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CÔNG TY CỔ PHẦN TƯ VẤN XÂY DỰNG ĐIỆN 1

12TH ASIAN ROCK MECHANICS SYMPOSIUM
22-26 Nov. 2022, Hanoi, Vietnam

Su-Pan 1 HPP - Vietnam: Underground solution

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Su-Pan 1 hydropower project

1. Project introduction
2. Challenges
3. Layout options
4. Norwegian experience
5. Stress measurement
6. Rock stress issue
7. Concluding remarks

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Su-Pan 1 HPP - Introduction

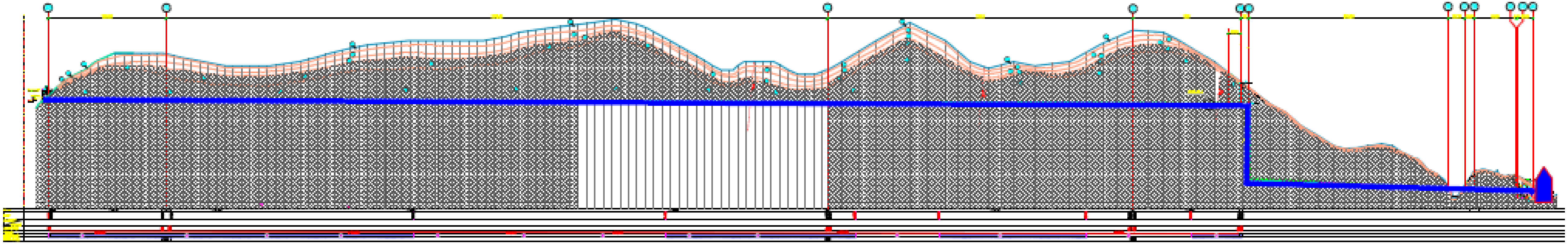
- Approximately 250 km, north-west of Hanoi.
- Installation capacity of 30 MW (two units).
- Maximum water head of 250 m.
- Maximum discharge of almost 17 m3/s.

Su-Pan 1 HPP – Challenges

- Located at foothill of a high mountain range with a steep slope.

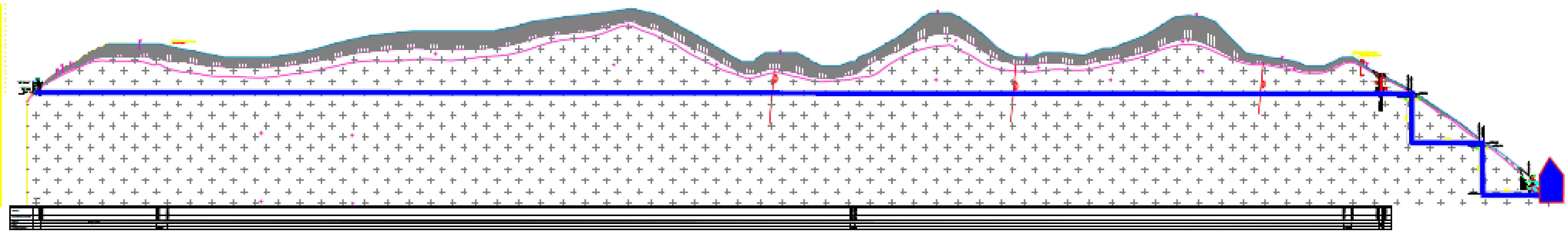
- At the boundary of a nature reserved area.

