Processing of the answers to the questionary

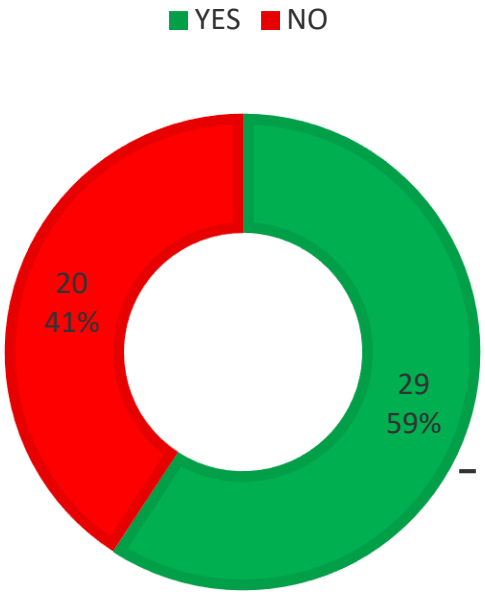
questionnaire

TC-221 – TAILINGS AND MINE WASTE

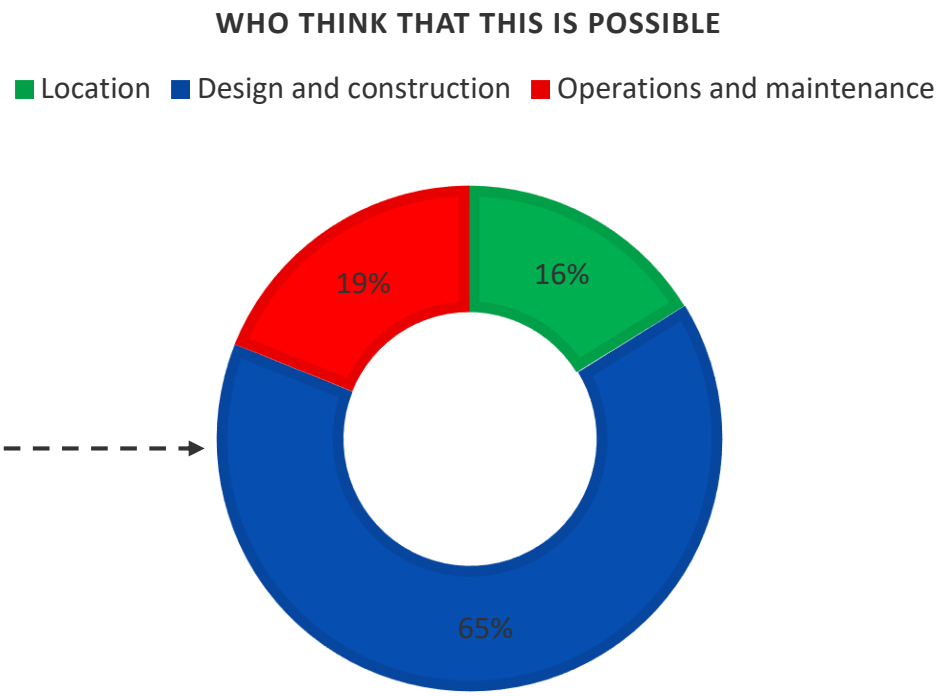
Q1

Question 1

Is it possible to design upstream tailings dams where their stability can be guaranteed on a long term basis? If so, which are the basic requirements that an upstream tailings dam must meet?



Summary:
TOTAL NUMBER OF PARTICIPANTS: **49**

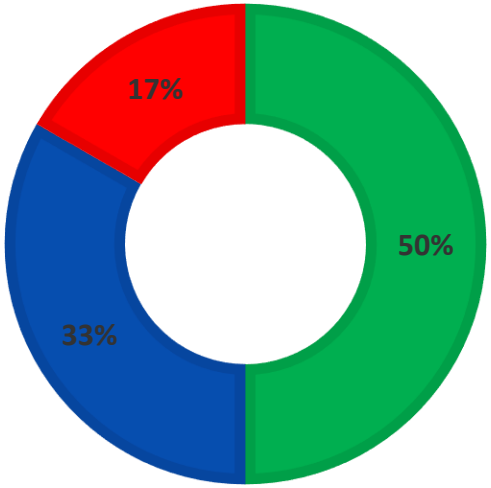


Question 1

Is it possible to design upstream tailings dams where their stability can be guaranteed on a long term basis? If so, which are the basic requirements that an upstream tailings dam must meet?

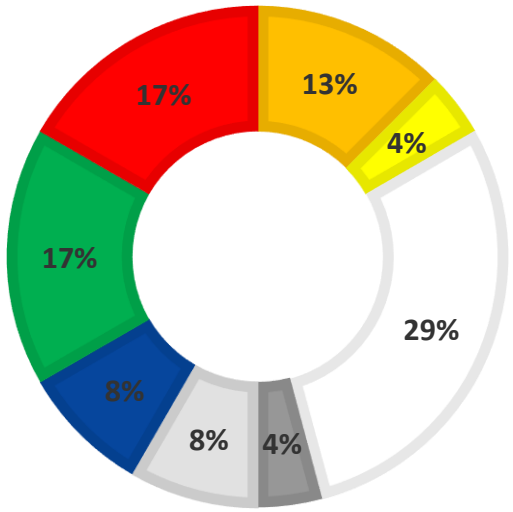
Location aspects

- Regions with low seismicity
- Arid regions
- Flat topography



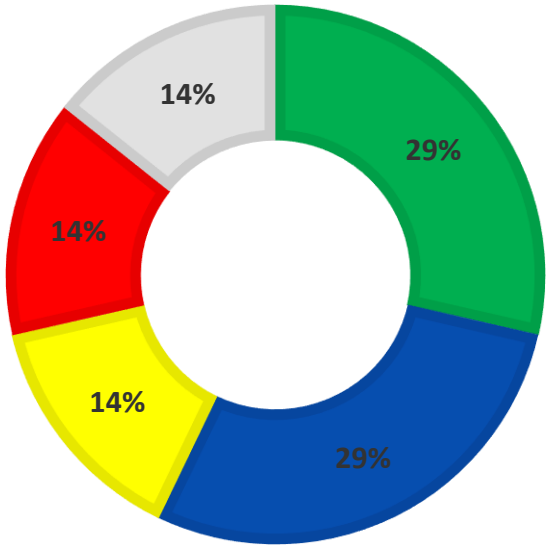
Design and Construction

- Compaction of structural zone
- Low raising rate
- Sustainable drainage
- Adequate foundation
- Buttress strength
- Flatter d/s slope
- Construction QA/QC
- Rigorous design



Operations and Maintenance

- Segregation of tailings
- Instrumentation and monit.
- Routing of supernatant water
- Capping system
- General



