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# The lotus effect

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*Refractory bricks containing magnesium oxide tend to have a high reactivity to moisture and water, increasing their vulnerability to cracking and ultimately, failure when installed in the kiln. Thailand-based Siam Refractory Industry Co has developed a refractory brick that is less prone to such reactions and hence has a longer shelf-life, both in terms of storage and use in the kiln.*

**H**ydration reactions occur in all magnesium oxide (MgO)-containing bricks. MgO reacts with H<sub>2</sub>O (either as water or moisture in the air) and turns into magnesium hydroxide (Mg(OH)<sub>2</sub>), which results in volume change, eventually leading to cracks on the brick, as well as loss of structural strength. The rate of hydration reaction depends on factors like humidity and ambient temperature (ie, the higher humidity/temperature, the faster the reaction). Stored bricks are particularly vulnerable to hydration reactions and therefore, most MgO brick manufacturers do not recommend storage for periods of longer than six months from the date of manufacture.

While bricks are delivered in highly-protective packaging, this only prevents them from coming into direct contact with water. Such packaging does not offer protection against ambient moisture. Meanwhile, vacuum-packaged bricks are impractical due to their high cost. Moreover, when scratched or opened, the packs lose their air-tight properties and the bricks become vulnerable to hydration, impairing their structure and strength.

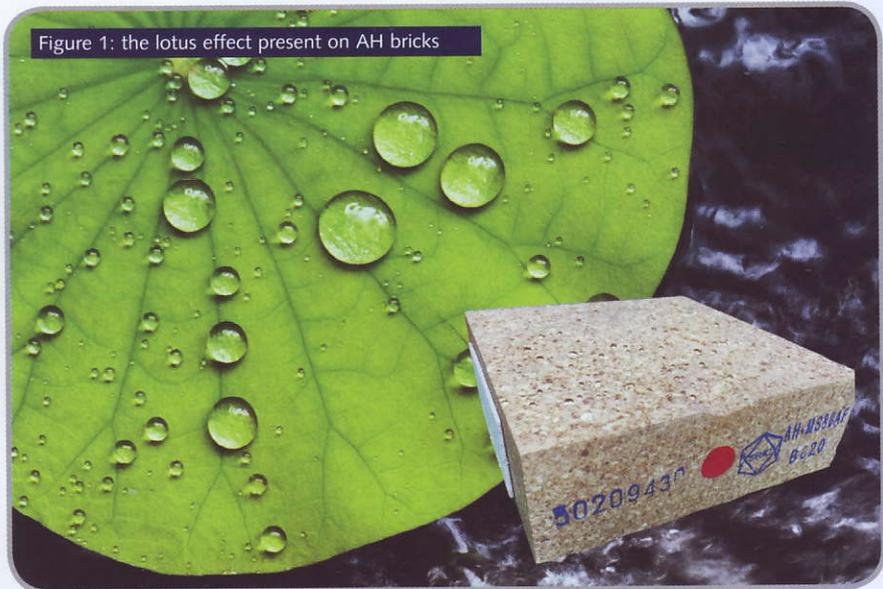


Figure 1: the lotus effect present on AH bricks

## Finding a solution

To solve the issue of brick hydration, Siam Cement Group (SCG) has conducted research, trials and verification procedures in recent years to launch the world's first real Anti-Hydration Brick (AH). The new brick has a prolonged shelf life of 24 months with no changes in brick quality, properties and performance (including its ability to pick up coating).

This anti-hydration technology enables the particles of MgO-based bricks to have a higher surface tension, like the skin of a lotus leaf (see Figure 1). This property is present not only on the surface of the brick but in its entirety, so if the brick loses its surface or gets chipped, the anti-hydration property still remains as verified during tests by the company (see Figures 2 and 3).

