

Road No. 60 tunnels, Israel

Dr. Roberto Schuerch
ETH Zürich, 18.11.2021



TABLE OF CONTENTS

INTRODUCTION

GEOLOGY IN THE AREA OF THE PROJECT

NORTHERN ALIGNMENT PORTION

SOUTHERN ALIGNMENT PORTION

SPECIAL SECTIONS

CONSTRUCTION EXPERIENCE

CONCLUSIONS

INTRODUCTION

INTRODUCTION

GEOLOGY IN THE AREA OF THE PROJECT

NORTHERN ALIGNMENT PORTION

SOUTHERN ALIGNMENT PORTION

SPECIAL SECTIONS

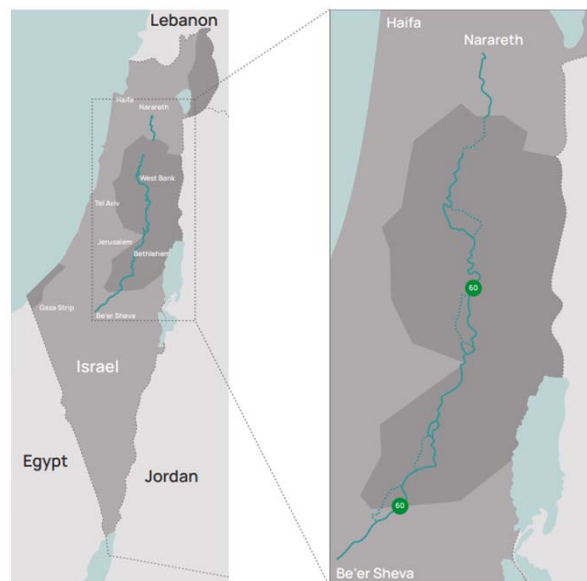
CONSTRUCTION EXPERIENCE

CONCLUSIONS

3 | 18.11.2021 | Road 60 tunnels, Israel



INTRODUCTION



4 | 18.11.2021 | Road 60 tunnels, Israel



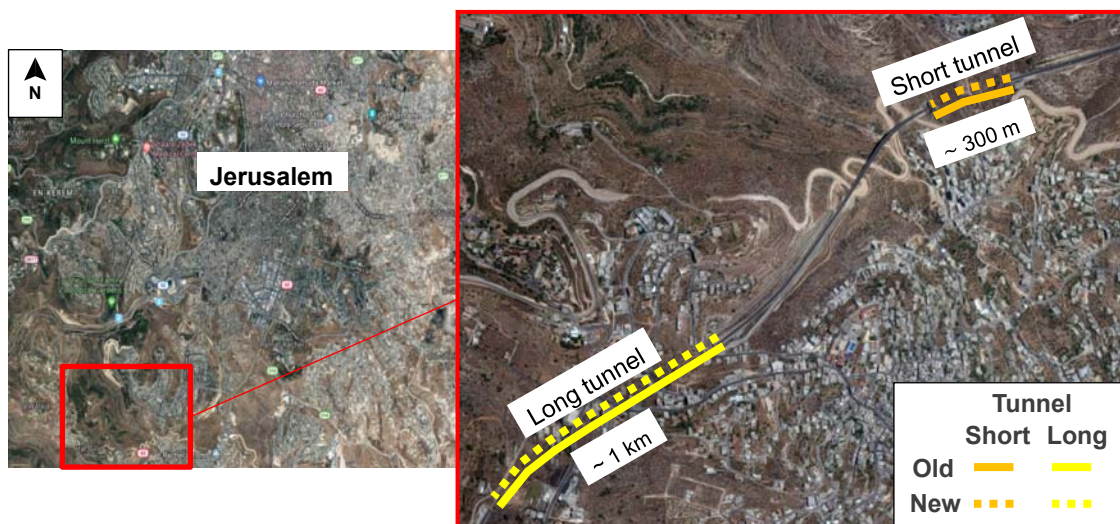
INTRODUCTION



5 | 18.11.2021 | Road 60 tunnels, Israel



INTRODUCTION



6 | 18.11.2021 | Road 60 tunnels, Israel



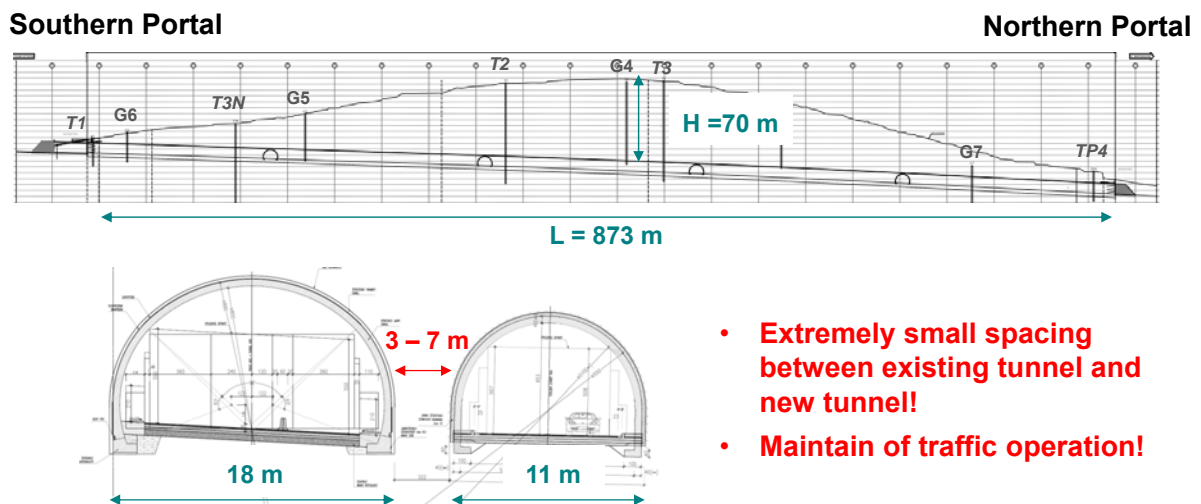
INTRODUCTION



7 | 18.11.2021 | Road 60 tunnels, Israel



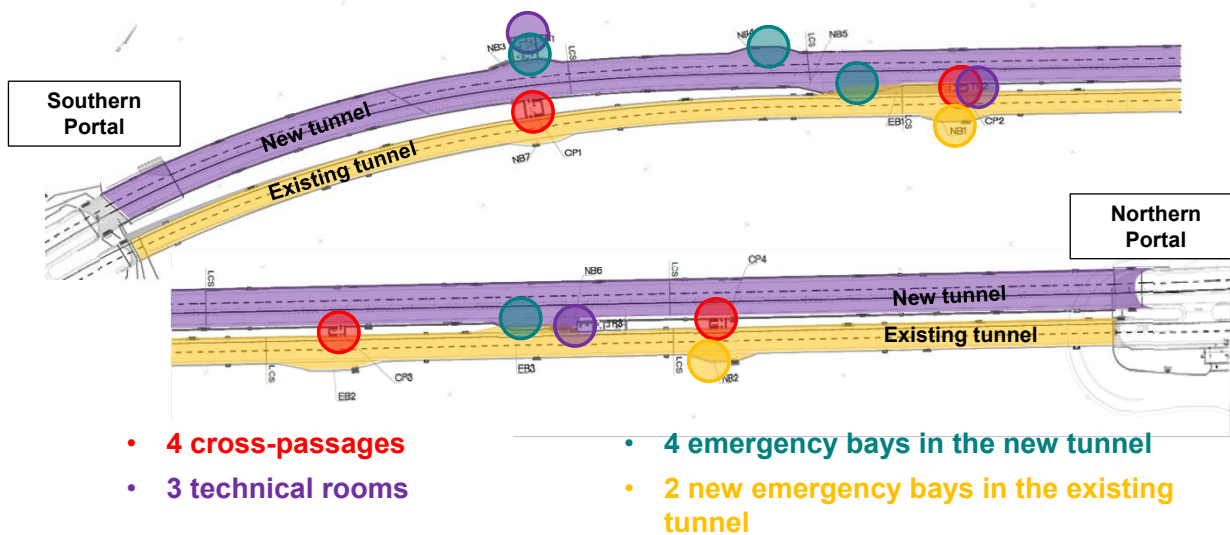
INTRODUCTION



8 | 18.11.2021 | Road 60 tunnels, Israel



INTRODUCTION



9 | 18.11.2021 | Road 60 tunnels, Israel



GEOLOGY IN THE AREA OF THE PROJECT

INTRODUCTION

GEOLOGY IN THE AREA OF THE PROJECT

NORTHERN ALIGNMENT PORTION

SOUTHERN ALIGNMENT PORTION

SPECIAL SECTIONS

CONSTRUCTION EXPERIENCE

CONCLUSIONS

10 | 18.11.2021 | Road 60 tunnels, Israel



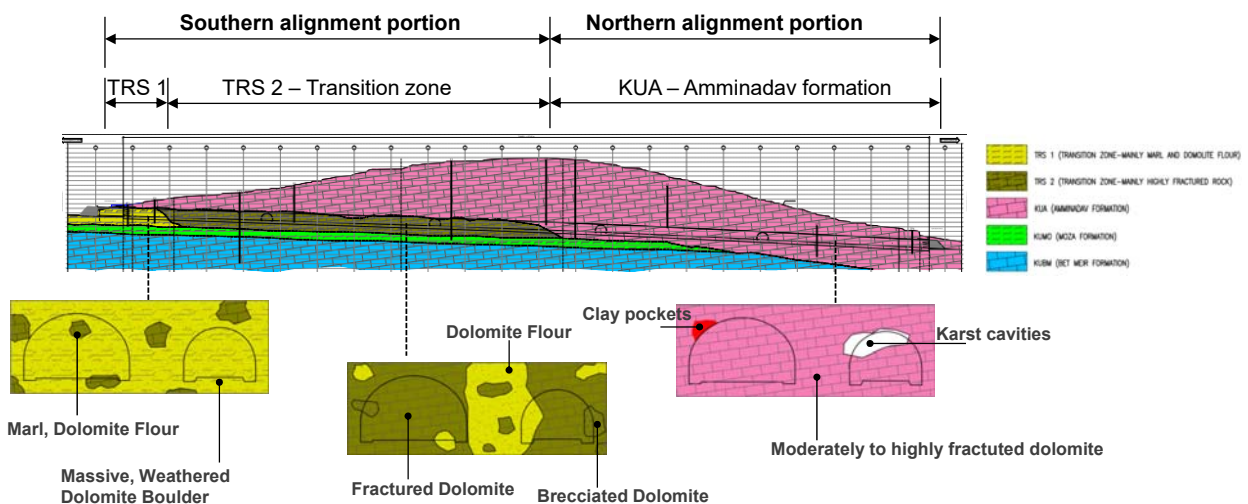
GEOLOGY IN THE AREA OF THE PROJECT

Data considered for the geological and geotechnical characterization	
