Purpose

The **RAT** (Rapid Alkali Test) measures the amounts of sodium and potassium ions that contribute to alkali-silica reaction (ASR) if reactive aggregates are present. ASR leads to expansive products that can cause extensive cracking in concrete structures. The alkalies (potassium and sodium ions) in the cement paste react with reactive (amorphous) silica particles in fine or coarse aggregate and cause expansion and cracking, provided sufficient moisture is present.

To reduce the risk of ASR in new concrete structures, the quantity of sodium and potassium ions in the cement paste of fresh concrete should be reduced so as not to exceed the critical limit defined in standards, guidelines or particular project specifications.

The **RAT** measures the amount of sodium and potassium ions in fresh concrete or in its constituents and can also be used for testing powder samples of hardened concrete. Concrete powder samples from existing structures can be obtained by drilling or by using the **Profile Grinder** (see Technical Data Sheet) if sampling at controlled depths is desired.

Principle

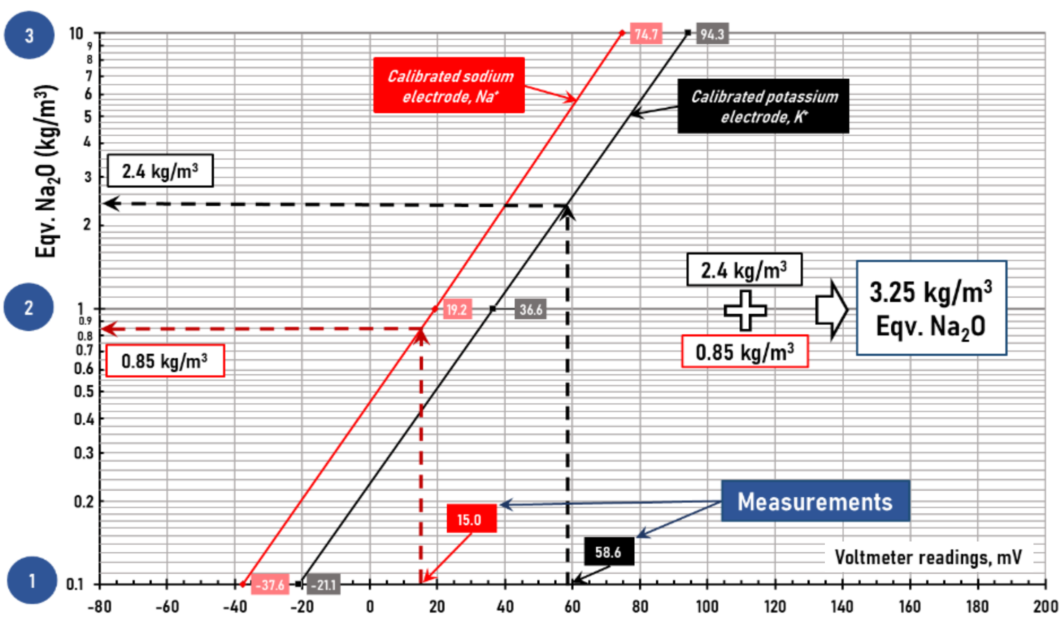
A sample of the fresh concrete, or its constituents, is taken and dissolved in a specific amount of acid extraction liquid. A calibrated set of ion-selective electrodes, one for measuring the sodium ions and one for measuring the potassium ions, is submerged into the solution and the corresponding electrode readings (in mV) are taken with a high impedance voltmeter. Calibration of the electrodes is performed using calibration liquids, three for sodium and three for potassium, so that two calibration curves are plotted.

The mV-readings are transformed directly into amount of Na_2O and 0.658 x K_2O in kg/m^3 by means of calibration curves. The two values are added together to give the equivalent amount of total Na_2O.

Similarly, for hardened concrete, a powder sample may be analyzed. If aggregates containing reactive material need to be excluded, a core is taken, the core is fractured, and the aggregate particles are removed. The remaining material is then pulverized and analyzed.

Testing Example

In this example, the mV-reading for the Na^+ electrode is 15 mV and for the K^+ electrode it is 58.6 mV. The corresponding amounts of equivalent Na_2O and K_2O are 0.85 kg/m^3 and 2.4 kg/m^3, respectively, which give a total equivalent Na_2O content of 3.25 kg/m^3. Once the calibration curves are plotted, a test takes about 10 minutes to perform.



The limit of the total alkalis in the mix to prevent or minimize ASR varies for different aggregate types and binder alkali classification and depends also on the size of the concrete member and the environmental exposure. Typical alkali limit values for controlling expansion from reactive aggregate (in kg per m³ of concrete) for various countries and from RILEM, are given here as a reference only.

