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# Health and Safety in Swiss Tunnelling

Santé et sécurité dans la construction de tunnels en Suisse

Gesundheit und Sicherheit im Tunnelbau in der Schweiz

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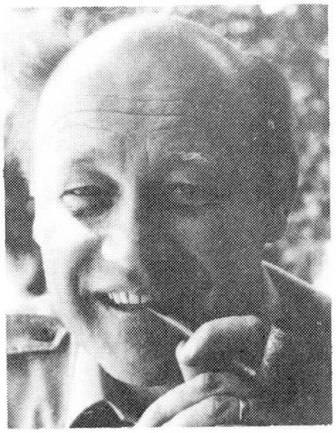


Robert Fechtig, born 1931, got his civil engineering diploma at the Swiss Federal of Technology (ETH) in 1956. Two years in water works construction in Sweden. Two years as a research assistant at the ETH. In construction firm Zschokke 1960 – 1981, active in the field of large civil engineering projects and especially subsurface projects. Professor of construction engineering and management at the ETH since 1981.

**SUMMARY**
The introduction shows the basic law for Swiss accident protection; its structure is given and the specific laws, ordinances and guidelines for tunnelling accident protection are explained, as well as the financial resources and the whole organization. Four actual examples illustrate the problem of tunnelling accident protection and conclusions are made.

**RESUME**
L'article présente les bases légales de l'assurance suisse contre les accidents professionnels. Il mentionne les directives, règlements et lois dans le domaine de la prévention des accidents lors de la construction de tunnels. Il mentionne également les moyens financiers et l'application de ces règlements. Quatre exemples choisis illustrent le problème de la protection des accidents dans la construction des tunnels.

**ZUSAMMENFASSUNG**
Einleitend werden die gesetzlichen Grundlagen des schweizerischen Unfallschutzes erläutert und deren grundlegender Aufbau dargestellt. Es folgt die Nennung von Richtlinien, Verordnungen, Gesetzen für den Bereich des Untertagebaues unter Einbezug der finanziellen Mittel und der Art und Weise der personellen Durchführung. Anhand von vier ausgewählten Beispielen des Tunnelbaues wird das Thema abgerundet und zum Gesamtproblem Schlussfolgerungen gezogen.

## 1. INTRODUCTION

Each country has its own way of organizing its activities towards better health and safety of its workers and of providing adequate accident prevention during the works in progress. Let me present a short general survey of health and safety in Switzerland and then let me deal with the specific questions concerning tunnelling.

**BREAK DOWN OF THIS PRESENTATION**

- BASIC LAW FOR SWISS ACCIDENT PROTECTION
- STRUCTURE OF THE SWISS ACCIDENT PROTECTION
- BASES FOR TUNNELING ACCIDENT PROTECTION
  - LAW/ORDINANCES/GUIDELINES
  - FINANCIAL RESOURCES
  - ORGANIZATION
- ACTUAL EXAMPLES OF TUNNELING ACCIDENTS PROTECTION
- CONCLUSIONS

Fig. 1
Break-down of this presentation

## 2. BASIC LAW FOR SWISS ACCIDENT PROTECTION

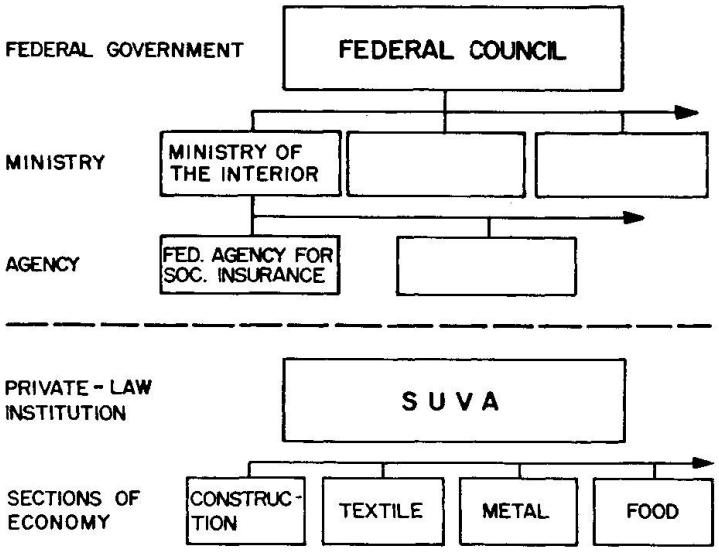
Since 1911 the Swiss law provides a particular basis for health and safety at work.
The law in question is called SAIA (Sickness and accident insurance act).

