A leading light in Norwegian tunnelling, Emeritus Professor Einar Broch has advised and lectured extensively around the world.

Outline your educational achievements and your career to date.

In 1941, I graduated from the Norwegian Institute of Technology (NTH) as a civil engineer, majoring in hydropower engineering. During a so-called ‘black summer’, from 1969-70, at Imperial College, London, I obtained an MSC in engineering rock mechanics and in 1977 at Dr ing. in geological engineering from the University of Trondheim (NTH).

I have worked at NTH-NTH in Trondheim throughout my career. In 1984, I received the chair at professor of geological engineering. In 1995, we started an international course in hydropower development, so I have been teaching students from more than 60 countries. I have also given lectures and presentations at universities and professional bodies on all continents, including Greenland. I have also given advice on investigation and design to a number of tunnel/underground projects in Norway, and in 15-20 countries around the world. I have also been a member of panels and expert review boards. Two years ago, I became Professor emeritus – which means I am no longer teaching.

Also, since its launch in 1985, I have co-authored the world-leading Tunnelling and Underground Space Technology, and I am about to stop down grades.

You were TNA president in the 1980s. How has the organisation changed since then and what advice would you give the current president, Professor Ina Mele?

Since my tenure as president, the number of member nations has doubled. Particularly important is the increase in members from Asia, so the dominance of the European countries has been gradually reduced. Thus the election of the first Asian president this year was an important event.

I have great confidence in Prof. Ina Mele, and I am sure she will move the association forward considerably.

Working Groups have always been an important part of NTA, and I feel it is important to give the new president advice that he should do whatever he can to create the best possible working conditions to allow the optimal efficiency of these groups.

An interesting development in TNA during the last years has been the establishment of committees (in addition to working groups). As a retired professor, I regard the Committee on Education and Training (CETAC) as of particular importance. It includes a worldwide university network, and I am sure it will have a positive influence on the quality of education in our field globally.

Some notable tunnel projects you have worked on and the lessons you learned from them, which might be useful to other engineers.

Last year, at the opening ceremony of the World Tunnel Congress in Vancouver, I had the great honour of giving the first Murk Wood lecture. The title of my presentation was ‘Tunnels and underground works for hydropower projects – lessons learned in home country and from projects worldwide’. The lecture can be downloaded from the TNA website at www.tna.no.

Some of the projects described in some detail include: the 45km-long tunnel in ‘tough’ basaltic rocks in Lesotho; two tunnels in ‘stable’ sandstone in Lesotho and Colombia (Guajira) and collapse in shale in the Chigeta tunnel, Colombia. I also include the lessons learned from the Cvikov Olympic Mountain Hall in Norway – still the largest public underground hall in the world.

I use the lesson learned at Cvikov to demonstrate that the installation of 345 No. 1.500KN wedge anchors in the roof of the powerhouse of the Xiaolongpi project in China was most probably unnecessary.

What, in your opinion, have been the main advances in support and rock improvement over the past 20 years?

Thirty years ago I was involved in a Norwegian road tunnel where steel fibre reinforced concrete was used for the first time, replacing the traditional, time-consuming method of placing metrised reinforced shotcrete.

Since then there has been considerable development of fibre-reinforced shotcretes, not least in the techniques of application. Thus the use of shotcrete as a means of support in tunnels has increased over all the world. In some cases, however, I feel that the use has turned into an overseer or misuse. It is too easy to apply a layer of shotcrete close to the tunnel face, or even at the tunnel face, thereby concealing a potential problem instead of solving one.

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Sub-sea tunneling for oil extraction was first discussed seriously in 1984-85 in Norway when planning for the Troll field began. This field was located 500km off the West Coast. Sub-sea tunneling had existed in the oil industry for a number of years, but the time needed was one of the negative factors. Improved tunneling techniques during the last 25 years may now improve the applicability of this solution.

Given the Norwegian specialties in areas such as hard rock, hydro-power and sub-sea tunneling, are there any lessons that Norway can teach the global tunneling fraternity?

Norway has 230 underground powerhouses, 8,000km of hydropower tunnels, 750 railway tunnels, 1,200 road tunnels (including Lærdal, the longest in the world at 24.5km long), 30 sub-sea road tunnels (including Eype, the deepest in the world at 287m), and, as mentioned above, Cvikov, Europe’s biggest public mountain hall in the world.

Against this background in the early 1980s, the Norwegian Tunnel Society (NTN) started publishing a series of books in English for the international market. The books vary from 65-375 pages long.

The issue, No. 19 – Rock Support in Norwegian Tunnelling – was presented at the World Tunnel Congress in Vancouver in May. I had the pleasure of editing the first publications and can strongly recommend them to people who want to be informed about different aspects of Norwegian tunneling. The books are available at www.tunnel.no.

LEADERS

Glendoe was excavated by TBM... pieces of rock that normally fall out in a drill-and-blast tunnel remain in place around the tunnel perimeter. This may lead to an overoptimistic evaluation

How are Norway’s students encouraged to become tunnel engineers?

Over the past few years there has been a clear increase in students wanting to study geological engineering, particularly related to tunnelling, but the number of female students has also increased. Today, they are in the majority.

The increased possibility of doing a challenging job is probably the main reason students are selecting this field.

One important factor explaining the good job market is, beyond doubt, the collapse we had in the tunnel industry last year. This was due to a series of incidents which led to a lack of trust in the collapse of tunnels. This resulted in a number of collapse engineers, not least within the road and railway administrations.

Do you think today’s tunnel designers and engineers have a good enough understanding of geology and rock mechanics, or is more education needed?

One special feature about tunnels is that they are constructed by excavating material and not by reinforcing material, as is the case with concrete buildings and steel bridges. So, when the location for a tunnel is decided, the choice of material has already taken place. This construction material is very special as it is already filled with joints and cracks, and is normally only really visible when you have started the construction. It is thus absolutely necessary that tunnel designers and engineers really understand the geology and mechanics of the rock mass.

Geology and mechanics forms, beyond doubt, the fundamental studies in the training of tunnel engineers. They are therefore always a main place in the field and on site, the better it will be for their understanding.