

Preventive measures against concrete damage to ASR in the Netherlands

current state-of-affairs

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In CUR-Recommendation 38, various vital measures that need to be taken during design of new concrete-mixtures in order to prevent damage due to ASR in the concrete have been outlined. The most important of these measures are:

- the use of blast furnace slag cement (with a high slag content: ≥ 50 % by mass of cement as slag);
- or the use of portland fly ash cement (containing at least 25 % by mass of cement as fly ash).

If one of these cement types is used, then the potential reactivity of the aggregates is assumed to be of no concern. These measures were cautiously adopted on the basis of several years of experience with the performance of these cements, especially blast furnace slag cement. Although, to date, no cases of damage due to ASR have been found in concrete structures prepared with such cements, various questions have been raised recently as to whether these measures are adequate enough, especially in cases such as large infrastructures.

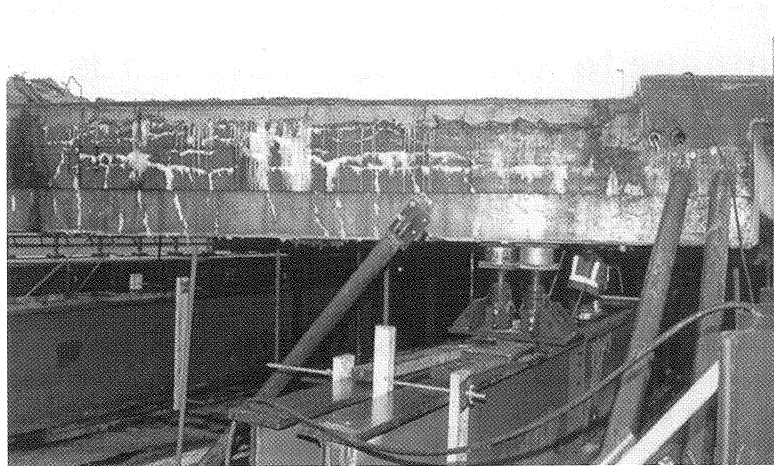
This paper is intended to throw more light onto the current state-of-affairs concerning these measures with a view to answering the most commonly asked questions.

1 Introduction

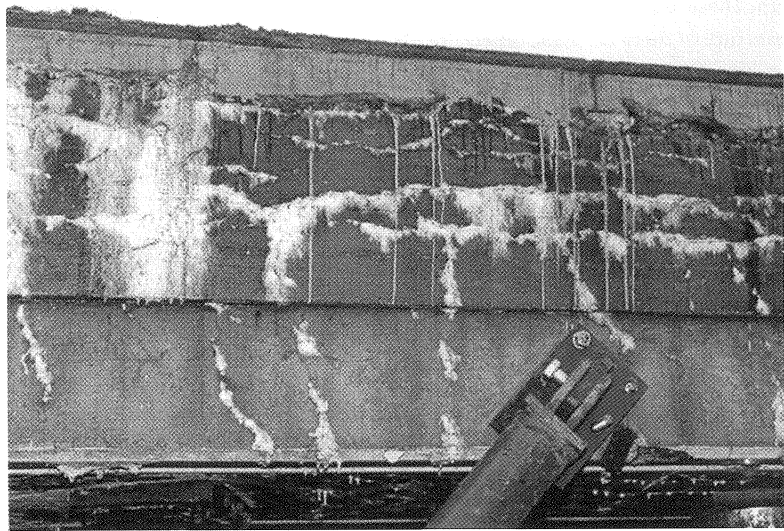
1.1 Background

In The Netherlands, during the past decade, several cases of damage of concrete structures due to alkali-silica reaction (ASR) have been diagnosed, detected, reported or published [1]. The structures include bridges, locks, balconies and viaducts (see Figure 1). Although these structures are different from each other with regard to their usage, they seem to have common characteristics with regard to the damage. These are [1]:

- **Structures:** all the structures are relatively old, that is, at least 25 years, but most of them are older. All the structures involved concern only cast-in-place concrete. No cases of ASR affected structures are known which involve prefabricated concrete.
- **Concrete:** the concrete, in general, has relatively high water-cement ratios and exhibits locally large fluctuations in water-cement ratio, contains a high amount of voids and is poorly compacted.



