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Seismic monitoring during the excavation of a shallow NATM tunnel using the plasma blasting method

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Presented by:

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Seismic Monitoring During the Excavation of a Shallow NATM Tunnel Using the Plasma Blasting Method

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Introduction

Densely urbanized environment

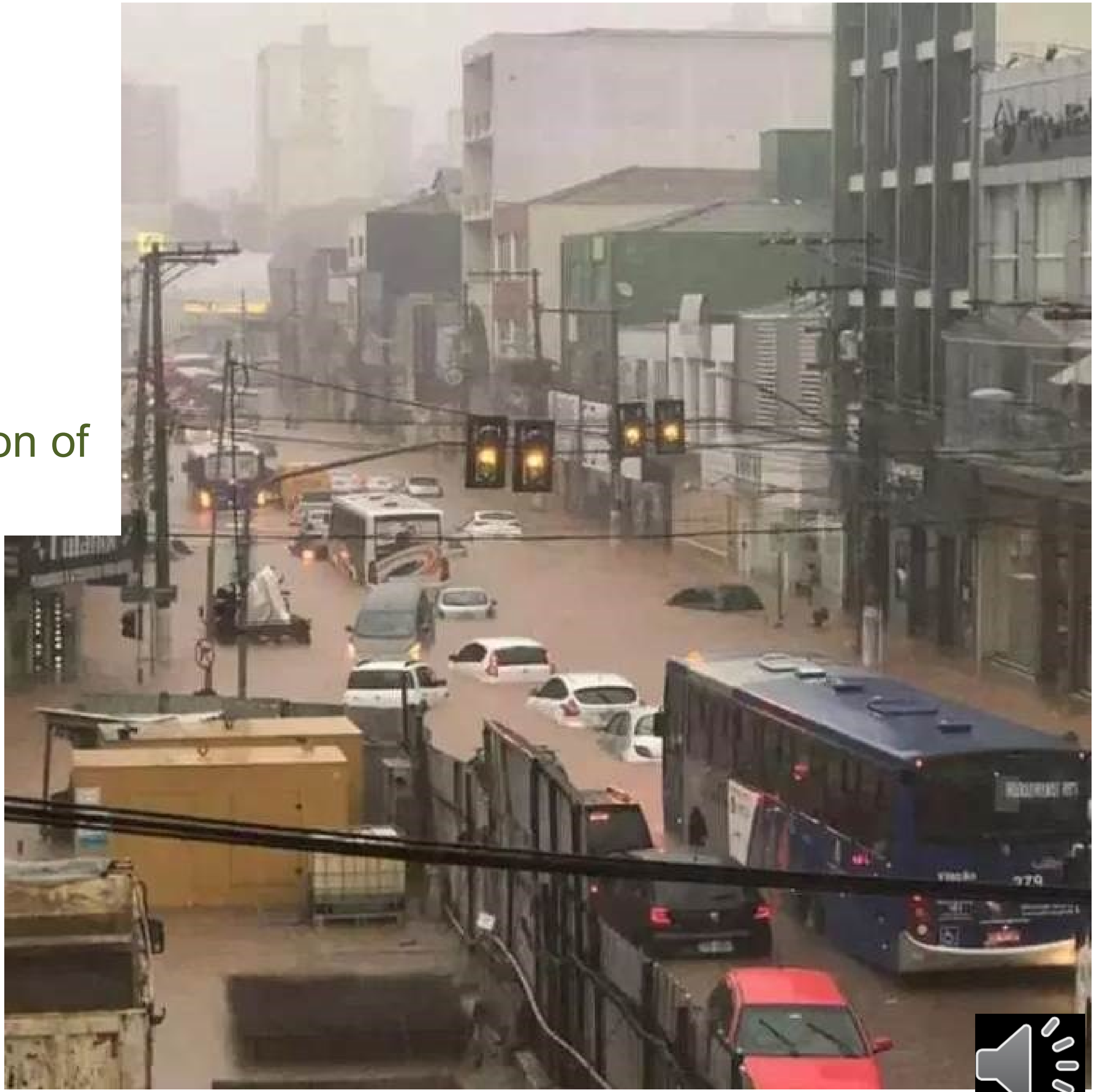
Shallow NATM tunnel

Geotechnical monitoring

Seismic monitoring

Localization

- Jurubatuba Street
- São Bernardo do Campo
- Metropolitan Region of São Paulo, Brazil