Existing general literature (no detailed data on the construction experience of the existing tunnel)	✓
Documents on the existing tunnel – Site investigation, summary of the geotechnical data (design stage)	✓
Documents on the existing tunnel – Site investigation, summary of the geotechnical data (as - built)	✓
New geological exploration campaign (vertical drillings)	✓
Additional exploratory drilling from the existing tunnel (horizontal drillings)	✓

11 | 18.11.2021 | Road 60 tunnels, Israel



GEOLOGY IN THE AREA OF THE PROJECT



12 | 18.11.2021 | Road 60 tunnels, Israel



NORTHERN ALIGNMENT PORTION

INTRODUCTION

GEOLOGY IN THE AREA OF THE PROJECT

NORTHERN ALIGNMENT PORTION

SOUTHERN ALIGNMENT PORTION

SPECIAL SECTIONS

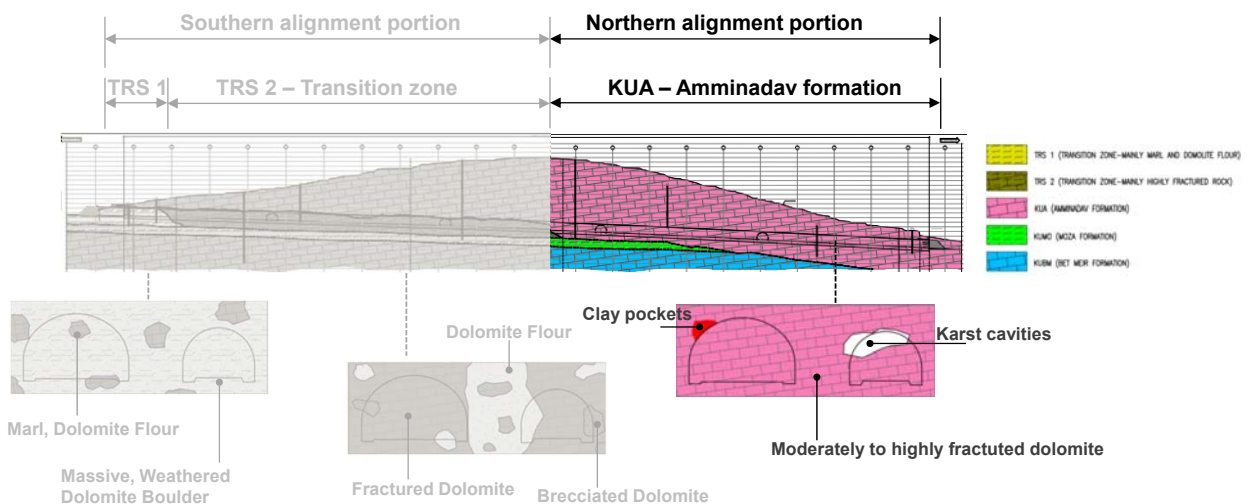
CONSTRUCTION EXPERIENCE

CONCLUSIONS

13 | 18.11.2021 | Road 60 tunnels, Israel



NORTHERN ALIGNMENT PORTION



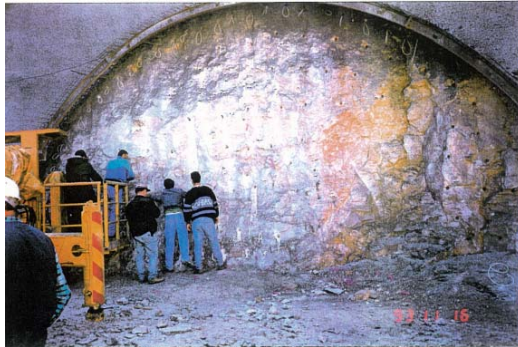
14 | 18.11.2021 | Road 60 tunnels, Israel



NORTHERN ALIGNMENT PORTION

Northern portion of the tunnel (St. 0.480 - 0.873 km)

- *Massive to moderately fractured dolomite (pictures taken during the construction of the existing tunnel)*



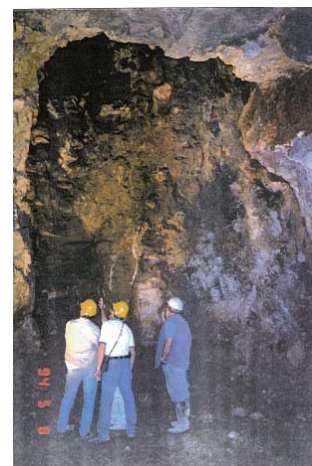
15 | 18.11.2021 | Road 60 tunnels, Israel



NORTHERN ALIGNMENT PORTION

Northern portion of the tunnel (St. 0.480 - 0.873 km)

- *Karst cavities empty or filled with clay and rock fragments (pictures taken during the construction of the existing tunnel)*