The law stipulates (in Art. 65.1) that all company owners or employers are responsible for protecting their employers from accident and occupational diseases.

The Government had to create the necessary organizational structure to ensure the implementation of the accident protection act.

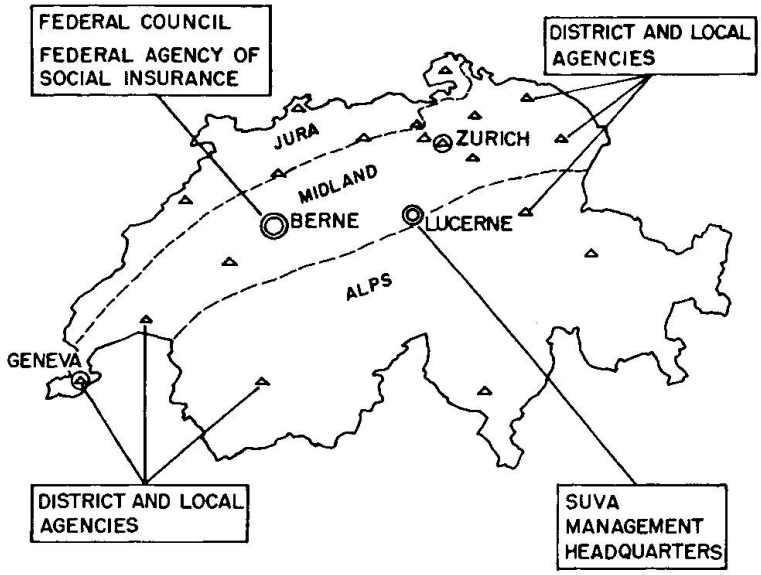
## 3. STRUCTURE OF THE SWISS ACCIDENT PROTECTION

In 1918, the Swiss Accident prevention agency was established in Lucerne. This insurance organization is not a Federal agency, but a public company for the purpose defined in the sickness and accident insurance act. The concept of the structure and the procedures of this organization are described in both the sickness and accident insurance act and the organizational directives of the Swiss accident prevention agency Board.



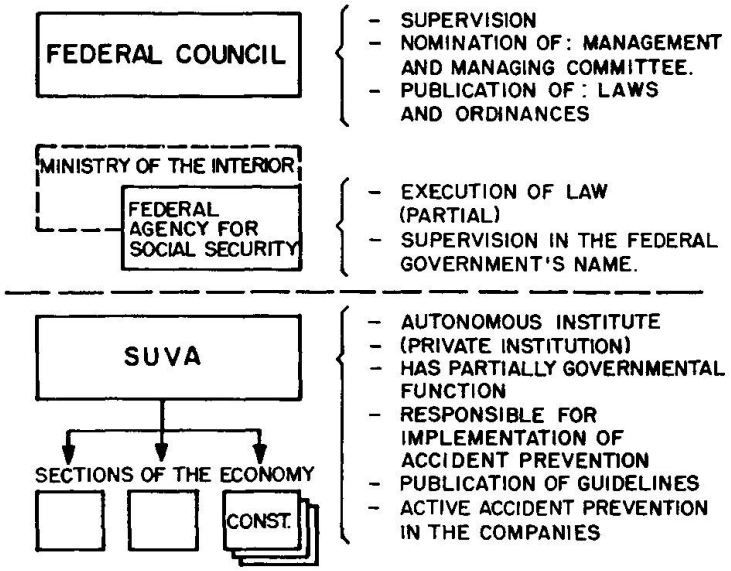

ORGANIZATIONAL STRUCTURE

Fig. 2
Organizational structure (according to the sickness and accident insurance act)




GEOGRAPHICAL DISTRIBUTION

Fig. 3
Geographical distribution




RESPONSIBILITIES/PARTICULARITIES

Fig. 4
Responsibilities/Particularities

## 4. BASIS FOR TUNNELLING ACCIDENT PROTECTION

### 4.1 Law, ordinances, guidelines

Many ordinances and guidelines were created and became effective within the last seventy years. They are based on the sickness and accident insurance act. The rapid technical development during the last thirty years, however was responsible for most of them.