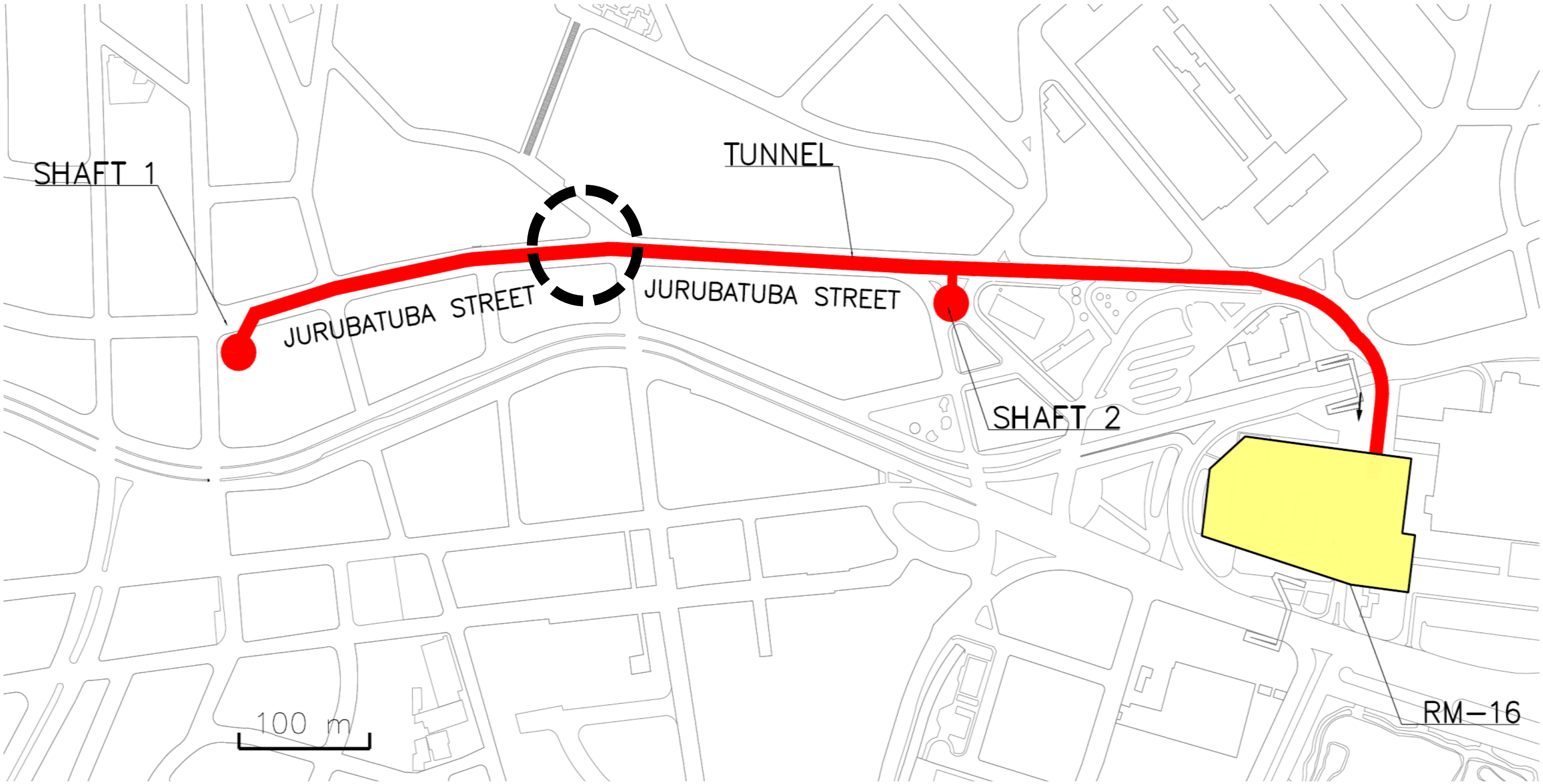
SãoBernardo.Info (2016)