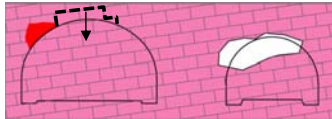


16 | 18.11.2021 | Road 60 tunnels, Israel

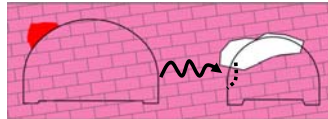


NORTHERN ALIGNMENT PORTION

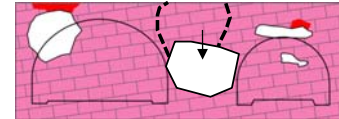
Main geotechnical risks



Sliding of rock blocks



Damage of the existing tunnel induced by blasting



Instability of karstic cavities

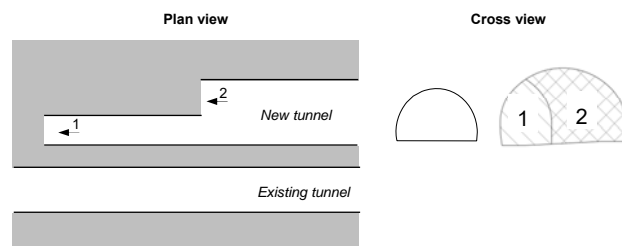
17 | 18.11.2021 | Road 60 tunnels, Israel



NORTHERN ALIGNMENT PORTION

Requirements

- Protection of the existing tunnel from excavation induced vibrations
- Assessment of the rock mass condition in the pillar and installation of auxiliary measures if required (cross bolting, filling of karst cavities) before full face excavation



Excavation concept

Partial excavation with one side drift

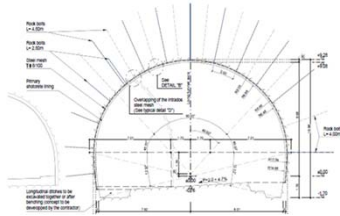
18 | 18.11.2021 | Road 60 tunnels, Israel



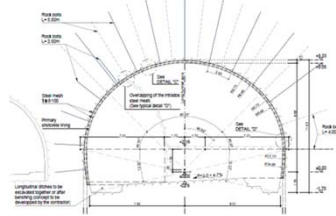
NORTHERN ALIGNMENT PORTION

Support classes

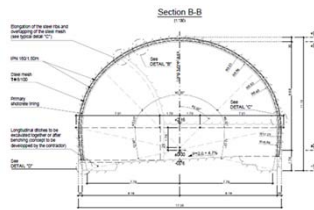
Class 1 – Good rock



Class 2 – Good - fair rock



Class 3 – Fair rock



Reinforced shotcrete and bolts

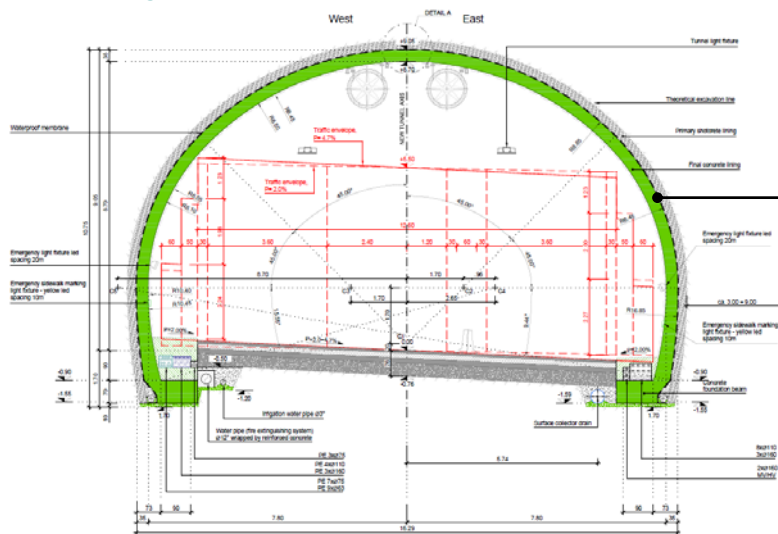
Reinforced shotcrete and steel ribs

19 | 18.11.2021 | Road 60 tunnels, Israel



NORTHERN ALIGNMENT PORTION

Final lining



35 cm reinforced casted concrete without closed invert

20 | 18.11.2021 | Road 60 tunnels, Israel



SOUTHERN ALIGNMENT PORTION

INTRODUCTION

GEOLOGY IN THE AREA OF THE PROJECT

NORTHERN ALIGNMENT PORTION

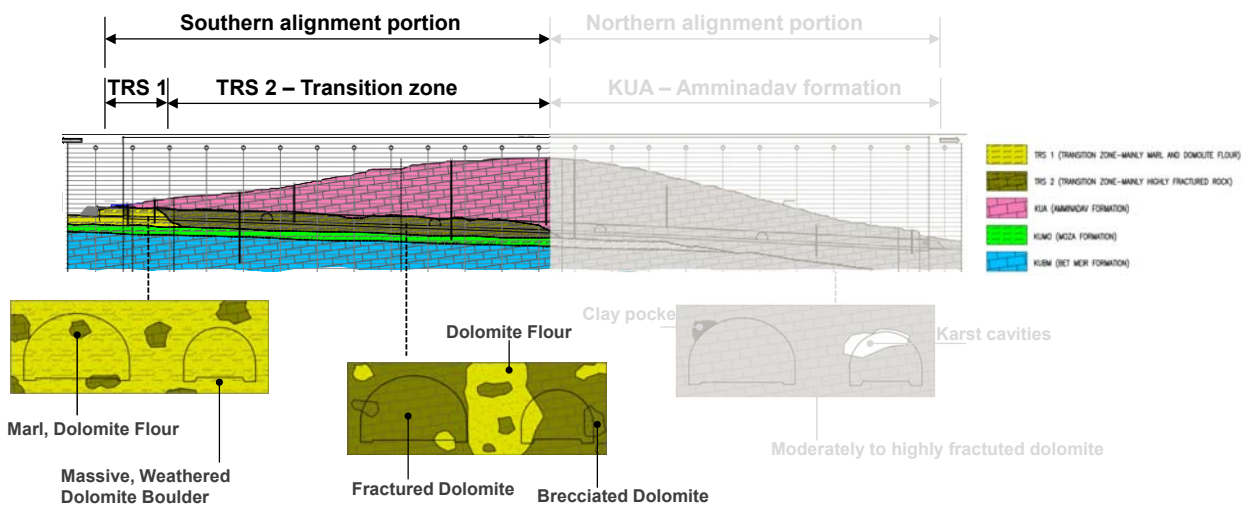
SOUTHERN ALIGNMENT PORTION

SPECIAL SECTIONS

CONSTRUCTION EXPERIENCE

CONCLUSIONS

SOUTHERN ALIGNMENT PORTION



SOUTHERN ALIGNMENT PORTION

Southern portion of the tunnel (St. 0.00 + 0.480 km)

- *Massive dolomite boulders and soft weathered dolomite in marl and dolomite flour (pictures taken during the construction of the existing tunnel)*



23 | 18.11.2021 | Road 60 tunnels, Israel



SOUTHERN ALIGNMENT PORTION

Southern portion of the tunnel (St. 0.00 + 0.480 km)

- *Moderately to heavily jointed dolomite with minor to major pockets of dolomite flour (pictures taken during the construction of the existing tunnel)*



24 | 18.11.2021 | Road 60 tunnels, Israel



SOUTHERN ALIGNMENT PORTION

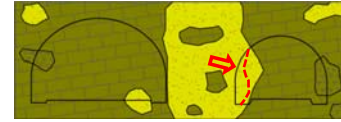
Main geotechnical risks



Instability of the pillar



Instability of the foundation



Damage of the existing tunnel induced by stress redistribution



Damage of the existing tunnel induced by



Instability of karstic cavities

The main geotechnical hazards are associated to the influence of the excavation of the new tunnel on the existing one!