Figure 2: verification of lotus effect inside the AH brick

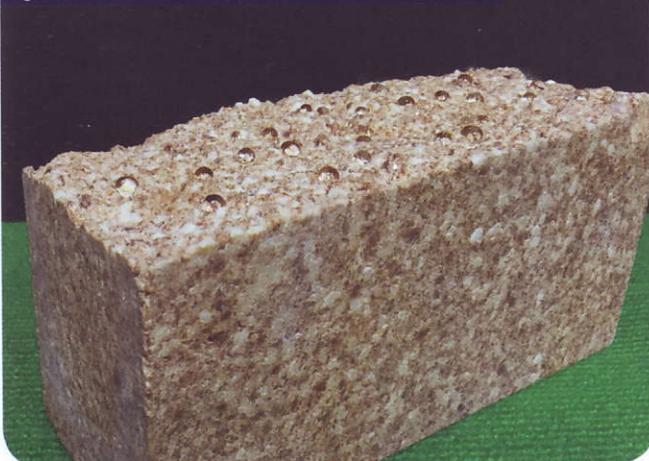


Figure 3: verification of lotus effect at particle level of crushed AH brick



**Table 1: the AH brick's physical properties after anti-hydration treatment and 1.5 year storage**

Properties	Data sheet	Results	
		Post-treatment	Post treatment + 1.5 year storage (with whitish colour)
Density (g/cm <sup>3</sup> )	2.97	2.99	3.01
Apparent porosity (%)	14.00	12.63	11.49
Modulus of rupture (kg/cm <sup>2</sup> )	50	52	53
Cold crushing strength (kg/cm <sup>2</sup> )	500	512	517
Hot modulus of rupture at 1400°C (kg/cm <sup>2</sup> )	35	37	38
Thermal shock resistance at 1200°C (2min) + air quench (5min) (Cycles)	>1000	>1000	>1000

Figure 4: normal bricks after 1.5 years of storage

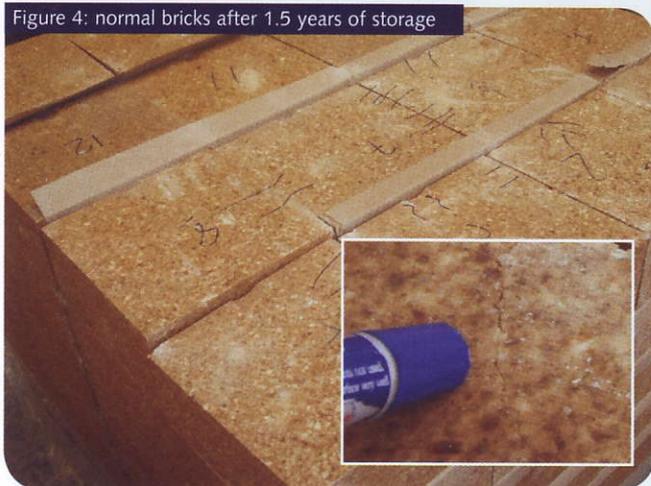
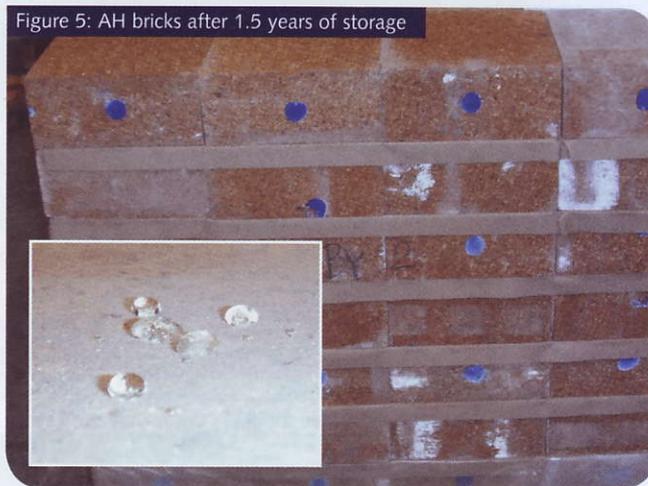


Figure 5: AH bricks after 1.5 years of storage



### Verification tests

Siam Refractory Industry Co, part of the Siam Cement Group, has undertaken numerous tests to verify the properties of AH bricks.