(a)

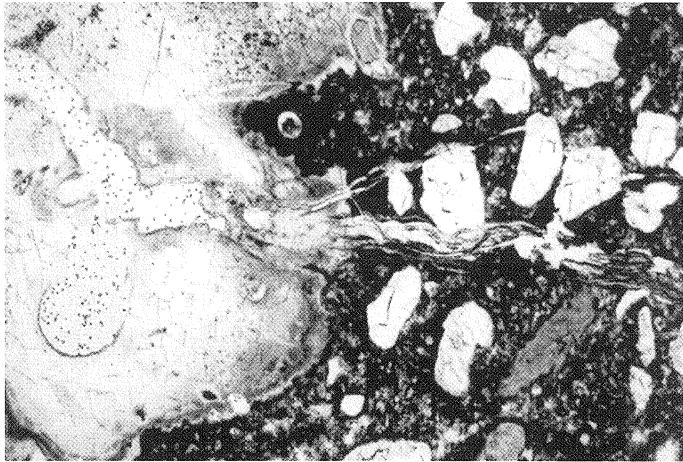


(b)

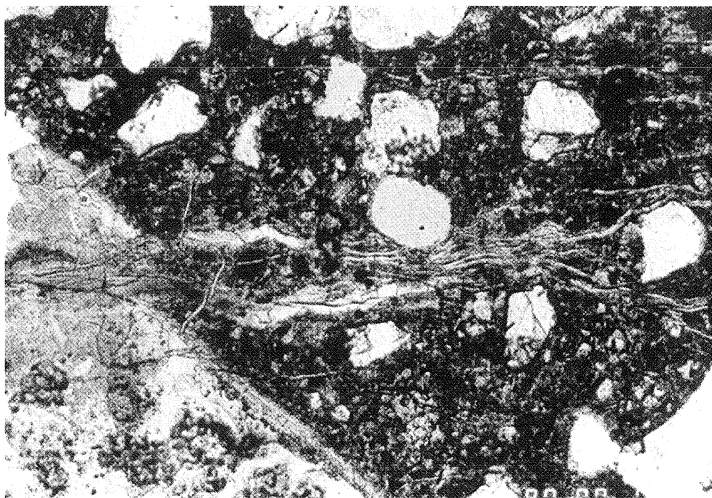
Fig. 1. A concrete affected by alkali-silica reaction in The Netherlands. (a) overview of structure; (b) details of deterioration.

- **Cement:** the concrete of all the structures concerned was prepared with coarse-grained portland cement. The older the structure, the coarser is the cement. The original alkali content of these cements is not known and there is hardly any information available about the alkali content of the concrete. No case has been reported of a concrete structure in which the concrete employed was prepared with blast furnace slag cement with a high slag content (≥ 50 % by mass of cement as slag).

- **Moisture condition:** all the structures are exposed to wet conditions, with most of them very often subjected to de-icing salts. The severest ASR-damage occurs at the areas of the structures which are continuously wet.
- **Aggregates:** the reactive aggregates involved are almost always porous chert in the river gravel used (see Figure 2a). Occasionally, the reaction also involved coarse particles of sericitic sandstone or micro-(crypto)crystalline quartzite, together with porous chert in the same concrete structure (see Figure 2b). No case is known in which only sericitic sandstone or micro-(crypto)crystalline quartzite particles were involved. Reaction of the porous chert in the river sand normally used is very much limited.



(a)



(b)

Fig. 2. Thin section micrographs of ASR-affected concrete showing reacted aggregate particles. (a) porous chert; (b) sericitic sandstone. Size of micrographs is 5.4 mm × 3.5 mm.

