Contractual issues in Fast Track Tunnel Construction

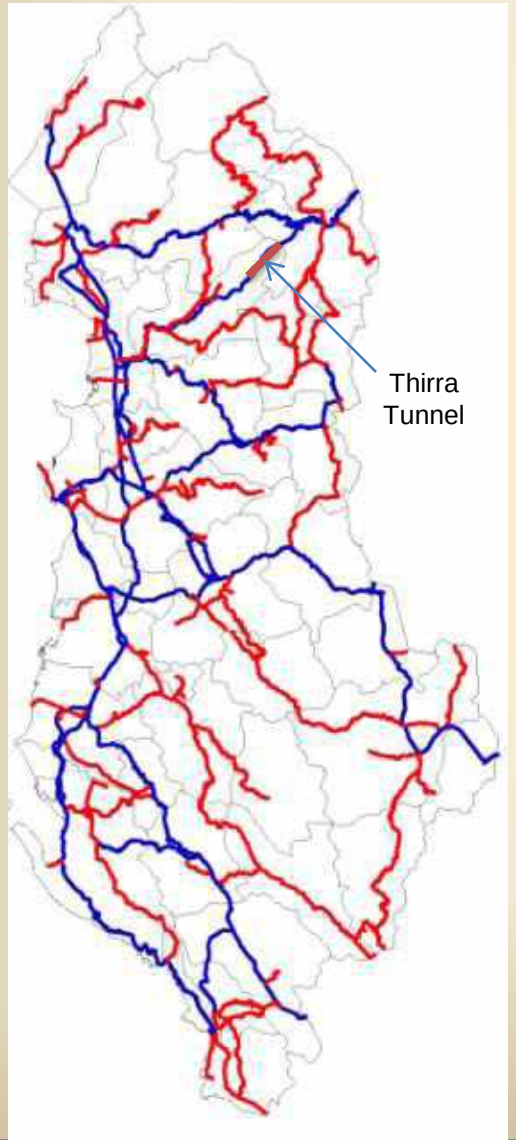
The Albanian Motorway A1

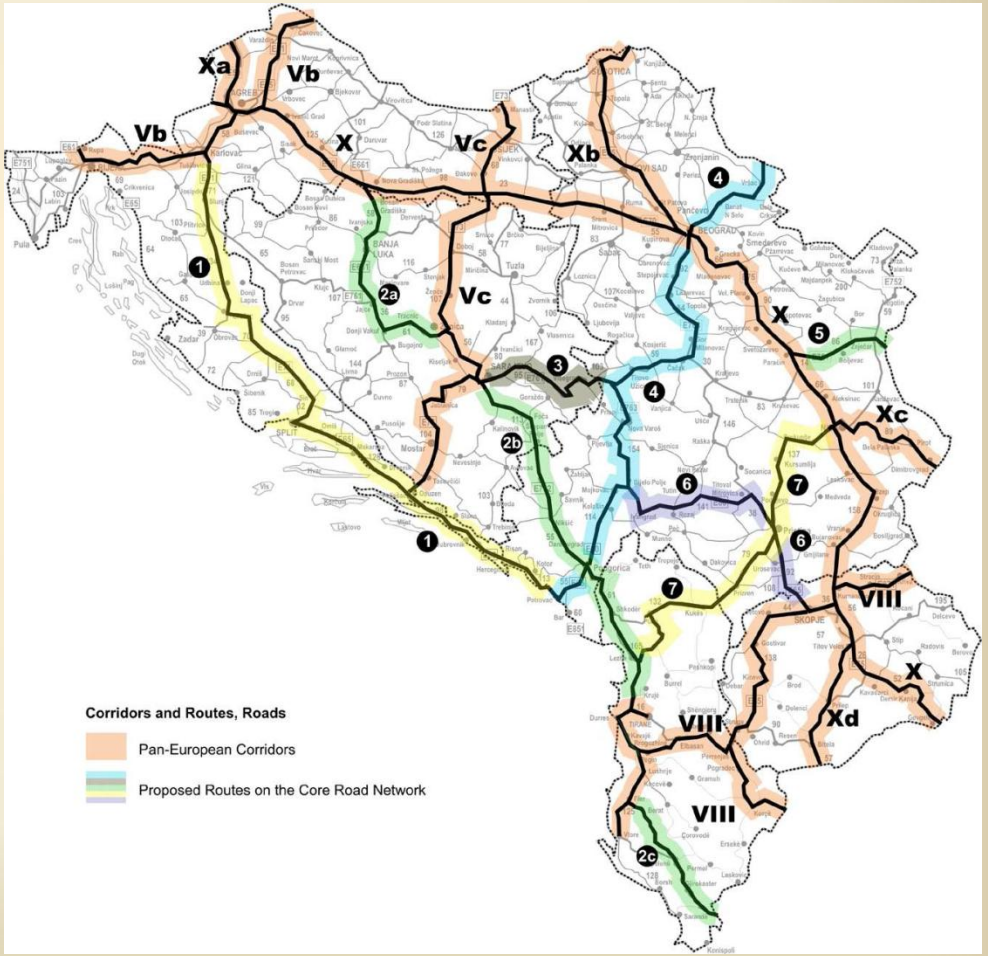
Rreshen-Kalimash Section

Thirra Tunnel Experience

Contractual issues in Fast Track Tunnel Construction

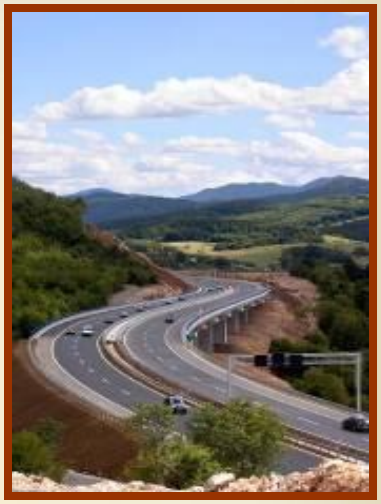
The Albanian Motorway A1 Rreshen-Kalimash, Durres – Pristine – Nis, Route 7





The Albanian Motorway A1 Rreshen-Kalimash

- 61 km dual-carriageway motorway
- Total cost 825 m.€
- 5.6 km dual-tube tunnel
- 4.5 km of 29 bridges
- 34 million m^3 of earth excavation
- 595,000 m^3 of concrete
- 6 km of retaining structures
- Completion in almost 27 months



5.6 km Dual-Tube Tunnel at 800m level

One of the longest in the Balkans

Formwork for lining

Finished lining

Outstanding achievement, Results beyond expectations,
A landmark in the country's infrastructure but...

Tunnel Costs

- **Estimated and Outcome Costs**

1.	Estimated by Employer's Consultants before the Tender	**144m. Euros**
2.	Target Price of Bechtel – Enka Joint Venture	**125m. Euros**
3.	Final Outcome Price	**258m. Euros**

- **The 133m. Euro cost increase was distributed between the work categories**

- **Quantities of Rock Excavation in Classes IV and V**

1.	Initial Estimates	**11%**
2.	Final Outcome	**76%**

The Contract and Critical Provisions

- **Employment of the Contractor**

1. The Contractor was employed through a 'Qualification Based Selection Procedure'.

