to the great importance of water resources management, from the time of ancient civilizations, and he made reference to examples such as the Hanging Gardens of Babylon created thousands of years ago with associated canals for irrigation, water supply and irrigation. He also drew examples from other parts of the world, such as the Dujiangyan irrigation system in China, built in the 3rd century before the Christian era, which has operated continuously since then. The Pont du Gard aqueduct, near Nîmes in France, built during the time of the Roman Empire, was another example of outstanding engineering in ancient times, Lino pointed out; it conveyed water some 50 km, and is still well preserved today.

Lino then addressed the issue of water as a source of conflict, taking as examples the tensions in the Tigris-Euphrates basin between Turkey and the two countries downstream, Iraq and Syria, and similarly on the Nile between Ethiopia and downstream Egypt and Sudan. Another case has been the waters of the Jordan valley, which has been a contributing cause to conflict between Israel, Lebanon, Syria and Jordan. For all such cases, Lino stressed the great importance of having water sharing treaties in place, as a first means to avoid disputes. The political will must exist for transboundary collaboration, Lino said, for conflict to be resolved or avoided. In the case of tensions between the neighbouring countries around the Aral Sea, he added, in the context of planning the Rogun dam in Tajikistan, a special study had led to recommendations for downstream water management, and the situation had now improved in the region.

Another example of the beneficial effects of collaboration, he said, related to the Senegal river basin,



Far left, ICOLD President Michael Rogers giving his opening talk at the Annual Meeting; and, in the Central Office, from left, Michel Lino, President of the French National Committee (CFBR), Laurent Peyras and Christine Noret (CFBR members), and ICOLD Secretary-General, Michel de Vivo.



where under the auspices of OMVS there had been a high degree of cooperation between Mali, Mauritania, Senegal and Guinea in the development of water resources for dams and hydropower, with power being shared between the neighbouring countries.

## Technical sessions of the symposium

### Theme 1: Territorial and water multipurpose issues

This session was chaired by Giovanni Ruggeri (ITCOLD President, Italy) and Joel Gailhard (EDF, France). In his introductory remarks, Ruggeri commented that 29 papers had been received including some strong examples of good practice at the national level, at project level, at design level and also at the operating level. Four papers reflecting these scales were selected from the submissions for presentation during this event.

Antonella Frigerio (RSE, Italy) presented at the national level on ITCOLD's initiatives to promote proactive dialogue between stakeholders across Italy. The research investigated how dam owners and stakeholders interact on topics including the environment, fauna protection, sustainability, safety, and the different uses of water resources, she explained. Three best practice case studies were presented: a hydropower scheme in the north of the country, a drinking water supply scheme in the centre of the country, and a multipurpose project towards the south. A series of six annual workshops as well as questionnaire surveys had been used to elicit factors deemed to be of greatest importance by stakeholders. These included: the release of water for the development of the local economy; the protection of fauna and actions to reduce environmental impacts; control of hydropeaking and thermo-peaking phenomena; and, water quality control during the flushing of sediments.

Responding to a question from the audience, Frigerio said that few dam owners had initially wanted to be involved with the study, but interest had soon grown and larger owners had become interested and were active in the events and consultations. Smaller companies had fewer resources to contribute to meetings and consultations but were also also proactive, she added.

Daisuke Nohara (Kyoto University, Japan) described a decision support system for the preliminary release of reservoir water for flood control using ECMWF medium range ensemble rainfall forecasting. The occurrence of extreme floods is getting more frequent and geographically more widely distributed, Nohara said. "There is therefore a greater need for enhanced capability of flood control at reservoirs", he said.

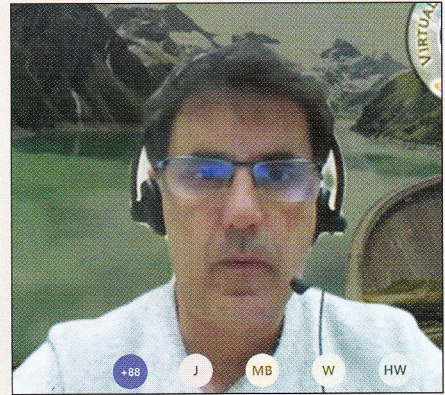
Preliminary release operations to decrease levels prior to flood events can help flood management but keeping water levels as high as possible is often important for revenue generation. Complicating dam operations is the fact "many hydro dams do not have lower outlets for pre-release so operators need to plan further ahead", Nohara said. Better quality, 7-15 day-long range forecasts help facilitate this by reducing prediction uncertainty. He presented results derived from the ECMWF medium- and long-range forecasting, using a post-processing method developed by the Japan Weather Association. The work included statistical downscaling from a 25 km grid to a 1 km grid and the data were then applied to four simulation cases to show the effects of different preliminary release operations to reduce the risk of false releases while achieving optimal protection against flood events.

A delegate asked Nohara what priority weighting hydro generation was given in relation to flood prevention. He replied that it depends on the primary purpose of a given project, for example, multipurpose schemes give greater weighting to flood prevention, whereas hydro schemes focus more on generation. In another question, he was asked what happens in the case of a false alarm, when water is released in anticipation of flooding, but it proves to be unnecessary. Nohara answered that compensation for lost revenue is available from the government to dam owners.

Arnaud Le Peillet (EGIS, France) spoke about the proposed Malewa dam in Kenya. The scheme was originally studied in 1990 and again in 2020. The latter study did, among other things, update the original design work to take into account new standards for sedimentation and probable maximum flows, as well as environmental considerations and water scarcity concerns of local communities. Le Peillet noted that Lake Naivasha, a Ramsar site located upstream of the new dam, presented significant socio-economic and conservational benefits, but was subject to rapidly intensifying pressures. These include a reduction in the level of the lake, deterioration in water quality and increasing extraction demands from a growing population. Solutions proposed by Le Peillet included involving stakeholders for a fair distribution of the water resource, the integration of a waste treatment plant and a new water management system.

Jongchan Kim (IHE Delft Institute for Water Education and K-Water, South Korea) described the innovative operation of the Imha reservoir in Korea, with consideration given to the current and future impacts of climate change. The scheme, built for water supply, is equipped with a water transfer tunnel facility

*Below: Giovanni Ruggeri (ITCOLD President, Italy) co-chaired the session on multipurpose projects with Joel Gailhard of EDF, France (shown right). Session speaker, Antonella Frigerio of RSE, Italy (shown centre) spoke about a project undertaken at sites across Italy to evaluate stakeholder perceptions of different multipurpose schemes in the country.*





and a selective withdrawal facility. In addition, the project is operated with various non-structural measures that Kim described with reference to controlling highly turbid water flows during periods of torrential rain. Persistent turbidity, he said, causes problems including poor water quality and increased water treatment costs. During October 2019, turbid water had flowed into the Imha reservoir during Typhoon Mitag. The highest turbidity level recorded during the event had been 473 NTU. K-Water had had to decide how much water should be released, while balancing the demand from water users, Kim said. The depth from which the water should be released using the selective withdrawal facility was also a factor that necessitated considerable attention. Following successful releases, Kim reported turbidity was stabilized at 30 NTU by November that year.

