Towards an improved use of underground Space

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Round-Table Session on the Subsurface Use in Developing Countries

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Abstract: The round-table session on subsurface use in developing countries gathered the representatives from 12 countries (South Africa, Algeria, Federal Republic of Germany, Belgium, France, India, Iceland, Japan, the Netherlands, United Kingdom, Sweden and United States of America). This fruitful exchange of information on needs and present possibilities will help to define the role of ITA in this field.


Remarks: This issue of the ITA Journal is devoted to the reports: - of the round-table session on the subsurface use in developing countries. These session took place in Nice in May 1981 at the opportunity of the 7th ITA Annual Meeting and AFTES International Symposium on Cost-Cutting in Underground Work. The ITA, as a first step, organised a round-table session at their Nice General Assembly in May 1981 to collect further examples and investigate the needs in developing countries. The present paper reports the discussion as it was presented in Nice. It does not form in any way a conclusion yet.
II — TABLE RONDE SUR L'UTILISATION DU SOUS-SOL DANS LES PAYS EN VOIE DE DEVELOPPEMENT/ROUND-TABLE SESSION ON THE SUBSURFACE USE IN DEVELOPING COUNTRIES

Co-animée par: L. LUPIAC, Président AFTES
Vice-Président AITES

J. K. LEMLEY, Vice-Président AITES


The round-table session on subsurface use in developing countries gathered the representatives from 12 countries (South Africa, Algeria, Federal Republic of Germany, Belgium, France, India, Iceland, Japan, the Netherlands, United Kingdom, Sweden and United States of America). This fruitful exchange of information on needs and present possibilities will help to define the role of ITA in this field.

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En 1980, la Suède prit l'initiative d'organiser une nouvelle conférence "Rockstore" consacrée à l'utilisation du sous-sol. Les conférences techniques furent complétées par la présence des représentants de nombreux pays (environ 20) invités par le gouvernement suédois et par les représentants de plusieurs organisations internationales.

Il fut décidé de poursuivre les efforts pour introduire l'utilisation du sous-sol là où il peut contribuer à résoudre les problèmes, par exemple dans les régions en développement.

Les organisateurs de Rockstore ont alors suggéré à l'AITES de reprendre et de poursuivre leur initiative.

Dans un premier temps l'AITES a organisé une table ronde lors de sa réunion annuelle 1981 à Nice afin de rassembler des exemples et déterminer les besoins des régions en développement. Le présent document rapporte les discussions telles qu'elles se déroulèrent à Nice. Il ne constitue en aucun cas une conclusion.

L'AITES travaille actuellement à la mise sur pied d'un programme de travail sur le sujet et espère être en mesure prochainement de présenter ses projets.

In 1980 Sweden took again the initiative to organise another Rockstore Conference devoted to the subject of subsurface use. The technical conferences were fully attended by official delegations from several countries (around 20) invited through the Swedish government and also by representatives of several international organisations.

A very clear wish was expressed to continue the effort of introducing subsurface use to developing countries also wherever this can help solve their problems.

Following this, the Rockstore 80 organisers suggested that the International Tunnelling Association takes over and pursues such initiative.

The ITA, as a first step, organised a round-table session at their Nice General Assembly in May 1981 to collect further examples and investigate the needs in developing countries.

The present paper reports the discussion as it was presented in Nice. It does not form in any way a conclusion yet.

ITA is now working on developing a further programme on this important subject.

In a near future more detailed plans will be announced.
L. LUPIAC (France): I am in charge to introduce the subject. Since the Association's foundation, the ITA thanks to its working groups and its contacts with its thirty international members has made progress with different problems concerning tunnels, e.g. project design, conception and economic aspects of their realization. This evolution and the acquired correspondents must be useful to the developing nations too, and give them the transfer of know-how of the best means of subsurface uses and improve to a greater degree their actual condition.

However, it is necessary to focus actions of the ITA to a greater degree to subjects which apply best to the specific problems of the developing nations and to adopt the means to the local conditions of these countries.

This round-table is therefore destined to precise priorities, to seek for new aims which are worth to follow and to lead to conclusions which motivate the ITA to new aids in all the fields of underground works.

In order to generalize the debates, it is proposed to proceed according to the following outline:

— different axes of development,
— perspectives for the utilization of subsurface and the projects of underground works,
— local data and their influence on the execution of the works,
— nature of research aids — role of the ITA.

J. K. LEMLEY (U.S.A.): As co-chairman with Mr LUPIAC for the purposes of explaining the outline we would like to start with general comments:

(1) On agriculture: we know its importance to all countries in the world and all peoples. Particularly important are: the control of water and irrigation projects for the optimal utilization of existing farmlands. This is a foundation upon which all countries have to build to be able to feed their people. Underground spaces are particularly important as they relate to many of these projects, e.g. in addition to dams, canals and other works tied to the overall development schemes.