Su-Pan 1 HPP – Layout options



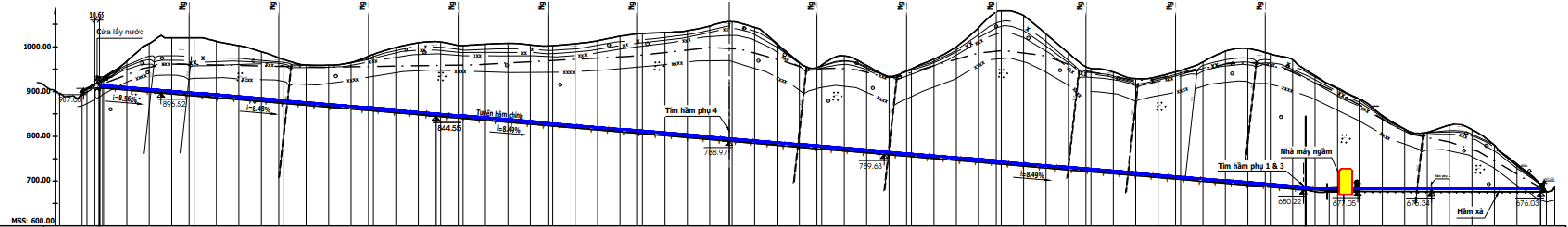
- Option 1: Upper headrace tunnel – Vertical shaft – Lower pressure tunnel – Open powerhouse on the other side of the river.
- Advantages: Less surface excavation.
- Dis-advantages: High vertical shaft – not easy to get local contractor, complicated connection over the river with steel pipe.

Su-Pan 1 HPP – Layout options



- Option 2: Upper headrace tunnel – 2 vertical shaft – Lower pressure tunnel – Open powerhouse on the same side of the river.
- Advantages: Shorter vertical shaft to fit local contractor.
- Dis-advantages: More surface excavation in a natural protected area.