Joel Gailhard concluded the session by commenting that further papers on this theme would be reported during the ICOLD 2022 event. Papers to be presented there would, he added, include coverage of hydro-climatic projections and their associated difficulties, as well as experiences from multipurpose schemes in a world of increasing risk aversion.

## Theme 2: Governance and funding

Juha Laasonen (Fortum Power and Heat Oy, Finland) introduced this session by commenting that the papers received were grouped into sub-themes ahead of being accepted for the ICOLD 2022 Congress in Marseille, France. These sub-themes include ‘participatory approaches, stakeholders’ involvement’ with papers from France and the USA. Laasonen reported the French papers focused on stakeholder participation and involvement for environmental, ecological, and biological acceptance of dam projects. One aimed to ensure the biological flow in the Aude river where hydropeaking causes environmental consequences downstream and a second paper described the Roseland project, which was to be presented during this online symposium.

Laasonen then introduced a separate sub-theme on ‘special cases of cross-border assets’ that included cases from Iran as well as from France. The Iranian papers, he said, described different aspects of reservoir operations. These included the optimum operation of Zhadev dam to minimize the water supply deficit with hedging based rules.

In the first of two presentations made in this session, Prof Tetsuya Sumi (Kyoto University, Japan) spoke about the challenges of flood control operations and gave examples of lessons learned from record breaking heavy rain in July 2018 during Typhoon No. 7. Flood control operations had been carried out at 213 dams and emergency spillway operations undertaken at a further eight dams, he reported. These measures, including releases at the Hiyoshi dam had helped reduce flooding along the Katsura river near Kyoto city.

At the Nomura dam on the Hiji river, a preliminary drawdown of the reservoir was executed and its spillway gates were opened. However, as the warning and evacuation directives were issued at 5.15 am and 5.18 am when most people were asleep, not all were evacuated, with the result of five deaths as well as the inundation of 650 homes.

An expert panel, established to identify lessons from the 2018 events concluded that both structural measures, including upgrades of existing facilities, and non-structure methods, including preliminary releases, should be introduced. Furthermore, Sumi said, basin-

wide measures, including river improvement works downstream of dams for the management of sediment, should also be undertaken along with improved evacuation plans informed by risk information provided by dams operating offices.

Following his presentation, a delegate asked Sumi whether there were sufficient personnel available during typhoon events to undertake the reported measures, including spillway gate operations. Sumi confirmed labour availability was not a major constraint. “The 213 dams where flood control operations were carried out during the 2018 event have different flood control measures”, he said, adding that not all needed gates to be opened and some measures could be undertaken remotely.

David Lemarquis (EDF, France) discussed how support had been generated for operation of the Roseland project, located in the Alps region of France, to provide multipurpose benefits. The 150 m-high dam was constructed between 1955 and 1962 and in 2013 investigations were proposed to explore opportunities for developing the Roseland area as a protected wetland and high-altitude grassland zone. However, the proposal initially led to strong local stakeholder opposition and plans were stopped in 2014.

During this stoppage, consultations and discussions were held between stakeholders and a way forward was agreed using ‘reasoned negotiation’. This approach, Lemarquis explained, is centred on the needs, interests and concerns of stakeholders. The outcomes, agreed by all key stakeholders, are based on three lines of action to develop new and existing activities, preserve natural and cultural heritage, and manage visitors with appropriate signage, trails and car parks, he said. “These three actions will help to promote the balanced development of tourism, hydroelectric, biodiversity and pastoralism in the Roseland area”, Lemarquis added.

Following the presentation, a delegate asked if the success of the project would have been possible without following the approach described. Lemarquis expressed doubts. “Working with the different stakeholders to foster support and shared benefits, after the project was initially stopped, was essential”, he said.

In concluding the session, Juha Laasonen commented that maintaining dam safety is always the main consideration for dams while it is very interesting to see how additional benefits from flood control to tourism can also be delivered. “In Marseille”, he added “we look forward to learning more about the partnerships and institutional arrangements for sustainable projects”.



*Prof Tetsuya Sumi (Kyoto University, Japan) explained how lessons had been learned from past typhoon events in Japan to help improve safety and reduce flooding risk in the future.*



### Theme 3: Innovative solutions in reservoir uses

This session, co-chaired by Aries Firman of INACOLD, Indonesia and Jean-Pierre Person of CFBR France, featured four talks.

Özge Türk a PhD student from Geneva, Switzerland, spoke of criteria to be considered when integrating a dam in a region with multiple existing reservoirs. She first spoke of increasing demands on water, over the past decades, such as changing demographics, increasing industrial needs, and climate change. Against this background, she outlined the criteria to be considered when planning a dam, such as the appropriate site, intended purposes, and impacts. Turning to legal and political aspects, she referred to the necessity to adhere to the general principles of international water law, which were:

- equitable and reasonable utilization of the water;
- the obligation not to cause significant harm; and,
- the obligation to cooperate.

She concluded that hydro reservoirs were easier to integrate, for the basic reasons that water would not be consumed; cheap and clean energy would be produced; and, there would be tangible and positive impacts on national and local economies.

Takahiro Koshiba of Japan gave a talk emphasizing the advantages of the use of sediment bypass tunnels (SBTs), outlining experience in his country, and in particular describing the case study of the SBT at Koshibu dam.

He stressed the benefits of SBTs, yet he pointed out that there were relatively few in the world (only about 30), with most being in Switzerland, Japan and Taiwan. He described research topics relating to SBTs, including an evaluation of their bypassing efficiency, abrasion control, and environmental impact. He commented that work was going on to develop bedload transport monitoring under high flow velocities. A device known as an Impact Plate system was used to record acoustic energy caused by gravel impact, and the raw signals were then analysed to extract information on the sediment transport, he explained. Tests were being conducted at the Koshibu dam, where the largest SBT in the world was in operation. The upstream bedload monitoring provided guidance for SBT management, Koshiba said, and he concluded that the Impact Plates were especially applicable for small and medium scale floods.