(2) In the mining area, underground works are more obvious for haulage tunnels as well as for the mining of minerals in the various rock formations.

(3) We have energy sources and their impact on development and use of underground space.

(4) The subsurface can economically be used for the storage of various commodities and products. There are many advantages to this type of storage in that you have a controlled environment and in certain circumstances this is much more economical to develop than a surface storage.

(5) In urban environments, the obvious reasons for going underground are: traffic and security which many countries in the world — whether they are developing or developed — have as primary consideration.

These are the main areas we would like to suggest as an outline for consideration and discussion this afternoon. We would like to encourage comments from all of you who are present, both as to your personal experience in participation and development of schemes related to any of these topics, or to planning or implementation problems that you may have. We would take the information, consider it and direct the ITA's working groups to respond and assist in developing more information, by making available expertises to assist with these problems.

I guess the invitation for comments really comes on the heading of prospective initiation of the subsoil, and we would like to call on anybody who would like to speak particularly on agriculture and water resource or on storage projects for comment.

Maybe Hans Christian FISCHER can give us some comments and I know he, as the past President of the ITA, has provided much information and food for the previous discussion we had.

H. C. FISCHER (Sweden): I have not personally been involved in projects of agriculture and water resource, but there have been made various Swedish attempts to study the underground storage, not only of oil and energy, but also of food and even of drinking water, which are all old concepts, but which have not been given that place they have deserved under modern technological and development conditions. These are underdeveloped areas of application, and they seem to be areas of possible future activities in developing as well as in industrialized countries. So, I think these are very important areas. You could even continue mentioning the possibility of having some agricultural activity under the surface with artificial light under controlled climate conditions.

J. K. LEMLEY (U.S.A.): Have the Swedish got experience — included experiments — in those areas of growing food underground?

H. C. FISCHER (Sweden): Yes, but so far with mushrooms only.

McCUSKER (U.S.A.): I have recently been involved in water supply projects in South America, and the observations which I have made in relation with the discussion here concern the necessity to understand properly what has been attempted. The rock conditions are generally very poor, the amount of exploration which has been done is not very great, and the level of competence of the available labour force is also not very great. These things lead to difficulties which, in more fully developed countries, we do not consider as difficulties. The simple problems become the major problems. I think it is necessary perhaps to understand more and more detailed what has to be done. For example: training programmes could be instituted, so that those persons who are responsible
with the development of the project have a brighter idea of what information is necessary in order that the project can be accomplished successfully.

SIKKA (India): Regarding the use of underground space for agriculture and water resource, in India there has been a historical tradition. In the past we have constructed irrigation galleries below the hills to collect the seepage water from the hills, about 10-25 m below the ground-level. The concept of intensive agricultural zones where underground water is used find a place in near future again.

Secondly we are planning the underground space for the construction of siphons and tunnels. Numbers of tunnels have been constructed for major projects, only for transporting water to irrigate fields, for example the Tuwar Project in Central India: a long tunnel has been built only for taking the water from the dam to the cultivation point, disregarding the potential hydropower. So the use of siphons and tunnels has already been made, but in times to come intensive agriculture will also be on the first rank. We feel in many areas that we will have to select, for the construction of canals, an underground installing, and underground storage for transmission of water. Not only to save the cost of construction, but it is difficult to acquire the costly agricultural land, which will be otherwise damaged if you do the surface transmission.

J. K. LEMLEY (U.S.A.): I think the matter of water supply for potable water or drinking purposes, in all societies, is an ever increasing problem, particularly in industrialized societies. In the United States we have several examples of areas where underground aquifers are now polluted to the point that they cannot be reclaimed. Therefore a much more thoughtful approach to how we are allowing for the disposal of toxic waste and other material even underground should be given greater consideration. It is possible that these experiences, along with those of other industrialized countries who are faced with similar problems, can indeed serve as an example for others not to follow. It is an example of failure, not of success. Some of us have learned their lesson and we have to learn it, too. I would like to ask our South African friends to contribute to this. I know they have been engaged in many underground works, both related to energy as well as water transmission and other conduits for transport.

N. KRIGE (South Africa): We have constructed many tunnels either already built or on design stage. The longest continuous tunnel in the world — 81 km — is in South Africa, transporting water from one point to another. I am not quite sure that South Africa is still a developing country, from our point of view it is a developed country. Our contribution to the question will be this: we must be very careful to introduce methods and ways and means of using the underground to a country which still has wide open surface spaces. We must not necessarily bring something down, but we have to choose the more economical way before we start developing the underground. This is our experience in South Africa too: we only use the underground as a large resource. Obviously we have learned that we have to transfer water from one water-sheet to another, and to do so we have to make use of tunnels. But we have first developed all the other resources, and I think this is very essential in developing countries too. I realize that India is a country where there are overpopulated areas, so that they must go to the underground already, but I think that in Africa there are many wild open spaces to be utilized.