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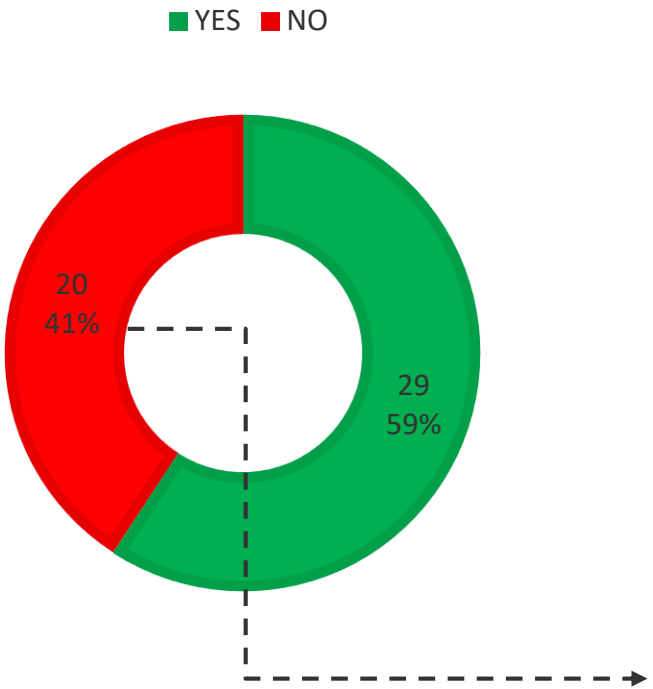

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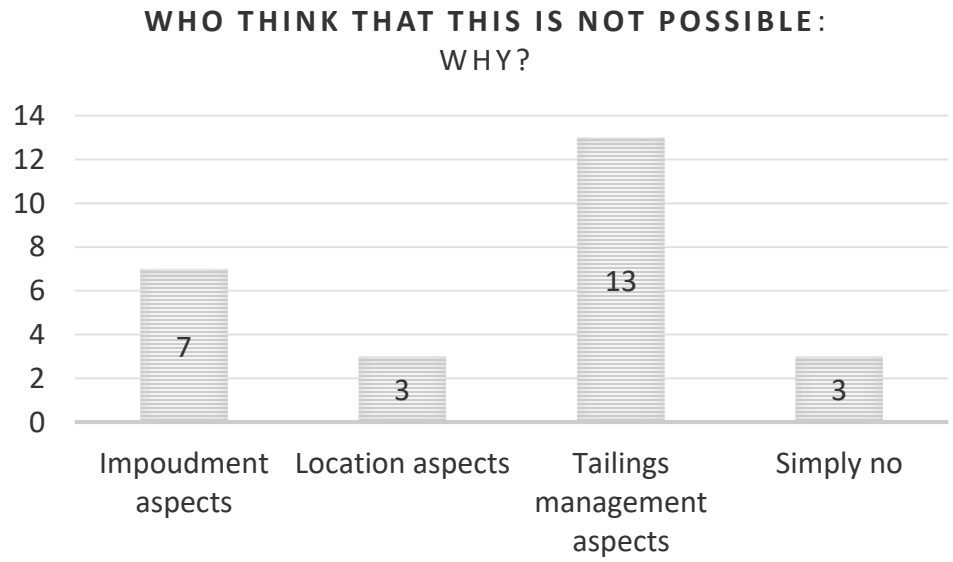

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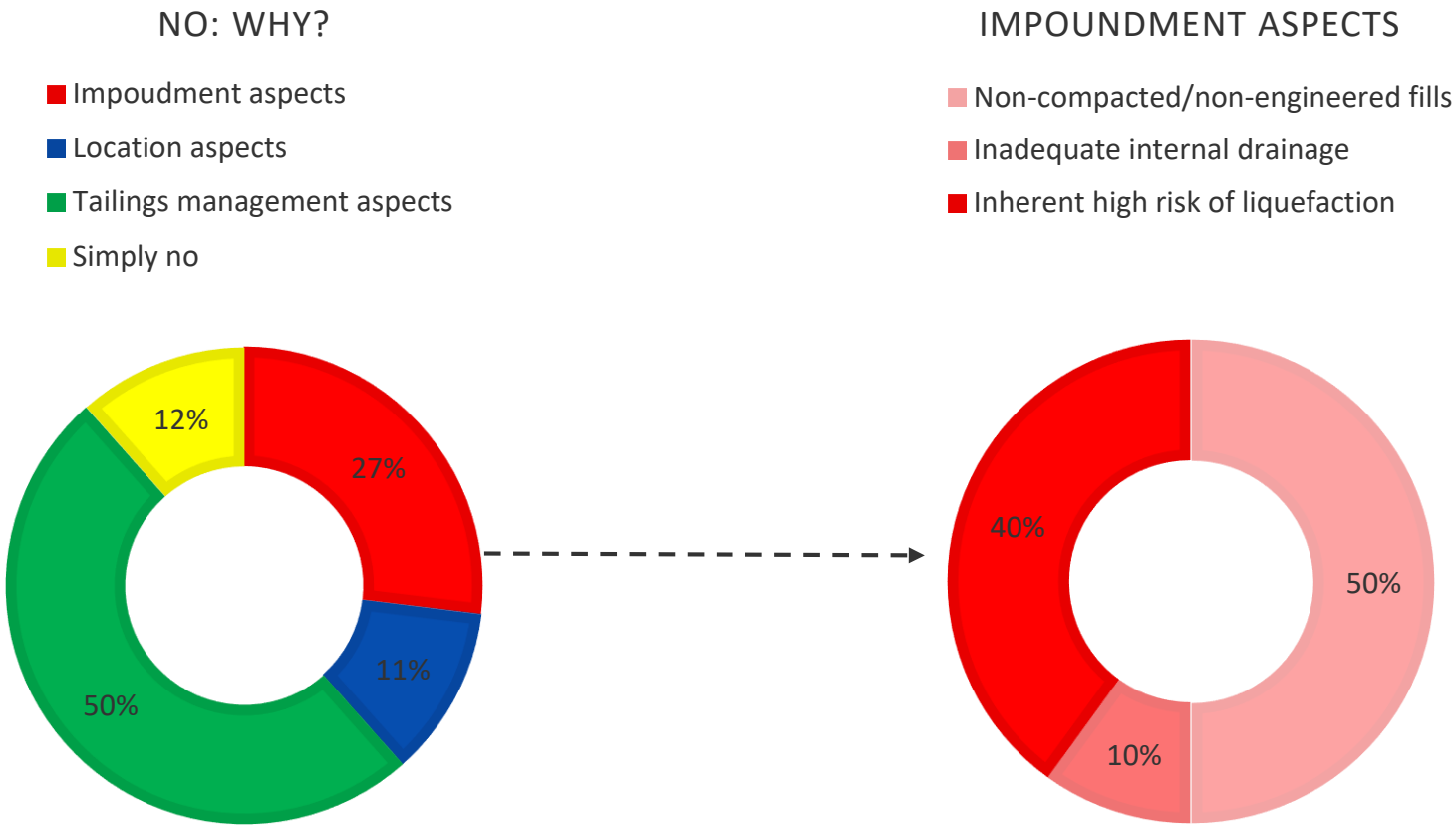