Oriane Cornille of France spoke about the Pwalugu scheme on the White Volta river Ghana, a project developed by the Volta River Authority, upstream of Akosombo dam. She explained that challenges in Ghana were difficulties in meeting increasing demand

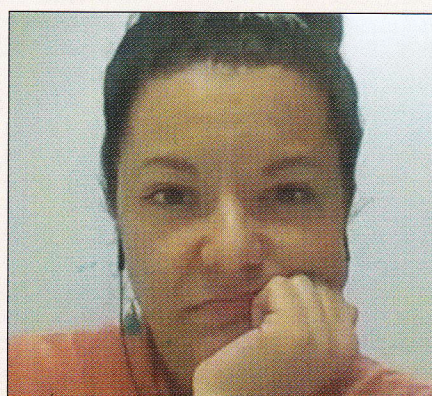
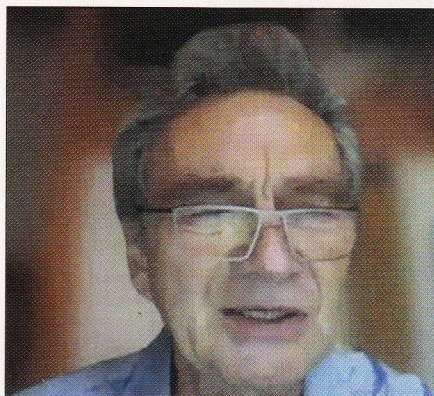
for electricity, and instabilities in the national grid. Ghana was one of the countries in West Africa most affected by floods and drought, she continued, and more and more families were dependent on agriculture, although conditions were not favourable. The multipurpose scheme was aimed at mitigating floods, developing the irrigation potential of the region, generating hydropower, and developing other economic activities such as fisheries.

Pwalugu had been designed with a 35 m-high RCC dam and 59.6 MW powerplant, expected to generate 176 GWh/year, and an area of around 20 000 ha would be irrigated as a result. She described revisions to original feasibility studies, hydraulic modelling for the scheme, and an environmental and social impact assessment carried out in 2016. The anticipated impacts of the scheme had been found to be high, so a study of five alternative designs had been carried out in 2019, which led to a reduction of the reservoir area by about 25 per cent, a dam height reduced by 5 m, and a slight reduction in power production; however, this will be compensated by the installation of a solar plant, which will bring the total installed capacity to 110 MW. Final reports for the project are expected next year, Cornille said.

Pavel Zvanut of Slovenia gave a talk on the monitoring of reservoir banks after extreme flooding on the Drava river in his country, which had taken place in November 2012. Floods in October and November of that year had taken place after a long drought, and on 5/6 November, the worst affected areas were the middle and lower reaches of the Drava, where record flow rates were reached, exacerbated by additional inflow from Austria.

Flows had reached about 3000 m<sup>3</sup>/s at the Dravograd dam, near the Croatian border (from 500 m<sup>3</sup>/s just before the flood). The incident exceeded the 100-year return period for a flood event, and caused the largest recorded damage from a natural disaster in the history of independent Slovenia. He then described detailed and extraordinary visual geotechnical inspections of the river banks and levees of diversion channels which had been carried out to check for instability, immediately after the flood. Topographic maps were used with recorded damage from previous inspections, so that newly identified damage could be registered. Reports had then been prepared, and a detailed inventory of all the damage was created with suggestions for remedial measures. It was found that there had been numerous landslides and landslips, with an urgent need for rehabilitation. The most extensive damage was registered in the area of the diversion canal from the Drava river downstream of the Formin hydro plant. Gravel

Speakers in the session on 'Innovative solutions in reservoir uses'; from left, J-P Person of France; T. Koshiba of Japan; and, O. Cornille of France.





deposits blocked the channel, and this led to flooding of the machine hall at the Formin plant.

During the discussion following the talks, Koshiba was asked about fish protection during operation of the SBTs. He replied that this was not really an issue, as the SBT only had to be operated a few times per year.

Koshiba was then asked why an SBT would be chosen above the more usual ways of flushing sediment, and he replied that the SBT would deal with sediment arriving from upstream, whereas other methods could only deal with material which was there already. He was then asked if SBTs were in operation on other rivers in Japan, and Koshiba replied that they had been constructed at about 300 locations. He added that research on SBTs was continuing.

Aries Firman asked Oriane Cornille whether, with the multipurpose scheme she had described, it would be possible to ensure that the irrigation element would proceed at the same pace as the other functions of the scheme. She replied that the irrigation scheme would require much longer, in view of its scale, and could take 8 to 10 years. He then asked whether the ratio of displaced people (compared with the benefits of the project) was in line with international standards. Cornille replied that a study had been done based on World Bank standards, and that displacement was not a major issue for this project. There would be 2600 physically displaced persons, and about 2000 economically displaced, she said, and considering the scheme comprised two dams and two reservoirs, these were low numbers compared with other projects on the same scale. She added that the main impacts to be addressed were biological/ecological ones, rather than social issues.

In summarizing and concluding the session, Jean-Pierre Person observed that innovative new solutions were necessary to meet new challenges, to ensure dam safety, hydraulic safety, and to tackle the effects of climate change. Enhancing social acceptance of dams was another key issue, and new actors in addressing these issues were lawyers, politicians and sociologists. Finally, he stressed that cooperation between stakeholders, as well as international collaboration, were vital, as had been highlighted in several of the talks.

#### Theme 4: Operating multipurpose facilities

This session was co-chaired by Henriette Anderson, of SANCOLD, South Africa, and Alain Carrère, of France. Two presentations had been planned, but for the first, the author (Faghihi Mohaddess Ali of Iran) was not present, and so Alain Carrère made a brief summary of the paper. The author had taken the examples of three major river basins, Helmand in Afghanistan, the Danube in central Europe, and the Colorado in the USA. For the first case, he noted that the Kajaki dam was located in the Helmand river basin, and water from the river which was used for irrigation and water supply also by Iran. During Russian occupation of Afghanistan, the author noted that a treaty between the two countries had been well respected, but he observed that this was not so much the case today.

On the other hand, although the Danube runs through a total of 13 countries, a special commission (ICPDR) existed which managed agreements between the riparian countries.

The second paper had been contributed by François Lempérière, and was presented on his behalf by Luc Deroo of France (Chair of ICOLD's Technical Committee on New challenges for dams and reservoirs

in the 21st century). The paper dealt with the vast global need for pumping in the coming years, and how this might be achieved, include several concepts developed by F. Lempérière (Twin Dams, and LLORDS). See full papers on the evolution of these concepts in *H&D* Issues 2 and 6, 2018, and 5, 2019, as well as a paper at HYDRO 2020.

