**Supporting Information**

**Physical model investigation on effects of drainage condition and cement addition on consolidation behavior of tailings slurry within backfilled stopes**

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**Table S1 Physical and chemical properties of the unclassified tailings**

|  |  |  |  |
| --- | --- | --- | --- |
| Physical parameters | Values | Chemical parameters | Values |
| Clay-sized particles content P*d*<2 μm / vol% | 9.43 | Silicon, Si / wt% | 26.99 |
| Silt-sized particles content P2 μm<*d*<75 μm / vol% | 67.60 | Aluminum, Al / wt% | 8.50 |
| Sand-sized particles content P75 μm<*d*<5000 μm / vol% | 32.40 | Sodium, Na / wt% | 3.51 |
| Ultrafine particles content P*d*<20 μm / vol% | 44.60 | Iron, Fe / wt% | 3.00 |
| *D*10 (effective particle size) / μm | 2.10 | Calcium, Ca / wt% | 2.11 |
| *D*30 / μm | 9.00 | Magnesium, Mg / wt% | 1.39 |
| *D*50 (average particle size) / μm | 27.20 | Sulfur, S / wt% | 0.91 |
| *D*60 / μm | 45.00 | Quartz / wt% | 24.88 |
| Coefficient of uniformity *C*u | 21.42 | Albite / wt% | 16.38 |
| Coefficient of curvature *C*c | 0.86 | Ofeldspar / wt% | 9.10 |
| Bulk density / (g/cm3) | 1.56 | Chlorite / wt% | 7.64 |
| Solid density / (g/cm3) | 2.53 | Orthoclase / wt% | 7.25 |
| Porosity | 0.38 | Pyrite / wt% | 2.16 |
| Hydraulic conductivity / (m/s) | 2.37×10-6 | Chalcopyrite / wt% | 1.62 |

**Table S2 Main properties of the cement**

|  |  |  |  |
| --- | --- | --- | --- |
| Physical parameters | Values | Chemical parameters | Values |
| Initial setting time / min | 630.00 | SiO2 / wt% | 23.70 |
| Final setting time / min | 715.00 | Al2O3 / wt% | 10.20 |
| Density / (g/cm3) | 2.96 | TFe / wt% | 4.30 |
| Specific surface area / (m2/kg) | 425.00 | FeO / wt% | 4.30 |
| Flexural strength (28 d) / MPa | 8.40 | MgO / wt% | 5.30 |
| Uniaxial compressive strength (28 d) / MPa | 32.00 | CaO / wt% | 39.30 |

**Details of column construction**

Fig. S1 illustrates a schematic of the constructed column used for the physical model tests on the consolidation behavior of the tailings slurry. The physical model, with a scale factor of 50, was used to simulate a typical stope at an underground copper mine in China, applying long-hole open stoping with subsequent backfill mining method with a stope height of 60 m and a width of 15 m. However, the constructed physical model does not totally meet the similarity theorem, especially along the column length. In addition, some similarity conditions were unachievable here, for example, some spaced access drifts to stopes with barricades and drainage pipelines in stopes.

The model measures 120 cm in height and has a horizontal square section of 30 cm × 30 cm, which is convenient from installation to disassembly during filling and cleaning of the tailings slurry. These properties can ensure a smooth inside surface at the points of insertion of PWP sensors to avoid disturbance of backfill settlement compared with a curved cylindrical column. In addition, the front plate of the column was made of acrylic glass, and the other parts were constructed with stainless steel plates with 1 cm in thickness. The transparency of the front acrylic plate allowed observation of the settlement of tailings slurry during consolidation. Moreover, the acrylic and steel plates were stiff enough to reduce the inflation of the column after filling with tailings slurry to avoid possible influences of noticeable lateral deformation. The front plate was detachable and connected to the main body by fastened bolts, between which different seepage boundary modules constructed with rubber and/or geotextile were considered and installed.

The different drainage conditions of the column were achieved by inserting elastic rubber mats and nonwoven geotextiles between the front plate and the main body of the column (Fig. 3) to construct three seepage boundaries to simulate various drainage conditions for the tailings slurry in mine stopes. The elastic rubber mat and nonwoven geotextiles both measured 5 cm in width and 0.5 cm in thickness. The three seepage boundaries can be obtained by adjusting the length of the rubber mat and nonwoven geotextiles. Other details can be obtained from the Supporting Information.

(1) Undrainable (UD) along the whole height of the filled column. The elastic rubber mat was sealed along the full height of the interface between the front plate and the main part of the column. It can simulate the impermeable lateral boundaries of mine stopes surrounded by intact rock mass and/or dense cemented backfill in adjacent stopes, and the drainage holes in barricades (e.g., concrete or brick barricades) and wick drains can be possibly sealed by hydrates or fine-grain particles. UD is a relatively conservative condition but not an uncommon one.

(2) Bottom drainable (BD) only along the lower part of the filled tailings slurry where drainage can occur on the lower 1/10 height of the column. The nonwoven geotextile was sealed along the lower 1/10 height of the interface between the front plate and the main part of the column, and the other 9/10 was sealed with the elastic rubber mat. This condition can simulate the impermeable lateral boundaries of mine stopes surrounded by intact rock mass and/or dense cemented tailings backfill in adjacent stopes, and the barricade is permeable (e.g., waste rock barricades). This case is the most common among the three drainage conditions.

(3) Full drainable (FD) along the whole height of the filled tailings slurry where drainage is allowed along the entire height of the column. The nonwoven geotextile was sealed along the full height of interfaces between the front plate and the main part of the column. This condition, which is an ideal drainage condition, can simulate the permeable lateral boundaries of mine stopes surrounded by rock mass, which have joints, fractures, and other geological structures through which water flow can occur, and the barricade is also permeable.

In all columns, water bleeding can occur on the top surface of the tailings slurry, and the column floor was impermeable. The top part of the columns was covered with a configured plastic cap during the test process to reduce water evaporation. Sealing strips can be found along the outer edges of the interfaces between the front and side plates in full height to allow drained water to flow vertically into the bottom collectors. The column was placed on a steel frame base to collect drained water conveniently during the consolidation tests.



**Fig. S1. Schematic of physical model test column.**

 

**Fig. S2. (a) Schematic of three drainage conditions for the slurry in the column tests and (b) nonwoven geotextiles used.**



**Fig. S3. Drainage water collection of the bottom drainable column.**