2. The Bechtel-Enka J.V. was awarded the Contract for their *'competences and vision on the Project in order to ensure efficient and effective implementation.'*

- **Support to be Provided by the Contractor**

1. The Contractor employed a Design Liaison Group to work with the Designers.

2. DLG was to *'ensure that the Employer's objectives were met'* through designs that support Fast Track Construction.

The Contract and Critical Provisions

- **Terms Negotiated with the Contractor Proved to be Critical to the Development of the Project.**

1. .*'....the Contractor shall not have any design liability whatsoever in respect of the Permanent Works.'* (Sub-Clause 5.2)

2. The Value Engineering provisions of the FIDIC Contract were written off as not applicable (Sub-Clause 13.2)

Contract and Critical Provisions

- **The Contract Schedule was of Critical Effect**

1. **On 26th September 2006**, the Designers' Contracts were signed.

2. **On 29th September 2006**, the Main Works Contract was signed.

3. The Employer was committed to start providing Deliverables according to an Information Production Schedule.

4. **On 29th September 2006,** the locations for the Tunnel Portals were required in order to allow for fast mobilisation of the Contractor before winter.

Contract and Critical Provisions

- **A Risk of Accruing Heavy Delay Penalties was Imposed upon the Parties**

1. The *'Interruption of Tunnel Excavation'* carried penalties at a rate of **931.50 Euros/hr** for the Employer. Any standing time for external equipment was also at very high rates.