### Committee Workshops

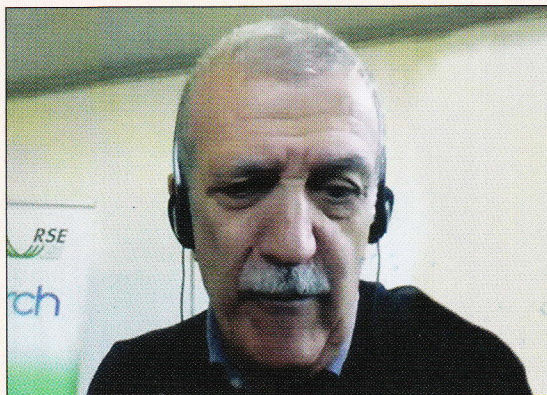
#### Non-linear modelling of concrete dams

*(Technical Committee A: Computational aspects of analysis and design of dams)*

In his introductory remarks, Committee Chairman Guido Mazzá (RSE, Italy) expressed his hope that more young engineers would join the committee and "take the baton forward". Numerical modelling, he said, represents a key tool for dam engineers during the design processes, as well as in the safety assessment and rehabilitation of existing dams. However, he added: "The application of numerical models in dam engineering practices suffered, for many years, from a gap between numerical modelling specialists and dam engineers". To address this and other challenges, he outlined the activities of the committee, including creating stronger links between the modelling process and the observed dam behaviour, and the promotion of mathematical modelling improvements to approach safety-related problems, in particular those that cannot be properly analysed. Another key activity of the committee is the issuing of guidelines to be used in current practice, he said, for educational purposes and knowledge transfer.

Mazzá then discussed the structure of the committee's ongoing work for its current Bulletin. The Bulletin will begin with an overview of when non-linear modelling of concrete dams is needed, with chapters following on the types of structural non-linearities and solution methods. A separate chapter will report on finite element codes for non-linear modelling, and other chapters will discuss the selection of material parameter values for practical non-linear modelling of concrete dams, and examples presenting application and case studies will be reported.

Mazzá and another contributor to the Bulletin, Frigerio Antonella (RSE, Italy), then detailed some of the key messages and recommendations from this work. These included the importance of using laboratory tests carried out on core samples extracted in-situ rather than the use of data found in existing literature. "The numerical model should also be calibrated to be representative of the physical reality with reference given to the surveillance and monitoring systems",



Guido Mazzá (RSE, Italy) presented the ongoing work of the Committee on Non-linear modelling of concrete dams.



Antonella said. Antonella also highlighted sensitivity analysis as being paramount not only in the selection of material parameters, but also in the understanding and validation of numerical results.

### Arch dam design methodologies and criteria

*(Technical Committee D: Concrete dams)*

Marco Conrad (AFRY, Switzerland) and Quentin Shaw (ARQ, UK) welcomed online delegates and expressed their intention for the meeting “to get teams together to complete the Bulletin, which is only at the ‘bare bones’ stage currently”. A key objective of the Bulletin, Shaw said, was to contextualize modern methods and criteria for the analysis of arch dams.

Jerzy Salamon then outlined the chapter structure of the new bulletin. It begins with a historical perspective of arch dam development, followed by chapters outlining design philosophy, analysis methods, design validation, material properties, and loads.

Shaw reported that the planned schedule is for a working draft of each chapter to be ready for discussion in ICOLD’s Congress next year. To meet this deadline, a draft of each chapter should be completed by the end of February and with this aim, delegates were encouraged to offer their own expertise to assist the lead author of each chapter.

### Residual tropical soils

*(Technical Committee RTS: Residual tropical soils)*

Dr Ahmed Chraibi of Morocco chaired the Workshop of the ICOLD Committee which he chairs, on tropical residual soils (known as TRS). He commented that this was a new committee, at the start of its work.

His opening talk began with a definition of this soil type; he explained that:

- Residual soil means soil which has been weathered in situ, where the original rock structure has been totally destroyed by weathering, and has not been transported from its original location. Several factors such as climatic conditions, parent rock, topography, humidity and age govern the engineering characteristics.
- Transported soil means soil that forms from weathered components transported to a different area.

He added that chemical weathering was especially effective in the presence of water, because of its reactivity, and high temperature, which could accelerate the reaction.

Continuing on the characteristics of residual soils, and the differences which distinguished them from sedimentary soils, Chraibi said that they were more

heterogeneous than sedimentary soils. They did not undergo a consolidation process, and their properties could not be related to stress history. Furthermore, residual soils generally had much higher permeability than sedimentary soils, which had important implications for their behaviour in dam foundations. He later pointed out that unsaturated residual tropical soils were susceptible to rapid changes in material properties when subjected to changes in external hydraulic conditions (for example reservoir impounding).

Reviewing the content of the planned Bulletin 151, to be produced by his Committee, Chraibi said topics would include a chapter on investigation methods used to analyse TRS: in-situ geotechnical testing methods; geophysical investigations; seepage investigations in the case of dams in operation; and, laboratory tests and interpretation of results, leading to physical, chemical and mechanical characterization.

Other topics to be covered in the Bulletin included: slope stability, erodibility and piping; voids in the soil (lateritic karst, canaliculi, and so on); and, foundation treatment.

Case studies would also be included, reflecting good practices, and covering investigations at a dam’s design stage, unexpected behaviour or incidents at dams in operation; and, repair works.

The Bulletin would conclude with lessons learned, and any differences identified between different geographical regions of the world, and finally, some recommendations would be put forward.

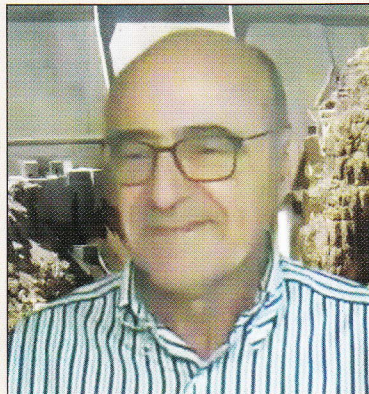
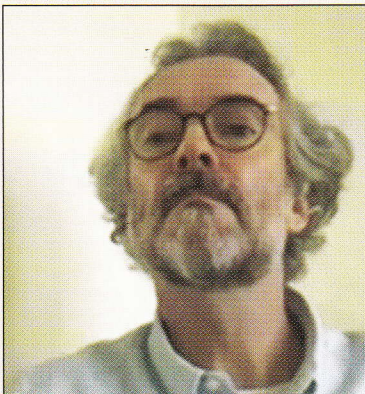
During the following discussion, both Henriette Anderson from South Africa, and Elias Baptista from Mozambique stressed the importance of the Committee’s work, for African countries. Anderson was aware of the need for expertise in distinguishing between transported and residual soils, and Baptista commented that studies on soil conditions and behaviour in dam foundations was an important issue for Africa. There was much work to be done in understanding behaviour, water content, and a number of other issues.

