

- Literature concerning spoil management
- Spoil = waste ?
- Need of new aggregates resources
- Use of spoil at the Gotthard Base Tunnel
- Key points for a successful material management
  Spoil management 1882





#### **B+ G AG Concrete Technology + Spoil Management**

1992 bis ETH Zürich: PhD on the use of TBM rock 1996: excavation material as aggregates for concrete

#### **Tunnel projects:**

- CH: AlpTransit Gotthard (57km Length)
  - AlpTransit Lötschberg (35km Length)
  - Nagra (National Cooperative for the Disposal of Radioactive Waste)
  - Bypass Luzern (3km Length)
  - Gotthard Second Road Tunnel (17km Length)
  - Albula II (6km Length)
  - Gletschergarten Luzern (Cavern system)
- F/I: TELT Lion-Turin-Ferroviaire (84km Length)
- AT: Koralm (33km Length)
  - Brenner Base Tunnel, Lot Pfons-Brenner (18km)

### Pump storage plan:

- CH: (ATEL/SBB): Nant de Drance
  - (REPower): Lago Bianco
  - (AXPO): Kraftwerke Linth Limmern, incl. dam
  - (KWO): Spitellam, new concrete dam
- Nepal: (Government): Budhigandaki Hydroelectric
- EU Proj.: European research project FP7 Nr. 308389 DRAGON (Development of ressource-efficient and advanced underground technologies, 2012-15; www.dragonproject.eu)

#### **Commissions:**

- VSS/SNV: President NFK 3.1: Aggregates
- CEN/TC 154: Aggregates Swiss Delegate
- SIA 162: Swiss Concrete Standards
- ITA AITES: International Tunneling and Underground Space Association.

Animateur WK15 "Underground and Environment"





PROJECT	COUNTRY	CONDITIONS		TUNNELLING METHODS			DAM SITE	
		Rock	Soil	D&B	твм	NATM	Rock	Soil
Brenner Base Tunnel	AT	Ø			Ø			
KoralmTunnel	AT	0	Ø		0			
Semmering Railroad Tunnel	AT	0	Ø	0	Ø	Ø		
Northside Storage Tunnels	AU	0		0	Ø			
Niagara Tunnel Project	CA	0			Ø			
BosslerTunnel	DE	0		0	0			
FidlerTunnel	DE	0		0	Ø			
Gotthard Base Tunnel	СН	0		0	0			
Nant de Drance	СН	0		Ø				
Lötschberg Tunnel	СН	0			0			
Les Farettes	СН	0			0			
GavetTunnels	FR	0		0	Ø			
St. Jean-de-Maurienne (LTF)	FR+IT	0		0	Ø			
Crossrail	GB		0		0			
A1 Andora – San Lorenzo Railway	П		Ø		ø			
Bologna RailwayTunnels	IT		Ø		Ø			
La Maddalena (TELT)	П	Ø		Ø	Ø			
Follo Line RailwayTunnels	NO	Ø		0	Ø			
Førsvatn Earth and Rockfill Dam	NO						Ø	
Kjela Hydropower Plant	NO			0				
OREA Sewer Plant Expansion	NO	Ø		Ø				
Rosten Hydroelectric Power Project	NO							
Vestfold Railway Line	NO	Ø		Ø				
Bay Delta Conservation Plan (water)	US		Ø		Ø			
Brightwater Tunnels (CSO)	US		0		0			
NYC Second Avenue Subway	US	0		0	0	0		
Port of Miami HighwayTunnel	US		Ø		Ø			
Portland West Side CSO Tunnel	US		0		0			
SR 99 Highway Tunnel	US		Ø		Ø			
Suhua Highway Improvements	TW	0				0		
Caopu HighwayTunnel	TW	Ø		0		٢		
Taiwan High Speed Rail								







### **TUNNEL SPOIL = WASTE?**



- In European countries tunnel spoil material is categorized for the purpose of the laws regulating as waste disposal...
- The goal of avoiding waste has become more important with the implementation of the Waste Framework Directive 2008/98/EC at the end of 2010.
- Recycling of material excavated from tunnels is thus more than ever an important issue.



### **TUNNEL SPOIL = WASTE?**

Possible anthropogenic	Drill & Blast		ТВМ		
pollution	Pumped	Cartriged	Convent. Lining	Segment	
Explosive cords, plastic, wood, etc.					
Shotcrete rebound, Steel fibres					
Chromium VI (cement)					
Nitrite / Ammonium					
Hydrocarbon		I			



### **TIME IS RUNNING OUT FOR SAND & GRAVEL**





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Cédric Thalmann, www.BplusG.ch



 AlpTransit tunnel projects as a pioneering role (Lötschberg)

 Pumped storage plant: (AXPO) Linth Limmen Power Plant (2500 meters above sea level)





### SPOIL MANAGEMENT: THE EXAMPLE OF GOTTHARD BASE TUNNEL





### **KEY POINTS TO THE SUCCESSFUL SPOIL MANAGEMENT**

- 1. Motivated client to handle the issue of spoil management plant.... Elaboration of spoil management concept
- 2. Competent planners, innovative solutions
- 3. Weighing not only economic but also ecological arguments: Transports, energy (LCA, CO2, etc.)
- 4. Careful preliminary investigation about quantity and quality
- 5. Active spoil management leads to goodwill and acceptance of the population (major public attraction: loading stations, gravel plant)
- 6. Spoil management contractual models



### TO POINT 1. "MOTIVATED CLIENT"

- The topic of spoil management is often underestimated, neglected and/or approached too late...
- The client transmits the topic of spoil management to the tunnel builder, Example:
  - Note 6: the tunnel builder takes over the construction waste, the demolition and the excavation materials and he **becomes the owner of these materials**.
  - The tunnel builder is responsible for the proper and professional disposal or recycling.
  - The **necessary tests** for the clarification of the suitability of the resulting materials are in the **responsibility of the contactor**. The corresponding **costs must be included in the prices**.