2. A Cost Sharing mechanism was intended to limit overrun costs. It was applicable up to a maximum overrun of **25m. Euros**.

3. The value of the LD payable buy the Contractor in case of failure to complete the works within scheduled time was **40 k€/day**

Causes of Difficulty

- **The Designs should have better been Based Upon a Programme of Geotechnical Studies and Investigations.**

1. The tunnel designs were progressed on the basis of the Designer's assumptions with respect to the geology.

2. By the time the Designer was ready to investigate the site geology, there was snow cover on the mountain.

3. By the time the Designer would have been able to make a detailed geotechnical study, the works were too far advanced to make any potential change of the portal locations.

Disagreements on Design Decisions

- **Disagreements concerning the Primary Support System for the Tunnel were Disruptive.**

1. The Designer assumed good rock conditions with minimal convergence. Only occasional supports would be required throughout half of tunnel.

2. Under Category IV and V, the Designer provided HEB arched girders in order to mainly counter the risk of rock falls. The design quantities for Category IV and V conditions were only nominal.

3. The Project Manager's tunnel expert and, later, the Supervising Engineer, had different opinion from the designer but wouldn't assume any responsibility which remained always with the designer.

4. BEJV also said their prices were based upon NATM designs with lattice girder supports and not HEB heavy support.

Contractor's Claims of Delay

- **The Contractor Claimed for Delays to the Works at the North Portal**

1. There was a 4 month delay in receiving design drawings.

2. Due to two rock slips of the portal benches, the Designer required the construction of a massive reinforced concrete support beam.

3. The beam was tensioned into the rock face by Dywidag bar anchors. It would require an estimated 3 months of procurement and construction.

4. The HEB tunnel support arches were also unobtainable in Albania

The Position of the Employer

- **The Employer had Engaged one of the Foremost Tunnel Designers in Europe**

1. The HEB girder supported designs were at the Designer's responsibility.

2. In accordance with Albanian law, the Designer has a legal status and his responsibilities cannot be disregarded.

3. The opinion of the Employer's advisers and of the Contractor supported the NATM and lattice girder support approach.

4. However, without a value engineered submission from the Contractor, there was no legal or contractual basis for setting aside the Designer's designs.

Difficulties Facing the Employer

- **The Employer's Situation was both Difficult and Different from his Expectations.**

1. He was far from seeing a Fast Track tunnelling to due date completion following a design programme managed by the DLG.

2. He was faced with escalating costs and a prospective completion delay of 8 to 12 months, and

3. He was unable to obtain any positive alternative support design proposal from the Contractor even though the Employer offered indemnity from all Design responsibility and liability.

The Anticipated and Recorded Rock Classes

- **The Encountered Rock Classes were More Difficult than had been Anticipated**

	As Designed For	As Recorded
Rock Mass Category I :	50,000 m.cu. 5.43%	0.00 m.cu. 0.00%
Rock Mass Category II :	400,000 m.cu. 43.48%	0.00 m.cu. 0.00%
Rock Mass Category III :	370,000 m.cu. 40.22%	235,297 m.cu. 23.74%
Rock Mass Category IV& V :	100,000 m.cu. **11.07%**	754,7m.cu. **76.32%**

HEB Arch Supports in a Fast Track Situation

- **The HEB Arch Supports were Intended to special case rock masses**

1. The HEB arches had to be erected as quickly as was possible.

2. This was somehow in contrast to NATM observational method, which relies upon permitting controlled deformation and the re-distribution of stresses.

3. The HEB arches carried marginal load until there was convergence. When it commenced, they blocked it and failed when their support capacity was exceeded.

4. The straight sided shape of the HEB girders did not provide the best primary support shell geometry, necessary to stress re-distribution.