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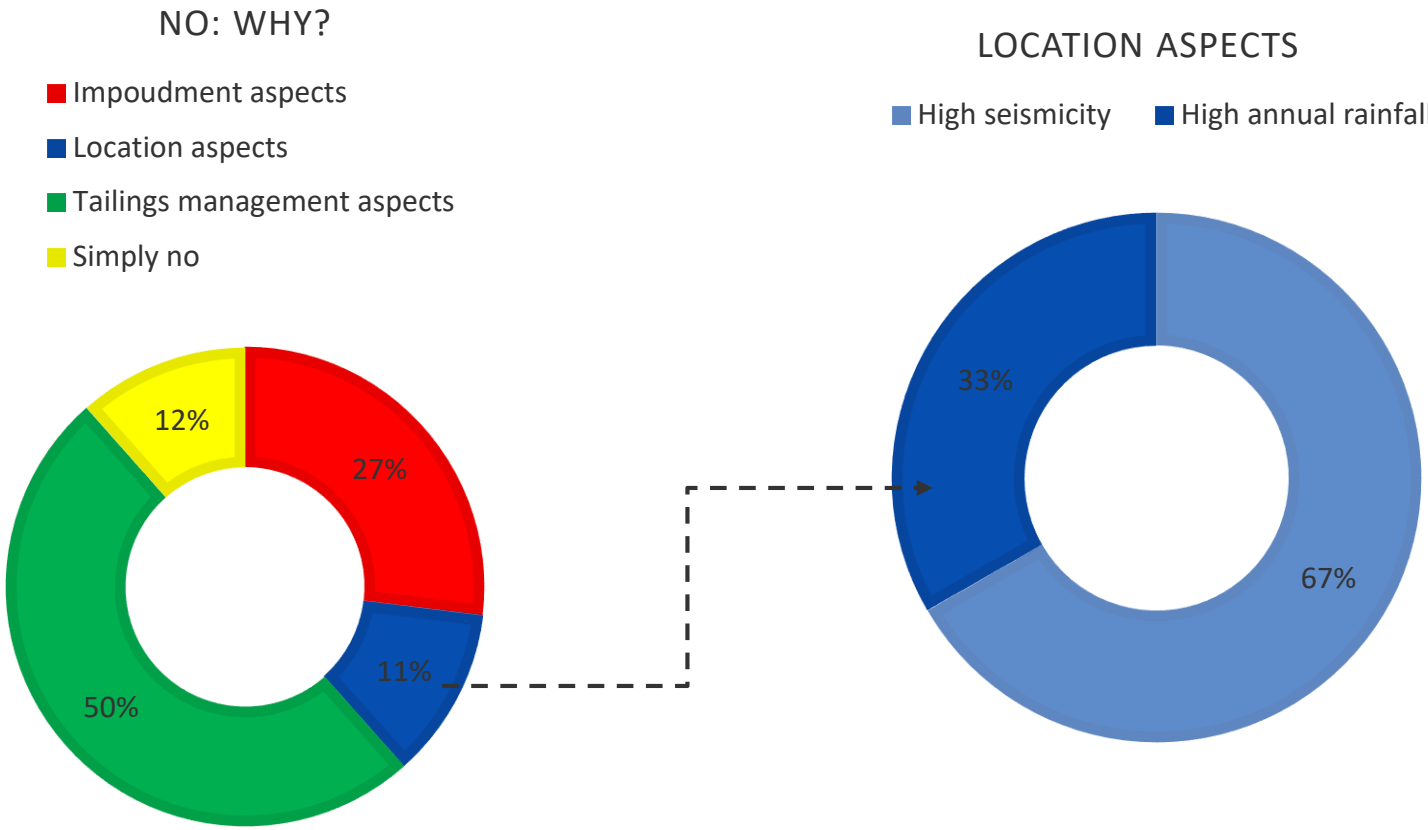

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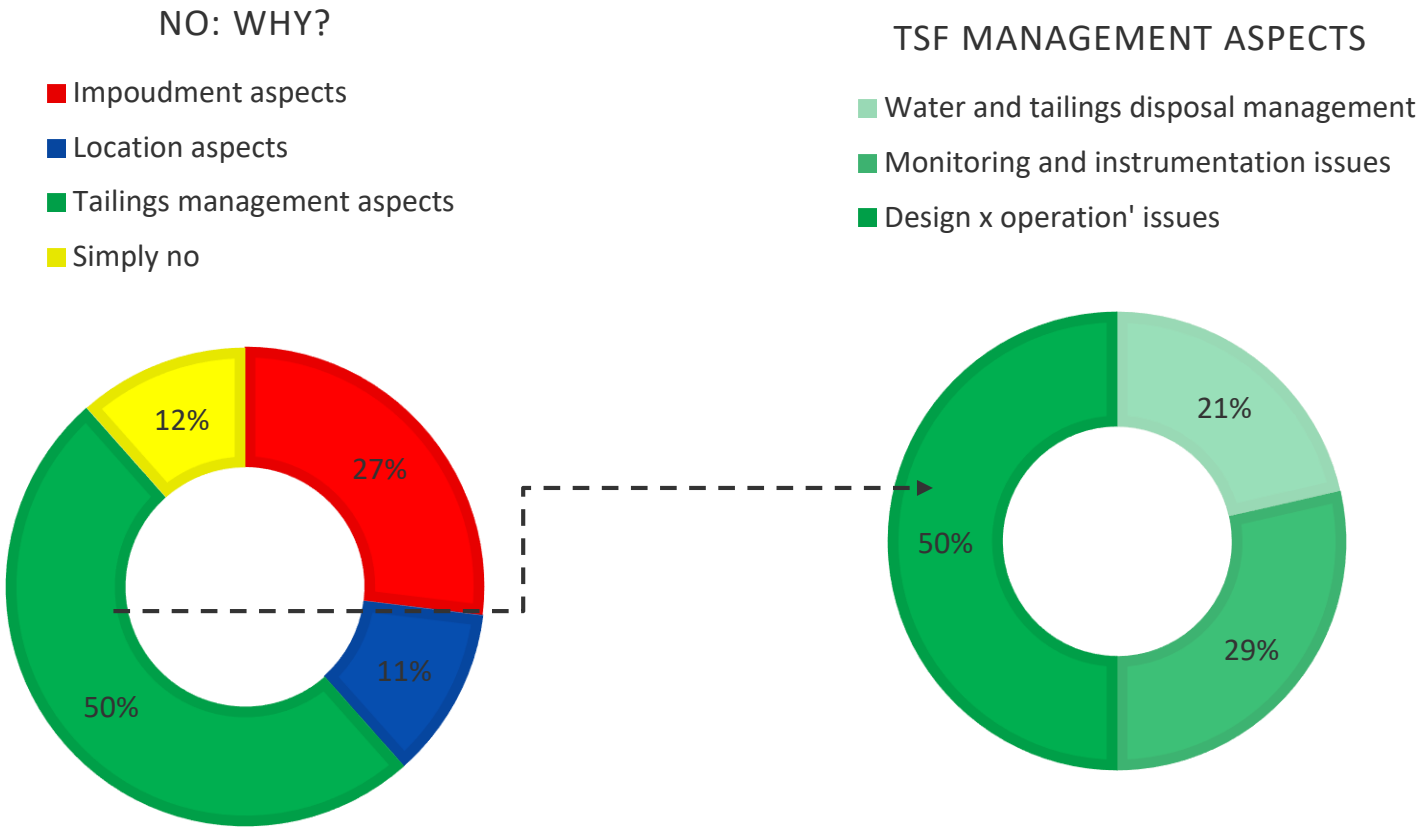


Question 1
Is it possible to design upstream tailings dams where their stability can be guaranteed on a long term basis? If so, which are the basic requirements that an upstream tailings dam must meet?