Su-Pan 1 HPP – Layout options

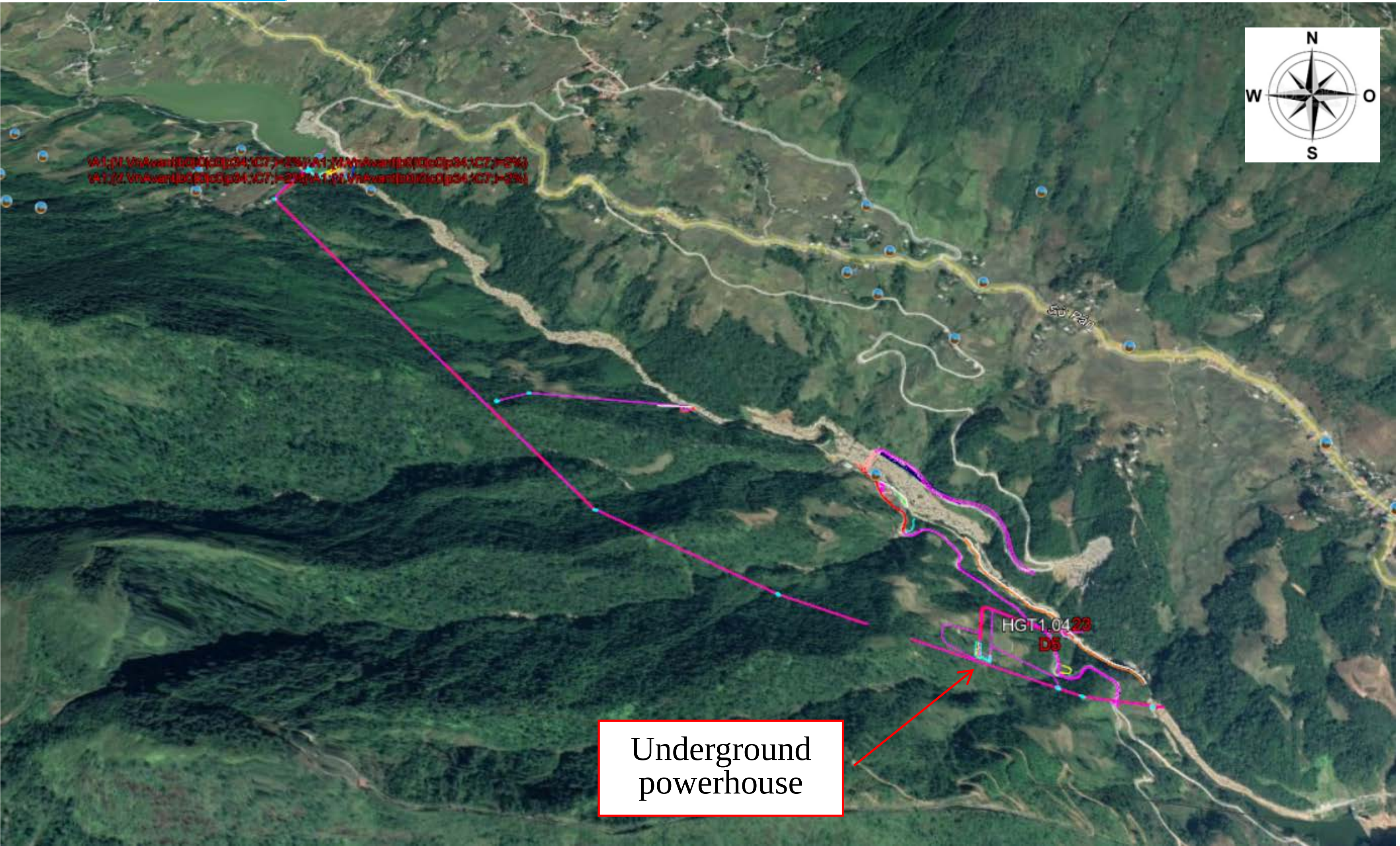


Cao độ tự nhiên (m)	Khoảng cách lẻ (m)
896.29	50
896.03	50
932.3	50
967.67	50
1007	50
1020	50
1020	50
1012.17	50
1002.46	50
988.73	50
971.17	50
959.29	50
958.83	50
964.68	50
982.95	50
998.59	50
1009.04	50
1010.68	50
1002.7	50
1005.79	50
1007.67	50
1004.34	50
1002.51	50
1006.83	50
1013.25	50
1023.44	50
1029.53	50
1031.71	50
1035.67	50
1045.85	50
1055.53	50
1043.31	50
1007.12	50
964.33	50
959.13	50
979.5	50
958.06	50
933.61	50
950.48	50
972.33	49.96
999.93	50.04
1042.67	50
1080	50
1069.74	50
1028.46	50
985.78	50
951.28	50
943.18	50
928.67	50
933.66	50
946.94	50
965.99	50.02
990	49.98
996.22	50
983.83	50
970.71	50
935.17	50
907.75	50
883.25	50
846.08	50
815.93	50
809	50
825.1	50
814.83	50
780.42	50
738.18	50
694.92	84.33
689	

Cao độ thiết kế (m)	Khoảng cách thiết kế (m)
907.55 / 907.65	7.00
844.55	743.00
788.97	654.52
680.22	1280.53
677.2	57.37
677.2	32.6
676.34	195.95
676.03 / 676.03	243.5
	11.35

- Option 3: Underground powerhouse – Inclined headrace tunnel.
- Advantages: No vertical.
- Dis-advantages: May require more investigation for underground powerhouse.
- This option is based on Norwegian experience in HPP development.

Su-Pan 1 HPP – Layout options



- Option 3 following Norwegian experience in HPP development.
- What is to be aware of when using Norwegian experience?

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Su-Pan 1 HPP – Norwegian experience

Hydropower industry in Norway:

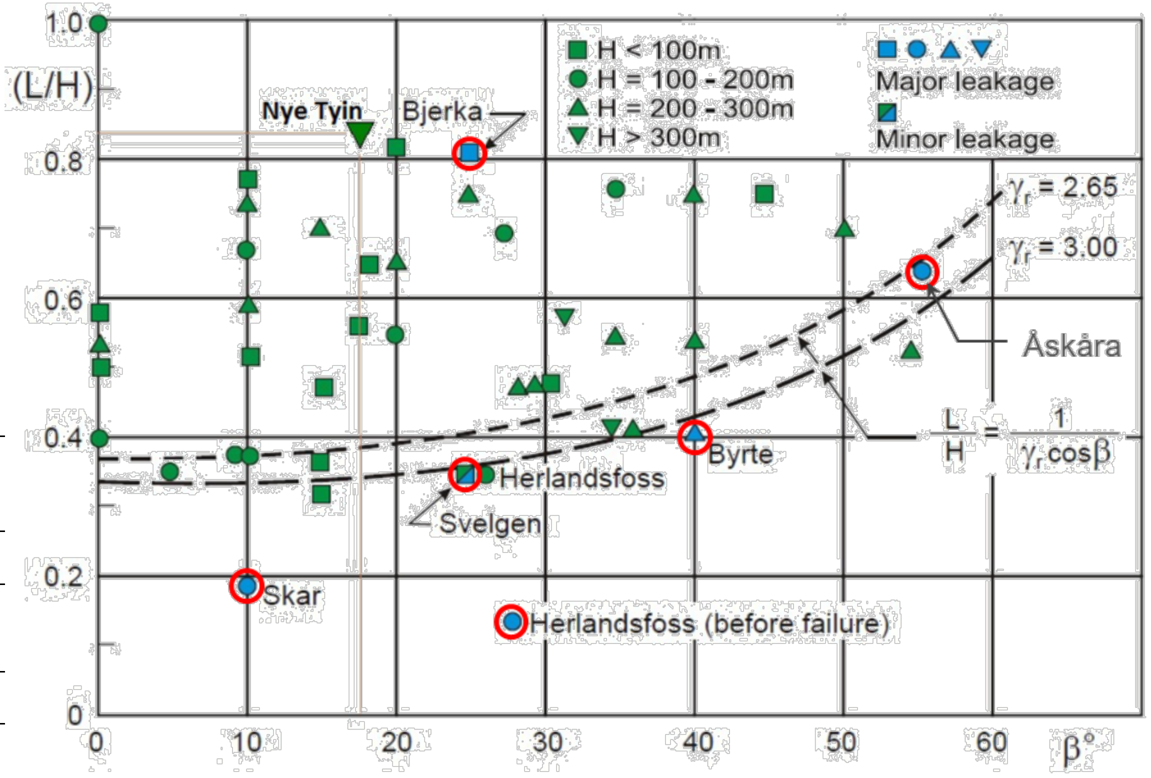
- Over 1.500 power plants.
- Installed capacity around 31.000 MW.
- Annual production around 130 TWh – Providing 90% of power demand in Norway.
- Around 5.000km of tunnels have been excavated for HEP.
- Around 200 underground HEP.

Su-Pan 1 HPP – Norwegian experience

- Experience in Norway:

Rock stress always play an important role in HPP development.

Project	Year	Water head (m)	Rock types	Cross-section Area (m2)	Failure condition
Herlandsfoss	1919	136	Mica-schist	8.0 (Tunnel)	Partly failed
Skar	1920	129	Gneiss-granite	Tunnel	Completely failed
Svelgen	1921	152	Sandstone	4.5 (Shaft)	Minor leakage
Byrte	1968	303	Granite Gneiss	6.0 (Shaft)	Partly failed
Åskåra	1970	210	Devonian Sandstone	9.0 (Tunnel)	Partly failed
Bjerka	1971	72	Gneiss	10.0 (Tunnel)	Partly failed
Holsbru	2012	63	Dark Gneiss	18.0 (Tunnel)	Leakage



Failure of unlined pressure shafts and tunnels in Norway (Broch, 1982; Selmer-Olsen, 1985)

