19th Australasian Tunnelling Conference – Acosta-Martínez, Stewart and Hudson-Smith (Eds.)
© 2025 Australian Tunnelling Society, ISBN 978-0-85825-002-4

Advanced spoil management in Gotthard Lot 111: Integrated solutions for a challenging alpine tunnel project

P.A. Scherwey
Marti Technics, MEA-APAC

ABSTRACT: The construction of the second tube of the Gotthard Road Tunnel, part of a monumental infrastructure upgrade connecting northern and southern Europe, presents significant challenges in material handling and spoil management. Located in a narrow Alpine valley traversed by one of the busiest highways in Europe, the project demands innovative solutions to handle vast quantities of excavation material while ensuring minimal disruption to traffic and the environment. This presentation will provide an in-depth exploration of the large belt conveying systems and processing plants implemented for spoil management in Lot 111, highlighting their role in meeting these challenges

1 INTRODUCTION

The Gotthard Road Tunnel expansion project in Switzerland involves constructing a second tunnel tube parallel to the existing 16.9 km tunnel, which was originally opened in 1980. This initiative aims to enhance safety and facilitate the comprehensive refurbishment of the first tunnel. Construction of the second tube commenced in 2021, with completion anticipated by 2029. Following this, the original tunnel will undergo renovations, and both tunnels are expected to be operational by 2032, each accommodating a single lane of traffic in compliance with Swiss regulations that prohibit increasing traffic capacity across the Alps.

The Gotthard Road Tunnel serves as a vital conduit in the European transport network, linking northern and southern Europe through the Swiss Alps. By providing a year-round, direct route, it facilitates the efficient movement of goods and passengers, thereby enhancing trade and economic integration across the continent. The tunnel's strategic position reduces travel distances and times between key European regions, bolstering connectivity and supporting the broader objectives of the Trans-European Transport Network (TEN-T) in promoting seamless cross-border transportation.

2 PROJECT OVERVIEW AND LOT 111 SCOPE

Lot 111 encompasses the construction and operation of integrated systems for the transport and processing of excavated materials. The scope of works includes the implementation of conveyor belt and rail-based systems to ensure the efficient transfer of spoil from the tunnel face to designated processing or disposal facilities. It further comprises the establishment of specialized plants for the sorting, recycling, and disposal of excavated material, with particular emphasis on compliance with environmental regulations and the optimization of resource utilization. In addition, Lot 111 requires the planning and management of transportation routes and schedules to mitigate potential impacts on local communities and to minimize interference with existing infrastructure (Figure 1).


Figure 1. South spoil management facilities in Airolo

2.1 *Interfaces with Adjacent Lots:*

Interface with Lot 341 (South Portal – Executed by Marti Tunnel AG):

- Lot 341 is responsible for Tunnel Boring Machine (TBM) driven excavation from the Airolo (south) side.
- Lot 111 supports Lot 341 by receiving and processing spoil directly from TBM via conveyor systems.
- The coordination with Lot 341 includes scheduling spoil extraction, monitoring transfer capacities, and ensuring minimal disruption to the southern access routes and processing systems.
- Material from Lot 341's TBM operations is either immediately processed or routed via belt and rail systems for intermediate storage or reuse.

Interface with Lot 342 (North Portal – Executed by Implenia-Frutiger JV):

- Lot 342 manages excavation from the Göschenen (north) side using both conventional methods and a TBM.
- Lot 111 collaborates with Lot 342 by providing continuous spoil removal capacity through belt conveyors connected to processing and logistics hubs.
- Given the constrained northern valley location, spoil management here is especially critical. Lot 111's system prevents excess truck traffic on the A2 motorway, which runs alongside the tunnel portal.
- Interfaces include joint coordination on TBM performance, conveyor throughput rates, and material flow timing to avoid bottlenecks or system overload.