- **Others:** the concrete concerned is rarely carbonated and almost always contains high concentrations of calcium hydroxide, $\text{Ca}(\text{OH})_2$. Beside the typical diagnostic features of ASR, a considerable amount of needle-like crystals of ettringite is almost always found in cracks associated with the reaction and in voids in the cement paste.

1.2 *Favourable conditions for ASR*

Alkali-silica reaction in concrete is a chemical reaction between the alkalis in the pore fluid of the cement paste and certain siliceous minerals in the aggregate forming a gel. This gel can absorb water, producing a volume expansion. In some cases, expansion of the gel can induce internal stresses in the concrete of such magnitude that extensive cracking occurs leading to structural damage and other durability problems.

Damage due to ASR can occur only when at least the following three generally accepted conditions are fulfilled simultaneously [2]:

- the concrete should contain sufficient alkali;
- the concrete should have a sufficiently high moisture content;
- the aggregate must be sensitive or potentially reactive with respect to ASR. In the case of Dutch river-dredged aggregate, the reactive constituent, that is, porous chert should have a critical amount (% by mass or by volume) in the concrete.

When all the three conditions above have been fulfilled in the concrete but the concrete contains **more or less** than the critical amount of reactive constituents, the reaction can occur at certain places locally in the concrete, but no damage will occur.

Additional conditions seem to be:

- The concrete should be prepared with ordinary portland cement. It is generally assumed that ASR does not affect concrete prepared with blast furnace slag cement with a high slag content ($\geq 50\%$ by mass of slag) or concrete prepared with at least 25% of pulverised fuel ash by mass of cement. Small amounts of blast furnace slag and fly ash have less effect in preventing the reaction.
- The concrete should have a high concentration of calcium hydroxide, $\text{Ca}(\text{OH})_2$.

1.3 *Problems associated with conditions*

A major problem associated with the five conditions mentioned in Section 1.2 is that they have only been qualitatively established. There are no clear boundaries, which define these conditions. Moreover, there are possible interactions between some of these conditions, which make them quite difficult to appropriately define.

In the case of reactive aggregates for instance, the critical zone of the reactive constituents in the aggregate shifts to lower values with increasing alkali content of the cement. There are also various forms of reactive constituents, each most likely with its own specific critical amounts or limits.

In some aggregates, the potentially reactive constituents are easily recognised in thin sections with the aid of an optical microscope and quantified by means of “point-counting”. Others, which are amorphous or poorly crystallised, can hardly be detected in thin sections and therefore cannot be quantified.

Furthermore, each of these reactive constituents reacts differently with regard to Na⁺ or K⁺, whereas both ions are used together to determine the alkali content of the cement and concrete.

In the case of the moisture content, information about the environment in which the concrete is placed may be known, but the actual moisture content of various parts and depths of the concrete can hardly be accurately determined. The term “sufficient” used is therefore difficult to define or establish accurately in this context.

2 Measures to prevent damage due to ASR

2.1 CUR-Recommendation 38

The Dutch CUR-Recommendation 38: “Measures to prevent concrete damage due to alkali-silica reaction (ASR)” [2], which was drawn by CUR-Research Committee B 56: “Alkali-silica reaction in concrete”, came into force in 1994. As the title reflects, it is a document which outlines the necessary measures that need to be taken during design of new concrete-mixtures so that damage due to ASR in the concrete can be prevented.

The CUR-Recommendation 38 makes provisions for the environments, which are favourable for the ASR, that is, for Environment Classes 3, 4 and 5 as defined in the Dutch Regulations for Concrete Technology (VBT) [3]. In short, this can be summarised as follows:

- Use of blast furnace slag cement: CEM III/B (with a slag content of > 65 % by mass, and an alkali-content of < 2.0 % by mass) or CEM III/A (with a slag content of > 50 % by mass, and an alkali-content of < 1.1 % by mass).
- Use of portland fly ash cement, CEM II/B-V (with a fly ash content of > 25 % by mass and an alkali-content of < 1.1 % by mass) to prepare concrete if the aggregate is known to contain potentially reactive constituents or if the susceptibility of the aggregate to ASR is unknown. This advice is independent of the type and amount of reactive constituents in the aggregate.
- If portland cement shall per se be used in combination with potentially reactive aggregate to prepare the concrete, then the content of reactive constituents in the aggregate should first be determined in order to establish whether it falls within the critical zone. The critical zone is the zone, which is favourable for the occurrence of damaging ASR, if other conditions have been satisfied. The method by which the content of reactive constituents in the aggregate should be determined is not clearly defined in the recommendation. Thus, various methods and procedures are indiscriminately used to determine this value. There is no control over the method used, especially for those constituents that are not detectable in thin sections.