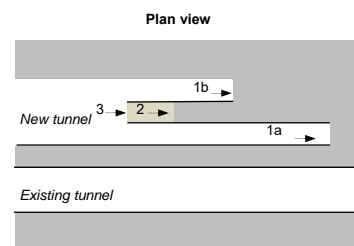
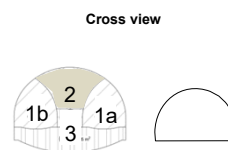
25 | 18.11.2021 | Road 60 tunnels, Israel



SOUTHERN ALIGNMENT PORTION

Requirements

- Limitation of the ground deformations and additional stresses around the existing tunnel
- Stability of the foundation
- Protection of the existing tunnel from excavation induced vibrations
- Assessment of the rock mass condition in the pillar and installation of auxiliary measures if required (cross bolting, filling of karst cavities) before full face excavation



Excavation concept

Partial excavation with side drifts and closed inverts

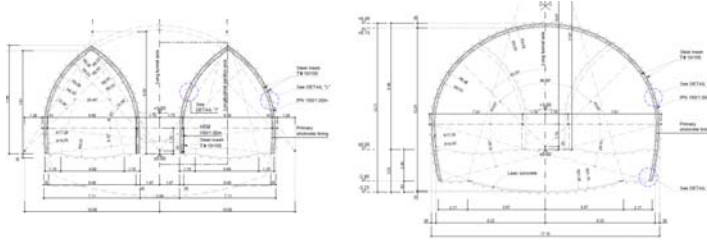
26 | 18.11.2021 | Road 60 tunnels, Israel



SOUTHERN ALIGNMENT PORTION

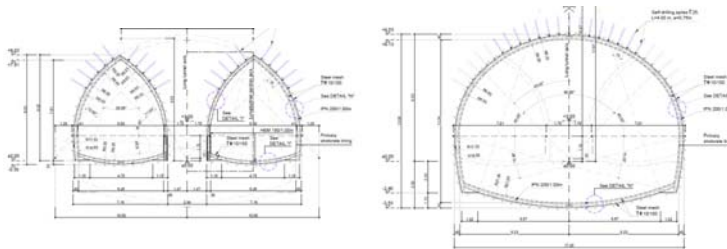
Support classes

**Class 4
Poor rock**



**Reinforced
shotcrete and
temporary steel ribs**

**Class 5
Very
Poor rock**



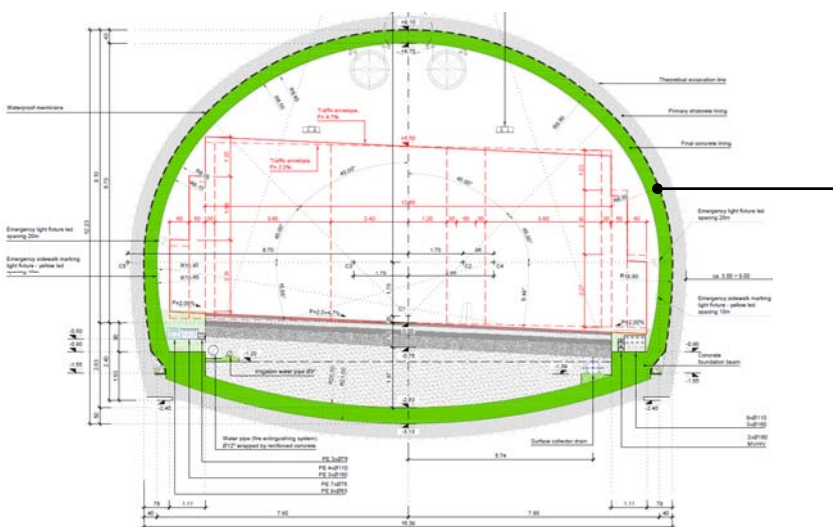
**Reinforced shotcrete
and steel sets with
closed invert**