In testing for permeability, the importance was stressed by Chraibi, and several others, of not testing soil to an adequate depth; at a case in Burkina Faso, excavation in the core had not reached a depth where soil was totally saturated, and as a result the dam had experienced leakage and downstream subsidence.

Adama Nombre gave a talk about dams in his country, many of which were under construction in areas of tropical soils. He discussed some of the difficulties which had been encountered in relation to identifying materials, in compaction, and in determining water content. At one dam, for example, he said there had been difficulties in compacting sapolite. Contractors had encountered difficulties, and during construction the consultant had had to change the material mix.

L. Moreno of Argentina gave a talk discussing the compaction of sapolite for the 62 m-high permeable core of a starter dam for the El Llagal tailings facility at the Pueblo Viejo mine in the Dominican Republic. The final height of the main dam was to be 140 m. He outlined the compaction control requirements, including the moisture content, plasticity index, minimum passes required of vibratory rollers, and the vibration frequency required. A challenge had been the variable properties of the material, and the compaction had required a thorough study, with field sampling and a review of specifications.

*Below: Dr Quentin Shaw of South Africa, who discussed the new Bulletin in preparation on Arch dam design; and, to the right, Dr Ahmed Chraibi of Morocco who chaired the session on residual tropical soils.*





Guillaume Veylon of INRAE, France, drew attention in his talk to the fact that tropical residual soils often occurred in seismic areas around the world, and this was a key point to take into account when doing seismic assessments of embankment dams incorporating such soils, because of the changes in strains which could cause damage in the case of a seismic event.

He went on to discuss the case of a 25 m-high embankment dam in Guadeloupe, and the analysis which had been carried out for remolded and compacted residual soils in the dam core and the body of the embankment.

Among his conclusions, were that he felt there was a need to establish more predictive equations for residual soils; it was a challenge to understand their behaviour because of their variability. He also stressed the importance of integrating an assessment of dynamic properties in the ICOLD Bulletin.

### Sediment bypassing and transfer

*(Technical Committee J: Sedimentation of reservoirs)*

This Workshop was chaired by Dr Marty Teal of the USA, who chairs the ICOLD Committee J on Sedimentation of reservoirs. He explained that a draft Bulletin had been prepared, which covered: sediment yield (production, transport and yield); sediment connectivity (morphological and ecological effects); sediment bypass design (including tunnel hydraulics and sediment transport; abrasion; invert maintenance and refurbishment; design recommendations; real time operation; monitoring and efficiency; sediment transfer (including hydrosuction, continuous transfer, and sediment-water mixtures in pipelines; and, case studies.

He commented that while mature methods for sedimentation management were well understood, new methods were not. There was therefore a need for guidance and documented experience.

He explained that the Workshop would mainly focus on: sediment bypassing, with contributions from Prof T. Sumi of Japan, C. Auel from Germany and R. Boes from Switzerland; and, sediment transfer methods, with contributions from T. Jacobsen of Norway and M. Detering of Germany.

In his overview of sediment bypass tunnel design, Prof Sumi said that the advantage of this method was that only newly entrained sediment would be diverted to the downstream reach. Sediments previously included in the reservoir would not normally be mobilized. The sediment pulse would therefore be of natural character, and sediment connectivity would be re-established downstream during floods, improving the downstream ecological system.

While SBTs might cost more, advantages were that it typically would not involve drawdown of the reservoir, with resulting storage losses. Prof Sumi described the main issues to be taken into account in the design, and the usual layouts which were adopted.

Christian Auel then continued the discussion, focusing on hydraulics and sediment transport. He explained that most of the year, the tunnel would remain closed, and would open during floods. He said the tunnels were generally operated in free-surface open channel flow conditions. This avoided hydraulic jump, pressure fluctuations, pulsations and subatmospheric depressions. He drew attention to the fact that the tunnels were operated with supercritical flow, so there is enough sediment transfer capacity without

requiring a very large diameter tunnel.

A challenge with SBTs concerned abrasion, and he cited the examples of the Asahi tunnel in Japan (where abrasion of up to 1 m had quite often occurred), and Palagnedra in Switzerland which had suffered two incidents of up to around 4 m of abrasion during its early phase of operation.

Dr Robert Boes then gave more details of abrasion modelling, and referred to a mathematical model by Demiral Yüzügüllü, which had covered material resistance, energy flux, cover effect, the particle hardness effect (a valuable new development) and, saltation probability. He continued by giving guidance on tunnel lining design.

Turning to maintenance and refurbishment, Boes stressed the importance of inspecting SBTs to assess damage to the invert and walls at the end of the flood season every year.

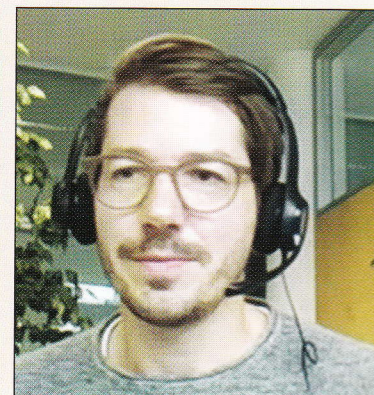
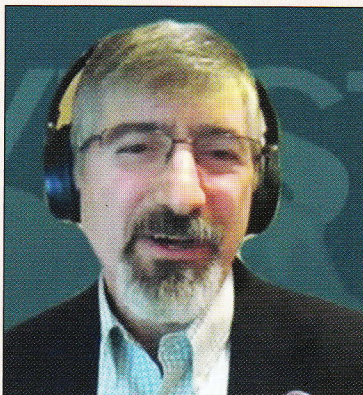
In his conclusions, he stressed the importance of minimizing loads on the tunnel by optimizing flow conditions, and taking care to select a suitably resistant material for the invert.

Tom Jacobsen then gave a talk on sediment transfer and removal through pipelines. He explained that this could be done either with continuous transfer by a permanently installed suction dredger, or by hydrosuction dredging, using the available head difference (gravity) to remove sediments and release them downstream (see also paper from SediCon starting on p42). Sediment transport in a pipeline is powered by gravity or by pumps, or both, he said. Jacobsen then outlined factors which could affect the capacity of the system: first, the energy gradient (length, head, and in the case of a pump, pumping power). He added that doubling the gradient would more than double capacity. Also the pipe diameter would be significant. In addition, he said, the sediment characteristics (fine sand, coarse sand or gravel and stones) would have an impact on the system capacity. To illustrate the concept he had described, Jacobsen cited the case study of the dredging system installed at the El Canadá hydro plant operated by ENEL in Guatemala.