At the time of drawing the CUR-Recommendation 38 [2], it was considered necessary to adopt only the above two main measures. At that time, CUR Research Committee B56 did not foresee any problems in connection with the two measures adopted because the use of both CEM III and CEM II/B-V was very popular in The Netherlands and for that matter would not pose any problems.

Also, at the time of preparation of the recommendation, the only reactive constituent known was porous chert particles that occur in the river gravel. Later, sericitic sandstone particles and some

micro- and crypto-crystalline quartz, as well as some quartzite particles containing chalcedony have been found to be reactive. These new findings, coupled with lack of good, standard procedures for quantitatively determining the contents of these constituents in aggregates have complicated the problem and have somehow limited the use of the above recommendation.

2.2 *Requirements proposed by RWS*

In March 1999, the Dutch Directorate-General for Public Works and Water Management (RWS) proposed new requirements and specifications to prevent damage due to ASR in concrete structures, which can be summarised as follows:

Use CEM III/B (with a slag content of > 65 % by mass and an alkali-content of < 2% by mass) in combination with aggregates containing less than the critical amount of potentially reactive constituents ("Low-reactivity" aggregates).

This new specification or requirement does not take the type of reactive constituents in the aggregate into consideration. Apparently, those who proposed these new requirements found "loopholes" in the CUR-Recommendation 38 and therefore had doubts about its use, especially with regard to large infrastructures requiring very long service life of about 100 years. The other possible reason was the fact that some extra certainty could be achieved with regard to the new requirements and specifications for just small costs. The specification or requirement of CEM III/B for new infrastructural concrete structures had already been issued a few years earlier because of the lower heat production and the better resistance to chloride ingress of CEM-III concrete as compared to CEM I-concrete.

The requirements and specifications put forward by RWS are stronger than any of the documented measures known elsewhere in the world. This choice of "double certainty" against the occurrence of damage due to ASR has the following implications:

- the use of CEM II/B-V or a binder consisting of a combination of portland cement and fly ash (at least 25 % by mass of fly ash) shall be forbidden;
- the use of CEM III/A with 50-65 % slag shall be forbidden;
- the use of North sea-dredged sand and gravel shall be forbidden; these materials generally contain more than 2 % (by mass) of reactive constituents, generally even such high amounts of potentially reactive constituents that they are no more harmful with respect to ASR;
- the use of secondary aggregates shall become almost impossible, because not only is the potential alkali-silica reactivity of such materials difficult to determine but also the results usually show large variations;
- standard procedures should be developed for determination of the content of potentially reactive constituents; such procedures should describe the various methods involved in determining the content of constituents as well as the criteria requirements or specifications for each potentially reactive constituent; also the limitations and variations of such tests and the frequency for each quarry or dredging location should be clearly outlined in such procedures;
- the aggregate supply industries should incur extra costs in order to determine the content of potentially reactive constituents in any aggregate material that they intend to produce.

The above-mentioned implications shall obviously have serious consequences on the Dutch aggregate suppliers and the ready-mixed concrete market as a whole. This can create a conflict with policy of the Dutch government regarding aggregates for concrete: the restrictions imposed on exploitation of river sediments and the promotion of the use of sea-dredged aggregates and alternative secondary aggregates in concrete.

In the subsequent sections, more light is thrown on the problems related to the new specifications and requirements from RWS with the aim of drawing an inventory of whether extra measures in addition to CUR-Recommendation 38 are required.

