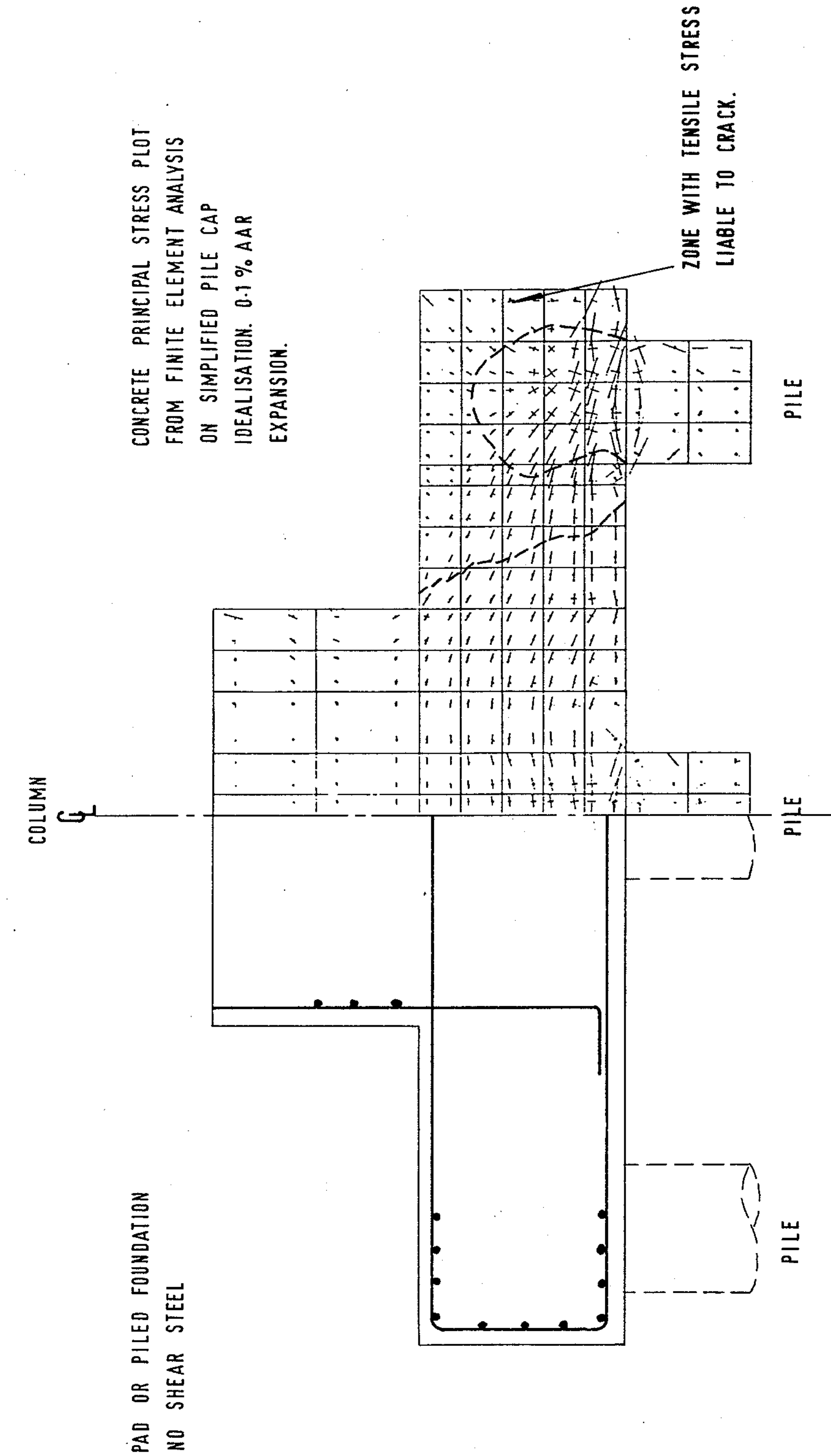

FIGURE 3b

FIGURE 3a

ALKALI-AGGREGATE REACTION IN LIGHTWEIGHT CONCRETE

Branka Zatler,M.Sc.; Edvard Mali,B.Sc.