Michael Detering of Germany began his talk by describing the scale of the global sedimentation problem as massive, threatening reservoir capacity and sustainability. He added that some dams had been built without taking sedimentation management into account.

He outlined various options available to reservoir owners, starting with 'do nothing', which would risk mid- to long-term loss of reservoir capacity, potential danger to a dam, and summer oxygen deficit with

*Far left: Dr Marty Teal of the USA, who chaired a Workshop on sediment bypassing and transfer; and below, Dr Christian Auel of Germany, who spoke about the hydraulics of sediment transport.*





downstream effects. Excavation/classical dredging would mean drawing down the reservoir, and would have environmental impacts, as well as often not being economical. He recommended as the best solution continuous sediment transfer, as the most natural solution: sediments would be sucked in, similar to a dredging system, but controlled and adjustable to downstream flow and transfer capacity. This system would be adaptive, ensure river preservation, and conform to the EU Water Framework Directive, he said.

During the discussion, Prof Luis Berga of Spain asked about the best solution in the case of a cascade of dams. Auel replied that flushing, dredging or sluicing could be effective in a cascade development, and this would be covered in the Bulletin.

Prof Berga then asked about the use of SBTs in very large reservoirs, for example extending >100 km; Auel replied that SBTs would not be the solution in the case of very large schemes. Prof Sumi added that there were examples of bypass tunnels extending at least 30-40 km in Japan, but greater lengths would be costly. However, he cited cases where a combination of concepts had been used: dredging in the upstream area, and the use of smaller tunnels downstream.

### Ageing concrete dams

*(ICOLD Technical Committee D on Concrete Dams)*

Committee D organized a second workshop on the subject of ageing concrete dams. Marco Conrad, Chairman of the Committee and also chairing the workshop, said that this topic had been a preoccupation of ICOLD since 1933, when it was a subject at the Congress. The last Technical Bulletin on the subject, however, had been published back in 1994, so Committee D had decided in 2018 to revise and update this Bulletin, and work on this was still ongoing.

Conrad referred to the recent report by the UN University which was based on the misconception that ageing dams represented increased risk (and he mentioned the response to this which had been written by President Michael Rogers pointing out the misconceptions). Conrad pointed out that a dam which had had a robust design, followed by a good standard of construction and subsequent control measures and maintenance, with refurbishment when necessary, could have its life extended well beyond the typical design life of 50-100 years.

Dr Erik Nordström of Sweden, Chair of the Subcommittee on the Bulletin, gave more details of the proposed content of the Bulletin now in preparation. The terms of reference, he said, stipulate that it will cover:

- physical properties of ageing concrete;
- guidelines for inspection of ageing concrete dams;
- expectation for the ageing of concrete dams; and,
- a framework for estimating the remaining life of ageing concrete dams.

The main topics selected for the Workshop were the first and third on the list.

Nordström commented that of around 10 000 concrete dams listed in the ICOLD World Register, the average age was about 55 years.

Members of the Committee working on the new Bulletin then contributed to the presentation on aspects which would be covered in their work.

Mario Berra of Italy described the four main causes of ageing in concrete dams as relating to:

- Design quality (geological evaluations at the site and stability of the reservoir area; hydraulic design of dam outlets; evaluation of loads acting on the dam; and construction details such as joints, drains, grout curtain).
- Materials and construction technology quality (concrete components, design mix, construction technology).
- Concrete deterioration process (chemical reactions and physical phenomena such as freeze-thaw action and erosion).
- Quality of maintenance work.

He later discussed the areas of the dam and appurtenance works where degradation would be most likely to occur.

Esperanza Menendez contributed more information on the phenomenon of leaching, a common problem for dams, which he described as a soft acid attack resulting from the pH of water. He described the mechanism of the chemical reaction affecting concrete. He added that aggregates were not as sensitive to attack.

Jerzy Salamon of the USA gave details of investigations which would generally be carried out in the case of concrete expansion, to evaluate the condition of the concrete. These included: testing of drilled cores; visual inspections; collection of project data; non-destructive geophysical surveying; photogrammetry; recording of dam deformations; and crack mapping.

Later, when summing up the workshop, Erik Nordström stressed the need for the committee to have real information from real dams, and he gave details of one case study intended for the Bulletin, which is Kafue Gorge in Zambia. There cracking and concrete swelling had led to jamming of gates and stoplogs; he ran through the procedures of inspections and actions which had been taken.

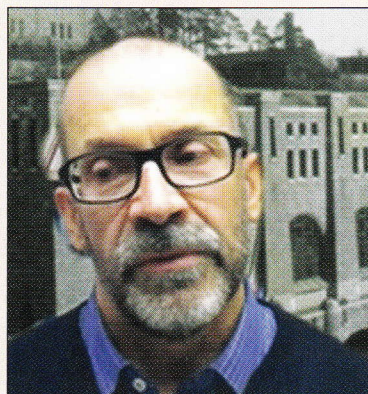
During the discussion, President Michael Rogers commended the work of the committee, but suggested that there could be more emphasis on design and engineering, and in particular how loading over time would affect ageing. Jerzy Salamon replied that a second bulletin was planned, which would include much more on design.

### Worldwide levee inventory and intercomparison of dams and levees

*(Technical Committee LE: Levees)*

Rémy Tourment (CFBR Vice President, France) chaired this workshop and introduced the topic by outlining the current status of work being undertaken by the Committee. The main concentration of effort is, he said, being given to the production of two reports. These are the 'levee situation report' and the 'dam levee comparison report'.

*Below left: Marco Conrad, who chaired two Workshops on concrete dams; and, Dr Erik Nordström of Sweden, who discussed the proposed content of the new Bulletin on Ageing concrete dams.*





The 'levee situation report' had collected information relating to key characteristics, policies and best practice for design, construction, operation, maintenance and ongoing management of levees in different countries. The report is now nearly complete, he said, with a full draft expected to be ready for distribution during the first quarter of 2022, with full approval planned during the General Assembly next year.

Tourment presented an overview of the four chapters: introduction; main results; data gaps, research needs, recommendations; and, references. The overall purpose of the report is to be a factual document rather than one that provides recommendations, Tourment emphasized. The introduction provides a definition of levees as well as their history and role in reducing flood risk. He noted: "Levees provide flood risk reduction for approximately 10 per cent of the world's population and help protect trillions of dollars in economic value". The main results chapter, Tourment continued, identifies more than 500 000 km of levees globally and for each country, where they are reported, the document provides a list of key facts and figures. He noted that information available from literature research is very limited, and he encouraged delegates, particular from the African continent, to contribute data from their own countries. Ideally, this country level information would include maps of levee portfolios as well as their status and contribution to flood risk reduction, he said.