Some common points of discussion and conclusions

NO, WHY?

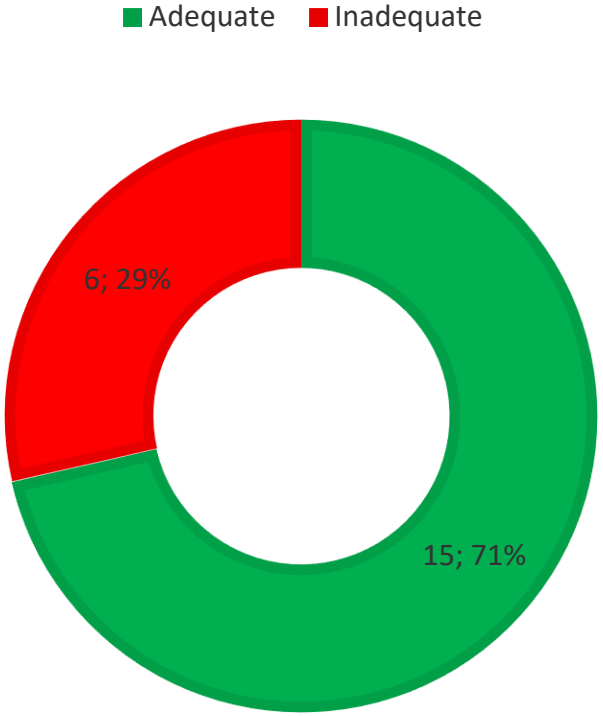
- In theory, it is possible. But, for the conventional type of upstream tailings dam – built as non-engineered fills or not well controlled structures – it is too risky and intrinsically prone to liquefaction failure.
- The occurrence of earthquakes (even minor events) and/or high annual rainfall are important factors in avoiding upstream tailings dams.
- Ensuring the stability of these tailings dams entails a complex interaction between many different areas and companies, in general.
- The operation of the dam is of great concern. Aspects such as: the control of water table, disposal of tailings and the adequate monitoring of the structures were mentioned several times.

Q2

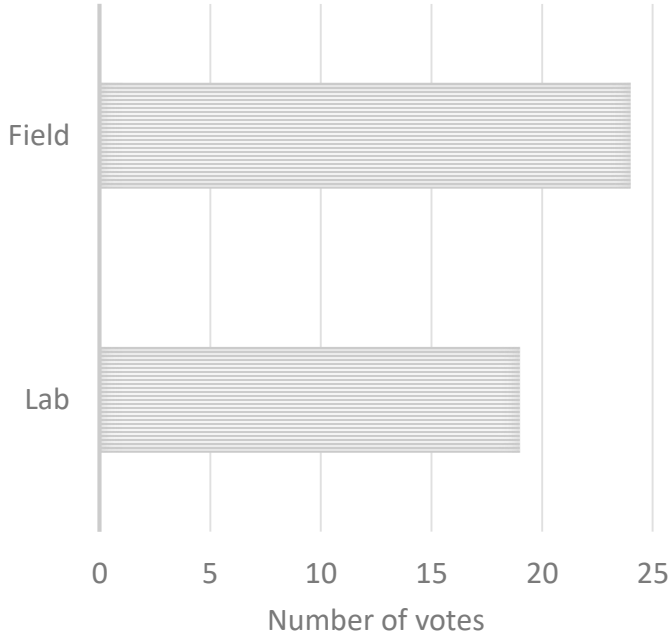
Question 2

Which are the most appropriate procedures to evaluate the residual undrained strength (shear strength of liquefied soils) in the laboratory and in the field?

Current available procedures are:



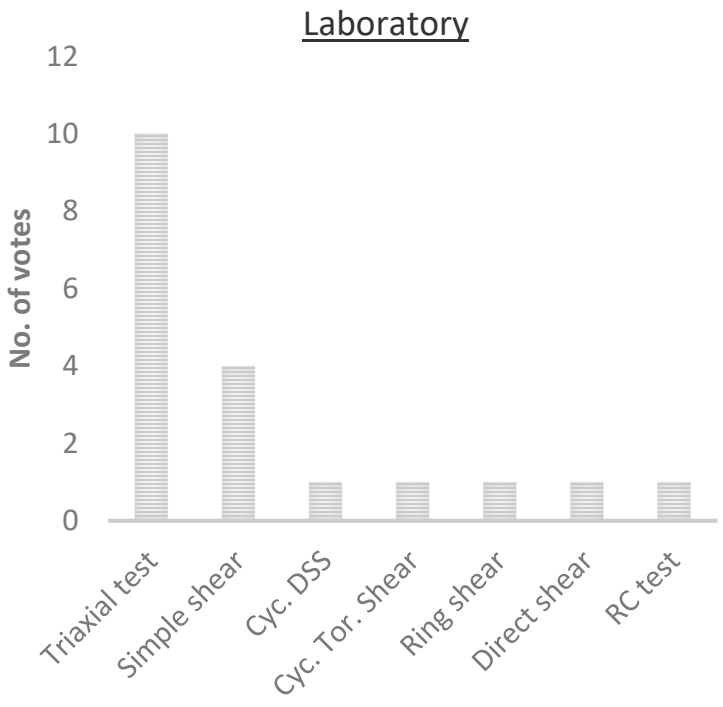
For all who think in terms of the adequacy of current available tests (either field approaches or laboratory tests) :