The Central Section of the Tunnel

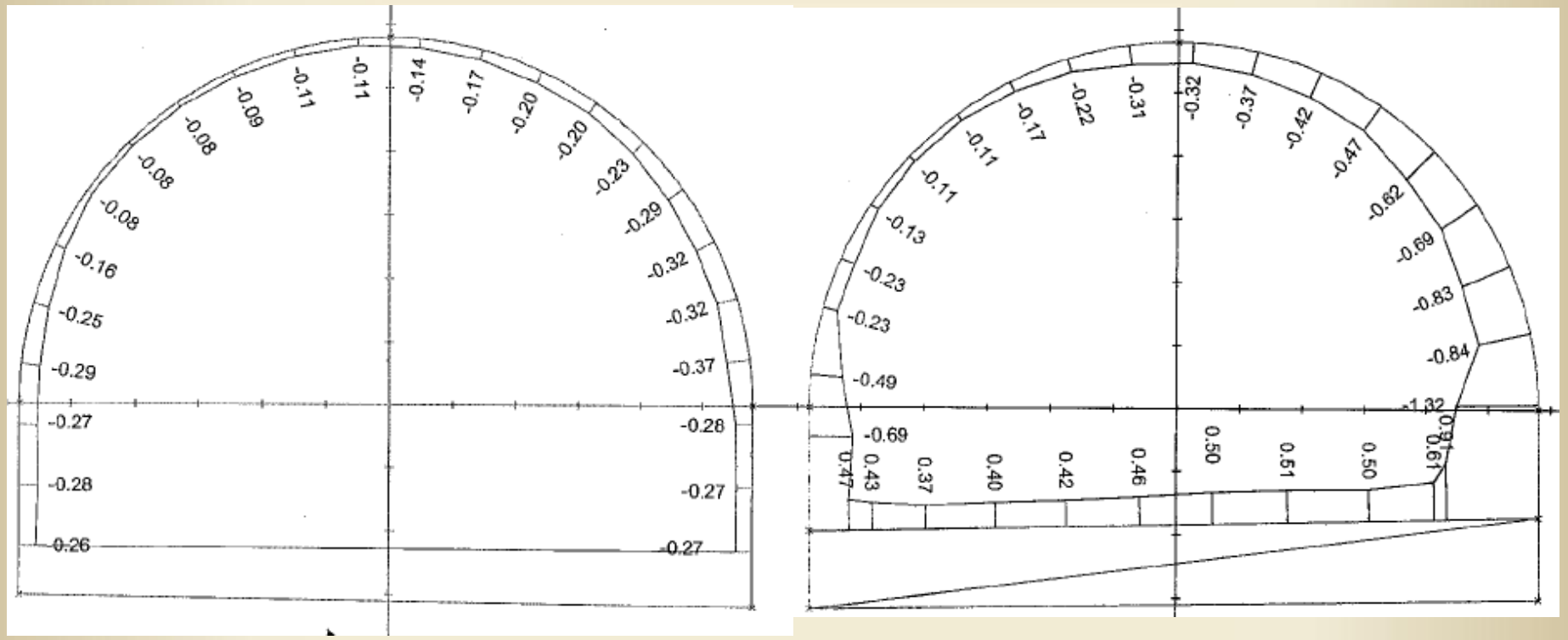
- **The Rock Conditions Deteriorated in the Central Section of the Tunnel (approx. 1 km).**

1. Under increased pressure in the most heavily loaded section, the brittle, highly fractured rock, with sheared serpentinised and slickensided joints, was unstable and prone to be possibly affected by the bolt drilling water.

2. Convergence rates increased, rates of progress were reduced and the parallel excavation of the second tube caused serious secondary effects

3. With deformations exceeding 50cm, the HEB steel arch supports were buckling and subsequently being destroyed by the forces upon them.