The Tunnel

- 960 m long
- Circular shape
- Steel ribs, wire mesh, spiles, shotcrete
- Tassometers, piezometers, settlement markers, monument pins

The Tunnel

- Four fronts and two shafts



Projection, in the plan, of the tunnel and shafts 1 and 2 (red line); the location of fragmentation u
plasma technology (black circle); and the RM-16 Reservoir (yellow)

Geological and Geotechnical Caracterization

- Embu Complex
- Alluvial sediments
- Water Level

The Plasma Blasting Method

Holes bored in the rock

Capsules triggered by electrical currents

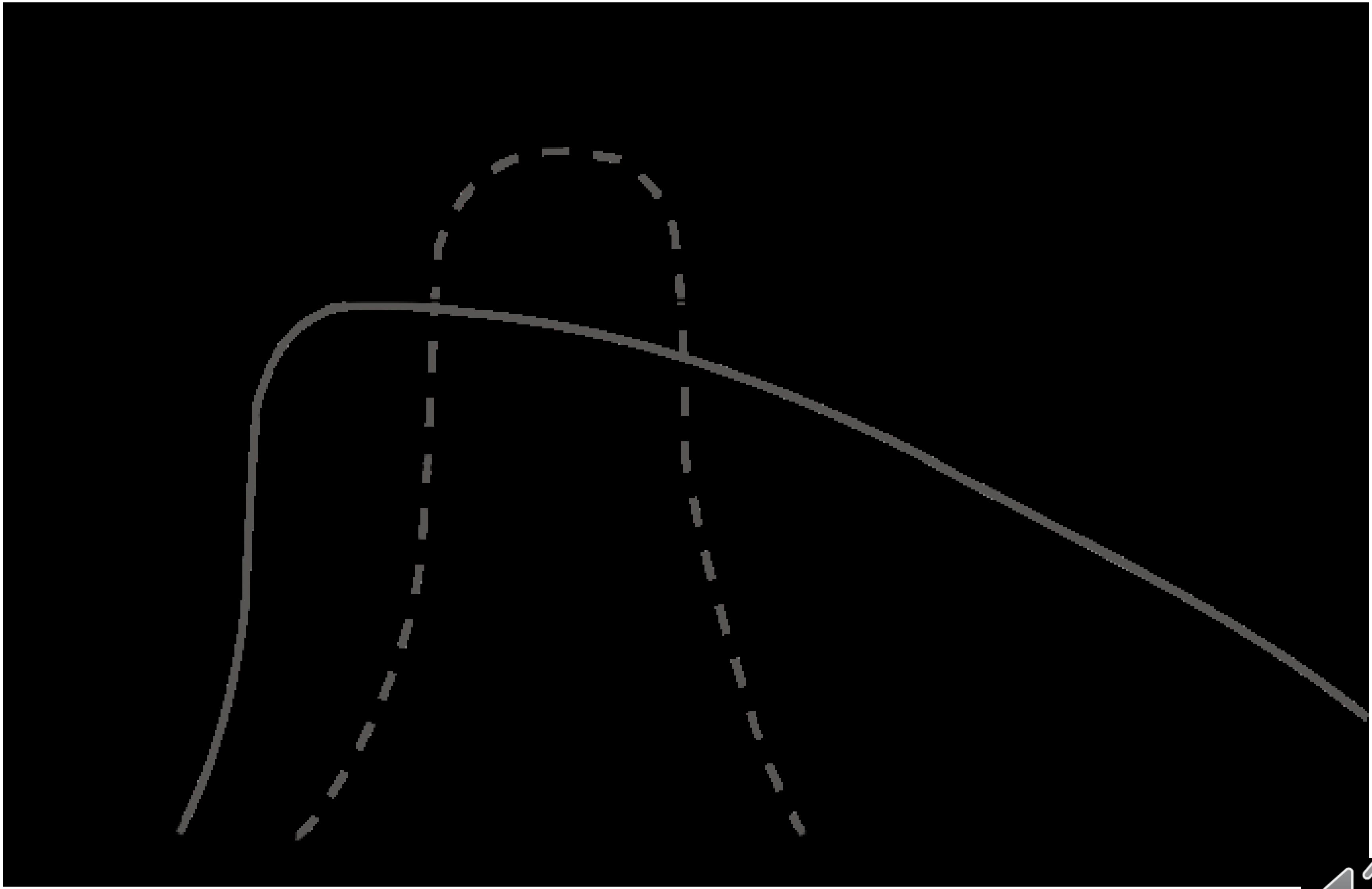
Energy accumulator

The Plasma Blasting Method

PLASMA TECHNOLOGY vs. BLASTING BY EXPLOSIVES

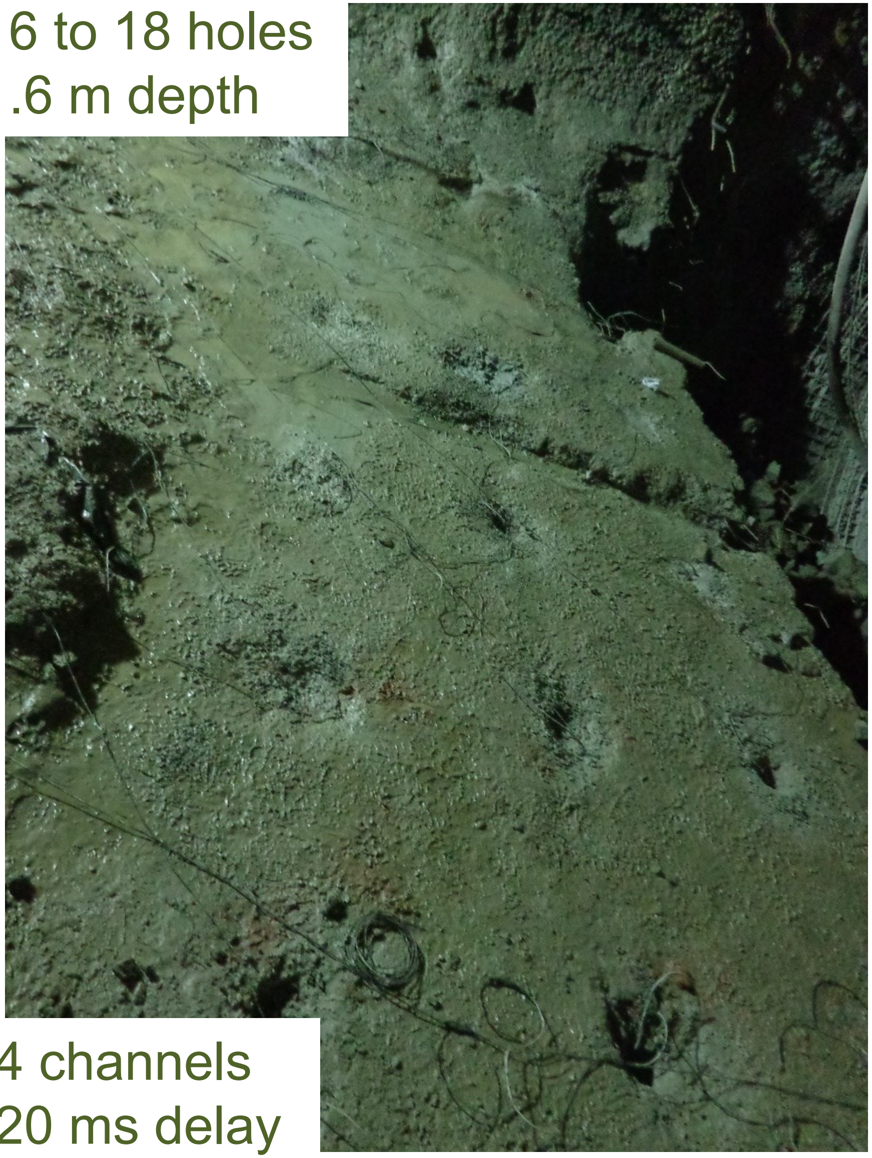
- Low volume of gases generated
- Attenuation of the peak particle velocity (PPV) as a function of the distance
- High vibration frequency of particles due to the blasting
- Attenuation of the occurance of flyrock fragments and noise generation