3 TENDERING AND CONTRACT AWARD PROCESS

The Swiss Federal Roads Office (FEDRO/ASTRA) conducted the procurement for the Gotthard Road Tunnel expansion in accordance with national and international public contracting standards. The evaluation of Lot 111 bids was based on a multi-criteria model, where technical and qualitative elements were considered just as important as cost. Key selection criteria included, technical innovation, cost-effectiveness, previous experience, environmental and safety measures. The contract for Lot 111 was ultimately awarded to the Marti Group, a Swiss civil engineering firm with extensive experience in large-scale underground infrastructure, including the Gotthard Base Tunnel.

4 SPOIL MANAGEMENT CHALLENGES AND REQUIREMENTS

4.1 *Estimated total spoil volume*

The construction of the second tunnel tube is expected to generate approximately 7.4 million tons of spoil. This includes material excavated via both TBM and conventional methods (drill-and-blast), depending on geological conditions. All the spoil will be processed, recycled, or disposed. (Figure 2)

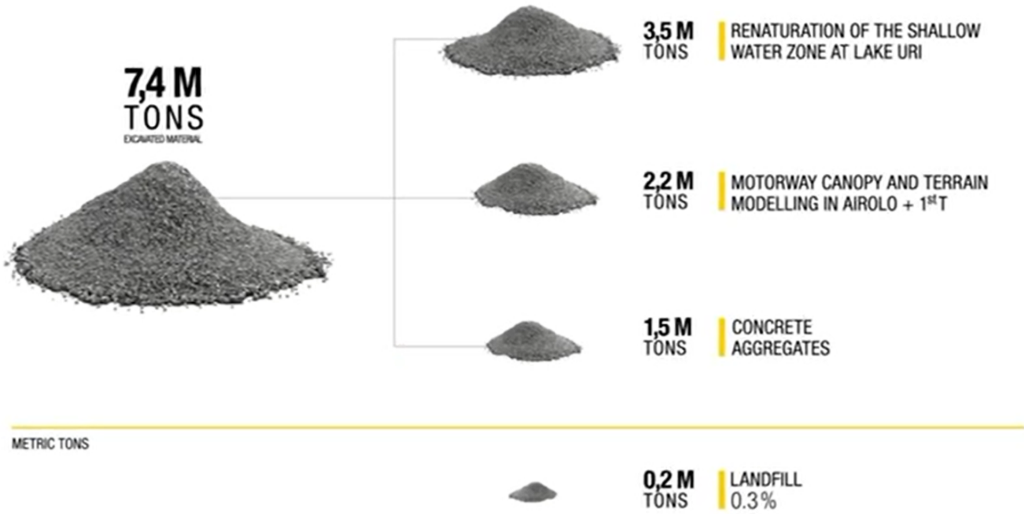

Figure 2. Spoil Bill of Quantity

4.2 *Material classification for spoil management*

To ensure appropriate reuse, recycling, or disposal of excavated material, spoil is classified into three main categories:

- Class A Material
  High-quality excavated rock, typically hard and clean (e.g., granite, gneiss), suitable for reuse in concrete production, tunnel lining segments, or structural backfill. Requires minimal processing.
- Class B Material
  Medium-grade material, such as weathered rock or mixtures with fines. Usable for non-structural applications like road sub-base or general fill, possibly with additional processing.
- Class C Material
  Low-quality or contaminated material (e.g., clay, silt, or chemically unsuitable spoil) that is not fit for reuse. Must be disposed of in accordance with environmental regulations.