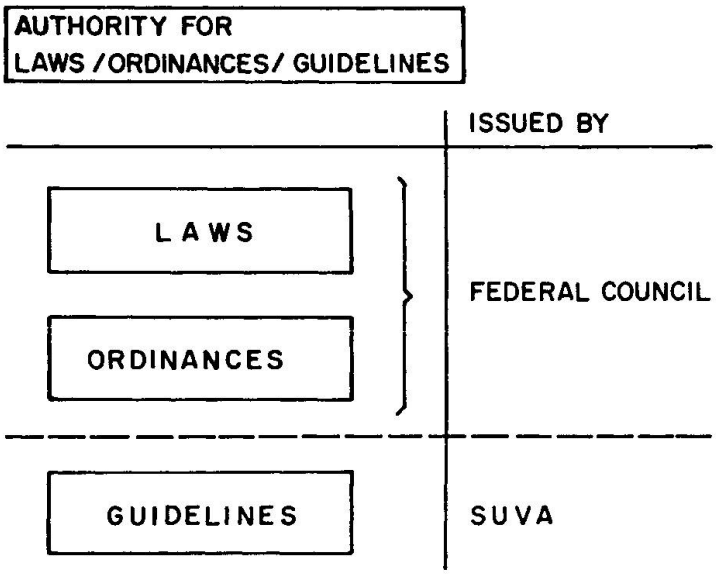



Fig. 5
Authorization for laws, ordinances and guidelines

**TUNNELLING**
**IMPORTANT H+S DOCUMENTS**

| SUVA FORM Nr. | DATE OF LAST ISSUE | L | O | G | LAW ORDINANCES GUIDELINES |
|---|---|---|---|---|---|
| 1382 | 15. 2.57 | | X | | CABLE CARS |
| 1420 | 22. 6.51 | | X | | CRANES |
| 1425 | 08. 9.48 | | X | | SILICOSIS |
| 1471 | 25. 3.77 | X | | | EXPLOSIVES |
| 1484 | FEB. 77 | | | X | VENTILATION |
| 1497 | NOV. 72 | | | X | FIRE AND EXPLOSIVES (GAS) |
| 1520 | 23.12.60 | | X | | OCCUPATIONAL DISEASES |
| 1574 | JULY 71 | | | X | EARTHMOVING + TRANSPORTMACH. |
| 1796 | 8. 8.67 | | X | | ACCIDENTS |
| 1845 | JULY 77 | | | X | CRANES |
| 1923 | JULY 71 | | | X | SILICOSIS |
| 1974 | FEB. 73 | | | | HUMID HOT CLIMATE |
| 1977 | FEB. 78 | | | X | ACCIDENTS |

Let me summarize some of the important documents for tunnelling:

Fig. 6
Important documents for the protection of tunnelling accidents

### 4.2 Financial resources

Like any other insurance company, Swiss accident prevention agency needs financial resources for achieving its objectives.

The law stipulates that Swiss accident prevention agency shall collect premiums to pay for the settling of insurance claims and administration costs.

The premium rates vary according to the professions and the risk of the workers involved. The rates are calculated at %o-part of the total amount of wages.

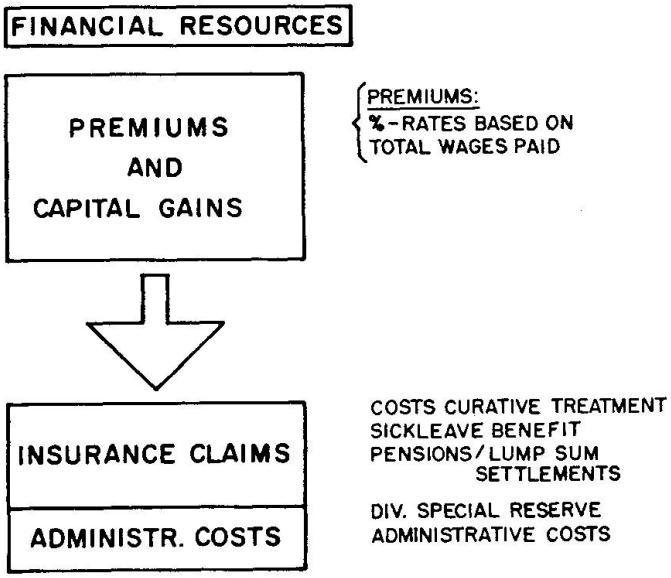



Fig. 7
Use of financial recources

A survey over the whole of Swiss accident prevention agency shows the following figures, if we intend to compare the total of Swiss accident prevention agency's field of activity with its construction part.

