# ALKALI-SILICA REACTIVE AGGREGATES IN BEIJING AREA

Fu Peixing,
Beijing Academ y of Construction Engineering
Li Yaling
Beijing Construction Committee
Feng Huimin, Huang Qiang
The state Geological Institute for Building Materials

## ABSTRACT

The main results of a series of field surveys of concrete aggregates used in Beijing construction industry are reported in this paper. It was found that the main silica reactive aggregate is mainly located in Yongding as well as Wenyu river. Effective measures should be taken when the reactive aggregate is presented. Proposals, which have been adopted by the local government, were raised by the authors to limit the risk of alkali-silica reaction.

*Keywords: Alkali silica reactivity, Field survey, Control measures .*

## INTRODUCTION

In recent years, there is a large construction market in Beijing area. The annual consumption of cement and aggregate are about 5 and 30 million tons. The aggregates used in Beijing are mainly supplied by gravel deposited in river beds in nearby suburbs. Since the several cases of alkali-silica reaction damage in Beijing was reported in the early 1990' (1,2), government officers and construction engineers have become widely concern on this concrete durability problem. Researches and discussions on alkali-aggregate reaction also arouse interests among geologists because of the large verity and complicity of aggregates. Limestone, clay, siliceous shall, sand stone, salt, gypsum mirabilite and so on are very significant in cement and concrete industry as well. A research program on AAR, which was supported by Beijing Construction Committee and the Bureau of Construction and Architecture Industry, was conducted in early 1991. This paper reported some surveys of the alkali reactivity of aggregates used in Beijing concrete industry. Discussions are also made in terms of geology.

During 1990 to 1993, geological inspections were made thirteen times in Beijing suburb areas where concrete aggregates were produced. The total amount of the sand and coarse aggregate collected was about 2.8 tons. Detailed petrographic examination and X-ray diffraction analysis were performed for the determination of rock types and minerals involved. The reactivity of the aggregates was determined by the autoclave mortar bar method, ASTM C227, NBRI as well as ASTM C289 method. 7479 mortar bars were prepared and tested.

## RESULTS AND DISCUSSIONS

Based on the Tang's results (2) and the findings obtained by the present investigation, it was found that most sands collected in Beijing area are non-reactive and only small amount of samples showed very slight reactivity. Thus it is believe that alkali-silica reaction in Beijing was mainly due to certain coarse aggregates.

Coarse aggregates used in Beijing can be grouped into 8 rock types, among which five types showed obvious reactivity as listed in Table 1. Only four groups of samples among sixteen random-selected samples gathered from eight typical quarries presented considerable expansion according to C227 and autoclave method test. (Table 2)

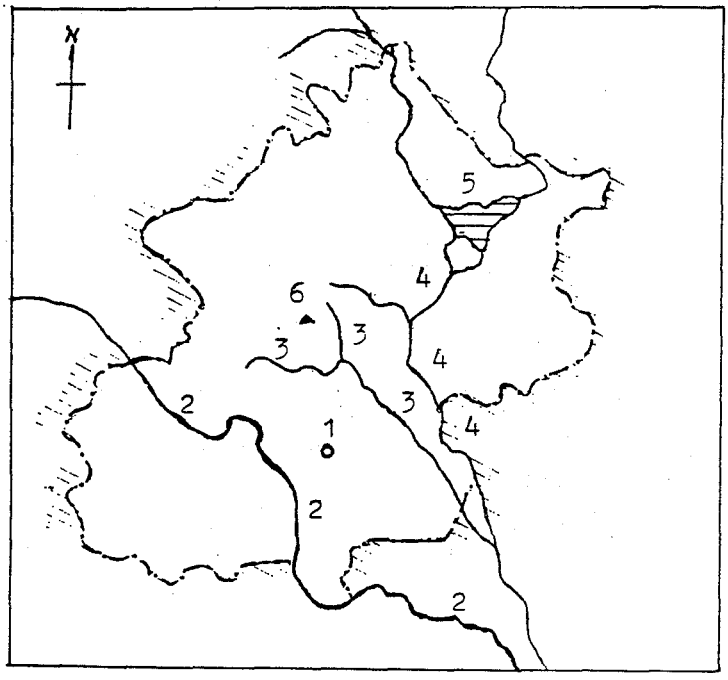
Table 1 Classification of coarse aggregates in Beijing area and their alkali reactivity

| No. | Rock Types | Petrographic characteristics | Alkali Reactivity evaluated by | | | |
|---|---|---|---|---|---|---|
| | | | C289 method | C227 method | Autoclave mortar bar method | Reactivity |
| 1 | Sedimentary of feldspar and quartz | Microlite, chalcedony and microcrystallized quartz | Interrupted by carbonate | 0.218 % | 0.189 % | Reactive |
| 2 | Pyrolith of feldspar and quartz | Absence of reactive silica | non-reactive | 0.042 % | 0.085 % | non-reactive |
| 3 | Striped silicolite | Microlite and chalcedony | Potentially reactive | 0.254 % | 0.200 % | reactive |
| 4 | Massive silicolite | Microlite and chalcedony | Potentially reactive | 0.236 % | 0.269 % | reactive |
| 5 | Morderate acidic pyrolith | Absence of reactive silica | non-reactive | 0.078 % | 0.083 % | non-reactive |
| 6 | moderate basic pyrolith | Absence of reactive silica | non-reactive | 0.071 % | 0.126 % | reactive |
| 7 | Carbonatite | Chalcedony, fine-grained dolomite and aplite | Interrupted by carbonate | 0.152 % | 0.079 % | non-reactive |
| 8 | Pay siliceous carbonatite | Microlite and chalcedony | Interrupted by carbonate | 0.207 % | 0.186 % | reactive |