4.3 *Spoil flow*

About half of this will be transported by rail to Flüelen, where it will be handed over to a subsequent lot and used for lake infill projects. The remaining A-material will mostly be processed into aggregate for concrete (approximately 1.5-1.7 million tonnes). The rest will be used as fill material, including for the Airolo highway cover. (Figure 3)

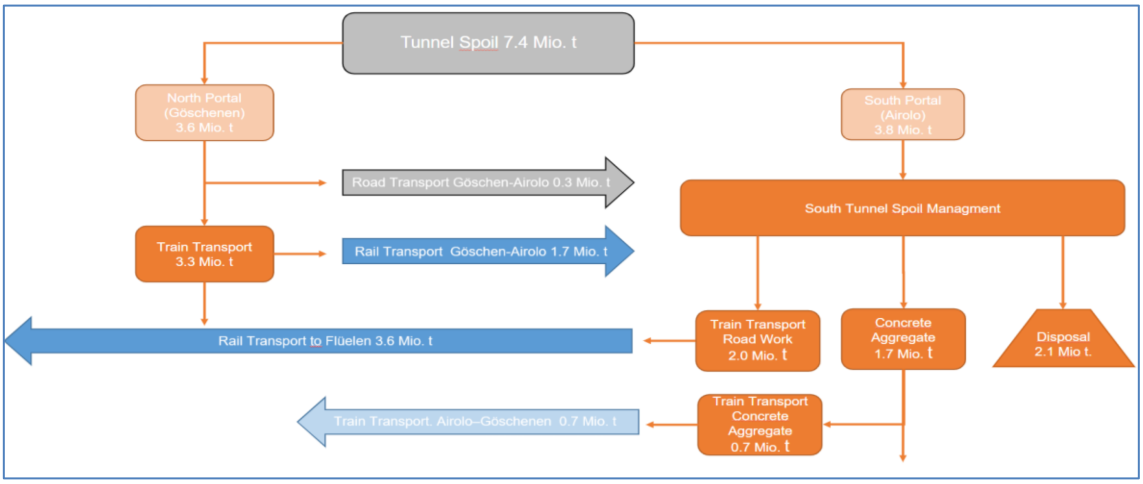

Figure 3. Spoil flow principle

4.4 Environmental sensitivities and compliance requirements

The tunnel portals are located within protected Alpine ecosystems. The project must comply with the Swiss Federal Law, requiring dust suppression systems, noise mitigation barriers, water protection measures. Spoil material is subject to geotechnical and chemical testing to classify it for recycling, reuse or landfill disposal.

5 DESIGN AND TECHNOLOGICAL INNOVATIONS

The key objective is to provide continuous, high-capacity transport and processing of spoil material directly from the tunnel face to treatment or storage areas.

5.1 *Core system components*

The overall solution integrates several sub-systems.

Belt Conveying Systems, including:

- 12km of multi-stage long-distance conveyors, with enclosed belts to minimize dust emissions. Automated loading points from TBM discharge areas, enabling uninterrupted material flow
- Designed for high throughput, with capacities exceeding 1,000 tons/hour in peak operation.

Rail Systems: New logistic facilities include

- a train station with spoil loading facility in Göschenen.
- a train station with spoil loading facility in Airolo.
- and a train station with concrete aggregate loading facility, and a train station with spoil unloading facility in Airolo (Figure 4-5-6-7-8-9).

Rail operations also leverage the existing rail network and the Gotthard Base Tunnel infrastructure to optimize the transfer of materials. This approach avoids reliance on road transport and minimizes disruption to local communities and the surrounding environment.

Material Processing Plants in Stalvedro: The material processing facilities are strategically located near the tunnel portals within secured zones, equipped with noise and dust mitigation barriers to minimize environmental impact. These plants are fitted with:

- Screens and crushers for the breakdown and sorting of excavated spoil.
- Magnetic separators for the extraction of metallic debris.
- Moisture control systems to prevent operational issues associated with slurry handling.

The processed outputs are classified into streams suitable for reuse in tunnel lining segments, backfilling and grading applications, or for external disposal as inert or non-inert waste, in full compliance with environmental standards.

Storage and Recycling Units: Dedicated units are provided for the intermediate storage and recycling of excavated material. These include:

- Covered storage areas designed for temporary buffering of material flows.

– Recycling loops enabling the immediate reuse of suitable spoil in on-site concrete batching plants.
– Environmental protection measures, such as leachate collection systems, dust suppression equipment, and infrastructure designed to allow rapid loading and unloading operations.