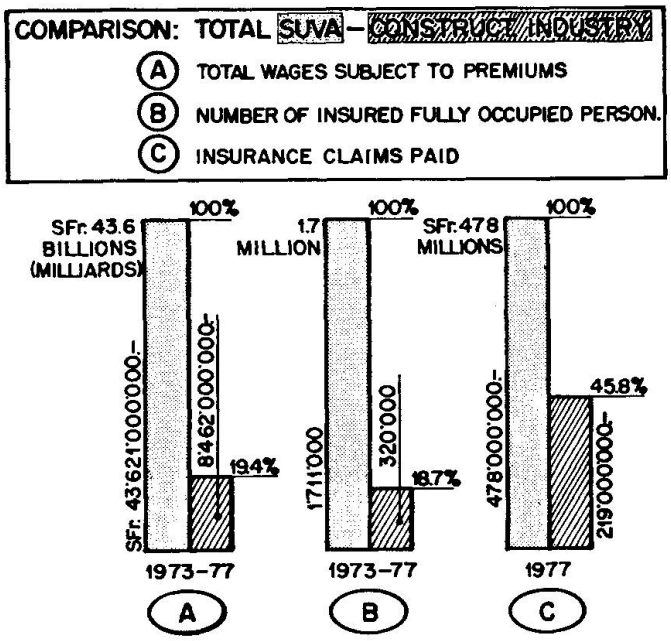



Fig. 8
Comparison of Swiss accident prevention agency as a whole with the construction industry:
- total wages subject to premiums
- number of insured fulltime employees
- insurance claims paid

How much is the amount of premiums paid by the construction industry? Until 1971, each company had to pay at an individual rate (percentage of the total wages paid) according to the risk appraisal of Swiss accident prevention agency. Since 1971, all companies of the construction industry are paying at the same rate of 4,3% of the total wages. However, companies which do not fulfill their obligations of accident prevention on construction sites and act against regulations, will have to pay a surcharge of 0,5 to 1,5%. This increased rate will be imposed regardless of the number of accidents happening on the sites of that company.

A tunnelling construction company is paying premiums in the same way companies engaged in the construction of bridges, hydraulic works, building or roads are paying theirs.

## 4.3 Organization

SUVA's staff (S.A.P.A.) is made up of specialists of a great number of different professions.
Each sector is responsible for enforcing the ordinances in their field and for convincing the various companies of the Swiss industry to apply the corresponding guidelines.

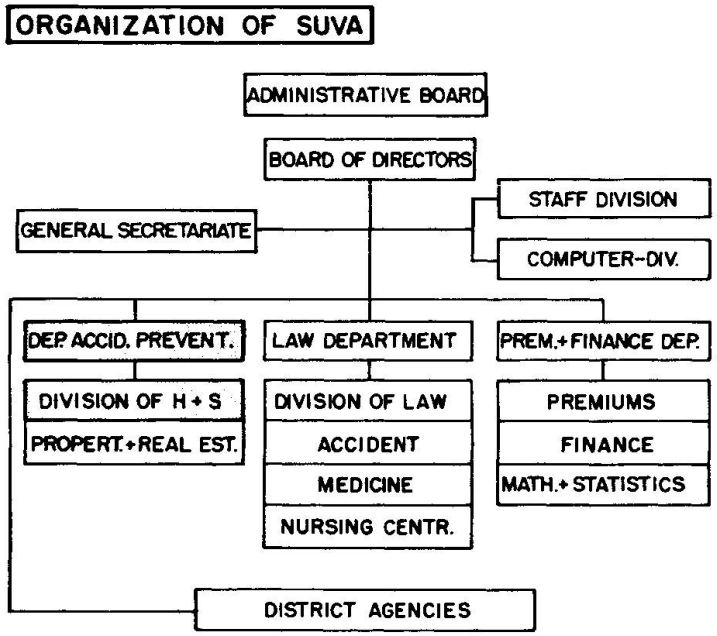



Fig. 9
Organization of SUVA (SAPA)