N. SCHMIDT (South Africa): I would like to do just an addit on a possible social model which would include tunnelling. I think the prime necessity in any country, whether developing or not developing, is that the people should have enough food. This immediately means that you have to control your water: it has to be brought to the right place so that e.g. the fruit can be grown, and it has to be distributed in the best possible way. Here I see tunnels as a forming part of the thing. Having the water, having built the tunnel, you can produce electricity. You may not have this sort of society, that can use the electricity as an exportable commodity. But your neighbour may have mines, that he would wish to operate but does not have the power or the energy to do it. He can buy the energy from you, so you have the tunnel being used as a means of getting an export and giving someone else something he has not got. If on the other hand you have got the mines and you have managed to get some energy from somebody else, you now have underground construction as a means of developing a mine to build up industry, so that you can in fact come up to the need that you have for survival. With all this comes some form of communications between the cities and in certain underdeveloped countries the difficulty of communications. So, there is a developing tunnelling need, depending on to what extent the country has developed. If I could give the priorities, I would say: people first and that means food and water — and following on that the needs for a better life. Then, when you get to the urbanization side of the thing, you have a different problem: there are some developing countries which have extreme urban populations, and the urbanized area is the one in fact, where the problem lies. I do not mention that developing countries have built underground facilities for defense, because I think it is the last we want.

SUKHI RAM (India): I must confess that our economical conditions in India do not allow us to go on for underground agriculture at present. As a matter of fact we are an agricultural country — 80% of the population depends on agriculture — and as you know we were deficient in food production. But now, with the advancement of the modern technology and design, it has been possible for our country to become self-sufficient, and not only that, but we are also in a position to export food and grains to certain countries. Due to some difficulties in our country, for two years
we could not export, but at the same time we did not import.

Our main problem is that: whatever potential we have got, this has not been exploited to its full extent. Our scientists need help from the advanced countries; with your technology, we are trying to exploit our resources. As a matter of fact you, in these advanced countries, have exploited the resources on the surface and underground. So we have a very dreadful need for the help we are getting from your countries and your scientists, and of the technology you have got. Within that range our main problem is exploitation of the hydropower. For that I am here, simply to find out means how we can exploit that; I will talk tomorrow in the open session on what is our potential; Mr SIKKA will state the things very clearly.

J. K. LEMLEY (U.S.A.): I do not think that anybody here has applied the economical extreme uses of underground water; certainly it is a very expensive resource to utilize. There are times and places where no other alternatives exist but to go underground, e.g. to maintain the movement of population, the supply of available commodities and distribution of services. In those instances, we are able to bring together experts from certain fields to advise and counsel on economical methods of development use of underground space. That is the purpose of the discussion today with the aim to attempt to get a field, where we may properly focus the activities of the ITA and make a greater contribution to proper solutions.

Hydro-electric development, as with other aspects of the energy topic that we put on forth, is certainly an area where underground activity has been concentrated for many years, both with the siting of powers underground as well as the use of tunnels for water transmission. The problem of water is common to most of all countries and its development — for human consumption as well as for growing foods — is a primary concern of all societies.

I would like to invite other comments on the subjects, either in the area of transportation of energy or of agriculture and use of agriculture in the broader sense.

NACABUSHINARA (India): I just wish to say what has been done in using the subsurface for utilization and conveyance of water for irrigation. About 15 or 16 yr ago tunnels have been built for conveyance. As long as canals could be done, they have been done when the water had to be transported somewhere else; even now for the Indian conditions, we are dependent on the rains and we are getting problems when the storage is not being filled up. The idea of connecting the different valleys by tunnels so that proper utilization of water of the different valleys can be made would involve a very extensive use of tunnels. And also, there are some places where the water was washed to the sea, and we planned to collect this water and lead it to the other valleys. We were not accustomed to build tunnels for this use.

Regarding the agricultural use, the main problem is now that most of our tunnelling works are in Himalayan Ranges; the most of the tunnelling works in the Southern country where we have a different relief are almost over. The problem that we are facing is tunnelling works for the underground power plants in the Himalayan sector, along the Himalayan Ranges. It is a great problem particularly in those areas where the preliminary investigations concern the old methods; we started our projects before the full investigation results came up. When we start the project of any subsurface work, we are getting into problems. If proper investigations could be done, then the experiences of the developed countries would be very much of assistance, particularly which investigation methods are recommended. Another part is the interpretation of geological data. I think this is something where a lot needs to be done in our country.

J. K. LEMLEY (U.S.A.): The matter of geological interpretation is one that those who work underground are very interested in continuing best.

One aspect of this discussion that has not been developed at all is the construction and operation aspect of underground facilities. I know the Japanese have studied long-term effects of underground facilities and even the effect of earthquakes. I wonder if Mr KITAMURA can comment on their underground works and experience.