Figure 4. Train and train loading/unloading facilities in airolo, south portal


Figure 5. Spoil loading facility


Figures 6. Spoil unloading facility

5.2 *Key design principles*

Continuous Transport and Processing: The continuous transport and processing of excavated material minimizes delays and ensures alignment with excavation rates. A centralized control system oversees key operational parameters, including conveyor speeds, belt loading, equipment status, and environmental compliance, thereby ensuring both efficiency and regulatory adherence.

Environmental and Energy Performance: The system is designed to operate with low emissions, incorporating enclosed conveyor belts, high-efficiency dust filtration units, and energy-efficient drives. These measures significantly reduce noise and airborne pollutants, safeguarding both workforce health and the surrounding environment.

Scalability and Adaptability: The transport infrastructure is based on a modular design, enabling adaptation to varying excavation progress and changes in spoil composition. Custom conveyor alignments have been engineered to traverse confined corridors between valley walls, existing infrastructure, and road networks, thereby minimizing surface disruptions.

Rail Integration: For long-distance spoil removal, the system integrates with the existing rail network, thereby reducing reliance on heavy truck movements through protected Alpine areas and mitigating environmental impact.

Dynamic Load Balancing: Real-time monitoring and control allow material flows to be redirected dynamically, distributing loads based on available capacity at processing stations. This prevents overflows, particularly in sites with limited storage capacity.

Embedded Environmental Monitoring: Sensors installed along the conveyors continuously measure dust concentration, vibration levels, and acoustic emissions. These provide real-time feedback to ensure compliance with strict Alpine environmental regulations.

6 MANUFACTURING, DELIVERY, AND ASSEMBLY

Timeline and Milestones of Component Production:

- Q1–Q2 2022: Finalization of design and technical specifications for key system components, including conveyor structures, drives, rollers, and steel frames.
- Q2–Q4 2022: Fabrication of modular components began at specialized manufacturing facilities in Switzerland and neighboring EU countries.
- Q1 2023: Factory acceptance tests (FAT) were conducted to ensure compliance with mechanical and environmental performance requirements.
- Q2–Q3 2023: Components were staged for delivery in line with excavation milestones at Lots 341 and 342.
- Q1-Q4 2024: Assembly and staggered commissioning
- Q1 2025 2025 Lot 341 interface commissioning

6.1 *Transport logistics to site*

- Due to the narrow access roads and proximity to the A2 motorway, component transport required precise logistics planning.
- Large structural elements (e.g., conveyor gantries, belt supports) were delivered via flatbed trailers during night shifts, avoiding daytime traffic.
- Smaller mechanical and electrical components were delivered in modular crates, optimized for minimal handling and rapid on-site deployment.

6.2 *Assembly strategy*

The system was designed with a modular and staged assembly strategy, suited for confined Alpine spaces and evolving excavation fronts.

Modular Subsystems:

- Conveyor belts, transfer stations, hoppers, and control units were prefabricated in sections and assembled on-site using mobile cranes and specialized lifting platforms. (Figure 10)

– Intermediary storage on site and preassembly area. Large number of components required multiple storage areas. Accurate inventory was kept continuously to not lose components. (Figure 11)

7 COMMISSIONING AND OPERATIONAL SETUP

Once the spoil management infrastructure was assembled and integrated, Lot 111 entered the commissioning and operational phase. This phase was critical to validate the performance of mechanical systems, optimize logistics, and ensure safe, efficient operation in tandem with ongoing excavation work in Lots 341 and 342.

7.1 *Commissioning Process and Testing*

– System Pre-Checks, Dry Run Testing, Integrated Trials, Acceptance and Handover
– Commissioning was completed in phases to match excavation progress and allow early sections of the conveyor system to go live while others were still being installed.