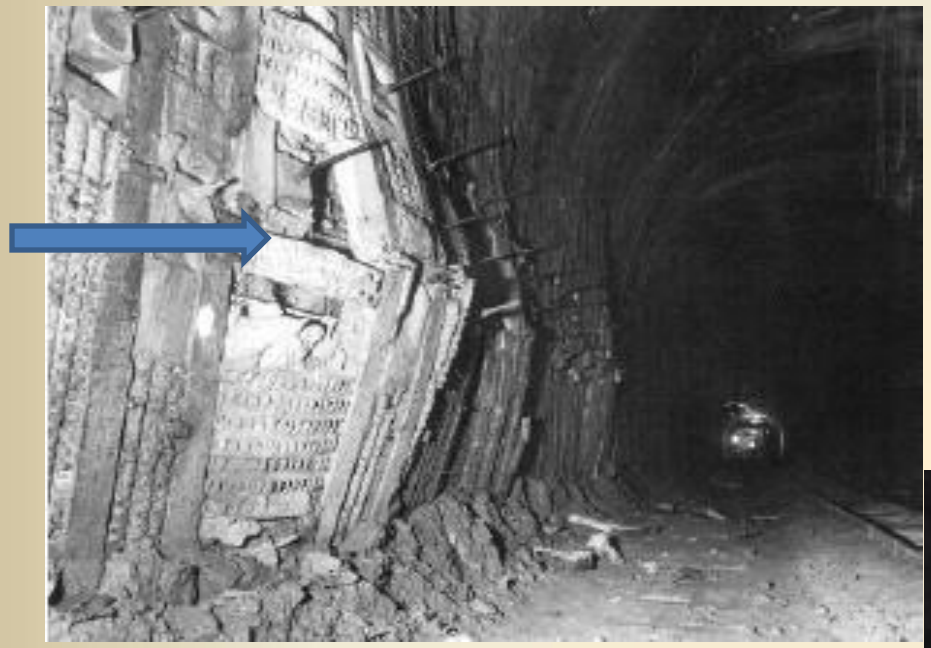
Figure 3 -Tunnel profiles from the 08/06/2009 and the 15/08/2009 at KP 3+145 in North Tube



Worrying deformation of the sides with 1,40m of displacement in 2 months

Evidence of high deformations

Evidence of high deformations



The Fast Track Commitment to Opening the Tunnel

- **The Employer was Committed Opening the Motorway to Traffic by June 2009, before the Summer, Touristic Season.**

1. The emphasis was put upon stabilising the North tube with additional rock bolting to make it safe for public use.

2. Continual convergence monitoring and daily rectification and maintenance works safely allowed the controlled passage to traffic throughout the summer season of 2009.

3. The Designer re-appraised the situation and designed a close grid of 9m. rock bolts as the plastic zone around the tubes had extended beyond the limit of 6m. bolts.

4. After bolting, the tubes would require re-profiling (which would destroy the bolts), and then re-bolting. A heavily reinforced lining would be required, at least 1m. thick.

Rupture of Primary Support and Up - heaving of Pavement

The Re-design and Completion of the Tunnel

- **A Sub consultant was finally Employed to Provide a Value Engineered Re-design**

1. The extensive rock bolting works caused problems in that the drilling water was lubricating the rock joints and actually accelerating the rate of convergence.

2. The Designer proposed dry drilling but this was difficult in the Fast Track context as it would take time to locate, procure and ship the necessary equipment.

3. The Employer would then be faced with a great deal of additional expense as well as delay and the Contractor's claim to an extension of time.

4. A provisional sum for the sub-consultant to provide an alternative, value engineered solution was used within the SE Contract.