### TO POINT 1: ELABORATION OF THE SPOIL MATERIAL MANAGEMENT CONCEPT





### TO POINT 1: ELABORATION OF THE SPOIL MATERIAL MANAGEMENT CONCEPT

- Objective: Proof of feasibility
- 1 Introduction
- 1.1 Purpose
- 1.2 Scope
- 1.3 Information Required
- 2 Consistency with Traffic and Access Management Plan
- 3 Spoil Production
- 4 Material Types
- 4.1 Classification
- 4.2 General solid waste or other classifications
- 5 Spoil Reduction, Reuse and Disposal
- 5.1 Spoil Management Hierarchy
- 5.2 Reuse of Spoil
- 5.3 Monitoring and Reporting
- 5.4 Reuse within the Project
- 5.5 Reuse in environmental works/community works
- 5.6 Reuse in development works/land restoration

- 6 Spoil On-site Management
- 6.1 Tunnel Spoil Stockpiles
- 6.2 Spoil stockpiles at temporary decline excavations
- 6.3 Other Spoil Stockpile Locations
- 6.4 Stockpile Management
- 7 Spoil Disposal and Reuse Locations
- 7.1 Approval of Spoil Offsite Reuse Locations
- 8 Spoil Transport
- 8.1 Spoil haulage routes
- 8.2 Spoil tracking
- 9 Review and Improvement
- 9.1 Continuous Improvement
- 9.2 Update and Amendment



### **TO POINT 2. COMPETENT PLANNERS, INNOVATIVE SOLUTIONS**

## Simple, flexible systems. Dry preparation (if possible). New processing technologies and further developments in concrete technology.

### Les Farettes (Romande Energie)

- Total spoil 135,000 t
- aggregates 50'000 t
- Dry preparation

### Muttsee Linth Limmern (AXPO)

- Total spoil 1.7 mio. t
- Aggregates 1 mio. t
- Dry preparation (dam)





### **TO POINT 3: ECONOMY VS ECOLOGY**



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### **TO POINT 3. COSTS**





Material tests on drill cores, surface samples

Sondage 56	Sondage 58	Sondage 59	Échantillon de
Échantillon:	Échantillon:	Échantillon:	surface
n° 1	n° 2	n° 3	Échantillon:
370.0 – 371.6 m	517.0 – 518.0 m	296.0 – 297.0 m	n° 4
Riting     M*12       Sibe - 147.60     6.5.75	Hym Tentin 66.05.13 B1G 171-511E M Sg	59 B+6 296- 257 M C6. 05. 13	





NFF / TBM APPLIVATION III



- EN 12620: Aggregates for concrete
- EN 933-3: Flakiness Index
- EN 933-6: Flow coefficient of aggregates
- EN 1097-2: Methods for the determination of resistance to fragmentation
- EN 1097-3: Determination of loose buld density and voids
- EN 1097-6: Determination of particle density and water absorption
- EN 1367-1: Determination or resistenz to freezing and thawing
- EN 1367-2: Magnesium sulfat test
- EN 1744-1: Chemical analysis
- SIA MB 2042: Prevention to Alkali-Aggregate-Reaction

Usefull as first indication, but: more important is to fulfil the concrete requirements





Granodiorit  $\sigma = 250 \text{ N/mm}^2$ 



# TO POINT 5. ACTIVE SPOIL TREATMENT PLANT LEADS TO GOODWILL AND ACCEPTANCE OF THE POPULATION

Public attraction: loading stations, gravel plant, concrete plant





### **TO POINT 6: SPOIL MANAGEMENT - CONTRACTUAL MODELS**

- Spoil management concept needs a lead time (at least 2 years)
- Underground basically belongs to the client
- Proof of feasibility (incl. preliminary tests) of the client to show the usability
- The client determines the spoil quality during the excavation (together with tunnel builder)
- Tunnel and spoil preparation lot: possible as combination lot or separate single lots or mixed form (spoil preparation lot is integrated into the tunnel lot)
- Tunnel builder has little interest in spoil processing
- Only few tunnel builder that offers tunnelling combined with spoil processing
- Create incentives for the tunnel builder to be "interested" spoil processing E.g. by free delivery of the spoil



### **INNOVATIONS IN SPOIL MANAGEMENT**

DEVELOPMENT OF RESOURCE-EFFICIENT AND ADVANCED UNDERGROUND TECHNOLOGIES

#### www.dragonproject.eu



Automatic analysis of raw material quality (chemical and physical) Automatic sorting in quality classes



### SPOIL MANAGEMENT FACTORS VS SERVICE TUNNEL LIFE





### **GLÜCK AUF!**

### **Progress is not possible without deviation** from the standards....

(Frank Zappa «I am the American Dream» 1988)