3 Mechanisms by which CEM III and CEM II/B-V suppress ASR

The following factors contribute to suppress ASR in concrete prepared with potentially reactive aggregates and CEM III as cement:

- The alkalinity of the pore fluid of CEM III-concrete is, in general, lower than that of portland cement, CEM I-concrete. A documentation of the alkalinity of the pore fluid in concrete from various sources has been given by Bartolini and Polder [4]. In this paper, a simple description is given to illustrate the alkalinity of the pore fluid of a non-carbonated CEM III-concrete with a water-cement ratio of 0.45.

CEM I-concrete	0.3 M KOH + 0.1 M NaOH	pH = 13.6
CEM III-concrete	0.1 M KOH + 0.1 M NaOH	pH = 13.3

Thus, CEM I-concrete contains about twice as much hydroxide, OH^- ions as CEM III-concrete. The alkali-silica reaction begins with attack and dissolution of silica. This means that the reaction will proceed faster as the pH increases. It is quite remarkable to note that while the Na^+ -concentration is the same in both types of concrete, the K^+ -concentration of that of CEM I-concrete is about three times that of CEM III-concrete. According to experts in this field, K^+ plays a more important role in damaging ASR than Na^+ .

- For equal water-cement ratios, the cement paste of CEM III-concrete has a denser structure than that of CEM I-concrete. Also the capillary pores of the cement paste in CEM III-concrete have a more tortuous structure than the capillary pores of the cement paste in CEM I-concrete. This makes diffusion of ions in CEM III-concrete up to two orders of magnitude slower than in the case of CEM I-concrete. The electrical resistance is a parameter that gives an indication of the ease of transport of ions in concrete. For water-saturated CEM I-concrete, the electrical resistance is about a factor 3 to 5 lower than for similar CEM III/B-concrete. There is a minor influence of the water-cement ratio, less than a factor of 2 from a water-cement ratio of 0.45 to 0.65, comparable to both cement types [5]. This implies that the water-cement ratio does not have any major influence on the electrical resistance, rather the type of cement. Hence a denser cement paste structure implies lower rates of transport of ions. For ASR to occur, the alkali ions need to be transported to the reactive aggregate constituents.

- CEM III-concrete contains only a small amount of free lime (calcium hydroxide, $\text{Ca}(\text{OH})_2$) in the cement paste, compared to considerably high amount in CEM I-concrete. According to some experts, the presence of calcium hydroxide is essential for damage due to ASR to occur. In the absence of calcium hydroxide the reaction can take place but the gel formed has less affinity for water and therefore is not able to imbibe water to swell. No damage is caused in that case. Fully hydrated CEM I cement contains about 25 % (by mass) of calcium hydroxide, while in the case of CEM III cement only a few percent of calcium hydroxide is present.
- The relatively porous and weak interfacial transition zone between the cement paste and aggregate in CEM I-concrete, with a thickness of about 40-50 μm , contains a high concentration of calcium hydroxide crystals. In the case of CEM III-concrete, the thickness of this zone is just fractions of that of CEM I-concrete and contains almost no calcium hydroxide.

All the aforementioned factors apply, in general, also to concrete prepared with portland fly ash cement, CEM II/B-V. For both cements, special specifications are required. For CEM III/A, a minimum slag content of 50 % (by mass) and an alkali content of < 1.1 % (by mass) are the requirements. CEM III/B (with slag content of > 65 % by mass and an alkali content of < 2 % by mass). In the case of CEM II/B-V, at least 25 % (by mass) of fly ash and an alkali-content of < 1.1 % (by mass) are the specifications.

It must be emphasised here that the relative importance of these factors is not very much known. Rather, it is generally accepted from practice that a combination of these factors leads to durable protection against the occurrence of damaging ASR.

Nowhere in The Netherlands or elsewhere in the world is a case known of damage due to ASR of a concrete structure prepared with CEM III with a minimum slag content of 50 % (by mass). This is the reason why in most countries, CEM III is used as a preventive measure against damage due to ASR. Thus, evaluation of the potential alkali-silica reactivity of an aggregate, prior to use in concrete in combination with CEM III with more than 50% of slag, is viewed as "over-exaggeration".