5. This culminated in the employment of the reputable Austrian tunnel consultants Dr. Sauer Bureau and IC Consulenten.

The Collapse

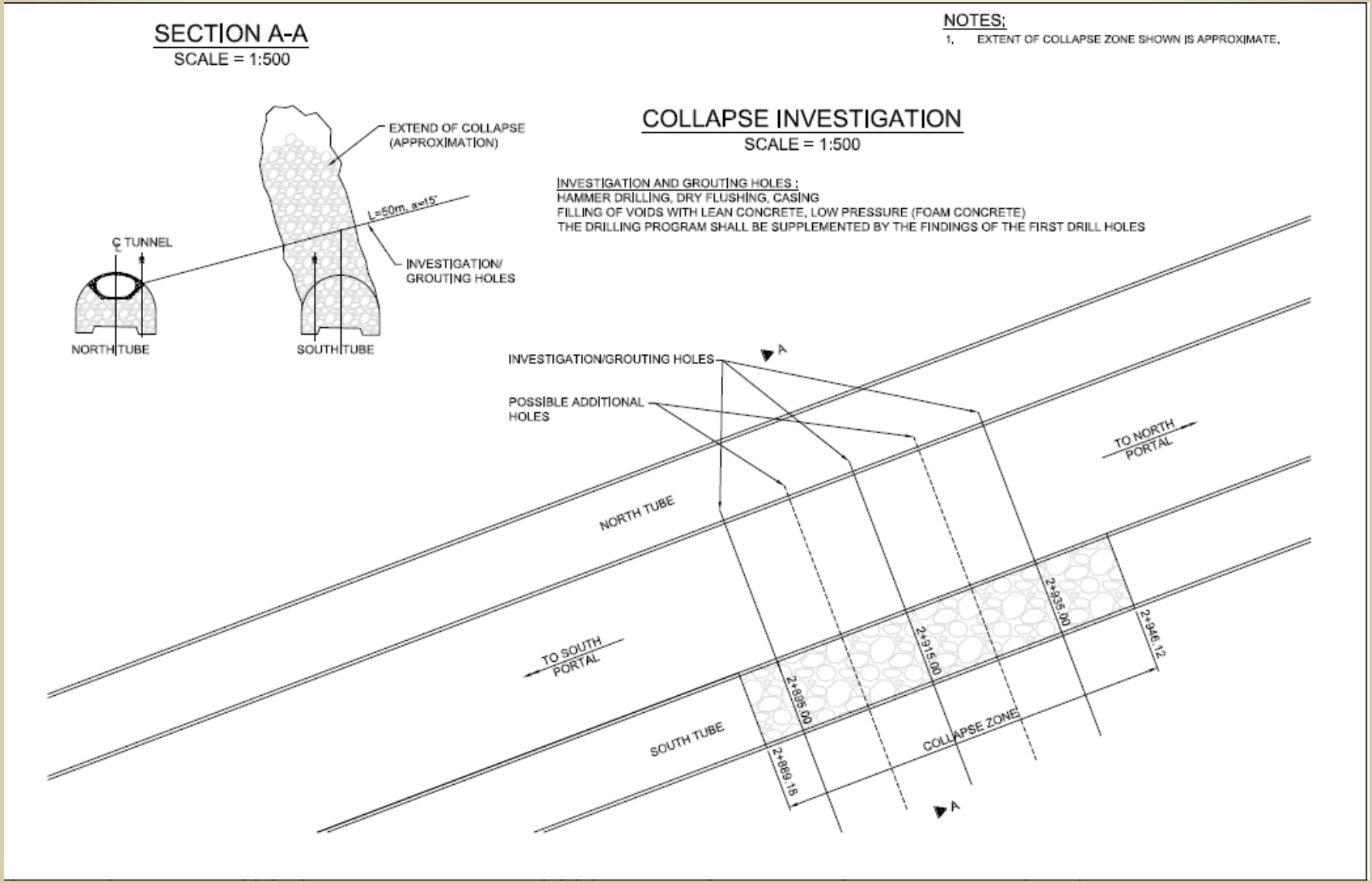
- **On 5th November 2009, there was a partial collapse some 60m Long in the South Tube.**

1. The cause was that a wedge shaped section of rock squeezed out under pressure with consequential unravelling of the rock matrix on either side.

2. The collapse happened in a section that had developed an irregular cross section due to convergence and the breakout of loosened material.

3. It was not in an area that was being worked and it caused no injuries.

The Collapse



Re-design and Progress to Completion

- **The Pattern of Faults Causing Problems in the Central Section was Promptly Identified by the Sub-Conultant.**

1. To block the convergence, the tunnels were partially backfilled through the critical area, leaving sufficient height for access.

2. The crown above the access road was supported by forming substantial, ovoid shot-crete arches.

3. It was a completely effective solution.

Safety measures in the North tube

Re-design and Progress to Completion

- **Dr. Sauer :**

  'Even Mouse Holes are Round'

1. The Sub-consultant primarily took issue with the tunnel shape and with the inflexibility of the rigid HEB arch girder geometry, as a primary support system.

2. He opted for using lattice girders, wire mesh and shot-crete in conjunction with the NATM observational methodology.

3. The collapse was tunnelled through by means of concrete capping of the void cone and fore-poling shielding of the excavation made through the fallen material.