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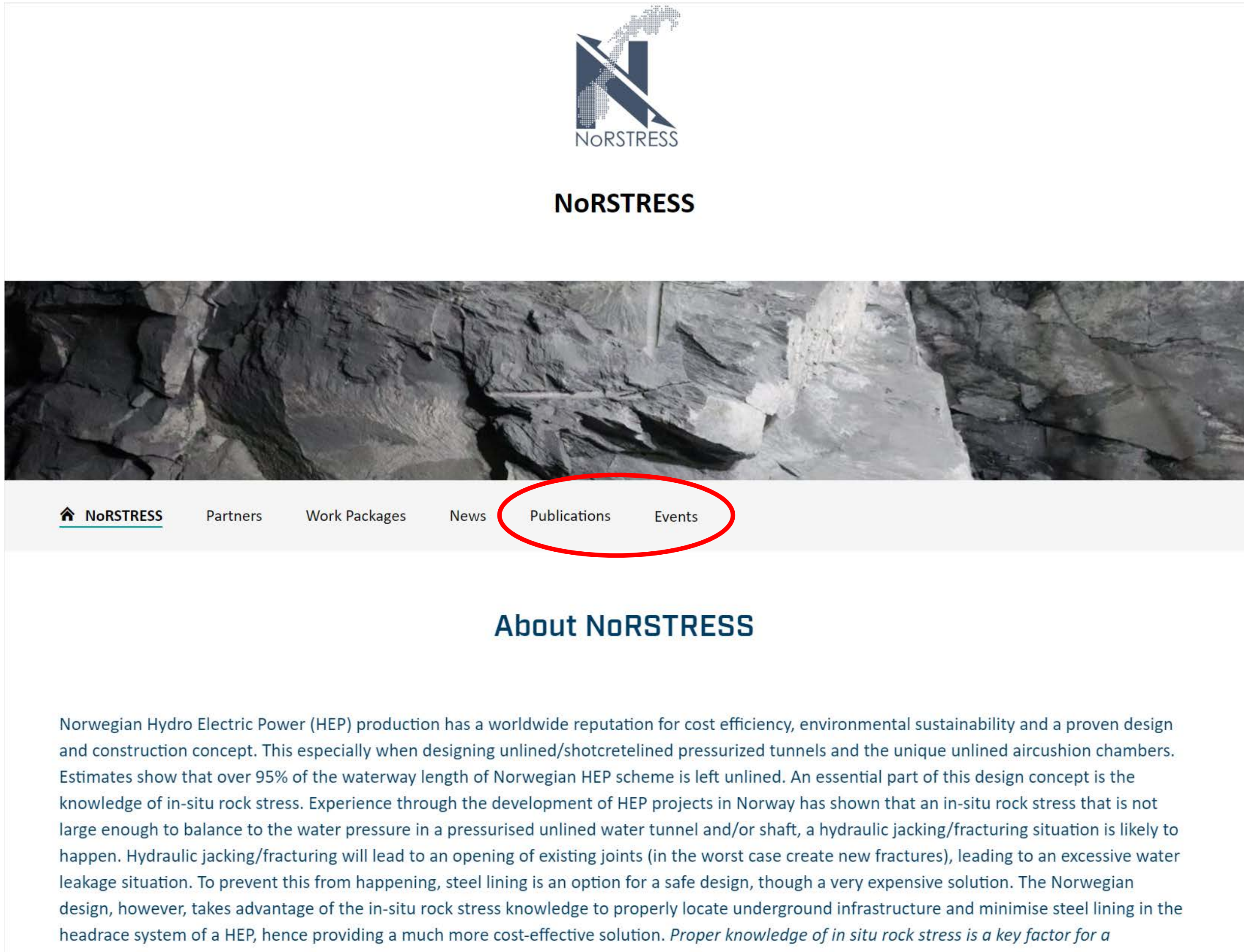
Su-Pan 1 HPP – Norwegian experience

- A research project is created in Norway to study rock stress in HPP development:

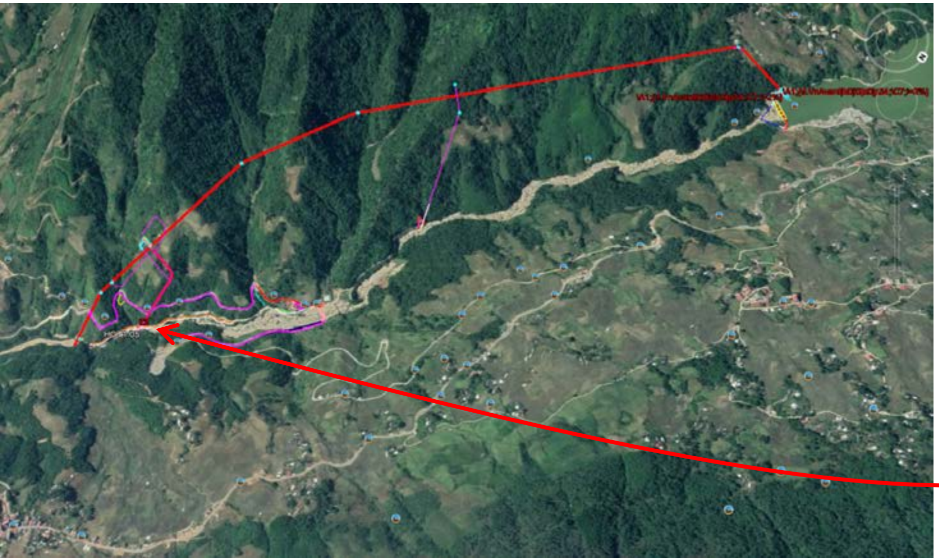
https://www.sintef.no/projectweb/norstress/

- Future workshops and publications will be announced in the website and can be registered and downloaded.



Su-Pan 1 HPP – Stress measurement

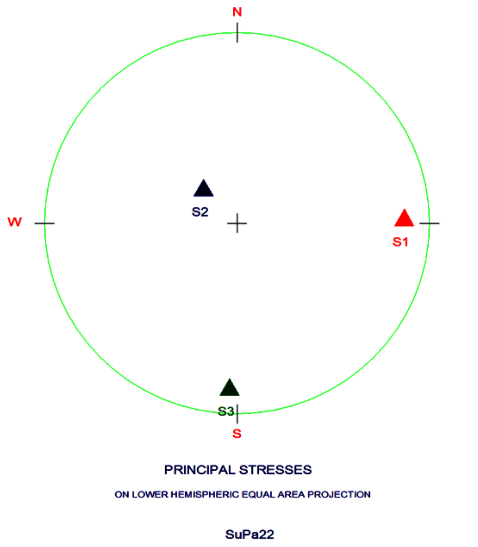
- Knowing the important role of rock stress => Rock stress measurement.

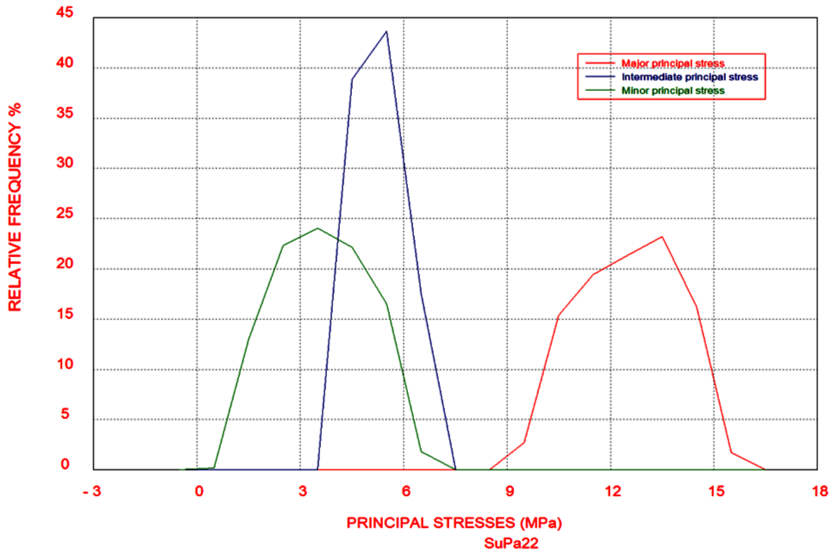


Su-Pan 1 HPP – Stress measurement

- Measurement method: 3D overcoring.