Based on experience, the measure to use CEM III to prevent damage due to ASR in concrete has not been adopted by The Netherlands alone in standard regulations and recommendations, but also by other countries, such as the United Kingdom, Belgium, Germany and Australia.

4 Aggregates with the amount of reactive constituents above the critical limit

It is generally known that damage due to ASR does not occur in concrete prepared with portland cement and aggregates containing potentially reactive constituents above the critical amount.

To date no clear explanation is given for this somehow remarkable phenomenon. There are two schools of thought concerning this effect:

1. In the first place, in hardened concrete the attack occurs at many places at the same time so that at each place only a small amount of gel is formed. Such small amounts of ASR-gel absorb only little amounts of water. Consequently, not enough high stresses are developed anywhere in the concrete to exceed the tensile strength of the concrete. As a result no cracks are developed.

2. The other reason is that the reaction between the alkalis in the pore fluid of the cement paste and the reactive constituents in the aggregate occurs to a large extent in the plastic phase of the concrete. The alkalis are then no more available to further the reaction when the concrete eventually hardens.

In both cases the availability of the alkalis is the limiting factor. A crucial question then remains as to whether the reaction can proceed if there is ingress of alkalis into the concrete from de-cing salts or from the sea. It appears that if damage due to ASR is to occur in this case then considerable amounts of the alkalis should be able to ingress deep into the concrete. For a good quality and well-cured concrete, the chance is very small or even impossible, in particular, if the "premises" for damage due to ASR in concrete include the fact that the concrete for most part of the time should remain wet. This means that transport of alkalis in the concrete should take place through diffusion mostly. If reinforced concrete can take-up enough alkalis from the environment to cause damaging ASR, then there should also be fear for other forms of attack that can arise due to simultaneous transport of associated anions such as SO_4^{2-} (sulphate attack) and Cl^- (reinforcement corrosion). The latter two damage mechanisms should occur earlier than ASR, because they already appear when the anions have been transported into the concrete to lesser depths than needed for the occurrence of ASR. In addition, it is wellknown that the rate of diffusion of chloride ions is higher than of sodium ions [5]. In England, there are many years of experience with the use of North sea-dredged aggregates in concrete. In The Netherlands, experience with the use of North sea-dredged aggregates dates more than 25 years back. Also the problems and issues associated with ASR are better known in England than in The Netherlands. However, there is no known case of ASR-damage of a concrete structure whereby the concrete used was prepared with sea-dredged aggregates only. In England, aggregates are divided into three groups according to their alkali-silica reactivity [6].

- **Low reactivity aggregates:** determined according to their petrographic name produced in crushed form are used, such as granite, marble and non-silicified limestone.
- **Normal reactivity aggregate:** this is the largest group and consists essentially of sand and gravel dredged or mined from river, land or the sea.
- **High reactivity aggregates:** these are aggregates that contain more than 10 % (by mass) of crushed greywacke or containing any crushed greywacke-related sandstone, siltstone and shale as well as recycled concrete.

In England, no more distinction is made between river-dredged and sea-dredged sand and gravel. Separate specifications are made for each of the groups (low, normal and high reactivity) with regard to the alkali content of the cement, depending on the type of cement with which the concrete is prepared.

5 Methods to determine the alkali-silica reactivity of aggregates

The Dutch Standard NEN 5905 (1997): “*Aggregates for use in concrete with density more than 2000 kg/m³*” [5] authorises the supplier of aggregates to provide information regarding the reactivity of the alkali-aggregate. According to this standard, evaluation of the alkali-aggregate reactivity can be determined on the basis of:

- Long-term experience with the use of the aggregate in concrete.
- Microscopical analysis of the mineralogical composition of the aggregate.
- Expansion tests using mortar bars or concrete prisms.
- Results of a chemical determination of the reactivity.