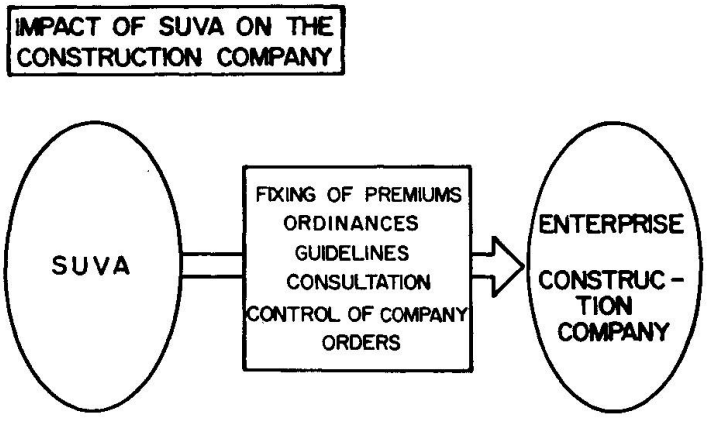



Fig. 10
SUVA's impact on the construction company

SUVA (SAPA) officials are checking both privat and public companies in their field with regard to the health and safety protection of their employees.

There are no detailed accident statistics in the construction industry - this means that an exact basis for specific accident prevention doesn't exist in this branch of industry.

Apart from surveys of the common problems of accident prevention in tunnelling (such as protection from falling stones or rocks, control of dust, the use of explosives) various Swiss galleries and tunnels have been systematically investigated during the last years as to the existence of Radon. Radon was found in zones of cristalline rock in the Alps. Therefore, the question of ventilation has to be studied very carefully.

## 5. CURRENT EXAMPLES OF ACCIDENT PREVENTION IN TUNNELLING

### 5.1 Historic development

Due to the very complex geology of Switzerland (over a region of 41'300 km2) the development of tunnelling systems shows great diversity.