27 | 18.11.2021 | Road 60 tunnels, Israel



SOUTHERN ALIGNMENT PORTION

Final lining



**40 cm reinforced casted
concrete with
closed invert**

28 | 18.11.2021 | Road 60 tunnels, Israel



SPECIAL SECTIONS

INTRODUCTION

GEOLOGY IN THE AREA OF THE PROJECT

NORTHERN ALIGNMENT PORTION

SOUTHERN ALIGNMENT PORTION

SPECIAL SECTIONS

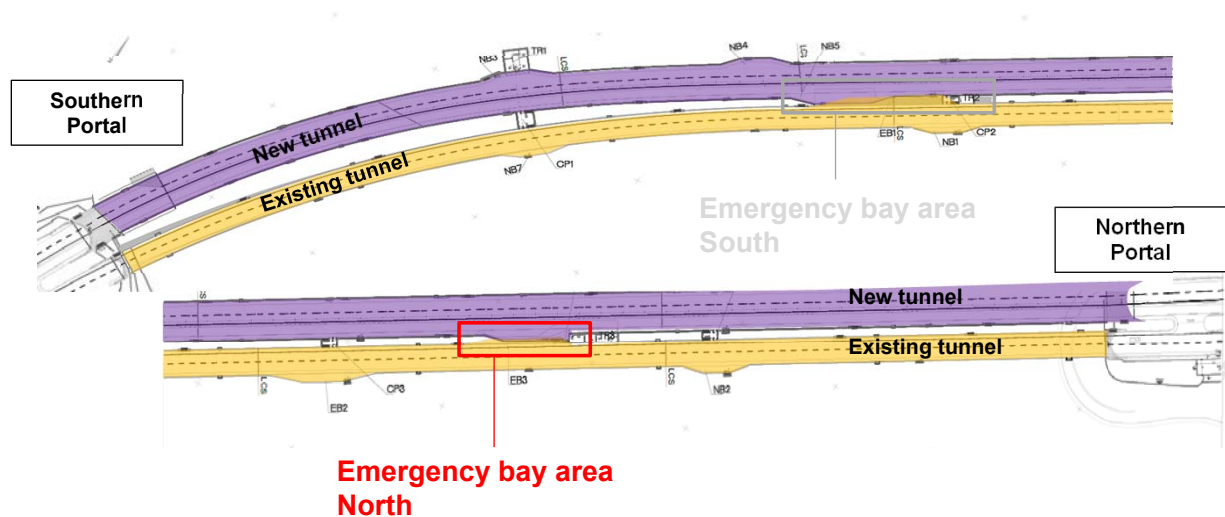
CONSTRUCTION EXPERIENCE

CONCLUSIONS

29 | 18.11.2021 | Road 60 tunnels, Israel



SPECIAL SECTIONS

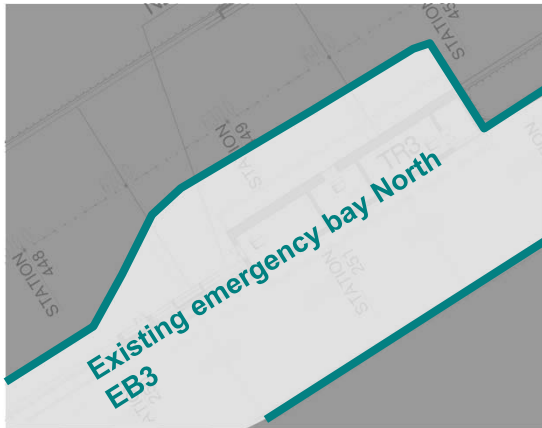


30 | 18.11.2021 | Road 60 tunnels, Israel



SPECIAL SECTIONS

Current layout

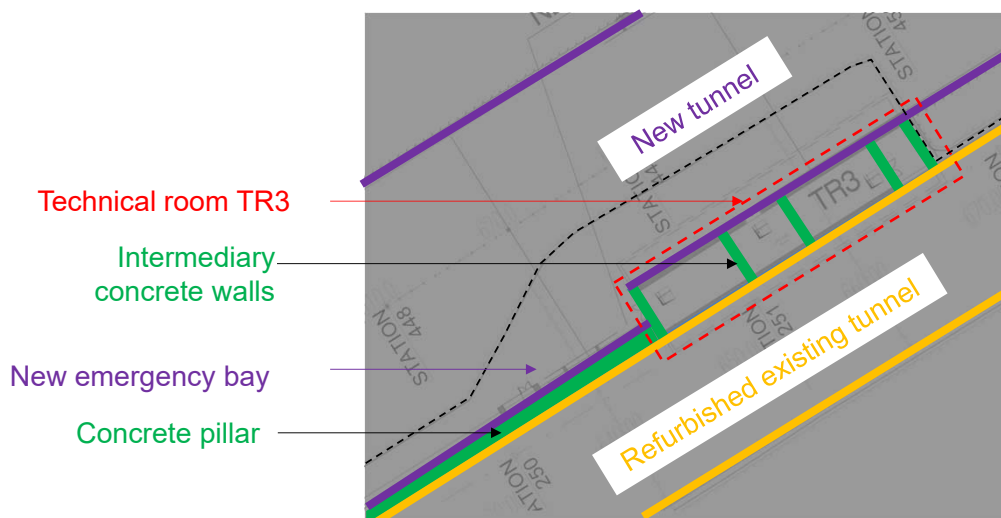


31 | 18.11.2021 | Road 60 tunnels, Israel



SPECIAL SECTIONS

Final layout

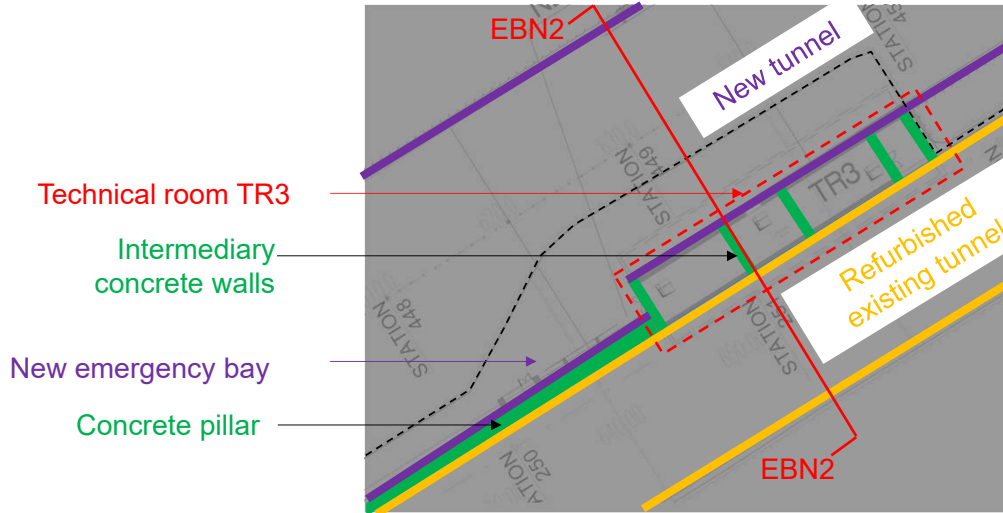


32 | 18.11.2021 | Road 60 tunnels, Israel



SPECIAL SECTIONS

Construction sequence (Section EBN2)

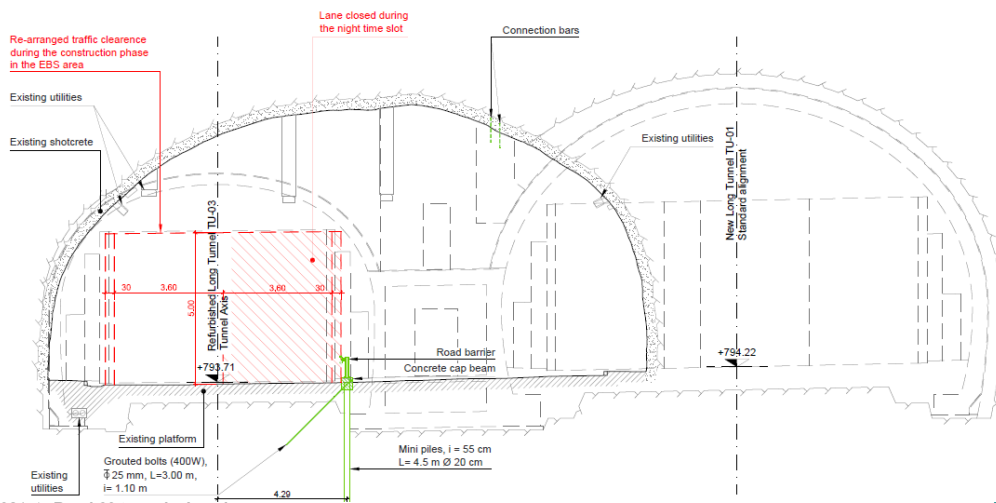


33 | 18.11.2021 | Road 60 tunnels, Israel



SPECIAL SECTIONS

Construction sequence (Section EBN2)

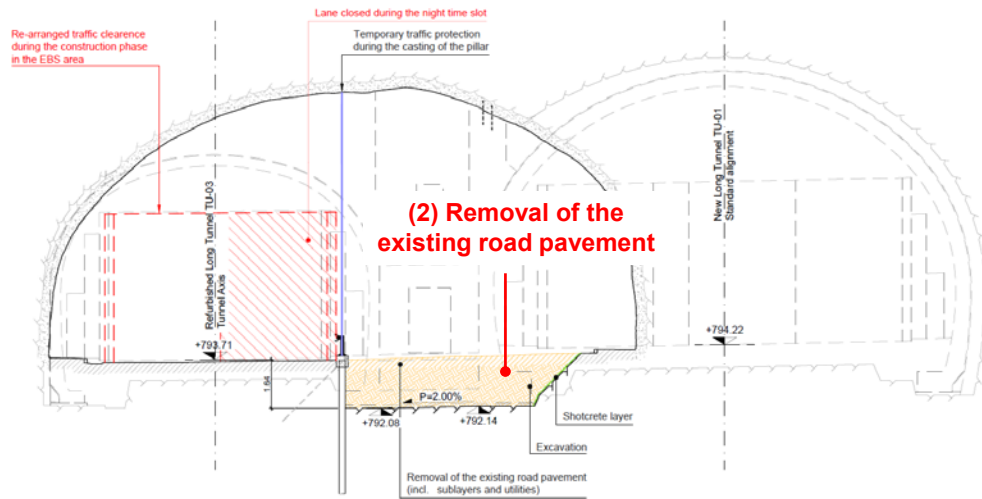


34 | 18.11.2021 | Road 60 tunnels, Israel



SPECIAL SECTIONS

Construction sequence (Section EBN2)



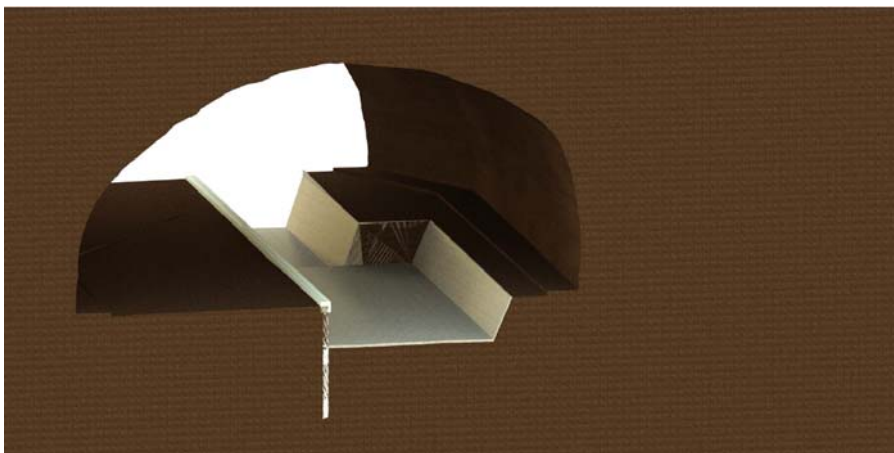
35 | 18.11.2021 | Road 60 tunnels, Israel



SPECIAL SECTIONS

Construction sequence (Section EBN2)

3D visualization after (1) and (2)