I. KITAMURA (Japan): As you know very well, we are now having a tunnelling activity of 1000 km/yr. Most of them are sewer tunnels. About 600 km of sewage tunnels are excavated each year, and most of them by slurry machine with control panel. That means there is no need for much labour and that the machine is controlled by the computer.

As you very well know, most of the tunnels in Japan are located in the deposit, where ground water is very high. About ten years ago, we have used a system to protect against ground water by grouting from the surface in order to stabilize the cutting face in the water-bearing grounds. But today we prefer the use of slurry machines because the slurry itself has a high density, which is very close to the natural ground. Thus it protects the cutting face. This is a new type of slurry machine.

In my view the most important thing is sharing technology on a worldwide scale. All countries have much to learn from the others — especially the developing countries — because their principal weak point is the lack of access to technology. The developing countries’ efforts towards greater technological self-reliance need to be fully supported through international cooperation.

Technology is transmitted in many ways. While some spread through published literature, personal exchanges, technological conferences like this symposium, sometimes by imitations and copying like Japan, it also comes with commercial sales of know-how, through training and technical assistance or through
participation in construction and operation of foreign enterprises.

We believe that much can be done, through more effective organizations, to increase the transfer and development of technology.

That is by:

— more free flow of information about technology,
— greater support for technical assistance, providing an important channel for transmitting technology effectively,
— promotion of the technical skill by education or training, by learning-by-doing.

Already the OECD Tunnelling Conference of 1970 recommended to the participating countries a review of the adequacy of education and training of engineers in tunnelling, and a participation in international activities concerned with the application, planning and practice of tunnelling.

We should remind these recommendations once more.

J. K. LEMLEY (U.S.A.): I have one question for you. Have the Japanese studied the economics of underground installations as compared with surface works?

I. KITAMURA (Japan): Economy depends to a great extent on the price of land. In urban areas land is very expensive in Japan. In such cases the use of underground space is becoming economical sometimes.

If the price of land is more than ¥ 3 million per m², underground markets become more beneficial and profitable compared with surface buildings. Generally the underground construction costs are four times the costs of a similar surface building.

Urban transportation in Japan becomes a serious problem, not only from the viewpoint of capacity, but also because of its financial aspects. The construction costs required for underground railways of today is twice higher than 10 yr ago. Today, 1 m of a double track metro tunnel costs some $ 20,000. Thus the construction costs cannot be financed by the normal operation revenues. Labour, material and land costs are increasing about 10% per yr. Therefore we are studying small-sized metro systems to save construction costs by an amount of about 20%. But it is still doubtful whether the mini-sized metro will become economical or not.

J. K. LEMLEY (U.S.A.): The experience is practically the same in the United States and other places. The economics of many underground works have to be viewed in a light of long-term operating cost, and cost effectiveness of the tunnel installation figured in a very wide context of secondary effects as e.g. environmental protection, safety, preservation of old city centers, etc. I know there is going on a great deal of works in restoring many old underground facilities constructed years ago. I would like to ask Mr MUIR WOOD to comment on the rehabilitation efforts they are and have been working on with a view for cost-effectiveness of the overall facility and its replacement value.

A. M. MUIR WOOD (U.K.): At a time of economic recession, the easier way to save money is to resort to capital expenditure which will need many years to recover its value. Nevertheless by avoiding spending money, we give also problems to the future and problems which will very soon imply costs. I believe this is a general point, a general application, to help the particular resort which is in care of the constructions that any country has. Certainly our experience in the United Kingdom is that we have had two counter-positions: regardless of the amount of warning that has been given by engineers concerned with civil engineering in general, we came to a situation where we have had damages and collapses of sewers in some of our cities where these belong to the early days of industrial revolution — 100-150 yr old. Only after that the Government has appreciated that this is a part of the capital of which money cannot be saved. As a result there is now a considerable programme of work underway to restore these facilities and put them back into order. My own firm is at present engaged in achieving the same sort of recovery of old infrastructure works and developing new ones. Some of our friends here today know what I am talking about concerning this problem and what it costs, and how it can be recovered.

J. K. LEMLEY (U.S.A.): We then should have the field of restoration of old infrastructure and maintenance because we have representatives here today who are in a process of adding to their infrastructure transportation systems in Algeria.

AYADI (Algeria): We have no experience so far in the use of the underground but we have programmes and studies for the construction of a metro in the capital of Algeria. We have a lot of towns which are growing very quickly and that causes the need for the use of the subsurface. Besides that we have problems with transport of water. In spite of having all these problems, we do not have an association to collect all useful information. Therefore we are happy to be here and to get some information. In this connection I want to say something concerning the papers we have heard this morning, e.g. on planification and costs: many problems in our country are quite different from the scientific approach we have heard this morning. It is too difficult for me to explain it in more detail here.