The Plasma Blasting Method



The Seismic Monitoring

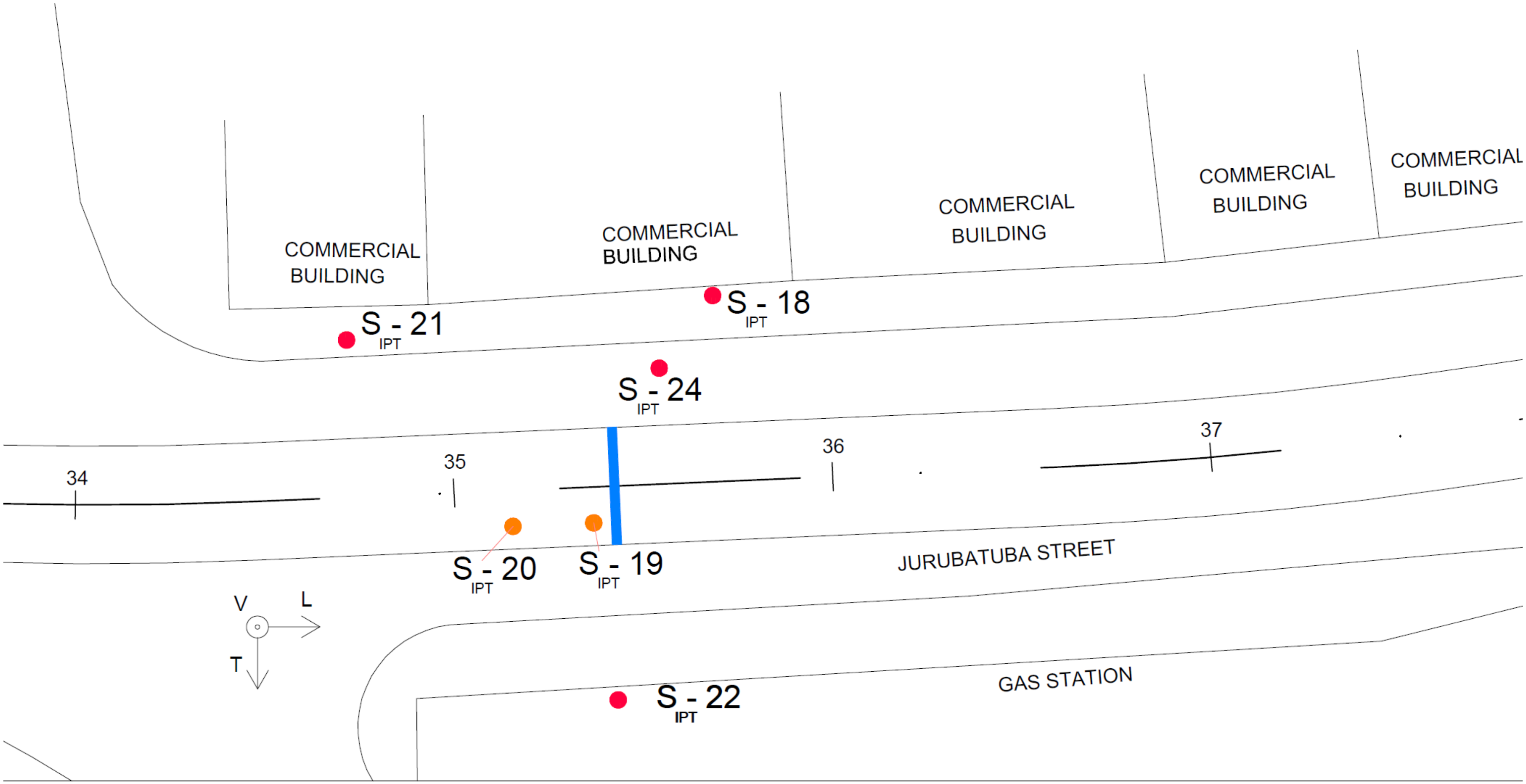
16 to 18 holes
1.6 m depth



4 channels
20 ms delay

Hydraulic breaker

The Seismic Monitoring



SUBTITLE

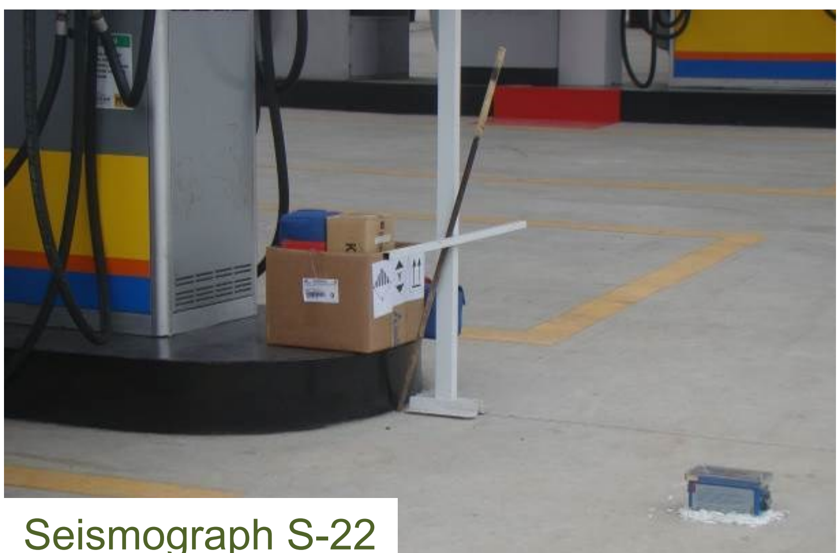
- IPT'S SEISMOGRAPHS INSTALLED ON THE SURFACE (JURUBATUBA STREET)
- IPT'S SEISMOGRAPHS INTALLED ON THE CAST CONCRETE ARCH (INSIDE THE TUNNEL)
- BOREHOLES LOCALIZATION (INSIDE THE TUNNEL).