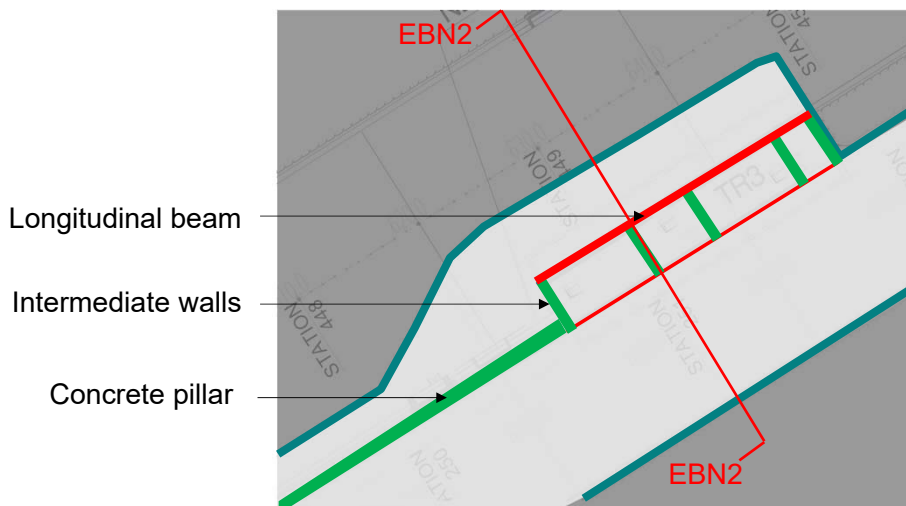


36 | 18.11.2021 | Road 60 tunnels, Israel



SPECIAL SECTIONS

Construction sequence (Section EBN2)

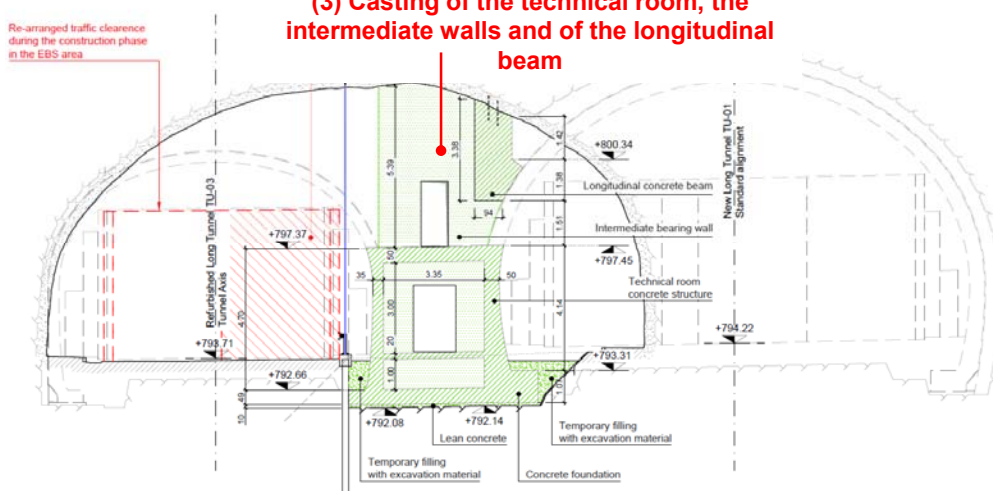


37 | 18.11.2021 | Road 60 tunnels, Israel



SPECIAL SECTIONS

(3) Casting of the technical room, the intermediate walls and of the longitudinal beam



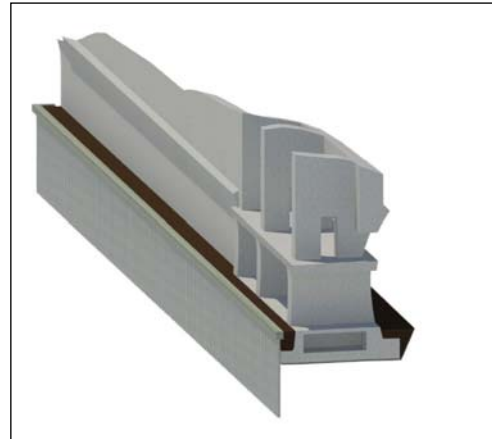
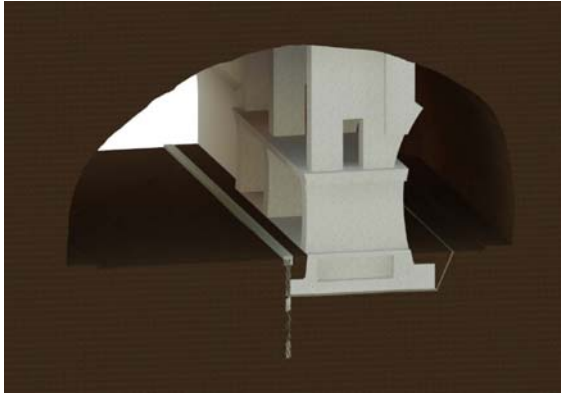
38 | 18.11.2021 | Road 60 tunnels, Israel



SPECIAL SECTIONS

Construction sequence (Section EBN2)

3D visualization after (3)



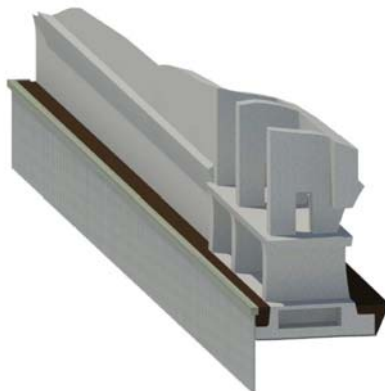
39 | 18.11.2021 | Road 60 tunnels, Israel



SPECIAL SECTIONS

Construction sequence (Section EBN2)

3D visualization after (3)

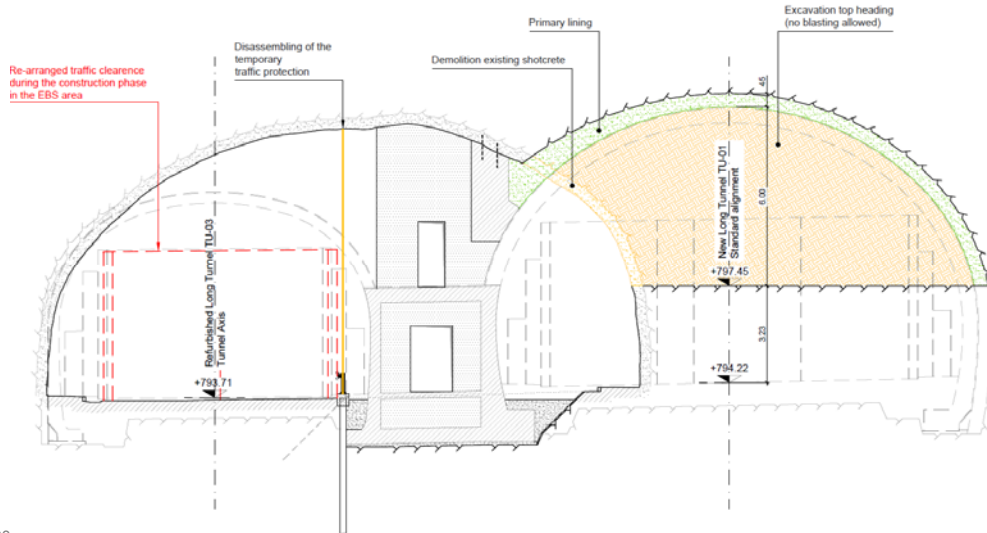


40 | 18.11.2021 | Road 60 tunnels, Israel



SPECIAL SECTIONS

Construction sequence (Section EBN2)