Jonathan Simm then presented an overview of the second document being prepared by the Committee, the 'Dams-levees comparison report'. He noted that the work identified many possible interactions between the topics of other ICOLD technical committees as it aimed to help demonstrate the importance of levees and facilitate an exchange of information and production of best practice for issues related to both dams and levees. The report is now at an advanced stage and should, Simm said, be ready for draft review by National Committees by the end of February 2022, with a final draft ready for the Marseille General Assembly, later in the year. The document is structured across nine chapters which include: flood risk management; governance; design; construction; operation, maintenance and emergency management; and, inspections and monitoring.

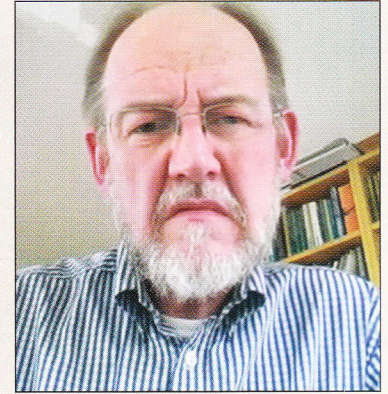
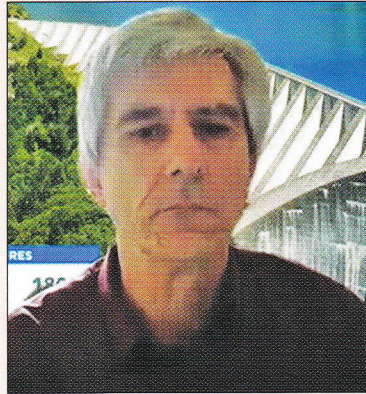
In the Q&A session that followed the presentations, Michael Rogers said: "Levees have only become a focus of ICOLD relatively recently but as they are so important for flood control, the reports should be published as full ICOLD Bulletins to help better inform the profession. Levees do not generate income like large dams and hydro", Rogers continued, "but their value is in the substantial cost saving to human life and loss of property, and they are therefore critical structures. I think the work of this Committee should be recognized with the same prestige as other Technical Committees and, I support the Bulletin".

Rogers added: "The comparison of dams and levees is a good basis for the work on levees and we need a ground swell to increase the recognition of the importance of levees. Levees often become the focus only when there is a failure, so we need to change that to show the good services they proved as critical infrastructure".

### IHA Climate Resilience Guide for the Hydropower Sector

*(Technical Committee Y: Climate change)*

Committee Chairman Denis Aelbrecht (EDF, France) presented the work of this group, with a focus on its



*Left: Remy Tourment (CFBR Vice President, France) presented some work from the Committee on Levees with Jonathan Simm of HR Wallingford, UK, (above).*

recently published Bulletin 169. As background information, Aelbrecht showed slides from the 6th Assessment Report of the Intergovernmental Panel on Climate Change detailing the observed, rapid rise in global surface temperatures since the middle of the 19th Century. Looking ahead, Aelbrecht cautioned "the current dynamics of global warming corresponds to the most severe projected scenarios", whereby the trajectory of further temperature increases look set to steepen even further. The effects of climate change are, he noted, both direct and indirect. Direct impacts include the physical conditions at dam and reservoir schemes, while indirect impacts include the socio-economic conditions, as well as changes in water demand and usage. In responding to the climate change challenges, Aelbrecht said: "There will be risks as well as opportunities for the sector".

In Bulletin 169, risk was classified as a function of hazard, multiplied by exposure and consequence. Each of these components do, he noted, have high levels of uncertainty relating to, for example, average and extreme temperatures, snowpack and glacier evolution, floods and droughts and sediment yield. The report therefore recommends the use of an ensemble of scenarios to help capture these uncertainties, rather than focus on only a single scenario. To demonstrate this approach, Aelbrecht presented a case study from Sweden in which climate change projections had been made with respect to both temperature and precipitation. The data had indicated larger increases in values for both these variables in regions towards the north of the country compared with southern areas, under a range of scenarios.

Building on the work of Bulletin 169, Aelbrecht said the Committee was currently preparing a second Bulletin with a focus on case studies, grouped under three themes. Theme 1 will present examples of climate-induced water shortage and drought management. Theme 2 will include case studies on flood risk evolution associated with climate change, and Theme 3 will present cases that assess the role of hydropower in climate change mitigation. This second Bulletin is now at the stage of initial review, and there are plans, he said, for a comprehensive workshop detailing the contents during the Marseille General Assembly in 2022, prior to final approval and publication.

### General Assembly

ICOLD's annual General Assembly took place virtually, for the second time. More than 150 attended from all parts of the world, despite the time differences.





President Michael Rogers began the meeting by honouring the memory of ICOLD members who had passed away since the last meeting: Vice President for the Americas, Carlos Henrique Medeiros of Brazil; Hon President Theo van Robbroeck of South Africa; former Secretary-General Jacques Lecornu of France; Terence Kabell of Zimbabwe; Christian Guillaud of Canada; and Maria Elisabet Pardini of Argentina.

It was announced that the elections which would normally take place this year had been postponed until the Congress in Marseille, now scheduled for June 2022. The terms of office of President Michael Rogers, and Vice Presidents Noorzad and Abebe had been extended until next year.

It was recalled that the next meetings after Marseille would take place in Gothenburg, Sweden (2023); New Delhi, India (2024); Chengdu, China (2025), (the next Congress); and Shiraz, Iran (2026). A representative from each of the host countries later gave an update on arrangements for the meetings, including the dates and venues, planned symposium topics, study tours, and more details about the host cities. President Rogers paid tribute to the patience of the host committees, during the rearrangements caused by the pandemic.

A resumé and video, was then presented about the ICOLD Board's participation in events, and other activities, which had included: the INCOLD hybrid symposium in February 2021 and a CFBR hybrid symposium in November; National Committee and dam safety events in Malaysia, USA, Spain, Brazil, China and others; Aqua-Media's HYDRO 2020 on line; and SOLAR-HYDRO 2021 co-hosted by ICOLD and Aqua-Media.

President Rogers then reflected on what had always been his priorities with the ICOLD Board since taking office. The first was dam safety, and he reaffirmed the global importance of this, particularly in the light of incidents and failures which had occurred over the past few years. He stressed that dam safety was a core value of ICOLD, demonstrated by its World Declaration. ICOLD remained committed, he said to continuous improvement of safety for dams and levees worldwide.

Support for National Committees had been another priority, and this had been achieved in a number of ways, including: attendance at many National Committee meetings; support to inactive Committees, by Secretary-General Michel de Vivo; support for new Committees, for example Malaysia; and also support for the Regional Club Meetings.