J. K. LEMLEY (U.S.A.): The problem of costs for both maintenance and new facilities is one that each of our countries is concerned with. As the burden of increasing costs becomes heavier the resort is not planned as it should be. Yet, it seems the life's process in most of the major cities of the world can be compared to the veins in our body that carry the blood:
the transportation, the gas, either energy which is required to keep the cities and our people alive. The entire subject of the use of underground and the development of underground space should be considered in a context of long-term application and long-term benefit. There are economical applications of underground space and there are situations when this is entirely inappropriate to consider. The resources require to determine whether or not the economics of a particular situation are open to argument in a political as well as in an engineering sense. It is necessary for our group to focus on the engineering aspect of the problem, but keeping in mind the influence and concerns of the policy areas. I think the Swedish have experience in dealing with the matter of policy with regard to applications. I would like to ask Magnus BERGMAN to address the problem relative to the public concern and to inform us about some of the answers that they have reached in the areas of public policy in Sweden.

M. BERGMAN (Sweden): We had a conference in Sweden in 1980, “Rockstore”, which addressed itself to the subsurface space use. As well as being a normal conventional technical conference, an official part of it was also aimed at attracting legislators, administrators, decision-makers, to come to Stockholm and discuss the more institutional, legal and society-oriented problems connected with underground space use. We succeeded in obtaining the participation of about 40 countries. Also we organised a special session where we discussed subsurface construction in less developed regions, in order to see whether some specific problems came up. One of the reasons why we were putting up that specific topic was that we happened to have a number of participants from the Asian Development Bank, the African Development Bank, the Inter American Development Bank, the FAU and from the United Nations Environmental Programme. We wanted to have these people to participate in this discussion, because there is a tendency that all the United Nations Agency and Development Banks are dealing more and more with questions of water supply and human survival on earth. Therefore they were coming to see how the money transfer can be utilized in an efficient way. In this respect they do not have a very large capability of dealing with projects related to underground space use, with the exception of hydropower plants because that is something that has been going on for 40–50 yr. The result of that special session and the official part of Rockstore, I think, was encouraging. It is evident that there are more existing experiences from projects in many countries of the world than we did know. But there is a problem, and that is the exchange of experiences from those projects. There is no real, source of information that can transfer these experiences from one country to another. There is a lack of design parameters or of models for designing certain important structures, like for example food storage. Also there are different problems in the industrialized countries and the less developed countries: we are defining our problems in each country in a very national-oriented way depending on the fact that we have different laws, different regulations and therefore different ways of solving the problem. For example, in Sweden, it is very easy to construct underground; in the United States, it is not a question of technical capability, but it is more a question of the contractual set-up of underground structures in civil work. And all this has effects on the development in each country. It is not so much a question of whether the project comes up in an industrialized country or a developing country, because the basic data for an underground structure can be utilized in any country, but there is a lack of data, a lack of ways of collecting these data.

Then there are also different ways of training and educating the workers which is the basis for understanding some of the scientific and technological methods that we are utilizing in certain countries but which cannot be transferred directly to other countries. To get an idea of the problem and solve it, there is probably a need for two types of development: one is the technical development, for example the kind of activities like the ITA is organising at present in the working groups and during the conferences. At the same time there is a need for raising an appreciation and an interest from the people who make the decision and the planning for the future in all our countries. By doing this, we must try to convince these people to put the right things — not everything — underground, because some cities are growing to 10 or 15 or 20 million inhabitants, many of them will be of that size in 1990 or 2000.

These questions have probably to be discussed in some United Nations organizations in order to get their understanding for the potential of the underground space use. But even if we are going on parallel, it may take 5–10 yr to really get into the basic. Here we all need a help from the ITA by finding ways of developing the different working groups activities and by a better understanding of institutional problems that we are faced with. There is not one country similar to another country; even if we go to countries like Sweden and Norway where we have a close relationship, we find there are a lot of differences in policies. Of course, there must be much larger differences if you go from Europe to Africa or South America, etc.

I think that ITA with its technical-oriented objectives and some kind of activities within the more institutional policy-making questions, would be a very good solution for the future. As specifically the United nations are interested in less developed regions, I think that things can easily be combined. I will go into more details about the future activities of the United Nations tomorrow in the Open Session.

J. K. LEMLEY (U.S.A.): I have been interested in some of these policy areas, as we in the United States have studied some of the cost problems of the underground works and where they have developed. Surprisingly this was not in the technical area, but it was in the institutional area: those are the largest costs that seem to be uncontrollable: environmental,
sociological and legal considerations in each of these major projects particularly in urban environment seem to be of special influence. I do not know whether we found a good way to deal with them.