Table 2 Alkali silica reactivity of typical coarse aggregate collected in Beijing area

| Location | Percentage of the reactive rocks containing in the sample | | | | | | Expansion of mortar bars (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 3 | 4 | 7 | 8 | Total | ASTM C227 | NBRI | Autoclave method |
| Yongding river | 12 | 5 | 4 | 11 | 21 | 53 | 0.082 | 0.131 | 0.090 |
| | 12 | 5 | 4 | 11 | 21 | 53 | 0.074 | 0.104 | 0.097 |
| | 11 | 6 | 3 | 11 | 22 | 53 | 0.096 | 0.122 | 0.092 |
| | 12 | 5 | 4 | 13 | 21 | 55 | 0.107 | 0.136 | 0.103 |
| | 11 | 5 | 5 | 10 | 23 | 54 | 0.114 | 0.099 | 0.106 |
| | 13 | 5 | 3 | 15 | 17 | 53 | 0.119 | 0.127 | 0.101 |
| | 14 | 4 | 3 | 16 | 14 | 51 | 0.090 | 0.105 | 0.084 |
| Wenyu river | 14 | 2 | 4 | 5 | 5 | 30 | 0.043 | 0.113 | 0.085 |
| | 16 | 2 | 3 | 5 | 5 | 31 | 0.044 | 0.098 | 0.094 |
| Chao bai river | 17 | 3 | 2 | 4 | 6 | 32 | 0.040 | 0.090 | 0.103 |
| | 19 | 3 | 2 | 6 | 4 | 34 | 0.051 | 0.073 | 0.095 |
| | 15 | 2 | 1 | 5 | 5 | 28 | 0.050 | 0.086 | 0.084 |
| | 15 | 3 | 2 | 6 | 6 | 30 | 0.050 | 0.066 | 0.096 |
| | 14 | 3 | 2 | 5 | 6 | 30 | 0.047 | 0.087 | 0.081 |
| | 16 | 3 | 2 | 5 | 6 | 32 | 0.052 | 0.070 | 0.092 |
| Nankou | 0 | 0 | 0 | 5 | 95 | 100 | 0.147 | 0.132 | 0.114 |

There are three rivers, Yongdin, Wenyu and Chaobai river, passing through Beijing area as shown in Figure 1. Rock types at the upper reaches are different. After many years weathering and scouring, the rocks were smashed and carried down to lower reaches. Thus the rocks at the upper reaches determine the gravel types in lower reaches. In upper reaches of Chaobai river there are mainly quartzite, granite and gneiss. The main part belongs to metamorphic rock group originated in Archaeozoic era. The rocks are very old and usually hard and condensed. The amount of the alkali-silica reactive rocks are very low. Sand stone, grammite, limestone, dolomite, marlite and volcanic emanation formatted rocks such as liparite, andesite, basalt and hyaline are distributed in Yongdin and Wenyu river. They formed in proterozoic, palaeozoic and mesozoic era younger than that of Chaobai river. The rocks belonged to sedimentary and volcanic rock group containing some reactive rocks. Therefore, care should be taken when gravel is used in cement concrete.




1. Beijing City 2. Yongding river 3. Wenyu river 4. Chaobai river 5. Reservoir 6. Nankou

Figure 1 River system in Beijing area

## CONCLUSION

Considering the complexity and unevenly distributed reactive rocks in Beijing area, the authors proposed some suggestions, which have been adopted by Beijing local government, to minimize alkali-silica reaction deterioration in Beijing area. It includes routinely reactivity evaluation of concrete aggregates used in important concrete structures, limitation the total alkali content in concrete no more than $3Kg/m^3$ and use of mineral admixtures to control the ASR expansion. High alkaline admixtures are strictly restricted in Beijing.

In the following years, output of aggregate should be controlled Yongdin and Wenyu area. Instead, local government will encourage the quarries located in Chaobai area to increase their production. On the other hand, high quality limestones have been found in the north of Beijing. Cement manufactures are trying to use them to produce more low alkali cement in recent years.

## REFERENCES


1. Qian Chunxiang, Han Sufen, Lu Yinon, Tang Mingshu and Fu Peixing, Cement (in Chinese) No. 8, 1990, pp. 7-11.

2. Tang Mingshu, Han Sufen, Lu Yinon, and Qian Chunxiang, The 9th International Conference on Alkali-Aggregate Reaction in Concrete, London, UK, 1992, Vol. 2, pp. 654-659.