The aim of giving more support to Technical Committees had been fulfilled by the issuance of

updated guidelines for committees, as well as making it a priority to deal with a backlog of Bulletins, and thanks were given for the latter to the Central Office team.

Prioritizing capacity building had been achieved in a number of ways, including support to CHINCOLD's annual Roundtable meetings on the subject. A survey had also been conducted in 2021 to assess developing country needs.

Increased support for young engineers had been another aim, and President Rogers reported that special pricing had been arranged for YEF members to attend ICOLD meetings. Support had been given to a new YEF national committee, in India (making India the 23rd country to set up a YEF). Another new initiative was that each Technical Committee was to have a second Vice-Chair who was a YEF member.

Michel de Vivo reported that ICOLD now has 104 member countries: 33 in Europe, 29 in Asia, 25 in Africa, and 17 in the Americas. He added that there were now 26 Technical Committees, bringing together around 700 technical experts. Four new Bulletins had been published, and around 10 more were in the process of being translated. Following the four Workshops which had just taken place, 15 were planned for Marseille next year.

Dr Ali Noorzad of Iran proposed the creation of a new Technical Committee, on the topic of historical hydraulic structures; this could draw on information on ancient dams in countries such as Iran, Spain, Jordan, Greece, Turkey and others, to demonstrate the influence dams had had on civilisations since ancient time, and to further collaboration with academic institutes to promote research in this field. The proposal was accepted.

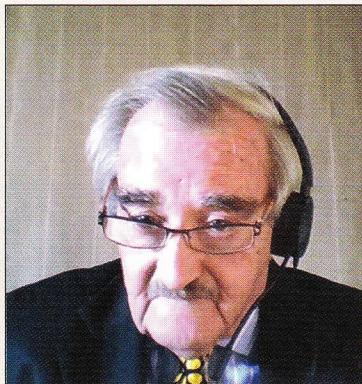
Jean-Jacques Fry reported on ICOLD's leading role in the EU-supported initiative Hydropower Europe, which aimed to provide a synthesis of research and development work to form a Roadmap for Hydropower in Europe. Fry recalled that the three key strategies were:

- providing economic and legal support for flexibility and storage;
- preserving biodiversity and improve river ecosystems; and,
- raising public awareness, increasing societal resilience and local employment.

Satoru Ueda of the World Bank gave a presentation in which he began by presenting examples of the many large dams (mainly multipurpose) which the Bank was currently supporting, as well as rehabilitation and upgrading schemes. He also stressed the commitment to dam safety of the Bank, and drew attention to evolutions in dam safety policies since the 1970s, and various World Bank publications on good practice. He mentioned the Bank's tiered approach for risk analysis and assessments, with the first tier of guidance being applicable to all dams, the second was for moderate-high risk structures, and the third for high risk dams.

He then announced a new World Bank publication, called 'Laying the Foundations', which provides a comprehensive set of country case studies, with a balanced representation among a diverse set of countries (51 in total) with varying economic, political and cultural circumstances. A comparative analysis had been done of legal, regulatory and institutional metrics. Finally, a set of guiding frameworks were recommended suitable for different country circumstances.

*Below: Satoru Ueda of the World Bank, discussing the Bank's support for water infrastructure; and, to the right, Hon President Luis Berga of Spain, who joined the discussions during the Annual Meeting.*







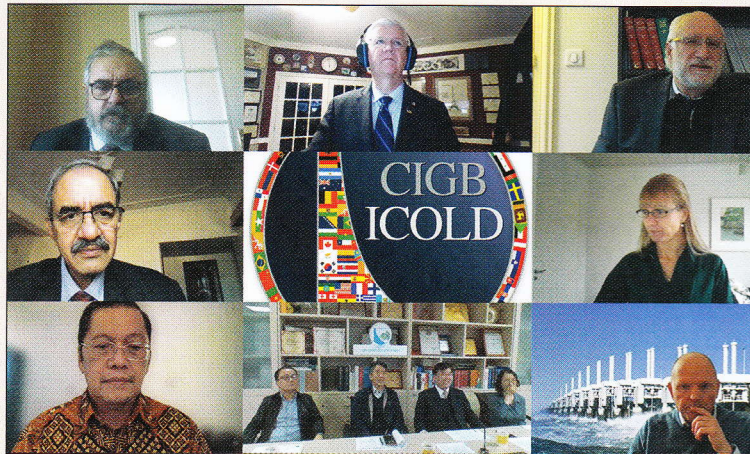
Four new Technical Bulletins were submitted to, and approved by, the General Assembly:

- Cemented material dams - Design and practice: Rockfilled concrete dam.
- Dam safety: Concepts, principle and framework.
- Dam safety: Governance considerations.
- Sediment bypassing and transfer.

Two Committee update reports were presented: Tony Bennett of Canada outlined progress with his Committee (I) on Public Safety around dams, noting that there had been some collaboration with other Technical Committees, where their work was in alignment on some common elements of the subject. He also referred to his Committee's important work on establishing and maintaining a database of incidents affecting public safety, and he noted that at least 1400 incidents had been logged in to the database so far. He urged more ICOLD Committees to contribute, so that valuable lessons could be learned. He presented some statistics which had already been drawn up from the data collected, relating to, for example, the types of incidents, and the activities taking place at the time of accidents.

Luc Deroo gave an update on his Committee (T) on New challenges for dams and reservoirs in the 21st century, and he referred to the successful SOLAR-HYDRO 2021 conference which had been co-organized with Aqua-Media, and which had dealt with floating solar panels on dam reservoirs. He mentioned that membership of his Committee had been extended to professionals from the solar PV sector.

Work would continue on this subject, Deroo said, and the Committee also proposed to publish a Bulletin on Low hazard small dams. The Committee's work could also encompass: reservoirs for arid and semi-arid



regions, and balancing costs and benefits by 'internalizing externalities', Deroo added.

Honorary Membership of ICOLD was awarded to two people, for their contributions to the profession and to ICOLD. These were Prof Jean-Jacques Fry of EDF France, an expert specializing in dam safety, especially embankment dams, problems of internal erosion and soil mechanics. He has served as President of CFBR, and has been active for many years in ICOLD and particularly the European Club.

The other was Zhang Chao-ran, who has devoted more than 50 years to hydropower development in China, and has served as Chief Engineer of the Three Gorges Project. He won a prestigious National Award for Science and Technology, for his paper on the project. He is described by CHINCOLD as 'a father of Chinese modern dam engineering'.

Awards to both will be made formally in Marseille.◊

*A view of some of the ICOLD officers and participants during the 89th General Assembly.*