Another country I would like to hear some of their experience is Netherlands. The underground works, I understand, are limited in the Netherlands. But taking into account the very difficult ground conditions they face, the complicated technical problems and the very high costs that come from that, I think their experience would be valuable to hear from.

VAN LOHUIZEN (Netherlands): As you know, Holland is a country that lies just over and partly below the sea level. So we have a very high ground water table, which always makes construction in the subsurface a very expensive experiment. The planning people therefore usually do not think of using the underground. But as problems are developing in our cities — just as in cities all over the world — we are reaching the point where we have to go underground with certain facilities. Since construction methods have developed in a way that they can be used in ground conditions like we have in Holland — mainly in Japan, especially in cities like Tokyo, where very much tunnelling has been done in situations which are for ground conditions comparable to the Dutch situation — we will probably in the near future reach a stage of development where tunnelling projects become feasible. Of course, it costs a lot of money; but you have to choose whether you are going to keep your city alive or not. Especially you have to go underground with some of the transportation facilities. As Mr LEMLEY already mentioned: urban transportation has to be handled like the important blood transportation system in our body; one of the means to keep the city in a healthy condition is the well balanced use of the subsurface.

Another point that we are just now developing in Holland is the water power question. India mentioned how important the works of hydropower development are for them. Part of India is high up in the mountains and they do not have much trouble in finding differences in height, so that they can generate the water power. In Holland we do not have these differences in height unless we go underground. There is a project for an underground hydropower plant in development just now — and it looks like a feasible project — where we will have an amount of water stored on the surface; through a shaft, this water can run down 1200 m deep to drive the turbines. At this level we will excavate a chamber to store the water, after it passed the turbines. It will be pumped again at night time when the electricity need is very low. This development in our country might be of interest for countries that have areas comparable to our low-lying land.

REDDY (India): We are situated at the Southern side of India. The rock formation there is very stable; we have no problems with tunnelling. Our main problem is the use of our hydro-potential. The reservoirs raise problems because a lot of ecologists and also environment specialists prevent us from building in particular places. But unfortunately in our State, we are only able to build the reservoirs there. I wonder whether the developed countries are also faced with this problem of ecology and environment, and we would like to gain by their experience.

J. K. LEMLEY (U.S.A.): You are correct. I think most of the countries represented here have suffered from problems of public policy and concerns from environment. Is there anybody at the table who would like to address that specifically?

J. PERA (France): I want to draw your attention to four points: the first is that the costs of a tunnel vary from factor 1 in hard rock to 10 in waterbearing soft ground. This means: good knowledge of the underground conditions in the field of geology and also in the field of geotechnics is very important.

The second point is that we need an interdisciplinary approach to the design of underground structures, beginning with the geologist who starts the first studies up to the user of the completed subsurface building. I hope that this interdisciplinary approach can be realized not only within one country, but also between people of different countries for a special project.

The third point is that attention has to be drawn to the fact that in the field of underground projects a more accurate design is needed as for surface projects. For example it is very expensive — sometimes impossible — to change the dimension of a tunnel during construction works. Therefore from the very beginning the final use of an underground structure has to be decided on, so that no changes during the process of construction and design are needed. If in spite of that, changes occur, they also have to be planned very accurately and with participation of various specialists.

The last point is that everybody has to observe that the underground is a natural resource. To use it without too much impact on the environment, a special training of all those who are concerned with the works is needed — for engineers as well as for the people who have to make the decisions.

McCUSKER (U.S.A.): I wish to answer the question on the environmental problems, which I think are significant. On one occasion we had tunnels to construct in New York City — in Manhattan — at politically very active locations. The construction shafts were located in some of the few parks in the city. We had very active opposition to the fact that we had to cut off some trees, but in spite of that we were able to proceed with the project on the scheme we had chosen and to keep the amount of interference with the work to a minimum by the simple technique of inviting the cooperation of all people who were involved to be informed of the design. Really you find that mostly people who object are not perhaps well-informed about the real effects of what they are objecting to. But they do have real concerns and they want to express them to somebody who can do something about it. I think in this way you can be quite effective. We had a similar problem in Colorado and again simply by talking to the people we were able to keep the project
going. So my recommendation is, to open the door to the people who oppose with you.

G. GIRNAU (Federal Republic of Germany): I also would like to respond on the environmental question: first of all I very much agree with what Terry McCUSKER has said, i.e. try to convince people, for example living along a metro line, on the benefits of the project — this corresponds to our experience.

But I have some other remarks. We have to distinguish between environmental protection methods during construction works and during operation, for example of a subway line. Concerning the first point, we are in Germany more and more forced to use underground construction methods. When we started metro construction works in the early 60s, we had more than 80% of the works done in the cut-and-cover method — for economical reasons only. But, if we look at our construction methods today, we find that more than 50% is built in underground methods, for example shield or New Austrian method — because we have mainly waterbearing soft ground in Germany.