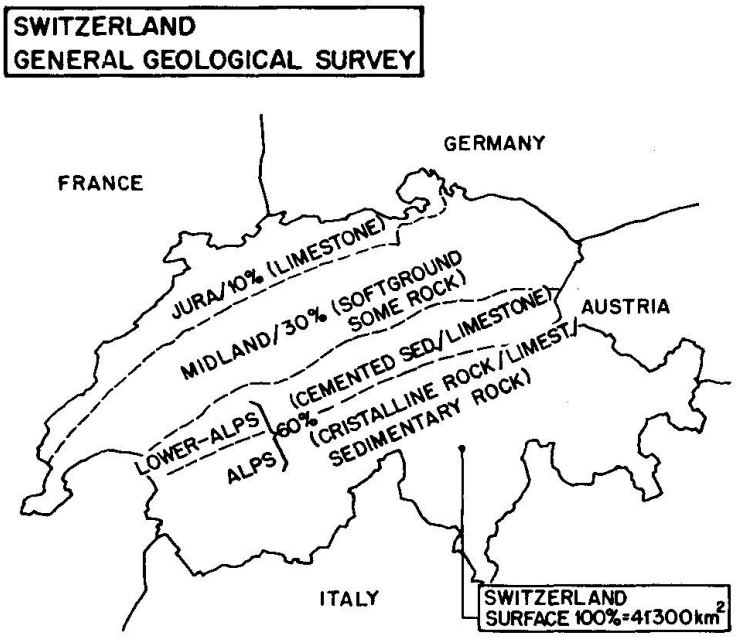



Fig. 11
Geological survey of Switzerland

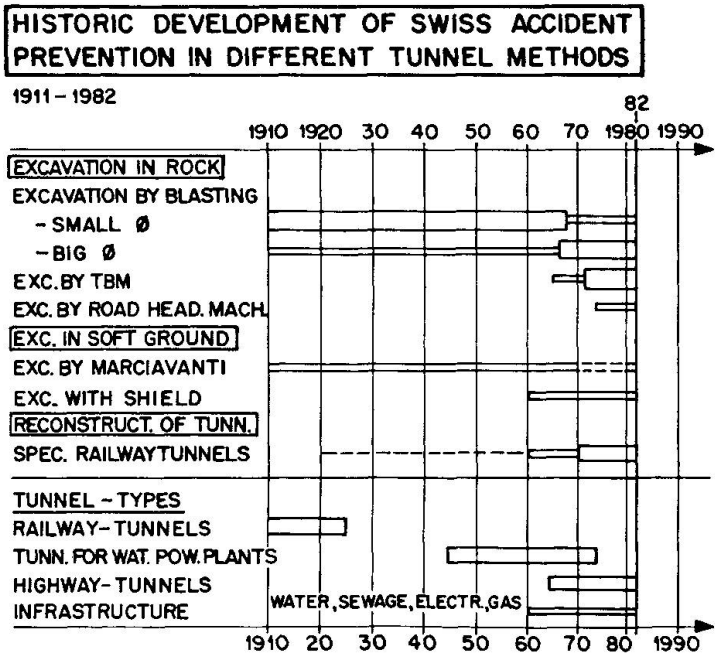



Fig. 12
Historic development of Swiss accident prevention of different tunnelling methods

During the last seventy years the main aspects of accident prevention have changed continously along with the development of tunnelling construction methods.

## 5.2 Current

**SUMMARY OF THE ACTUAL EXAMPLES**

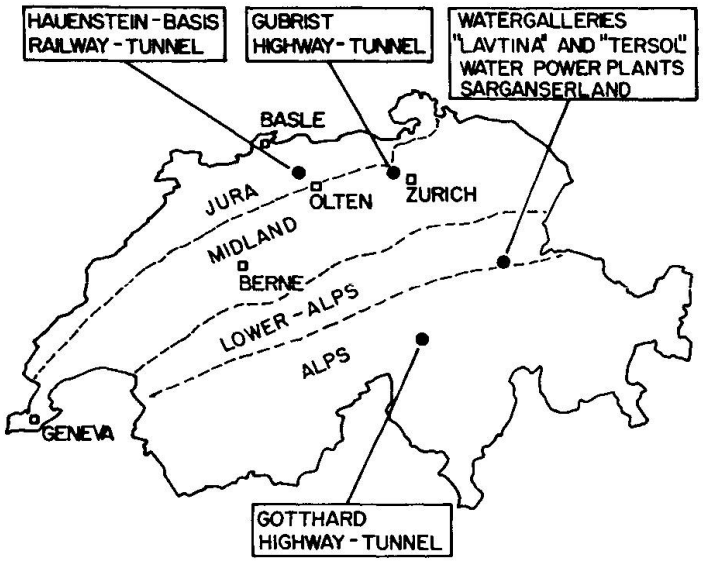



Fig. 13
Survey of current examples

a) Tunnelling in extreme parts of the Alps - water gallery "Lavtina" and "Tersol" of the waterpower plant "Sarganserland"

- Gallery Lavtina: Excavation ø 3.50 m with TBM
  Length 6'000 m
- Gallery Tersol: Excavation 6 m2 conventional excavation
  Length 1'300 m

**WATER POWER PLANT SARGANSERLAND**
**WATERGALLERY "LAVTINA" UND "TERSOL"**

**MAIN DANGERS:**

AVALANCHE (IN WINTER):
DANGER FOR ROADS AND ACCESS ROADS
DANGER FOR OFFICES / LODGEMENT / WAREHOUSE

HIGH TENSION (IN THE GALLERY 6000 VOLT):
SECURITY FOR THE ELECTRICAL INSTALLATION

GALLERY SECTION (WITH TUNNEL BORING M.):
LIMITED SPACE
DURING MACHINE OPERATION NO WALKING IN THE GALLERY
DANGER OF ROCK BREAK DOWN (BY 1000m ROCK-COVERING)

FIRE:
DANGER OF FIRE FOR TRANSFORMER
DANGER OF FIRE FOR OFFICE / LODGEMENTS

Fig. 14
Main dangers of the Lavtina site

b) Tunnelling in the Alps

Gotthard Highway Tunnel / National Highway N2

| | |
|---|---|
| Length | 16'322 m |
| Excavation section | |
| savety gallery | 6,5 m2 |
| Main tunnel north | 69 - 86 m2 |
| south | 83 - 96 m2 |
| Excavation method | blasting |

Vertical- and inclined shafts (for ventilation): 4 shafts

| | |
|---|---|
| Length | 304 - 844 m |
| Excavation diameter | 6,2 - 7,7 m (circle) |
| Excavation method | by TBM |