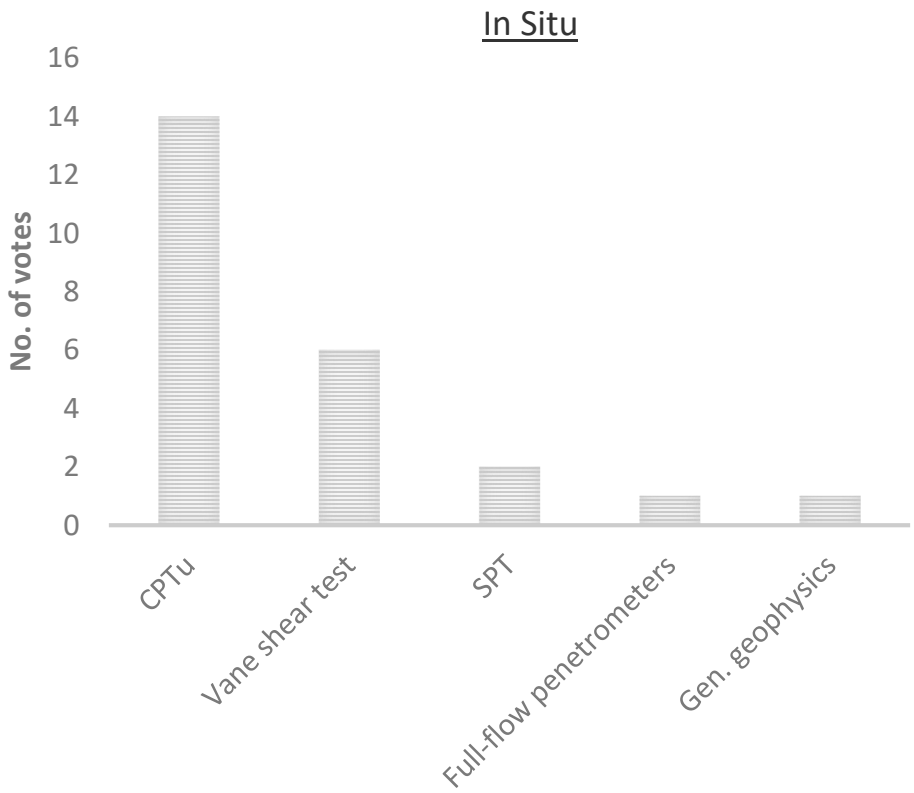


Question 2

Which are the most appropriate procedures to evaluate the residual undrained strength (shear strength of liquefied soils) in the laboratory and in the field?

The following tests are appropriate to evaluate the undrained shear strength:





Question 3

Is it possible to design upstream tailings dams where their stability can be guaranteed on a long term basis? If so, which are the basic requirements that an upstream tailings dam must meet?

Some common points of discussion and conclusions

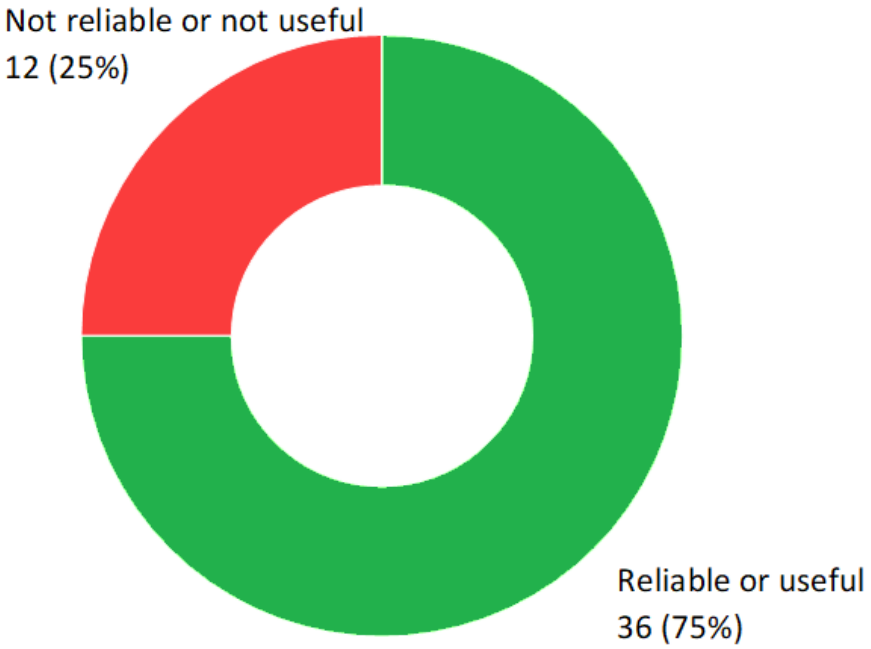
Comments from all who think the aforementioned tests are inadequate (or even not applicable):

- Lab. is not reliable. Estimation of state parameter from CPTu along with lab data and Norsand calculations.
- Estimation of state with CPTu, undisturbed sampling, testing and constitutive modelling to calculate the residual strength considering in-situ state.
- Empirical approaches can be misleading. Consideration should be given to fines content's influence on CSL of slimes. Empirical recommendations by Roberston shall be used with caution (Ko, clean sand equiv.). Robust analysis of case histories can be less-conservative and realistic estimates by using both field and laboratory tests. Transition is needed from LE to FEM on the back-end of empirical correlations.
- For the initial states of concern, entire stress-strain response of tailings is more crucial than pin-point liquefied strengths.
- Estimates from lab. tests and field performance experience are very rough and should not be used for design.
- Possibility of flow failure can't be judged merely on the basis of tailing's mechanics.

Q3

Question 3

In an upstream dam with zones of potentially liquefiable tailings, what would be the most appropriate instrumentation to monitor the dam for preventing flow failure?



General reasons for unreliable / unuseful:

- meaningful reaction/response time are not possible.
- fundamental changes cannot be identified.
- Instrumentation and theory to not developed enough.
- the trigger of a failure can be eventually identified, but prevention is not possible.

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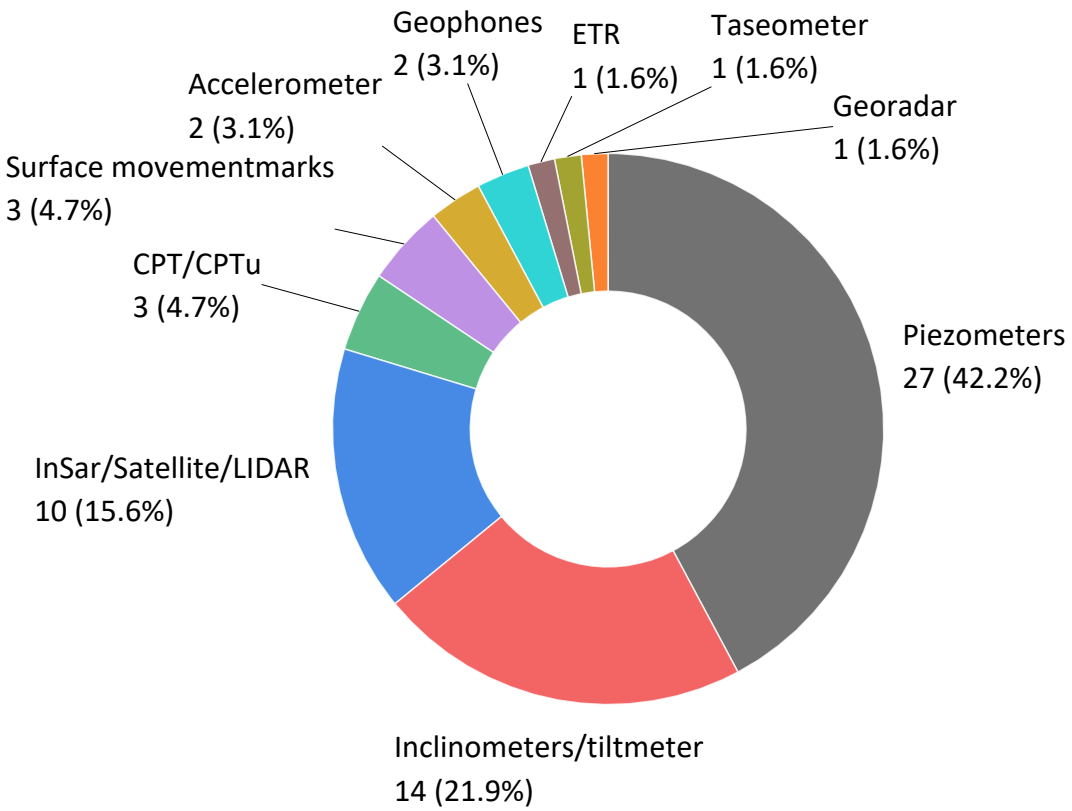