EVENT 3
2018.06

The Seismic Monitoring

Seismograph S-19

Seismograph S-18

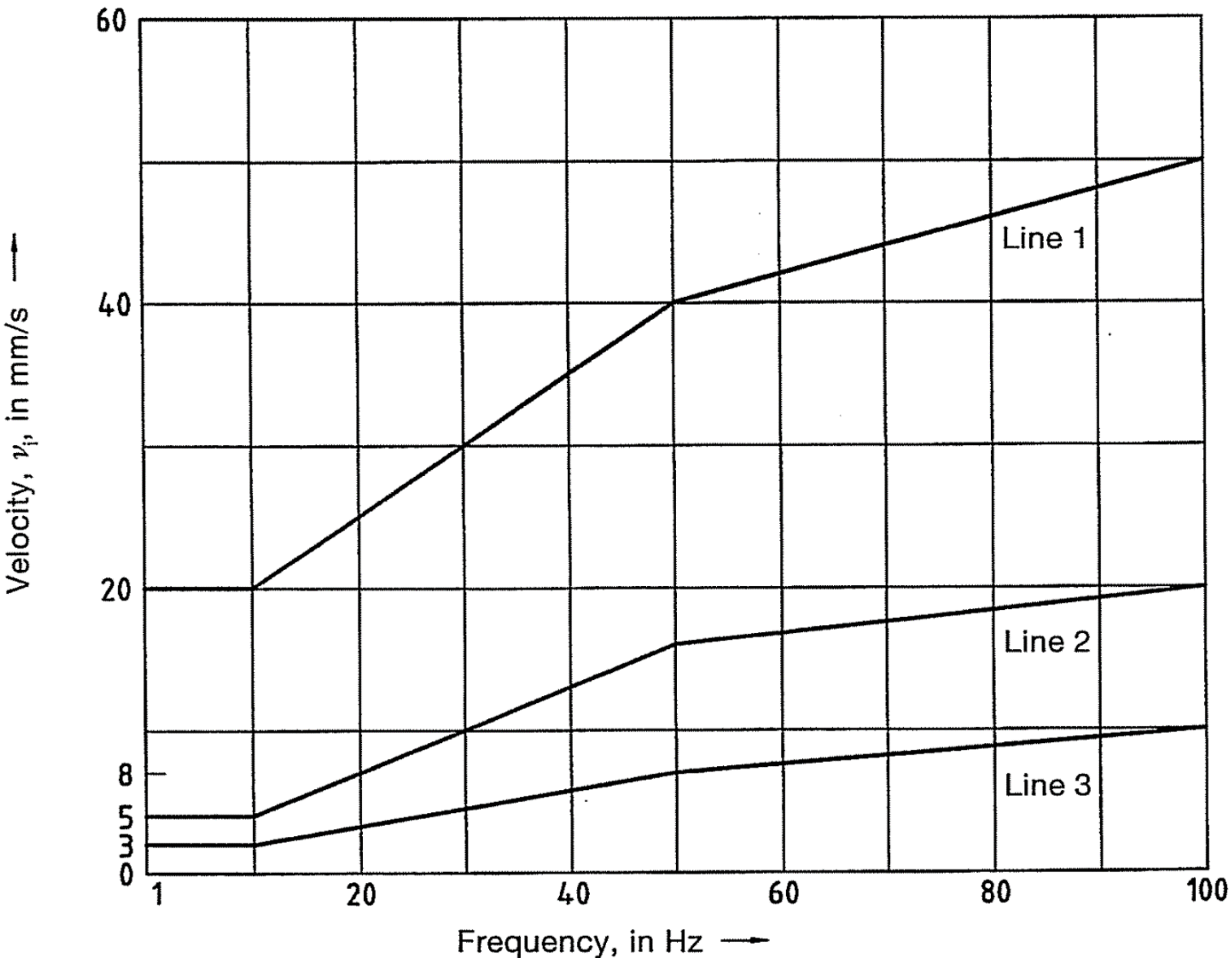


Seismograph S-22

Seismograph S-24

The Seismic Monitoring

- Trigger value of 0.5 mm/s (perceptual limit by people)
- Technical Standard: DIN 4150, NBR 9653 and CETESB D07.013



Line	Type of structure
1	Buildings used for commercial purposes, industrial buildings, and buildings of similar design
2	Dwellings and buildings of similar design and/or occupancy
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (e.g. listed building under preservation

