Political and social aspects of present and future tunnelling

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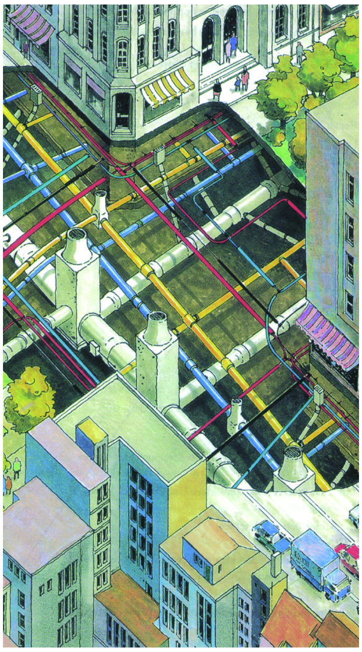
SIGNIFICANCE OF SUBSURFACE CONSTRUCTION

Generally speaking, we experience our cities from the surface. We can find our way around here, can recall certain groups of buildings and are thus aware at any time just where we are. In cities with which we are unfamiliar, we can obtain decisive initial impressions when encountering it for the first time and compare and evaluate the character of the place we are visiting with towns we have got to know before. This normal pattern of behaviour also explains why so many of our fellow human beings prefer transportation systems which are on the surface.

Most inhabitants of a city as well as its visitors are far more familiar with the structure above ground than the multifareous infrastructure below the surface of the earth. Supply lines for gas, water, electricity, telecommunications and distance heating are located here along with a diversified network of disposal lines. In large cities, there are also transport tunnels for rail commuter traffic, long-distance trains, motor vehicles and pedestrians. In many cases, this subsurface urban landscape is rounded off in built-up areas by private transport tunnels, underground garages, with as many as four or five storeys in the case of large administrative buildings, subterranean shopping malls and storage rooms, covered watercourses and many other special facilities.

Should local conditions demand and facilitate this, even production halls, offices, sports facilities and churches are set up underground. In this connection, especially impressive examples are to be found in North America, Japan and Scandinavia.



Variety of the underground infrastructure of a city

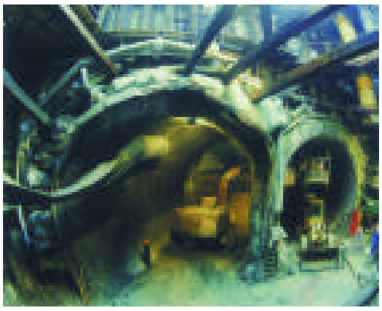
Our modern cities are almost incapable of sustaining themselves without this subsurface infrastructure, which is not identifiable at first glance. This very soon becomes evident when the chaotic conditions prevailing in some cases in the multimillion cities on the African, Asian and South American continents are taken into consideration. This does not simply apply to the hopelessly congested streets in the downtown areas. If anything, it is shown here too that a subsurface infrastructure represents an important prerequisite for public health right up to banishing the danger of disease. Even during the 1990s, this has been clearly underlined through examples of cholera and plague epidemics in parts of Central and South America as well as on the Indian sub-continent.

The overriding significance of an inner urban subsurface infrastructure in order to create decent conditions in the major built-up areas was once again emphasised not all that long ago at the United Nations HABITAT-II Conference in Istanbul, Turkey, in June 1996. More than 15,000 delegates from all over the world mulled over and discussed the prerequisites for humane living conditions in human settlements taking the varying climatic, topographical and cultural marginal conditions in different regions of the globe into account.

Fast train leaving a tunnel

Apart from the built-up areas themselves, the utilisation of underground space is experiencing high and ever increasing significance in less densely populated regions. Attractive and fast transport links between industrial centres call for high-performance transport arteries for the economic, speedy and unhampered carriage of people and goods. Important impulses for the economic power of a region or nation are provided by transport development and links. As a consequence, tunnels for roads and railways are being built or planned to a great degree for crossing mountain ranges, rivers and straits.

Let us briefly mention at this point that apart from the use of underground space for civil purposes, there is in some cases, exploitation world-wide for all kinds of military facilities. The construction and maintenance of these facilities possess a not inconsiderable economic importance.



Constructing a traffic tunnel by using the sequential excavation method

There is no doubt that the construction of transport tunnels and subsurface construction in general has reached a high standard in many countries. In more than 100 cities with populations in excess of 500,000, Underground railways, urban railways or rapid transport systems travelling beneath the surface in inner urban areas have been built or further developed during the last 30 to 40 years. In Europe, Budapest, London, Paris, Berlin and Hamburg are numbered among the first cities starting with such modern rail commuter systems at the end of 19th, beginning of 20th century. In conjunction with building tunnels for long-distance road and rail links, in Europe, first and foremost, the efforts which started in the early 1980s to develop high-speed rail traffic deserve mention. A number of these new lines possess a very high proportion of tunnels between say 30 and 40 per cent with overall section lengths of 100 to 350 km. Basically, the situation world-wide is similar as e.g. in Japan, or plans drawn up in Taiwan, South Korea as well as other countries.