Monitoring objects:

- Pore pressure or phreatic surface (Piezometers)
- Micro-seismic & seismic wave (Geophone)
- shear deformation (Taseometer)
- surficial/body movement/deformation (Tiltmeter, Surface movementmarks, RADAR method)
- superficial acceleration (Accelerometer)
- Vibration frequency of structures (Georadar)

Monitoring region:

- Liquefiable region, creep region.
- Foundation, abutment.

Question 3

In an upstream dam with zones of potentially liquefiable tailings, what would be the most appropriate instrumentation to monitor the dam for preventing flow failure?

Some common points of discussion and conclusions

Evaluate the I&M from the aspect of "realism"

Different opinions regarding the interpretability:

- Fully interpretable
- Partly interpretable
- A black box

Real meaning for preventing or reducing loss:

- Leave us enough time to adopt significant actions. This is for evolutionary damage
- Leave us enough time to response but we cannot make remedial measure or the measure we can take make quite limited effects.
- Leave us very narrow or a zero time span to take action. This is generally for brittle failure/sudden collapse.

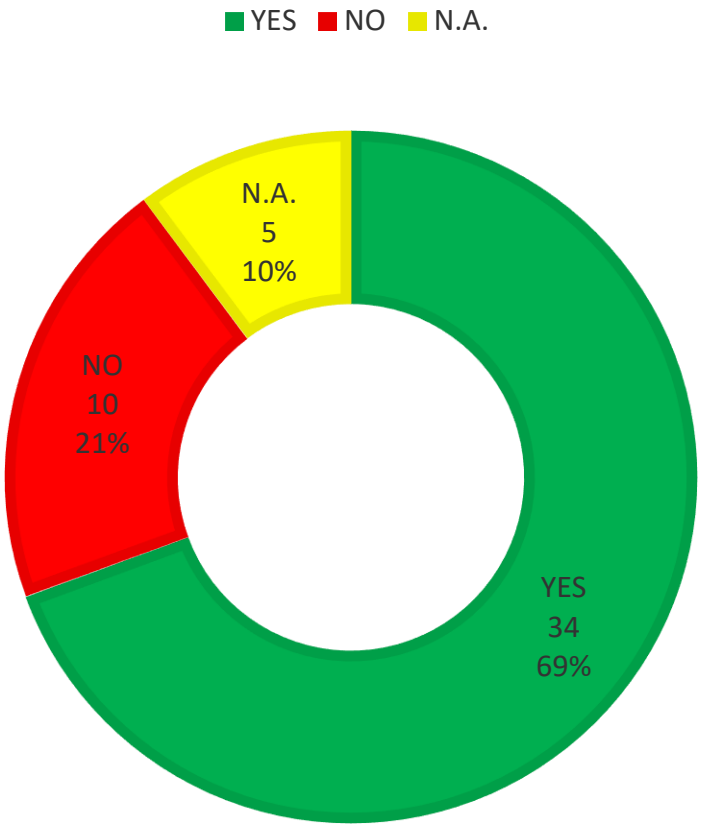
Conclusion:

Adopt and develop I&M that can produce interpretable data or is thoroughly understandable. I&M shall leave us enough time to make significant reactions.

Q4

Question 4

Is it correct to evaluate the stability of tailings dams using limit equilibrium analysis? If so, what would be the acceptable factor of safety for static and pseudo-static conditions?

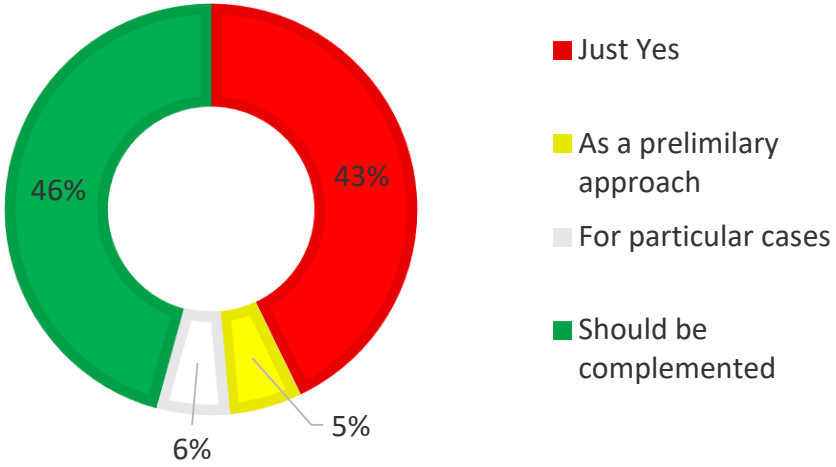


Reasons for not giving no voting for yes / no: 1) No straithforward answer, 2) lack of deep knowledge

Question 4

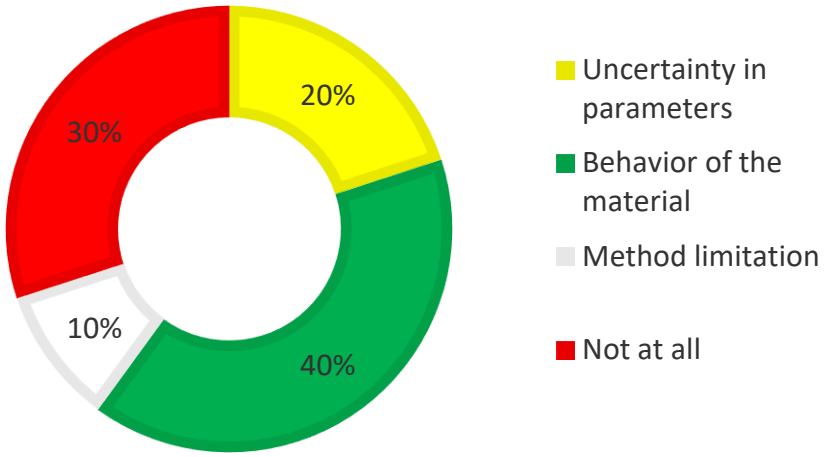
Is it correct to evaluate the stability of tailings dams using limit equilibrium analysis? If so, what would be the acceptable factor of safety for static and pseudo-static conditions?