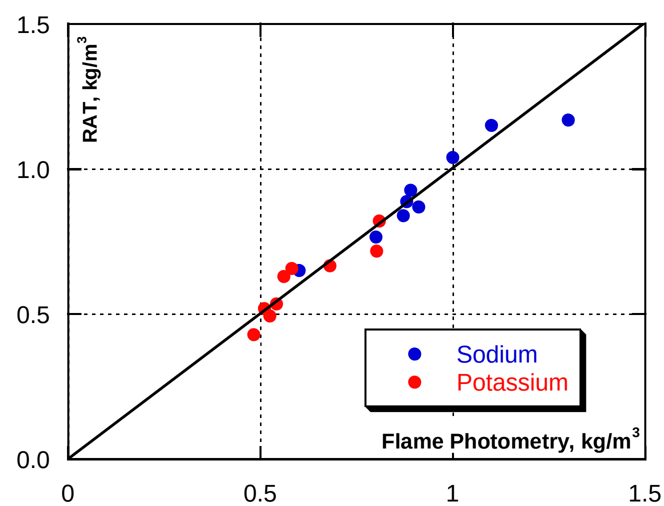
Country	***Specified Total Alkali Limit in Concrete (kg/m^3)***	***Comments and Performance Guidelines***
United States (ASTM C1567, 2013; ASTM C1293, 2018)	*1.8 – 3.0*	*Prescriptive and performance approach used. Performance using ASTM C1293 and C1567*
Canada (CSA A23.1&2, 2014)	*2.0 – 3.0*	*Limits based on environment and risk for each structure*
United Kingdom (BRE Digest 330.2, 2004)	*3.5*	*Alkali limits based on cement alkali limits and aggregate reactivity*
RILEM AAR 7.1—2016	*2.5 – 3.5*	*Limits based on aggregate reactivity, with classification being low, medium, or high*
Japan (JIS A5308, 2009)	*3*	*Prescriptive limit based on andesite data* *Performance limits from 1.2 to 3.0 kg/m3*
Australia (HB 79, 2015)	*2.8*	*Risk with reactive aggregate almost always controlled using SCMs* [a]
New Zealand (CCANZ TR3, 2012)	*2.5*	*Prescriptive limit widely used* *Performance limits from 1.8 to 3.0 kg/m3*
South Africa (SANS 6245, 2006)	*2.0 – 4.0*	*Limits based on aggregate reactivity* *SCMs widely used to control ASR*

a *- SCM: Supplementary cementitious material, such as fly ash or slag; also termed "addition" or "extender".*
Source: Mark G Alexander, 2019, "Developments in the Formulation and Reinforcement of Concrete (Second Edition). Adapted from Mackechnie, J. R. (2020). Alkali silica reaction in concrete. In Alexander, M. G. (Ed.), Fulton's concrete technology (10th (rev.) ed.). Midrand, South Africa: The Concrete Institute.

Correlations and Variability

The graph shows the correlation between alkali contents determined by flame photometry and **RAT**, for tests performed on the same solutions prepared from different concrete mixtures. The test solutions were prepared by acid extraction of the alkalies.

The correlation coefficient for these results is 0.97 and the alkali contents determined by **RAT** are within ±5 % of the values determined by flame photometry.



RAT Specifications

- Input Impedance: 1,012 Ohm
- Battery Type / Life: 1 x 9V / approx. 150 hours
- Auto-off after 20 minutes of non-use
- Environment: 0 to 50°C; RH max 95%
- Range: ±1,999 mV
- Resolution: 0.1 mV for ±700 mV and 1 mV for ±2,000 mV
- Accuracy: 0.2 mV for ±700 mV and 1 mV for ±2,000 mV

RAT-1000 Kit Ordering Numbers

Item	Order #
K^+ electrode	RAT-700
Spare cover for K^+ electrode	RAT-701
Na^+ electrode	RAT-800
Spare cover for Na^+ electrode	RAT-801
Reference electrode	RAT-900
Holster for electrodes	RAT-910
Electrometer w. spare battery	RAT-950
Adaptor switch box	RAT-960
Wetting agent for K^+ electrode	RAT-970
Wetting agent for Na^+ electrode	RAT-980
Wetting agent for ref. electrode	RAT-990
Set of filling syringes, three	RAT-1005
Spray bottle with distilled water	RAT-1010
Calibration liquid # 1	RAT-1020
Calibration liquid # 2	RAT-1030
Calibration liquid # 3	RAT-1040
Cleaning tissues	RAT-1050
Calibration sheets, 30 pcs	RAT-1060
Data sheets, 30 pcs	RAT-1070
Pencils (black and red) and ruler	RAT-1080
Spatula, 5 pcs	RAT-1090
Safety goggles	RAT-1100
Rubber gloves	RAT-1110
Mixing container	RAT-1120
Sampling cup for fresh concrete	RAT-1130
Plastic lid with holes for electrodes	RAT-1140
Temperature probe	RAT-1150
Vials for hardened concrete	RAT-1160
Vials for fresh concrete	RAT-1170
Manual	RAT-1180

RAT-1000 Kit