### Packaged bricks

In one test, AH and normal bricks were packaged and stored outdoors in Thailand's tropical climate. After 1.5 years under these conditions, results showed that 28.5 per cent of the normal bricks were affected by hydration (see Figure 4). The AH bricks, however, remained unaffected, showing no signs of hydration and retaining their physical properties (see

Table 1 and Figure 5). It should be noted that the white areas visible on the AH bricks are usually found after longer-term storage and are not a sign of hydration.

### Unpackaged bricks

A second test placed three different single types of unpackaged hard-burnt MS80AF magnesia spinel bricks outdoors (see Figure 6a):

- Brick A – anti-hydration MS80AF brick
- Brick B – MS80AF treated with a moisture-absorbent compound
- Brick C – normal MS80AF.

The bricks were then monitored for cracks every 2-3 days.

Results showed that within the first few months, cracks started to form on Bricks B and C, and large extensive cracks formed after just seven months (see Figure 6b). On the other hand, the AH brick (ie, Brick A) remained intact as it was not hydrated – even up to 36 months of storage (see Figures 6c).

### Savings

The installation of AH bricks offer cement producers significant cost and time savings, including:



Figure 6a: bricks placed under natural outdoor conditions (ie, humidity, sunshine and rain)



Figure 6b: status of bricks after seven months



Figure 6c: AH brick after 36 months



Figure 7: anti-hydration bricks require only standard rather than moisture-proof packaging

- **Disposal of hydrated and expired bricks**  
Cement companies often hold a spare brick stock of 30-40 per cent of annual MgO bricks for emergency use or unplanned repairs. If the bricks installed in the kiln meet their expected service life, these spares may become hydrated and scrapped as waste. With the AH bricks, the spare lining bricks have a longer shelf life, and therefore eliminate wastage.
- **Brick disposal following accidental contact with water or through factors beyond control**  
Factors beyond control such as storage conditions, transportation, packaging, unpredictable natural events, etc, can make MgO-based bricks unusable. However, AH bricks are less vulnerable to water intake under these conditions.
- **Sorting usable from hydrated bricks**  
When hydration is found on MgO-based bricks, it can cause delays in maintenance

procedures as skilled technicians need to separate usable bricks from hydrated ones. Labour costs vary from country to country depending on how many bricks need to be sorted.

However, the decision to classify a brick as 'usable' is subjective, and may or may not be 100 per cent correct. Moreover, question marks can still remain over the quality of the sorted bricks.

There is also the risk that some hydrated bricks may be used by mistake, leading to premature failure in the kiln. Further time can be subsequently lost and more work will need to be undertaken before a shutdown is considered, adding to cost and efforts. AH bricks eliminate such concerns.

- **Production losses due to unexpected kiln stoppages**

If some hydrated bricks do slip through the net and are installed in the kiln, they

will fail and need to be replaced during an unscheduled kiln stop. This in turn leads to expensive production losses – a situation that can be avoided with the use of AH bricks.

- **No need for special packaging, transportation or handling**

AH bricks do not require special, moisture-proof packaging or need to be stored in moisture-proof areas of a plant. AH bricks are packaged in regular cartons and placed on pallets (see Figure 7).

#### Identification

Since AH bricks look exactly the same as normal (MgO-based) bricks, marking up the AH bricks is critical in case the packaging gets damaged. However, each AH brick made by Siam Refractory Co is individually marked up and labelled with the AH-brick name to distinguish it from MgO-based bricks (see Figure 8).

#### Cement plant installations

Siam Refractory Co's anti-hydration treatment has proven to reduce the risks associated with brick hydration, including expired bricks, premature kiln brick failure, unscheduled repairs and production losses. AH bricks have an extended brick shelf life of 24 months, compared to six months with MgO-based bricks.

In the past two years, Siam Refractory Co has installed some 3000t of AH bricks in cement plants in many countries, including Pakistan, UAE, Indonesia, Philippines, Vietnam, Cambodia and Thailand.

Repeat orders and customer satisfaction reflect the quality and benefits that AH bricks can bring to kiln lines and cement plants worldwide.

Figure 8: as they have a similar appearance, Siam Refractory's AH bricks have clear markings on the brick surface (right) to distinguish them from MgO-based bricks (below)