THE ONES WHO SAYS YES, ADD...



- Just Yes: answers without justifying. Many of them think that the LEA should be done with residual strength only
- For Particular Cases: Depending on construction method
- As a preliminary approach: Just to calibrate values or have an idea in terms of safety, do some back analysis, to interpolate with experience, as a screening method, compare similar cases

THE ONES WHO SAYS NO, ADD...



- Difficulty of determining and uncertainty of strength parameters
- Limitations of LEA: Constant safety factor along the sliding surface, strength mobilized simultaneously, foundation movements not considered
- Material behaviour: Stress-strain analysis should be done. Brittleness or loss of stiffness should be considered

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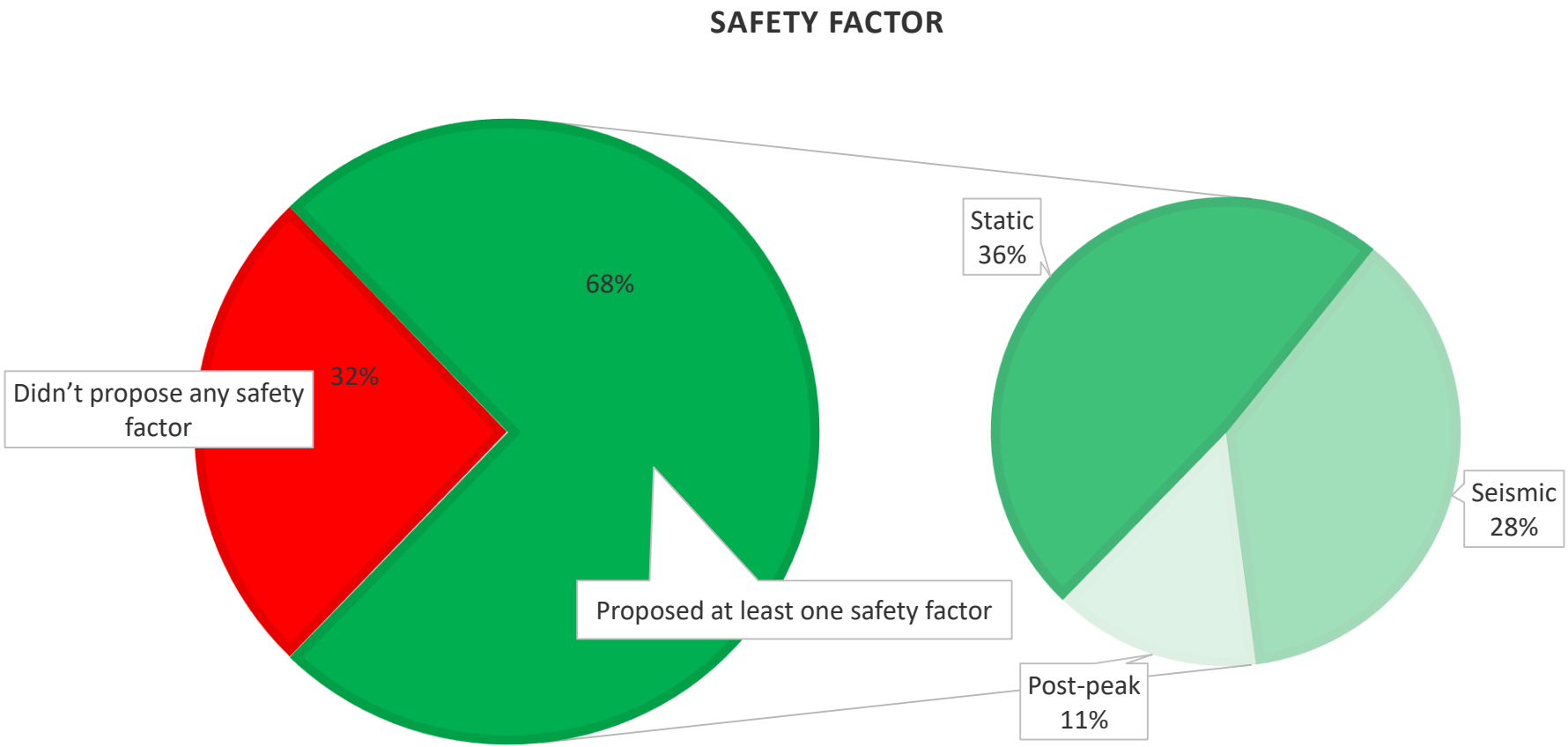

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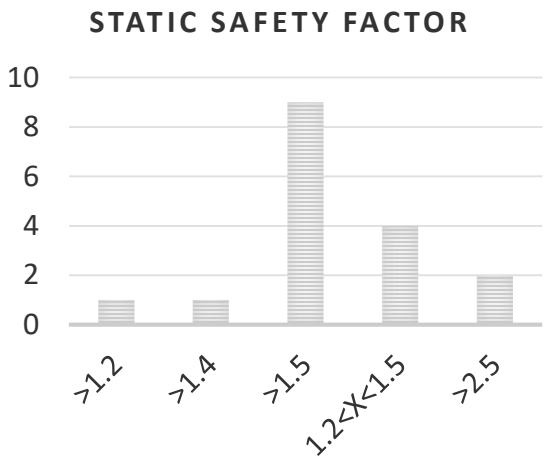
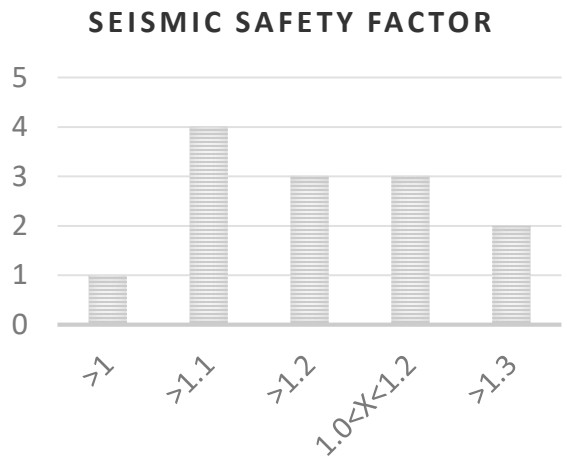
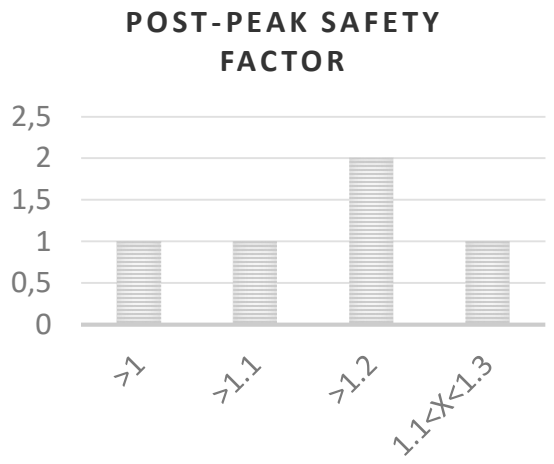






As a common point, participants mentioned that Safety Factor shall depend on:

- Data reliability
- Consequences of failure

Question 4

Is it correct to evaluate the stability of tailings dams using limit equilibrium analysis? If so, what would be the acceptable factor of safety for static and pseudo-static conditions?