Re-design and Progress to Completion

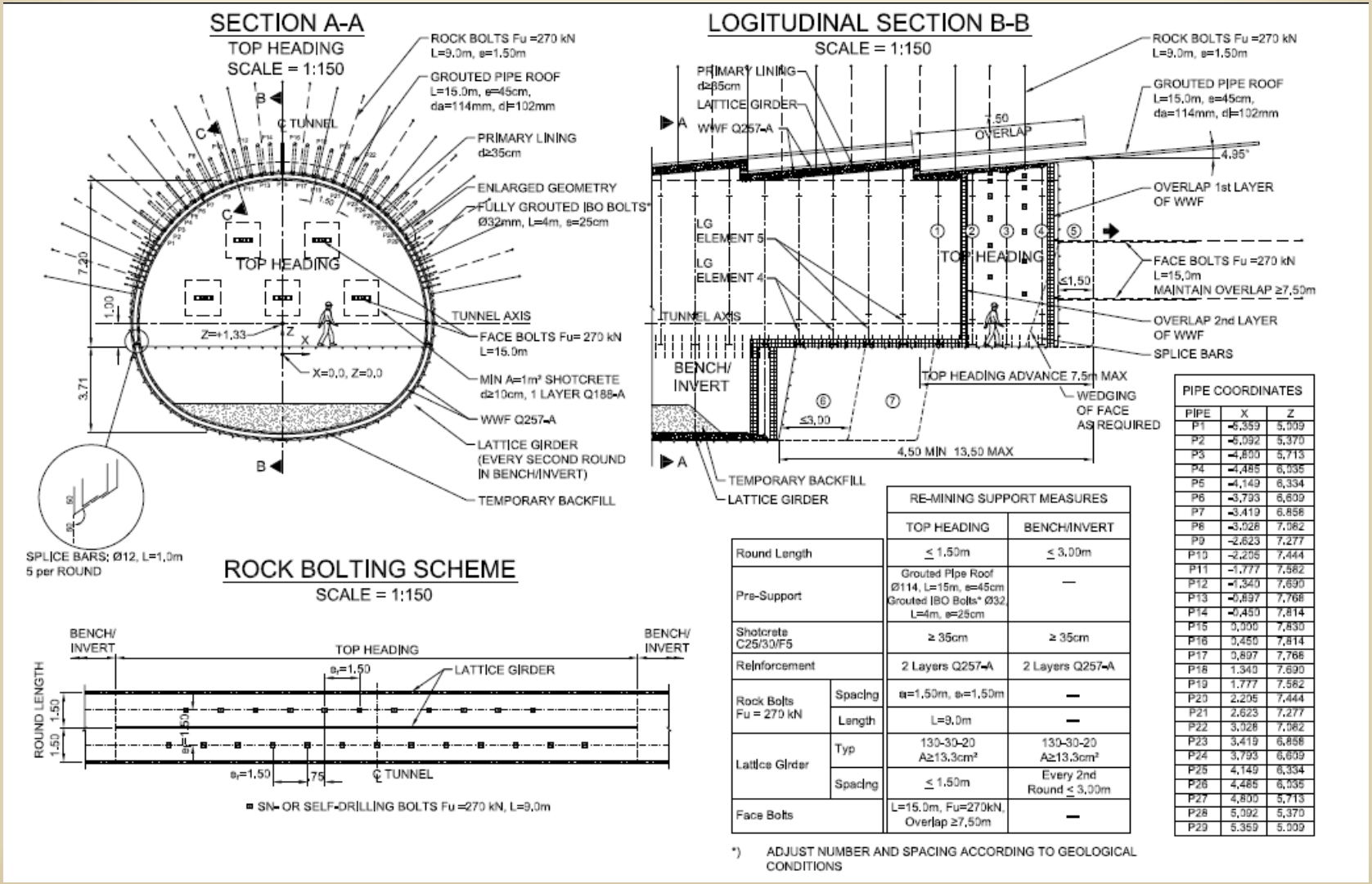
- **The Tunnelling Works Progressed to Completion Without any Further Complications.**

1. There were three stages of construction of each round, the arch, lower bench and the invert. The works were systematic and well controlled.

2. The tunnel lining was installed 35 – 50cm thick which varied due to the different inner and outer cross sectional shapes.

3. Strain gauges have been installed in the lining of the central section of the tunnel. Readings taken, more than a year after show stress levels in the lining well within its capacity.