DIN (19

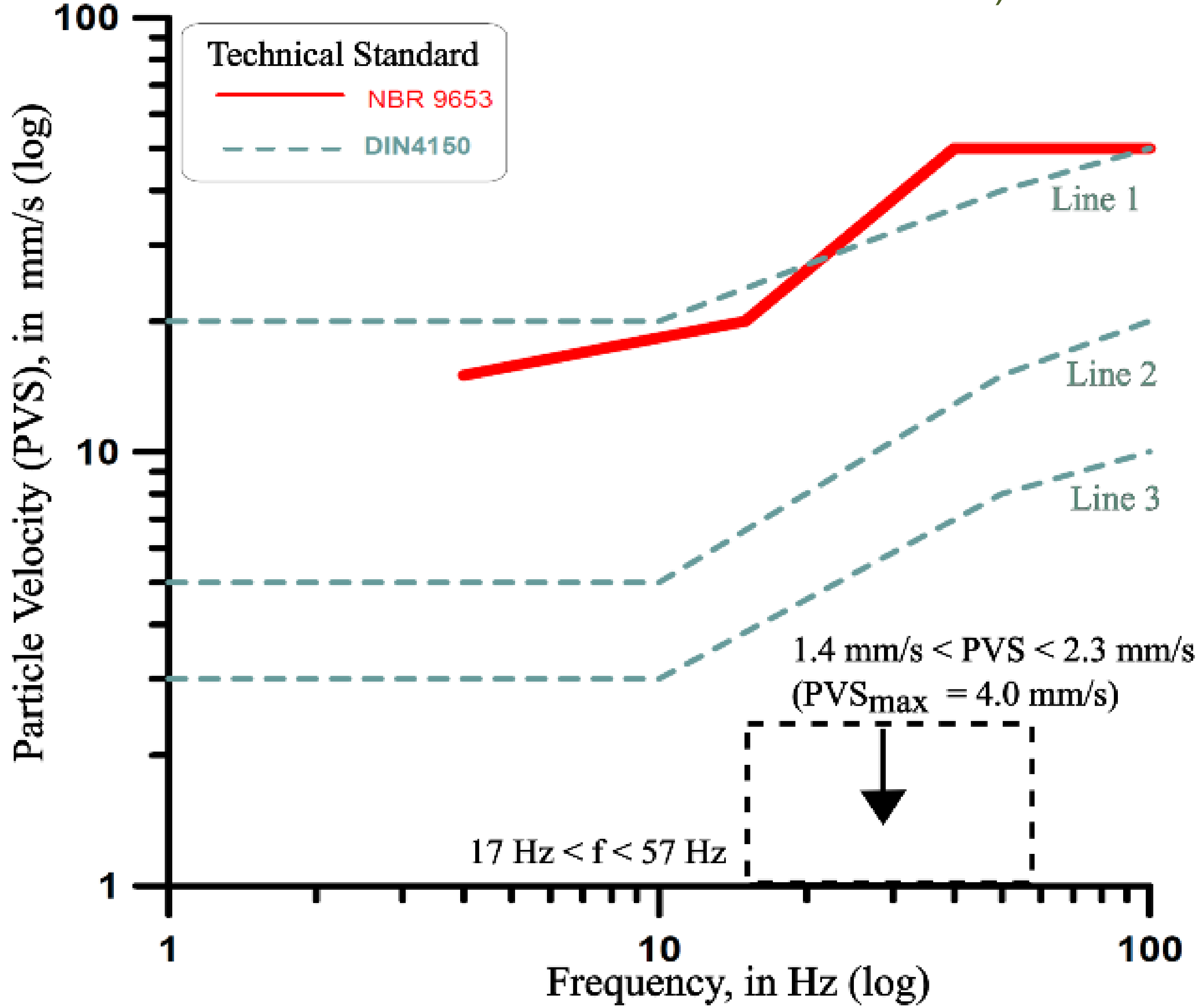
Results

Event	Sism.	fT (Hz)	fV (Hz)	fL (Hz)	PVS (mm/s)	D (m)
1	S-18	25.6	17.1	30.1	1.39	22.7
	S-19	>100	>100	>100	2.54	7.8
	S-20	>100	>100	>100	1.85	3.2
	S-21	-	-	-	-	41.3
	S-22	22.3	18.3	36.6	0.70	25.4
	S-24	24.4	21.3	25.6	1.46	20.5
2	S-21	22.3	19.7	30.1	1.85	29.0
	S-22	17.1	22.3	36.6	3.11	22.5
3	S-18	46.5	16.5	42.7	2.12	21.6
	S-19	17.1	34.1	13.8	7.35	4.7
	S-20	73.1	>100	>100	3.66	8.7
	S-21	32.0	23.3	30.1	1.87	27.7
	S-22	42.7	24.4	51.2	2.09	22.4
	S-24	30.1	25.6	42.7	2.88	20.5
4	S-18	51.2	56.9	56.9	4.03	22.1
	S-19	>100	>100	85.3	6.51	6.4
	S-21	39.4	19.0	24.4	1.48	25.8
	S-22	46.5	26.9	46.5	1.81	22.1
	S-24	34.1	32.0	46.5	2.29	20.3

- unregistered, because particle velocity fell short of the seismograph recording trigger (below 0.5 mm/s)
D (m): shortest distance, in meters, between the region of the holes drilled inside the tunnel for insertion of the plasma capsules and the position of the respective seismograph. Was considered, obligatory, the particle trajectory through the tunnel support and the soil/rock mass.

Results

The prevalance of PVS was between 1.4 mm/s and 2.3 mm/s (64% of monitored events)



Results

Conclusions

- Plasma blasting technology was adequate for the excavation of shallow NATM tunnel in densely urbanized area
- The limits established in the Project and in Technical Standards were integrally obeyed
- Two main points:
  - The control of vibration frequencies
  - The protection against flyrock fragments
- Adaquate rock drilling machinery
- Constant geotechnical and seismic monitoring during the excavation

References

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Thank You!
Terima Kasih
谢谢！
ありがとうございます
Je Vous Remercie!

감사합니다!
நன்றி
ขอบคุณ
Cảm Ơn!
Gracias!