In summing up, it can be established that currently there are a number of countries which are extremely active in tunnelling. In Germany for instance, contracts were awarded for roughly 25 km of transport tunnels annually on average during the last ten years, which were then completed following a commensurate length of time. 10 to 12 km of this total is accounted for by underground, urban and rapid transit system tunnels, some 5 km by long-distance rail tunnels and around 10 km by road tunnels. For the years to come, an increase especially with respect to long-distance rail tunnels can be anticipated. Mining has not been included in this study.

Currently, the overall length of operational transport tunnels throughout Europe can be accepted to amount significantly to more than of 10,000 km. The situation elsewhere in the world, for instance in North America or in South-East Asia is similar.

EFFECTS OF SUBSURFACE CONSTRUCTION ON THE ENVIRONMENT

"Till the earth and subdue it!" This biblical saying from the First Book of Moses (Genesis), Chapter 1, Verse 28 calls for a high degree of responsibility not only vis-a-vis one's fellow human beings but also with regard to dealing with nature and the world around us in a responsible fashion. Tunnelling and underground construction in general can afford a considerable contribution in this respect. Many examples from all over the world have been able to underline this, particularly over the past years. Thus the financial efforts which have gone on in Europe, ocating of especially busy roads in inner urban areas at greater depths, the conversion of railway lin o high-speed routes, and finally the expansion or renovation of many main collectors for sewage in t re areas of major cities have considerably enhanced their vitality and their acceptance by the citizen

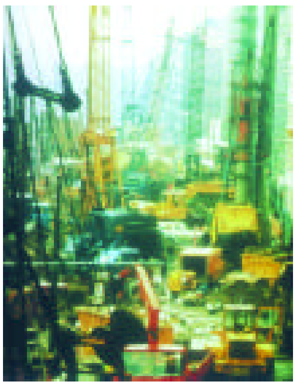
outstanding examples in this connection, let us mention: the subterranean shopping centres in Toror d Montreal, the Washington and San Francisco metro systems as well as those in Seoul, Beijing a anghai, expansion of the rail networks in Berlin, London, Paris and Tokyo. At present, enormous effo e being undertaken in the densely populated cities of Asia, Africa and Latin America aimed at estab ing properly functioning sewage disposal systems. Examples of this are New Delhi, Calcutta, Cai exico City and Sao Paulo.

oart from the direct positive effects for coming to grips with traffic flows, tunnels also generally ha nsiderable effects with regard to reducing loads on the environment caused by traffic. This immediat becomes evident in downtown areas with underground rail systems, in which extensive pedestri nes could be set up on the surface. Indeed, the effects are so far-reaching that complete regions ha en freed from the loads imposed by road traffic. This is for example, an important objective for the ma teries crossing through the Alps, by means of which in Austria and in Switzerland, through lorry traf tween central and southern Europe is to be transferred to rail.

conjunction with the construction of tunnels on new long-distance connections for road and rail, pr ction of the landscape and the environment has gained special and ever increasing significan gineers are called on to pull out all the stops here. For the ICE new route between Frankfurt and Colog instance, some 33 hectares of woodland had to be destroyed in the Greater Frankfurt area; howev order to compensate for this, the Deutsche Bahn AG planted 142,500 new trees on a similarly large are is represents one of the largest compensatory projects ever undertaken in the German federal state essen and at the same time is the biggest reforestation undertaking in this region for centuries. Alongsi ch highly positive effects, unfortunately, mistakes are also made. Thus it should not happen - as it d Europe recently - that in conjunction with the constructing of a two tube rail tunnel several km in len that grouting materials were used for closing the fissures in the rock, which to a large degree contam ted surrounding springs and brooks. As a consequence, cattle grazing there died of poisoning wh ey used their customary watering places. The population of that area had to be supplied with drinki ater transported there in tanks for months on end. In another case, a number of lakes above a tunn ute discharged into the tunnel tube that had been headed because fissures were either closed insu ently or too late. These examples reveal the balancing act between what is strived for and what is actu achieved that is encountered in some places. Also as far as tunnelling is concerned, in the end, you mu pend on the individual and the care he takes in planning and executing a project.

INTERNATIONAL TUNNELLING ASSOCIATION

all the cases put forward as examples, tunnelling has decisively contributed to enhancing the quality in urban centres. This is also numbered among the declared aims of the ITA - International Tunnelli sociation. This international tunnelling organisation currently has 45 members throughout the world not simply made up of industrial nations, many developing countries also belong to it, for which t vantages of subsurface construction are also evident: As far as these countries are concerned, how r, the construction of supply and disposal lines below the surface initially create the most urgent pre isites for a decent life in these multimillion cities which are concentrated in nstricted areas, free of the danger of disease and social tensions. First, once ese basic needs have been fulfilled, will it be possible that in the long run the proved and extended exploitation of subsurface space will come to terms with e immense traffic problems besetting the built-up areas of Asia and Latin nerica.



order to promote the utilisation of subsurface space to the advantage of the pulations of the developing countries as well, the ITA is co-operating closely with e United Nations and its sub-organisations. This, first and foremost, applies to e field of activities of the UNCHS - United Nations Centre for Human ttlements. In internationally composed working groups, the ITA provides experts m its member countries as well as from other interested countries, the opportunity for a comprehen

nstruction, health and safety in tunnelling, mechanised tunnelling, the application of shotcrete, unde
ater tunnels, long tunnels at major depths, maintenance and repair of subterranean structures, tunnelli
d the environment, contractual procedures for subsurface construction as well as research and dev
pment.