Some common points of discussion and conclusions

- the actual behavior of the tailings cannot be properly taken into account in LEA and should be complemented with other analysis

- LEA is unreliable due to the variability of shear strength, which depends on the in situ state,. Probabilistic approaches shall be applied.

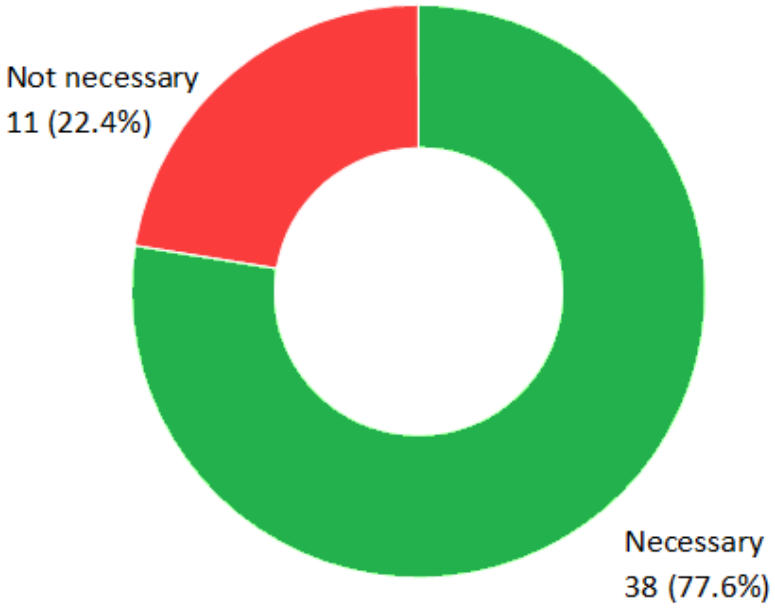
- Sampling undisturbed samples and the inaccuracy in the determination of the shear strength are mentioned are the main challenges for the application LEA.

- It is mostly agreed that the residual resistance shall be used in LEA.

Q5

Question 5

Would you consider stress-strain analysis with appropriate constitute models a necessary requirement for design?



Doubts concerns the reliability or necessity of CMs:

- Tailings differs from materials used for developing CMs
- Parameters for CMs vary from lab to the field Sophisticated testing needed for determining input parameters
- Applicability of CMs depend on the reliability of CMs and the simulation software
- Only required for certain cases, not for every design

Question 5

Would you consider stress-strain analysis with appropriate constitute models a necessary requirement for design?

Some common points of discussion and conclusions

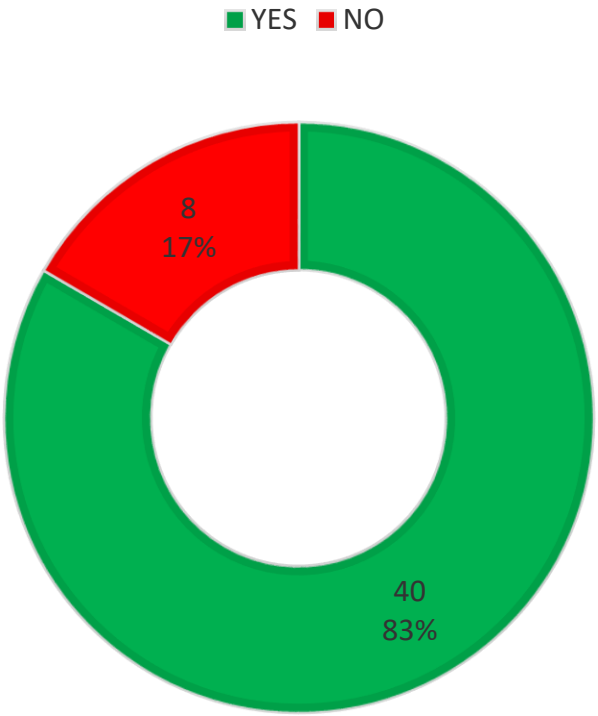
- Recommended CMs for stress-strain analysis of tailings
  - NorSand (3 times).
  - Cam Clay (2 times).
  - Modified Mohr-Coulomb (1 time).

- Appeal of participants
  - Simplify the process of data gathering, analysis for establishing CMs
  - Clarify the difference between tailings material and others materials when using CMs
  - Reduce the cost of test and numerical computation
  - Popularize the usage of advanced CMs and simulation software.

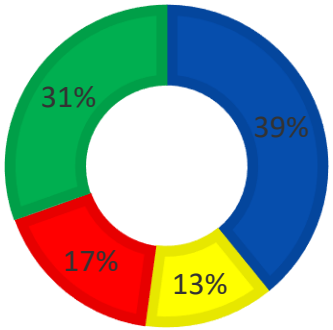
Q6

Question 6

Do you think it would be useful to write a technical document that addresses the stability of tailings dams built upstream, or on materials that may potentially lose strength?

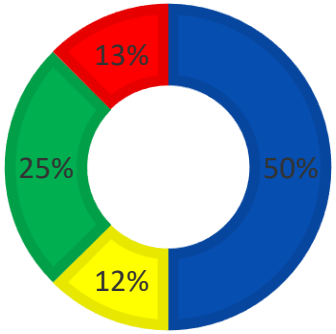


YES: WHY?



- To obtain some degree of uniformity
- To understand the behavior of the materials
- Lack of guidelines
- Innovation, high expertise and advanced knowledge are required

NO: WHY?



- Other documents already exist or have been developed
- More practical guidelines would be more useful
- Other types of media (videos, courses, workshops) would be better
- Others

Question 6

Do you think it would be useful to write a technical document that addresses the stability of tailings dams built upstream, or on materials that may potentially lose strength?

Some common points of discussion and conclusions

YES, WHY?

- A document would be useful and important for the industry, for new and old structures, for obtaining some degree of uniformity.
- It would be important for the industry, to understand the behavior of the materials that may potentially lose strength.
- There is a lack of guidelines specifically addressing design requirements for such structures.
- It is a complex topic and it requires high expertise, innovative solutions and advanced knowledge.

NO, WHY?

- There are several documents on this topic already and/or others being developed (ICOLD, ICMM, SME).
- A more practical guideline would be more useful for the industry (regarding proper soil investigation, laboratory testing and numerical modelling, for example). Also, videos, courses and workshops would be a more attractive form of communication.