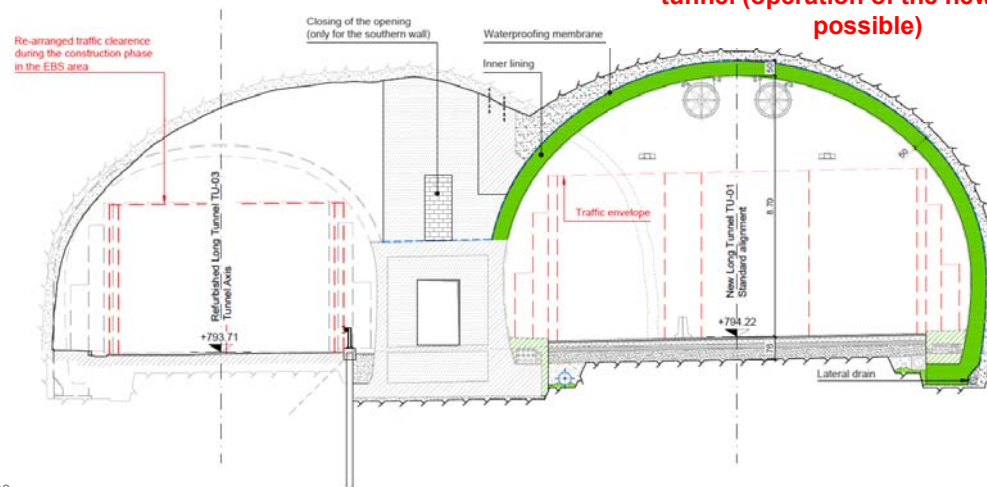
41 | 18.11.2021 | ROAD BY TUNNELS, ISRAEL



SPECIAL SECTIONS

Construction sequence (Section EBN2)

(5) Casting of the inner lining of the new tunnel (operation of the new tunnel possible)



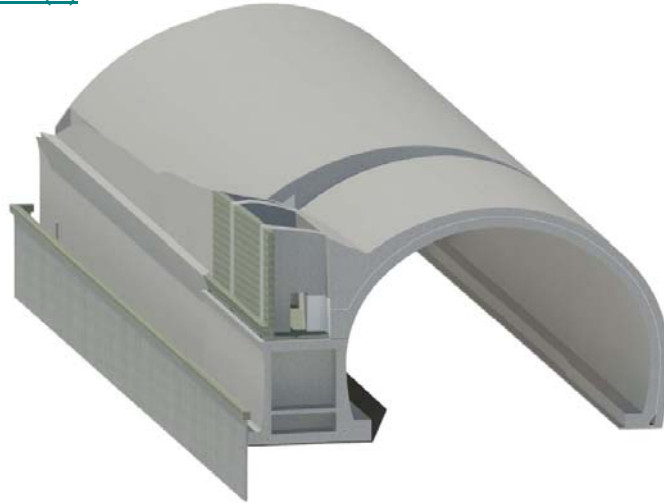
42 | 18.11.2021 | ROAD BY TUNNELS, ISRAEL



SPECIAL SECTIONS

Construction sequence (Section EBN2)

3D visualization after (4) and (5)

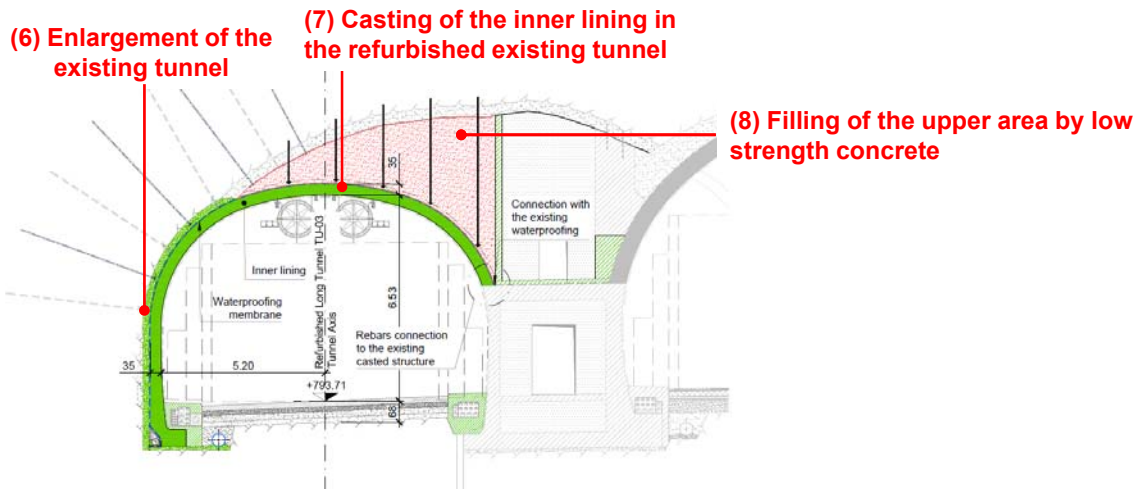


43 | 18.11.2021 | Road 60 tunnels, Israel



SPECIAL SECTIONS

Construction sequence (Section EBN2)



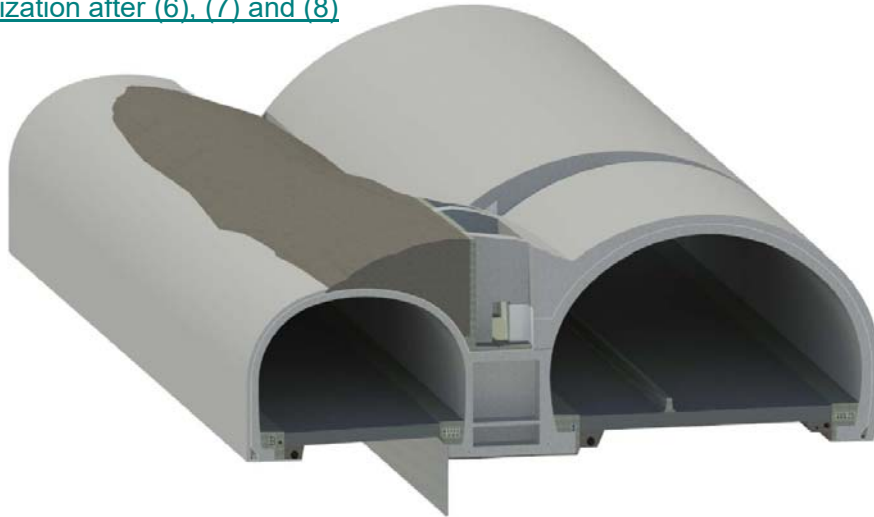
44 | 18.11.2021 | Road 60 tunnels, Israel



SPECIAL SECTIONS

Construction sequence (Section EBN2)

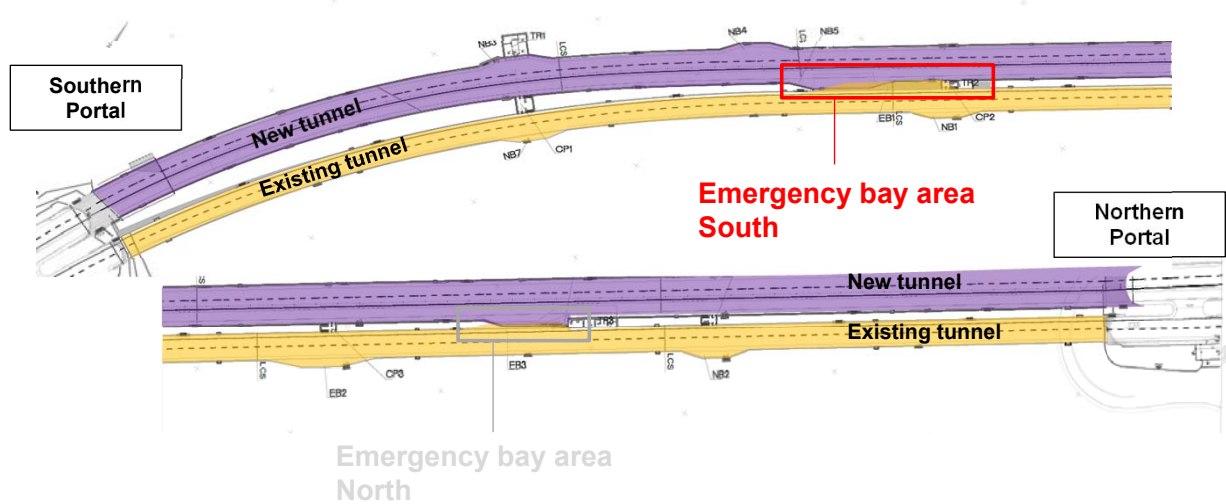
3D visualization after (6), (7) and (8)