CONSTRUCTION METHODS, SAFETY AND RESPONSIBILITY

e geology and topography which are encountered decisively influence the construction methods ch
n to build a tunnel. In this connection, we have to distin-
ish between tunnelling in soft ground and in solid rock.

r soft ground tunnelling, there are typical methods which
e applied. These include all kinds of variants of cut-and-
ver construction methods, shotcreting in combination
th additional supporting measures geared to improve the
aring capabilities in the surrounding ground as well as
echanised, shield-supported tunnelling. The latest most
ectacular examples for the application of shield-suppor-
d tunnel boring machines are the drives for the Trans Tokyo Bay Tunnel in Japan as well as the 4th El
nnel Tube in Hamburg. The last-mentioned project is being headed over a distance of 2.6 km with t
ggest shield diameter ever used amounting to 14.2 m (Fig. 5)

nnels in solid rock are usually driven as drill + blast projects making use of the shotcreting method. F
ng-distance links, the cross-sections amount to maximum excavated areas of 100 to 150 m2. The he
ng is undertaken in a number of sections depending on the strengths of the rock encountered, shou
e conditions be especially tricky, then divided up into several wall, roof and base tunnels. Howev
echanised tunnelling with boring machines is being increasingly applied for tunnels through rock as we
ongside high rates of advance, it, above all, caters for improved safety for the tunnelling crews.

goes without saying that underground construction measures pose high demands on technologic
perience as well as call for a highly responsible approach. Considerable differences exist in this respe
mpared with building activities on the surface. The geologists, geo-technicians and engineers, involv
planning and execution, must on no account succumb to the temptation of constantly further extendi
e limits of what is possible or supposed-ly possible. Over-assessment of one's own capabilities, co
d time pressure can then easily lead to setbacks. Such experiences have been made repeatedly of la
this conjunction, let us recall the tragic tunnel cave-in in Munich as a result of which an articulated b
l into the ensuing crater as well as the major earth collapses at London's Heathrow Airport or during t
ilding of the Sao Paulo metro in Brazil.

ainst this background, tunnellers must recognise their limits well in time and keep their sights train
the high degree of responsibility they bear for the crews working underground as well as for the re
nts and road-users above the tunnel route. Accidents, such as those that were mentioned, can all t
sily result in tunnelling, which from its very nature represents an effective and beneficial tool design
improve traffic and living conditions in our cities, receiving a bad reputation. Such a state of affairs c
cur very rapidly even if no tunnelling accidents worth mentioning have taken place for years or decad
end. The main task of the ITA as well as the national tunnelling associations in the years ahead will th
directed at - in addition to technical improvements - bettering the image of subsurface construction
e general public and consolidating confidence in tunnelling techniques and their application.

SUMMARY AND FUTURE PROSPECTS

ties which are capable of functioning both in social and hygienic terms form the prerequisite for a dece
e in built-up areas. This also necessitates the utilisation of under-ground space to an ever increasi
tent. The optimised translation of systematic underground development planning in our cities is o
ssible through applying the means presented by modern tunnel and line construction.

in all, it can thus be determined that subsurface construction has lost none of its topicality world-wic
deed it is actually gaining in significance. In economic terms, it represents a growth branch of indust

order to avoid possible misunderstandings, it must be clearly stated at this point that we are not conc d with building tunnels at all cost. However, there is no real alternative to constructing tunnels in mo ses when it comes to traffic links and the safe use of congested areas in large cities. This is impres ly reflected by the extremely positive examples of a large number of downtown areas in European, Asi d North and Latin American built-up areas. However, it is not at all essential to set up straddling rap nsport systems underground in medium-size cities. Instead considerable improvements can already hieved by ensuring that public transportation is operated underground along central lines in the core city only.

a nutshell, it can thus be said that the development of core areas in many big cities through the routi public commuter traffic as well as important road links via underground facilities clearly reflects the po e effects of subsurface construction. ITA working groups, which examined such issues on an intern nal basis, have been able to compile numerous examples of this. In a well considered fashion and taki st-benefit aspects into account, these opportunities should therefore also be exploited free of ideo es in future so that our cities become more worthwhile to live in and more loveable.

ten tunnels represent the sole alternative for crossing mountain ranges and waterways if large-sca nsport links have to be established. In many cases, cross-border projects are at stake. As a cons ence, effective co-operation on a political level as well is thus of decisive importance.