There is another question of environmental effect during construction work, that is the impact on the workers: noise and dust are the keywords. We are doing in the research institute STUVA some work in this field. Concerning the dust problem I distributed a paper to Mr KRIE and his working group. We now try to solve this problem by a special kind of ventilation during construction work, by which the workers are protected from the dust. The method keeps the dust at the face of the tunnel, thus preventing it from spreading out into the tunnel.

Concerning environmental protection during operation of an underground railway line, our main problem today is the vibration impact on the buildings adjacent to a tunnel track — vibration effects from the tunnel through the ground into the houses. We did a lot of measurements during the last two years concerning different kinds of ballast and insulation systems. We found solutions but effective measures are very expensive.

My last contribution concerning your question: we have had some problems in the past with ventilation shafts from road tunnels in urban areas, because the exhaust fumes are concentrated there — the protection of the surrounding area is a very important problem and it will become more important in the future.

An information for you: because all these problems concerning the environmental protection exist, we will deal with these in the ITA probably at our conference in 1983 which is held in Poland.

To conclude I would like to ask a question to our friends from India: you emphasized the need for technological aids and my question is: what kind of technology are you thinking? Are you thinking of highly sophisticated technology in tunnelling construction work, as we try to develop in our industrialized countries? If you are not thinking of these methods, then you need skilled labourers to build such a tunnel. Or are you thinking of labour intensive methods to construct a tunnel? This is very important for what we are going to do in ITA. We want to find out your needs, or on the other hand: what do you expect from us?

SUHII RAM (India): You have posed a problem for us and I reply concerning my own State: we have got a great hydro-electric potential. Mr SIKKA told you yesterday that this potential is 75,000 MW. Out of that 20% of the resource exists in our State. If we exploit the entire resource, we may exceed 20,000 MW in our State alone. The requirement of the country is to find scientists and other people concerned to exploit the resource and to generate the power. Then we will have the environmental problem which you are facing already today. Our other problem is, as you have rightly said, that we do not have the skilled labour to maintain the sophistication level you have reached.

The investigation part for example is very important. In our State, it takes about five to six years to investigate for a particular project. But the investigation is not so accurate as it should be. You have a developed technology by which this period could be reduced. We had a project in North India with the assistance of Canada. With our engineers, the investigation would have taken 3-5 years to be completed. The Canadian team — with the use of the latest technology — would have completed the investigation in ten months. Therefore we should use this technology. The biggest argument against the development of hydroelectric power in our country is, that the project might not be completed within an industry period. If we succeed in completing the project within the industry period, then we will exploit this power.

SIKKA (India): I just want to add one thing: as we have been talking, our problems are mostly going to be in the Himalayan ranges. In our long-term programme, we have decided to construct hydropower projects. Regarding other tunnelling works, we are going to have a good level of organization. Ultimately time is money and we want the completion of the works on time.

J. K. LEMLEY (U.S.A.): In the interest of our overall programme we have to conclude now. We will take the material and analyze what was provided to this discussion today, and we will try to determine how we might better direct our efforts in ITA, to developing countries too. Certainly I want to thank each of you for your participation this afternoon.

L. LUPAC (France): Concluding the round table, I would like to say: ITA can offer several kinds of information by the transfer of knowledge from its specialists and its expert groups. From the already completed works in the industrialized countries, we know the conceptions, construction methods and the references which are needed to make good proposals to the countries which may be interested.

I also want to express that requests concerning the training of local personnel for example for the study of projects, the planning of works, the methods of execution, can be satisfied by a co-operation with certain ITA member-countries which are more particularly specialized in the field of underground works.
Point de vue de A. M. MUIR WOOD, Président d’honneur de l’AITES / Written contribution by A. M. MUIR WOOD, Honorary ITA President

Je voudrais tout d’abord vous présenter les buts de cette activité de l’AITES que j’ai proposé voici deux ans:

(1) Principaux besoins dans les pays en voie de développement dans le domaine des projets et des travaux en souterrain.

(2) Comment utiliser au mieux les ressources locales, qu’il s’agisse de l’expérience, de l’équipement, de la main-d’œuvre, ou des matériaux (Principes d’une Technologie Appropriée).

(3) Rôle de l’AITES.

Je parlerai rapidement des points (2) et (3), d’une façon générale, et en m’inspirant des discussions récentes que j’ai eues en Chine sur les travaux en souterrain. Il est difficile de généraliser lorsque l’on tente de définir la technologie qui convient le mieux. Il nous faut tenir compte des traditions et des pratiques en cours, tout en sachant qu’elles peuvent avoir évolué au fil des années pour s’adapter aux conditions existantes. Il se peut aussi que nous constations qu’il n’y a aucune tradition, et que les travaux en souterrain effectués récemment ne reflètent aucun effort d’adaptation des traditions et des technologies apportées par d’autres pays aux besoins locaux. Entre ces deux extrêmes, il y a bien sûr un très grand nombre de possibilités.