These four methods have also been mentioned in CUR-Recommendation 38. These methods do not provide any sound basis either for accepting or rejecting of the aggregate. The tests have only been mentioned, but there are no proper Dutch procedures describing or outlining how the tests have to be carried out and the expected limitations, variations and possible errors.

In Belgium, the problem of alkali-silica reaction came to light some years earlier than in The Netherlands. In the Flemish region, measures have been adopted in Civil Engineering Regulations (Dienstorder LI 94/80 [8]) for preventing damage due to ASR in concrete. These measures (just as CUR-Recommendation 38) contain two main steps:

1. Use of portland cement with a low alkali content (less than 0.6 % Na₂O-equivalent) or use of blast furnace slag cement with a high slag content (≥ 50 % by mass of cement as slag). In that case, no evaluation of the potential alkali-aggregate reactivity of the aggregate is required.
2. In case none of the cements mentioned under “1” is employed, then evaluation of the potential alkali-aggregate reactivity of the aggregate is required.

The manner or procedures by which the potential alkali-aggregate reactivity of the aggregate is evaluated is fairly well described in [8]. The evaluation specifications have also been given for each type of method in the same document. The procedures, often called the “Flemish method” are split into two main methods depending on the type of aggregate:

- The potential alkali-silica reactivity of sand and gravel deemed to be evaluated petrographically or microscopically by determining the content of potentially reactive constituents. At the moment, a draft procedure [9], have been jointly formulated by TNO Building and Construction Research (TNO-BCR) and GEOS, an independent Belgian laboratory for determining this property. GEOS was involved in an extensive investigation on ASR in Belgium, which in part led to the regulation and guidelines outlined in [8]. On the basis of this new procedure a specification of 2 % has been proposed as the maximum acceptable content of potentially reactive constituents in river-dredged sand and gravel in The Netherlands. Problems regarding reproducibility and limitations, especially in the case of sericitic sandstone¹ and greywacke particles, which are also

¹ Not all the sericitic sandstone particles have been found to be potentially reactive. As such, the sericitic sandstone particles are not included in the amount of potentially reactive constituents. Work is currently going on to assess which particles should be included.

known to be potentially reactive, are yet to be resolved. In the recently published report of the STAR-project, reproducibility was also found to be one of the main drawbacks associated with the determination of the potential alkali-silica reactivity by means of petrography or microscopy [10].

- Crushed rock (in Belgium, this applies to limestone, sandstone and porphyritic rhyolite) deemed to be evaluated using expansion tests using Oberholster-test (NBRI-test [11]). At the moment, TNO-BCR and GEOS are examining possibilities of employing the RILEM TC 106 method [12] for similar purposes.

In the past years in The Netherlands, the "Flemish method" has been employed on regular basis to evaluate aggregates.

Sometimes there is confusion with the interpretation of the flowchart in the CUR-Recommendation 38 regarding the question:

"content of $\text{SiO}_2 \leq 2\%$ (by mass)"

Various users of the CUR-Recommendation 38 interpret this question incorrectly as identical to

"content of reactive silica $\leq 2\%$ (by mass)"

asked in the "Flemish method". What CUR-Recommendation 38 really means with this question is in fact,

the total content of SiO_2 , which is determined by means of a chemical analysis of the material.

The question is asked in the flowcharts of the CUR-Recommendation 38 to avoid other unnecessary investigations of aggregates that are essentially composed of other constituents than silica ($\geq 98\%$ by mass of other constituents). A well known example of such an aggregate is relatively pure, not silicified limestone.

6 Leaching of alkalis from aggregates

Another criticism that has been levelled against the CUR-Recommendation 38 is the fact that no consideration is given to the possibility of increasing the alkali content of the concrete through leaching of alkalis from the aggregate used. It must be pointed out that CUR Research Committee B 56 which drew the recommendation discussed this issue at length and agreed not to include this aspect in the recommendation. This standpoint of the research committee is still valid because there Recently, another case has also been reported [14, 15]. The latter involved alkali-silica reaction of a silica-rich dolomite rock, used as coarse aggregate in Canadian concrete road ties. The reaction was believed to be triggered by the occasional presence of alkali-rich silico-carbonate rock in the dolomite. The silico-carbonate rock was found as sills (intrusions) in the limestone rocks of the Francon Quarry, where the dolomite was mined. According to Jakobsen [14, 15], this rare rock consists of alkali feldspar and high amounts of rare alkali-minerals such as dawsonite, $(\text{NaAl}(\text{CO}_3)(\text{OH})_2$.