Re-design concept



		RE-MINING SUPPORT MEASURES	
		TOP HEADING	BENCH/INVERT
Round Length		≤ 1.50m	≤ 3.00m
Pre-Support		Grouted Pipe Roof Ø114, L=15m, s=45cm Grouted IBO Bolts* Ø32, L=4m, s=25cm	—
Shotcrete C25/30/F5		≥ 35cm	≥ 35cm
Reinforcement		2 Layers Q257-A	2 Layers Q257-A
Rock Bolts Fu = 270 kN	Spacing	a=1.50m, s=1.50m	—
	Length	L=9.0m	—
Lattice Girder	Typ	130-30-20 A≥13.3cm²	130-30-20 A≥13.3cm²
	Spacing	≤ 1.50m	Every 2nd Round ≤ 3.00m
Face Bolts		L=15.0m, Fu=270kN, Overlap ≥7.50m	—

*) ADJUST NUMBER AND SPACING ACCORDING TO GEOLOGICAL CONDITIONS

PIPE COORDINATES		
PIPE	X	Z
P1	-5,359	5,009
P2	-5,092	5,370
P3	-4,800	5,713
P4	-4,485	6,035
P5	-4,149	6,334
P6	-3,793	6,609
P7	-3,419	6,858
P8	-3,028	7,082
P9	-2,623	7,277
P10	-2,205	7,444
P11	-1,777	7,582
P12	-1,340	7,690
P13	-0,897	7,768
P14	-0,450	7,814
P15	0,000	7,830
P16	0,450	7,814
P17	0,897	7,768
P18	1.340	7.690
P19	1.777	7.582
P20	2.205	7.444
P21	2.623	7.277
P22	3.028	7.082
P23	3.419	6.858
P24	3.793	6.609
P25	4.149	6.334
P26	4.485	6.035
P27	4.800	5.713
P28	5.092	5.370
P29	5.359	5.009

Lessons Learned

- **The Successful Application of Fast Track Construction Procedures to Tunnelling Works Requires that:**

1. **The administrative and legal capacity of the Employer** must be sufficient to manage a complex array of responsibilities to promptly address any issues adversely affecting the progress.

2. **Comprehensive advance studies** must be carried out to minimise the risk of encounters with unforeseen circumstances and/or conditions.

3. **An appropriate allocation of risk between the parties** The Contractor should bring and employ the expertise and resources necessary.

The Administrative Capacity and Legal Authority of the Employer

- **The Employer had to Manage the Fast Track Construction of the Motorway with Limitations upon his Resources, Budget and Legal Authority**

1. The Employer was contractually subject to a range of very heavy managerial and administrative responsibilities. He was faced with an administratively, legally and physically impossible schedule of contractual commitments.

2. He was also bound by a range of procedural restraints, including that every aspect of the Designs was required to be reviewed by a Technical Committee which was not equipped for such a major project task.

3. He was also bound by high levels of Contractual risk and subject to restraints imposed by Albanian Law which is not familiar with this concept of construction.

Unfulfilled expectations of the Employer

- **The Expectation of the Employer was the Provision of Economic Designs within Target Price Consistent with a Fast Track Programme.**

1. The Employer did not receive such designs due to a combination of unreasonable design scheduling, misjudgements of the conditions, inappropriate time and resources allocation to investigations.

2. The Contractor's initial resistance to accepting responsibility for providing alternative design assuming formal responsibility for it.

Conclusions on Fast Track Tunnelling

- **Priorities for Future Tunnels :**

1. A sufficient pre-contract period should be provided for the full range of essential studies, assessments and decision making.

2. Comprehensive and detailed tunnel and portal geological investigations should be carried out by the Tunnel Designer for interpretation and confirmation by the Contractor.

3. Contractors should adopt the designed tunnel primary support system and methodologies, or propose alternatives / adaptations at their responsibility and according to their methodologies.

4. Contractors should be prepared to carry out value engineered proposals, designs, working drawings and methodologies as requested by the Engineer.

Conclusions on Fast Track Tunnel construction

1. The logistical limitations and particular conditions under which tunnels are built tend to weigh against their Fast Track' construction while the primary consideration must always be of safety.

2. On the other hand, much of tunnelling work is systematic, repetitive, and usually the work lends itself to the development of Fast Track procedures in a close understanding of the rock conditions.

3. There isn't so much place for special Fast Track provisions in NATM tunnelling, it must be carried out by skilled, experienced people who work in harmony with the tunnelling conditions.

4. **The Albanian Roads Authority intention, and not only in tunnelling, is to go to Contract with documents that fairly balance risk and ensure that we will employ not just the cheapest of Designers, Supervising Engineers and Contractors but those who will combine to provide the Employer with the most beneficial outcome.**