Location	Stress	Value	Trend (deg.)	Plunge (deg.)
K0+275	σ1	12.5±1.4	89	14
	σ2	5.3±0.7	315	70
	σ3	3.6±1.3	14	14





Su-Pan 1 HPP – Stress measurement

- Sigma 1 and 3 are almost horizontal.

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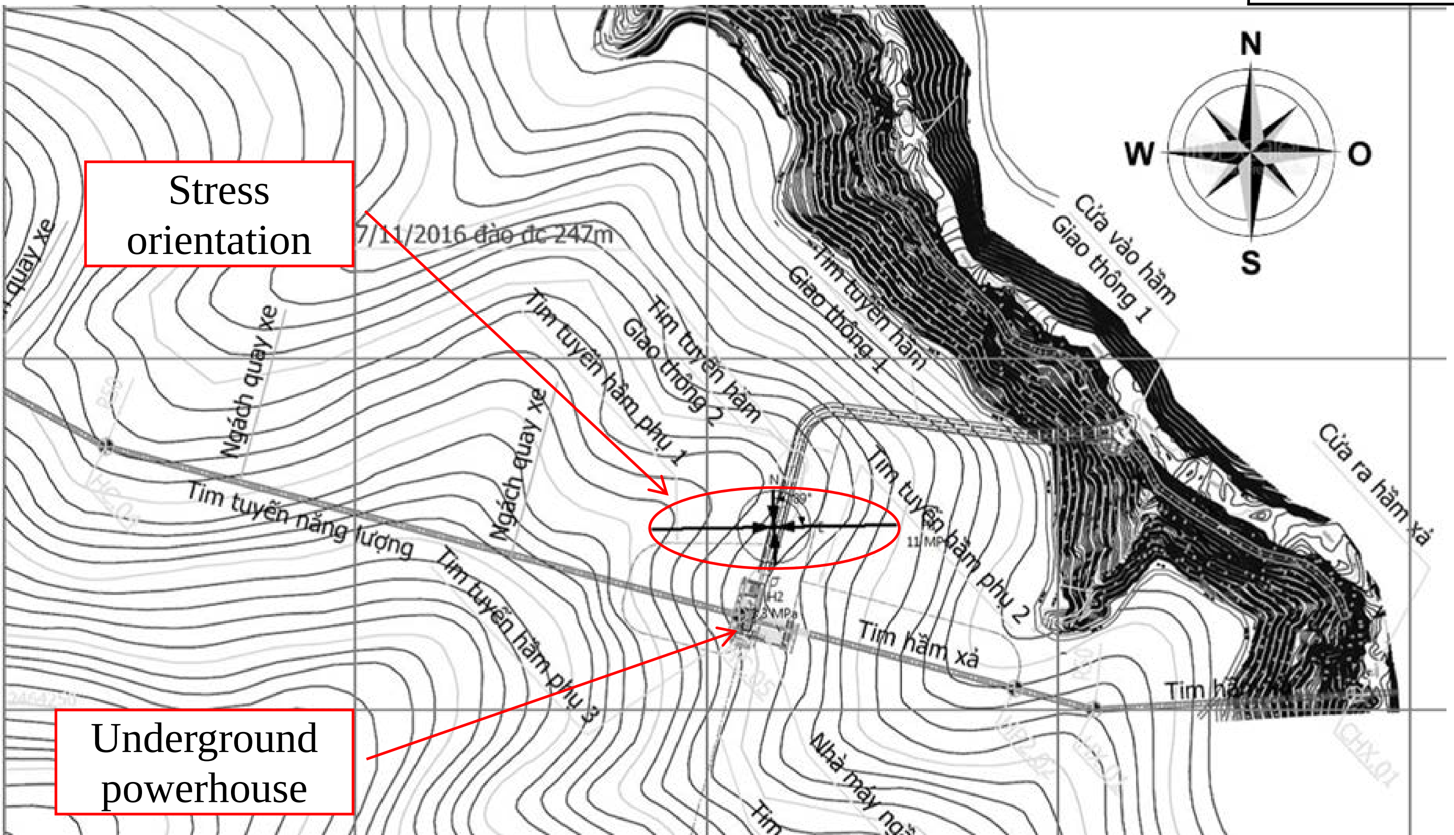
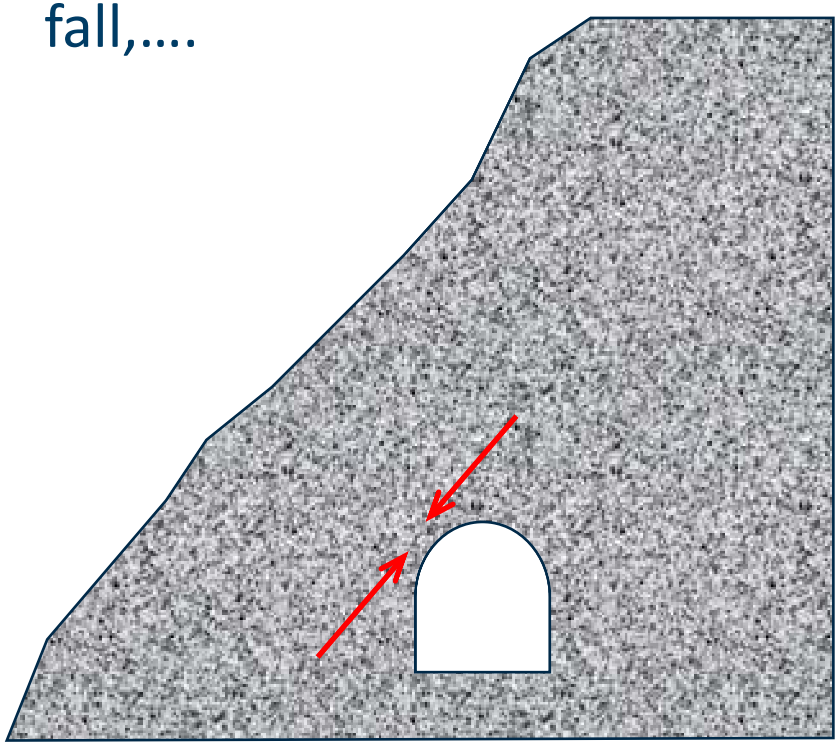


Su-Pan 1 HPP – Stress measurement

- Measured stress has been used for:
  - Design of powerhouse cavern.
  - Steel lining length and thickness.

Su-Pan 1 HPP – Rock stress issue

- Stress induced in tunnel: spalling with strong sound, rock fall,....



Su-Pan 1 HPP – Rock stress issue

- Stress induced in tunnel.

Su-Pan 1 HPP – Rock stress issue

- Stress induced in tunnel.

Su-Pan 1 HPP – Rock stress issue

- Stress induced in tunnel – rock fall.

Su-Pan 1 HPP – Rock stress issue

- Rock support for the stress induced in tunnel.

Su-Pan 1 HPP – Concluding remarks

- Su-Pan 1 is located in a stepp terrain and natural protected area.

- Few innovative solutions were applied in this project, including:
  1. Underground powerhouse.
  2. Inclined headrace tunnel without vertical shaft and no surge chamber.
  3. Unlined tunnel with minimum steel lining.
  4. Rock stress measurement to provide concrete information for the design of underground powerhouse and steel lining.
  5. Concrete arch dam (not included in this paper).

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