During thin section examination of the concrete, the dolomite aggregate appeared severely cracked and alkali-silica gel appeared in cracks radiating out into the adjoining cement paste. SEM-EDAX analysis showed that the reactive component of the dolomite aggregate was micro-crystalline quartz. A reaction zone consisting of calcite and gibbsite was observed around all of the silico-carbonate aggregate particles in the concrete. The interior part of the silico-carbonate rock was highly porous, apparently from the decomposition of the Na-rich mineral dawsonite. The decomposition of dawsonite was believed to have led to an increased alkali content of the pore solution, which then resulted in alkali-silica reaction in the silica-containing dolomite rock.

These two cases, which are quite exceptional, should not form any basis for incorporation into the CUR-Recommendation 38. Both cases concern rare volcanic rocks containing alkali-rich components or constituents. Such types of volcanic rocks are not used as aggregates for concrete in The Netherlands. The river and sea-dredged aggregates used consist of sedimentary rocks, which contain scarcely any volcanic rocks [1]. The assertion made by Broekmans and Jansen [16] that the alkali-silica reaction in concrete structures in The Netherlands may be influenced by the catalytic effect of sodium and potassium, leached from the mica and clay minerals in the interstices of the sandstone aggregates is questionable and needs further investigation. The usual content of (sericitic) sandstone in aggregates, dredged from the Meuse and Rhine rivers varies between 10 and 70 % (by mass). If the assertion of Broekmans and Jansen [16], were to be valid, the alkali-silica reaction would have involved almost all the sericitic sandstone particles in nearly all the ASR-affected concrete structures investigated during the past years. Our experience, however, is that of the nearly sixty cases of concrete structures that we have diagnosed to be affected by ASR, the main reactive aggregate is porous chert. Reactions involving sericitic or "impure" sandstones have been found to be secondary. Furthermore, no such case of contribution of alkalis from such so-called "impure" sandstones have been reported in Belgium, Germany and the United Kingdom, where similar aggregates are used in conjunction with CEM I cement to prepare concrete.

7 Concluding remarks

The issue of alkali-silica reaction in concrete is gradually becoming more important in The Netherlands especially during the design of concrete mixtures for structures which are required to have a long service life, particularly for large infrastructures. Some parties regard the current regulations (Dutch CUR-Recommendation 38 and Dutch Standard NEN 5905) as not adequate enough to provide the necessary guidelines and specifications regarding this issue. In fact, such parties are of the opinion that the regulations, especially, the preventive measures outlined in CUR-Recommendations 38 are inadequate for the purposes for which they are designed.

A major problem with the CUR-Recommendation 38 is that the effectiveness of the preventive measures have not yet been evaluated in practice because the manifestation of typical ASR-damage in The Netherlands takes place over a long period of time - several tens of years. The Dutch Department of Highways and Public Works has therefore recently proposed new supplementary specifications for the preventive measures.

Various arguments have been raised against the supplementary specifications proposed by The Dutch Department of Highways and Public Works. The general reaction is that introduction of such extra specifications will not only create serious problems in the Dutch concrete and aggregate producers and the market as a whole but will also be in conflict with the Dutch government policy regarding exploitation of aggregates for concrete.

Like most other regulations, the CUR-Recommendation 38 needs to be critically reviewed every now and then and where necessary, updated to conform to new developments². Such review should not only deal with the technical content but should also deal with questions arising from the market and its relation with similar regulations and standards.

8 References

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² All CUR-Recommendations are periodically reviewed. The duration of the period depends very much on the specific recommendation. The normal period for most recommendations is 3 years.

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