**GOTTHARD HIGHWAY – TUNNEL**

**MAIN DANGERS:**

AVALANCHES (IN WINTER):
- DANGER FOR APPROACHES
- DANGER FOR TECHNICAL INSTAL. (OUTSIDE THE TUNNEL)

BREAK DOWN OF ROCK:
- BY EXCAVATION IN THE WHOLE SECTION
- BY EXCAVATION IN CHAMBERS
- IN VERTICAL AND INCLINED SHAFTS

DANGER OF FALLING OFF:
- IN VERTICAL AND INCLINED SHAFTS
- ON HIGH FORMWORK CONSTRUCTIONS

DANGER OF COLLISION:
- BY THE TRANSPORT OF MUCK
- BY RESTRICTION OF PASSAGE

DANGER OF FIRE:
- FOR LODGEMENTS / OFFICE / WAREHOUSE

Fig. 15
Main dangers at the Gotthard site

c) Tunnelling in the Swiss Midland Area

Gubrist Highway Tunnel:

| | |
|---|---|
| Length (2 tubes at 3'300 m) | 6'600 m |
| Excavation section | 103 m2 |
| Excavation method | by TBM |

**GUBRIST-HIGHWAYTUNNEL**

**MAIN DANGERS:**

- HANDLING OF HEAVY MACHINE-CONSTR-PIECES
- HANDLING OF PREFABRICATED PIECES (ON STORAGE YARD AND IN TUNNEL)
- HEAVY TRANSPORT (MUCK AND PREFABRICATED PIECES)
- PASSAGE-RESTRICTION DUE TO THE TUNNEL FORMWORKS
- HIGH TENSION FOR TUNNEL INSTALLATION
- DANGER OF FALLING OFF:
  - THE TRAIL-CONSTRUCTION OF TBM
  - HIGH TUNNEL FORMWORK
  - THE FORMWORK OF THE SLAP