En ce qui concerne la Chine, il ne fait aucun doute pour moi que de grands efforts ont été faits, et avec un succès considérable, pour faire évoluer les technologies appropriées. Je pense que le problème principal dans ce pays — et je crois que c’est aussi le cas pour beaucoup d’autres — est de préciser les principes essentiels des meilleures méthodes de conception et des meilleurs procédés de construction de façon à pouvoir en tirer des procédés courants. Dans tout ce qui a été publié, la théorie n’est pas séparée de la pratique, ce qui implique que le choix se fait entre “tout” et “rien”.

Mon expérience m’a appris que l’on peut préciser les principes de base d’une conception réussie, puis discuter des différents moyens de la mettre en pratique.

C’est dans ce domaine particulier que le besoin d’un échange technique se fait le plus sentir. En particulier, il est nécessaire de définir les circonstances, c’est-à-dire la nature et la qualité du terrain, auxquelles peuvent convenir différents concepts de projet. En outre, il faut définir les contraintes que tout projet spécifique impose au plan de construction (et éventuellement la

I set out first in my own words the objects of this activity of ITA which I first proposed two years ago:

(1) The main needs in developing countries for underground planning and construction.

(2) How to make best use of local resources, in skills, plant, manpower, materials (Principles of Appropriate Technology).

(3) The role of ITA.

I will address myself briefly to points (2) and (3) in general terms, affected by recent discussions on tunnelling in China. Generalisations are difficult to make in attempting to define what technology is appropriate. We have to take account of traditions and practices, recognising that these may have evolved over the years and endeavoured to establish methods appropriate for the conditions. Alternatively we may find that there is no indigenous tradition and that recent tunnelling has made no attempt to adapt traditions and technologies from other countries to the local needs. There is evidently a wide spectrum of possibilities between these two extremes.

In China I have no doubt that great efforts have been made, with considerable success, to evolve the appropriate technologies. I believe that their main problem, one that I suspect is widely experienced, is that of distilling the essential principles of the most effective methods of design and systems of construction so that these may be grafted in to their current procedures. In far too much that is published about tunnelling, the principles are not separated from the practices, with the implication that the option is that of “all” or “nothing”.

My experience is that one can distil the fundamental principles of successful tunnel design and then discuss alternative means of their application. Fundamentally, this becomes a question of relating theory to practice. It is in this particular area that technology transfer is most needed. In particular, it is necessary to define the circumstances, e.g. the nature and quality of the ground, for which different design concepts are appropriate. In addition, it is necessary to establish constraints which any specific design concept imposes on the scheme of construction (and possibly the
base contractuelle), c'est-à-dire la mise en pratique des observations. Tous les pays présentent une tendance à mettre une barrière entre ceux qui s'occupent de théorie et ceux qui s'occupent de pratique, mais c'est dans les pays en voie de développement que ce problème se pose avec le plus d'acuité. Je me hâte d'ajouter que j'ai tiré de mes discussions en Chine, limitées dans le temps et dans l'espace, l'impression que ces problèmes étaient bien compris et que les intéressés étaient parfaitement à même de les surmonter.

La plus grande partie des travaux de l'AITES ont une portée mondiale, mais il nous faut apporter la démonstration que nous sommes au moins autant intéressés par les problèmes qui se posent dans les pays en voie de développement que par ceux des pays développés. Nous devons encourager les rapports, les communications donnant l'état des connaissances, que ce soit dans le domaine des projets, de la conception ou de la construction. Le rôle de l'AITES est donc, en partie, d'influer sur les conférences et symposia consacrés aux travaux en souterrain, en créant éventuellement un nouveau groupe de travail qui se consacrerait aux "technologies appropriées à l'utilisation du sous-sol". En faisant un pas dans cette direction, l'AITES rendrait encore plus crédible son intérêt pour les besoins spécifiques du monde en voie de développement.

contractual basis) e.g. the application of the observational method. In all countries there tends to be a lack of continuity between those concerned with theory and those concerned with practice, but this problem is seen in its most acute form in developing countries. I hasten to add that, from my discussions in China, in limited time and in limited areas, I gained the impression that these problems were well understood and the leading proponents were consciously and effectively applying themselves to overcome them.

Most of the work of ITA has general application worldwide, but we need to demonstrate that we are at least as interested in the problems of the developing world in the developed countries. We should be encouraging reports, state-of-knowledge papers and case histories to differentiate between principles and particular means of their application, in planning, design and construction. The role of ITA is therefore partly to be achieved by influencing the trend of particular conferences and symposia on tunnelling, possibly complemented by a new working group addressing itself to "appropriate technology for the subsurface". A move in this direction could add credibility to the ITA's profession of interest in the special needs of the developing world.