Figure 7. Assembly strategy requiring closure of highway lanes at night

Figure 8. Assembly strategy including temporary storage areas

8 PERFORMANCE AND ENVIRONMENTAL IMPACT

The spoil management system implemented in Lot 111 was designed not only for high operational efficiency but also for strict compliance with Swiss environmental regulations.

Performance metrics and environmental benefits demonstrate the system's value as a benchmark for sustainable tunnelling logistics.

8.1 *Key Performance Indicators (KPIs)*

Material Throughput:

- The belt conveyor system achieves an average capacity of 900–1,200 tons/hour, depending on excavation intensity and material type.
- Peak operational days handles over 20,000 tons of spoil with no system downtime or material backlog.

Reuse and Recycling Rates:

- Approximately 30–40% of excavated material is processed and reused, primarily for Segment production (tunnel lining) and Backfilling and sub-base for infrastructure components. Remaining spoil is classified and transferred via rail to certified disposal sites.

Energy Efficiency.

- The system is designed with high-efficiency motors and regenerative drives, reducing energy consumption by an estimated 20–25% compared to traditional diesel-powered haulage. Automated load balancing further optimized conveyor motor usage during variable throughput periods

8.2 *Environmental performance*

Dust and Noise Reduction: Fully enclosed conveyor belts and drop points, combined with spray and misting systems kept dust emissions well below Swiss thresholds. The conveyor lines is housed in acoustic enclosures where near residential or protected areas, reducing operational noise by over 30 dB(A) compared to truck haulage.

CO_2 Emissions and Climate Impact: By replacing thousands of spoil transport truck trips with belt conveyors and rail wagons, the system prevents an estimated 12,000+ tons of CO_2 emissions over the excavation phase. The use of electricity (with a significant share from Swiss hydroelectric sources) contributed to a low overall carbon footprint.

8.3 *Impact on Road Traffic and Local Community and Community Benefits*

The use of on-site conveyors and rail terminals eliminates the need for spoil trucks on local roads, preventing additional congestion on the A2 motorway, one of Europe's busiest north-south transit routes. This was particularly critical at both tunnel portals, located in narrow Alpine valleys with limited road capacity.

The avoidance of heavy truck movements significantly reduced noise, dust, and road wear for the communities of Airolo (south) and Göschenen (north). The local populations reported minimal disturbance during peak construction activity, and the project received positive feedback from municipal councils and cantonal authorities.

The system's performance contributed to maintaining public trust and political support for the project, reinforcing Switzerland's commitment to environmentally responsible infrastructure development in the Alps.

9 LESSONS LEARNED AND INDUSTRY IMPLICATIONS

9.1 *What worked well*

Seamless Integration with Tunnel Excavation: The alignment between spoil logistics and excavation activities (Lots 341 and 342) ensured that material is removed continuously without disrupting TBM performance or creating bottlenecks.

Use of Belt Conveyors and Rail Transport: The hybrid transport system, combining long-distance belt conveyors with rail freight, was instrumental in eliminating truck movements through sensitive Alpine corridors, significantly reducing noise, emissions, and road wear.

Modular, Scalable Design: The system's modular architecture allowed for staged assembly and adjustment as excavation progressed, improving flexibility and reducing upfront site occupation.

Environmental Compliance and Monitoring: Real-time tracking of emissions, noise, and dust helped maintain compliance with Swiss environmental standards, earning strong support from local communities and regulators.

9.2 *What could be improved in future projects*

- Earlier Integration of specific teams in Planning Phase
- Earlier involvement of the assembly team during the design stage could further optimize Assembly complexity, so reduce the efforts and shorten the Assembly period of time
- Earlier involvement of the operation team during the design stage could further optimize Operation routine
- Automation in Processing Plant. While conveying was highly automated, further automation in material sorting and quality control could improve throughput and reduce labour demands
- AI based operation management. To predict component failures, schedule maintenance before breakdowns occur, generation of reports, providing decision support and action suggestions on dashboard

9.3 *Broader applicability of this system design*

The Lot 111 system provides a highly transferable model for:

- Urban tunnel projects in dense environments with limited space for spoil handling or storage.
- Environmentally sensitive areas, such as mountain passes, coastal zones, or protected ecological regions.
- Multiphase projects where excavation and material processing occur in parallel and require dynamic coordination.