Fig. 16
Main dangers at the Gubrist site

d) Reconstruction / Restauration of tunnels

Hauenstein Basistunnel

Doubletrack railway tunnel of the Swiss Federal Railways (SBB)
Length 8'000 m

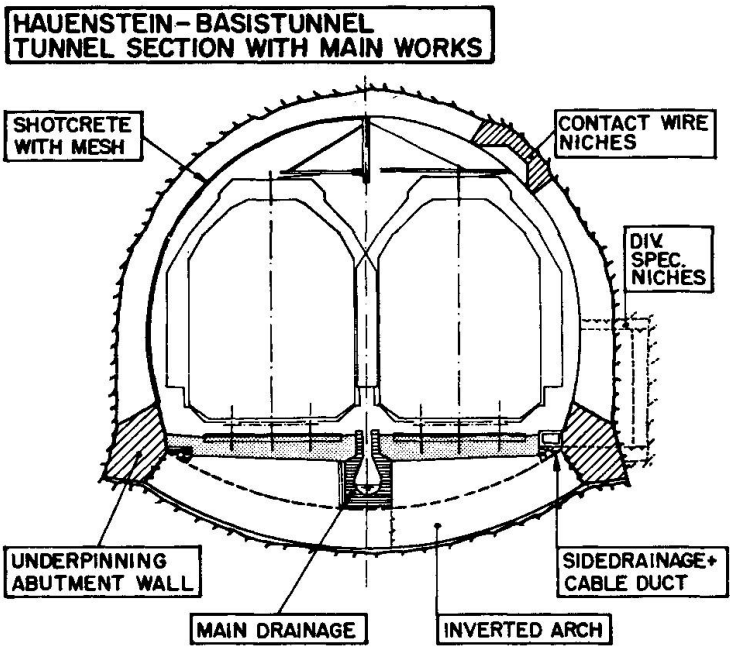



Fig. 17
Tunnel section showing the principal operations

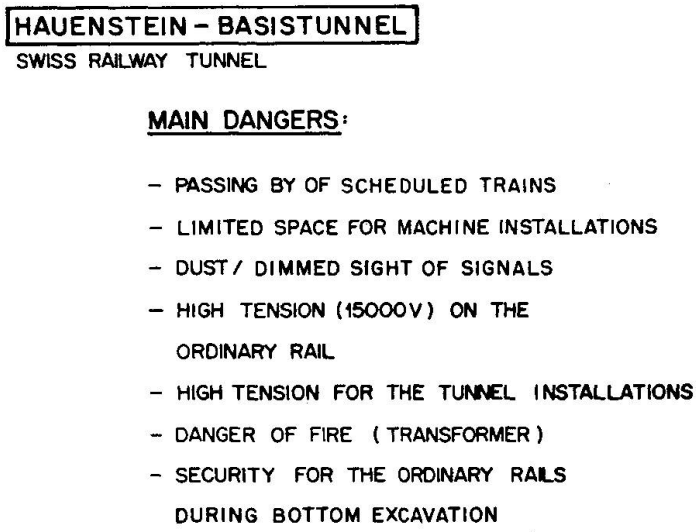



Fig. 18
Main dangers at the Hauenstein-Basistunnel

## 6. CONCLUSION AND OUTLOOK

Nearly 50% of the total annual accidents occur in the construction industry. As detailed accident statistics are missing, it is imperative to create computer based statistics in the near future, to improve the prevention of accidents. Less accidents in the construction industry are of great interest from the point of view of human health and for economy reasons. The tunnelling world is sure to participate in these efforts.

In the following years more attention has to be paid to the Radon problem in tunnelling works in different zones of the Alps. So far, lasting Radon damages have not been found in workers at Swiss tunnelling sites. Radon protection will nevertheless form an integral part of tunnelling health and safety measures in the near future.

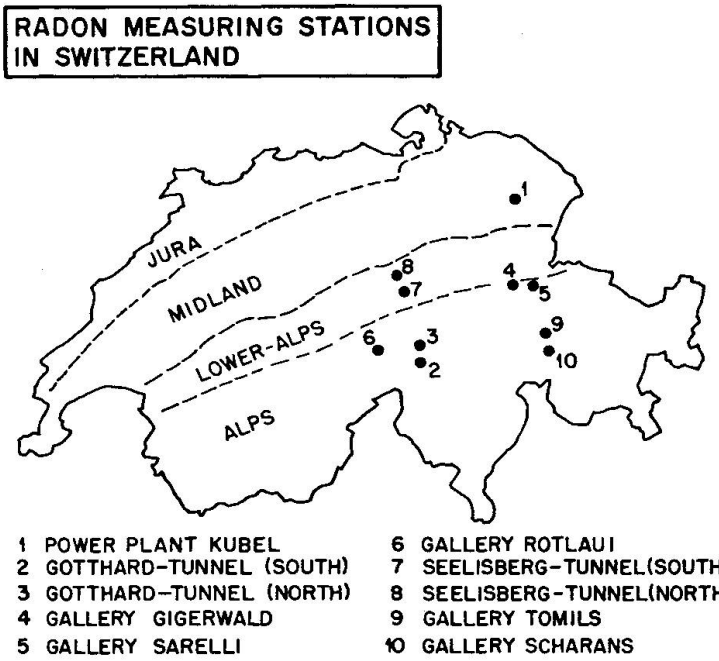



Fig. 19
Radon measuring stations in Switzerland

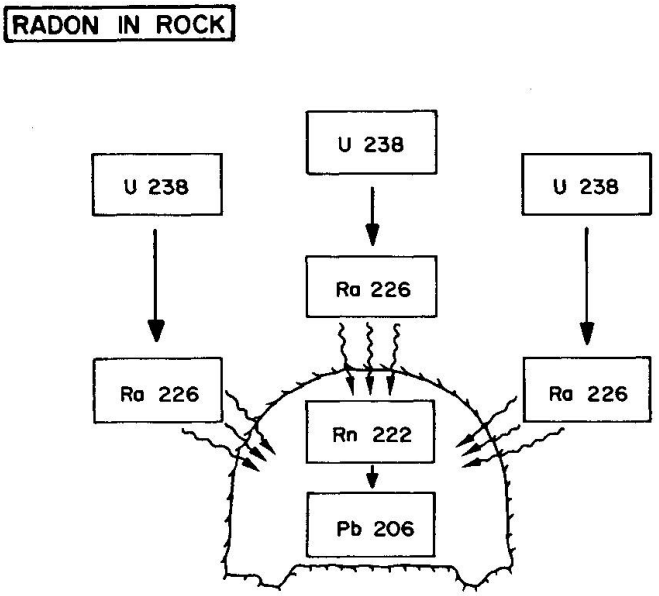



Fig. 20
Radon in rock

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