45 | 18.11.2021



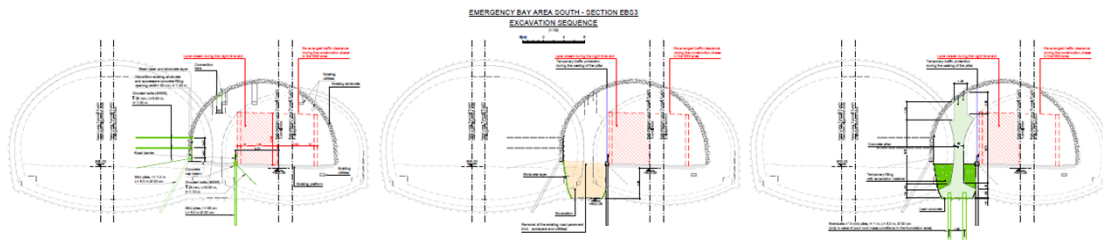
SPECIAL SECTIONS



46 | 18.11.2021 | Road 60 tunnels, Israel



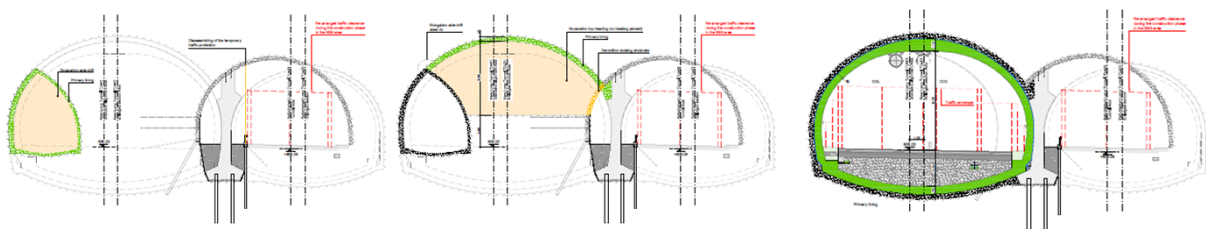
SPECIAL SECTIONS



47 | 18.11.2021 | Road 60 tunnels, Israel



SPECIAL SECTIONS



48 | 18.11.2021 | Road 60 tunnels, Israel



CONSTRUCTION EXPERIENCE



51 | 18.11.2021 | Road 60 tunnels, Israel



CONSTRUCTION EXPERIENCE



52 | 18.11.2021 | Road 60 tunnels, Israel



CONSTRUCTION EXPERIENCE



53 | 18.11.2021 | Road 60 tunnels, Israel



CONSTRUCTION EXPERIENCE



54 | 18.11.2021 | Road 60 tunnels, Israel



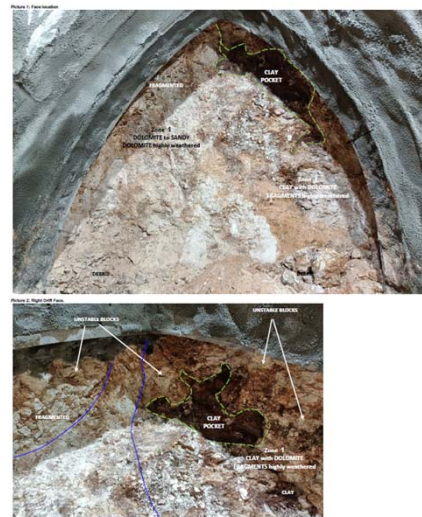
CONSTRUCTION EXPERIENCE



55 | 18.11.2021 | Road 60 tunnels, Israel



CONSTRUCTION EXPERIENCE



56 | 18.11.2021 | Road 60 tunnels, Israel



CONSTRUCTION EXPERIENCE



57 | 18.11.2021 | Road 60 tunnels, Israel



CONSTRUCTION EXPERIENCE

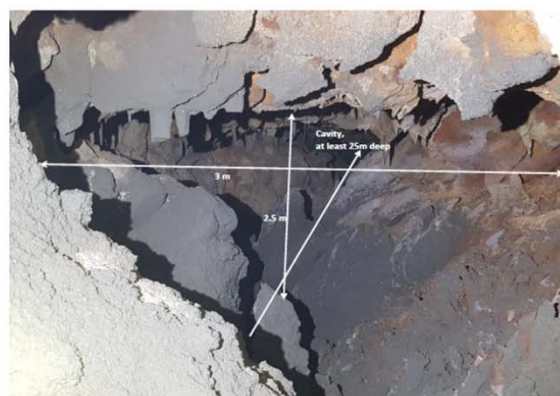


Fig. 4. Hebron (left) wall

58 | 18.11.2021 | Road 60 tunnels, Israel



CONSTRUCTION EXPERIENCE



59 | 18.11.2021 | Road 60 tunnels, Israel



CONSTRUCTION EXPERIENCE



60 | 18.11.2021 | Road 60 tunnels, Israel



CONSTRUCTION EXPERIENCE



61 | 18.11.2021 | Road 60 tunnels, Israel



CONSTRUCTION EXPERIENCE



62 | 18.11.2021 | Road 60 tunnels, Israel



CONSTRUCTION EXPERIENCE



63 | 18.11.2021 | Road 60 tunnels, Israel



CONSTRUCTION EXPERIENCE



64 | 18.11.2021 | Road 60 tunnels, Israel



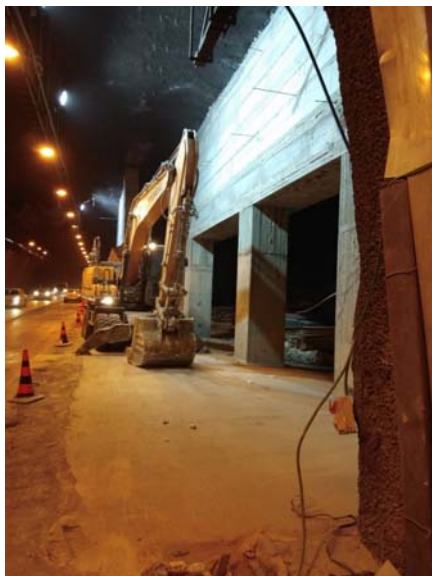
CONSTRUCTION EXPERIENCE



65 | 18.11.2021 | Road 60 tunnels, Israel



CONSTRUCTION EXPERIENCE



66 | 18.11.2021 | Road 60 tunnels, Israel



CONSTRUCTION EXPERIENCE



67 | 18.11.2021 | Road 60 tunnels, Israel



CONSTRUCTION EXPERIENCE



68 | 18.11.2021 | Road 60 tunnels, Israel



CONSTRUCTION EXPERIENCE



69 | 18.11.2021 | Road 60 tunnels, Israel



CONSTRUCTION EXPERIENCE



70 | 18.11.2021 | Road 60 tunnels, Israel



CONCLUSIONS

INTRODUCTION

GEOLOGY IN THE AREA OF THE PROJECT

NORTHERN ALIGNMENT PORTION

SOUTHERN ALIGNMENT PORTION

SPECIAL SECTIONS

CONSTRUCTION EXPERIENCE

CONCLUSIONS

71 | 18.11.2021 | Road 60 tunnels, Israel



CONCLUSIONS

Unique project with exceptional high technical complexity requiring unique engineering skills and solutions arising from the combination of:

- operational constraints (the existing tunnel in operation during the entire construction of the new tunnel);
- extremely difficult rock mass conditions (highly weathered dolomite);
- small distance between the tubes.

72 | 18.11.2021 | Road 60 tunnels, Israel



THANK YOU FOUR YOUR ATTENTION



73 | 18.11.2021 | Road 60 tunnels, Israel



Join our team!

Dr. Roberto Schuerch
roberto.schuerch@pini.group