9.4 *Recommendations for similar infrastructure projects*

- Design for Logistics First. Spoil management should be treated as a primary system, not secondary to tunnelling logistics drives excavation efficiency.
- Use Rail and Conveyor Systems Where Possible. These reduce environmental impact, especially in constrained or regulated zones, and can be scaled more sustainably than trucking.
- Invest in Modular, Mobile Units. Mobile processing and sorting plants reduce on-site footprint and can be deployed flexibly based on tunnel advance rates.
- Implement Smart Monitoring Systems. Integrate SCADA or IoT-based systems for real-time operational data and environmental compliance alerts.
- Engage Stakeholders Early. Early communication with local communities, regulators, and utility operators fosters trust and smoother project execution.

10 CONCLUSION

The core objectives of Lot 111 were to:

- Efficiently handle large volumes of excavation spoil
- Minimize environmental and community impact, and
- Integrate seamlessly with tunnel construction operations at both portals

These goals were achieved through the deployment of a high-capacity, modular belt conveying system, advanced material processing facilities, and rail-based logistics—all designed to operate within the strict spatial, environmental, and regulatory constraints of the Alpine setting. Continuous coordination with Lots 341 and 342 ensured that spoil removal supported uninterrupted excavation, while the environmental performance exceeded legal requirements and local expectations.

The solution design:

- Eliminated the need for thousands of spoil truck trips in a sensitive mountain corridor
- Achieved high reuse rates of excavated material,
- Maintained safe, quiet, and clean operations in close proximity to residential and ecological zones
- Operated with reliability, scalability, and resilience over extended construction timelines.

The Lot 111 experience highlights the importance of treating spoil management not as an afterthought, but as a critical, integrated component of tunnel engineering. The system demonstrates that logistics and sustainability can be embedded into core infrastructure delivery, without compromising on performance or budget. From modular system design and automation to environmental monitoring and stakeholder coordination, the solutions developed here set a precedent for future tunnel project in both alpine and urban contexts.

Lot 111 stands as a benchmark for modern spoil management in tunnelling projects and contributes valuable knowledge to the global tunnelling community while reinforcing Switzerland's leadership in sustainable infrastructure innovation. Future projects, whether in mountain regions, urban centres, or environmentally sensitive zones, can look to Lot 111 as a model for balancing efficiency, innovation, and responsibility.

11 REFERENCES

FEDRO/ASTRA – Project documentation for the Gotthard Road Tunnel second tube. - Swiss Federal Roads Office. Marti Group – Belt conveyor system and logistics design references for Lot 111.

https://www.marti.com - Academic or Industry Publications. ITA-AITES (International Tunneling and Underground Space Association). – Guidelines on material handling and spoil management.

https://about.ita-aites.org/files/WG14-15-ITA-REPORT-MudHandling.pdf. - Transweb / Mineta Transportation Institute – Report on spoil volumes and logistics strategies in long tunnel projects.

https://transweb.sjsu.edu/sites/default/files/1429-long-tunnels-trend-analysis.pdf. - Tunnel Magazine – Project overview and updates on Gotthard second tube construction.

https://www.tunnel-online.info - Environmental and Project Regulatory Documents. Swiss Federal Environmental Protection Act (USG) – National framework for dust, noise, emissions, and groundwater protection.

https://www.fedlex.admin.ch/eli/cc/1985/241_241_241/en . Alpine Convention / Alpine Initiative – Frameworks limiting traffic growth and enforcing sustainability in Alpine transit corridors.

https://www.alpconv.org - Cantonal environmental offices of Uri and Ticino – Environmental impact assessments and construction permits related to Lot 111 operations. - Marti Technik AG Tech News, Juni 2023