Institute for Research and Testing in
Materials and Structures, Ljubljana, Yugoslavia

1. ABSTRACT

The properties of lightweight concretes made of expanded clay, and expanded clay with perlite as aggregate was studied. As the expanded clay and perlite contain silicium dioxide components in amorphous form, the potential silica aggregate reaction was tested with the modified methods by ASTM C-227 and ASTM C-289.

2. KEY WORDS

Expanded clay, expanded perlite, alkali silica reaction

3. INTRODUCTION

Laboratory concretes were prepared from expanded clay and expanded perlite. They were watertight and stable against freezing and thawing. In accordance with the ACI classification /1/ their compressive strength alligned them in the group of "moderate strength concrete". Their composition and basic properties are presented in Table 1. If they were used as facade walls (monolithic or prefabricated) they would be exposed to the action of water and moisture ,alkali silica reaction could take place, and concrete stability would be uncertain.

4. EXPERIMENTAL

4.1 Chemical analysis of concrete constituents

Yugoslav expanded clays contain from 65 to 70 per cent of silicium dioxide and expanded perlites from 70 to 75 per cent. Free alkalies content expressed as Na_2O, in Yugoslav portland cements varies from 0,8 to 1,4 per cent.

4.2 Petrographic and X-ray analysis of aggregates

The main constituents of used expanded clay and perlite are silicium dioxide and glassy amorphic substances. They are evident from the X-ray diffraction patterns in Figure 1.

4.3 Testing of aggregates on alkali silica reaction in acordance with ASTM C-289 /2/

By this chemical method information about potential alkali silica reactivity is obtained in two days. It was prepared for normal weight aggregates. The base for the results evaluation was experimentally conceived on different samples of aggregates mixed with NaOH solution in ratio 1 to 1. It is possible to perform the experiments with the sample of 25 gramms of normal weight aggregate and 25 ml of 2 n NaOH solution in standarised vessel size, but practically impossible with 25 gramms of expanded perlite or clay because of their very low density and high water absorption. Therefore no results were obtained.

4.4 Testing of aggregates on alkali silica reaction in acordance with modified ASTM C-227 /3/

The modificiation of testing method was only in composition of cement mortars. The cement aggregate ratio in specimens with expanded clay was 1 to 1,15, and in specimens with expanded perlite 1 to 0,10 by weight instead of 1 to 2,25 as it is specified for normal weight aggregates. Because the maximum grain size of expanded perlite was not greater than 1 mm, the portion of 0,150 mm grains was raised from 15 to 23,10 per cent, and the portion of 0,300 and 0,600 mm grains from 25 to 38,45 per cent.

Ordinary portland cement with 0,99 per cent of Na_2O was used. For testing the influence of alkali content on the expansion the second series of specimens were prepared with the addition of NaOH to the mixing water.

Two year expansion of mortar bars is presented in Figure 2. After five years no visible deformation or cracks were detected on the specimens.

The test specimens before and after storing over water at temperature of 38 °C are presented in Figures 3 and 4. On the microscopic testing of specimens there was no gel formation observed.

5. CONCLUSION

On the basis of presented experimental work it can be concluded that in lightweight concretes made of expanded clay and expanded perlite alkali silica reactivity is small and does not cause deterioration.

6. REFERENCES

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Table 1: The basic properties of lightweight concretes

Cement content (OCP) : 320 kg/m^3
Maximum size of aggregate: 20 mm

Type of aggregate	Type of concrete	Hardened concrete at age of 28		
		Compressive stength 20 cm cubes (MPa)	Unit weight* (kg/m^3)	Thermal conductivity* (W/mK)
expanded clay 100 per cent	plasticised	21,4	1420	-
	air entrained**	16,3	1330	0,42
expanded clay 75 per cent expanded perlite 25 per cent	plasticised	14,5	1260	-
	air entrained**	11,6	1200	0,32

* - in air dry conditions
** - 10 per cent of air content in fresh concrete

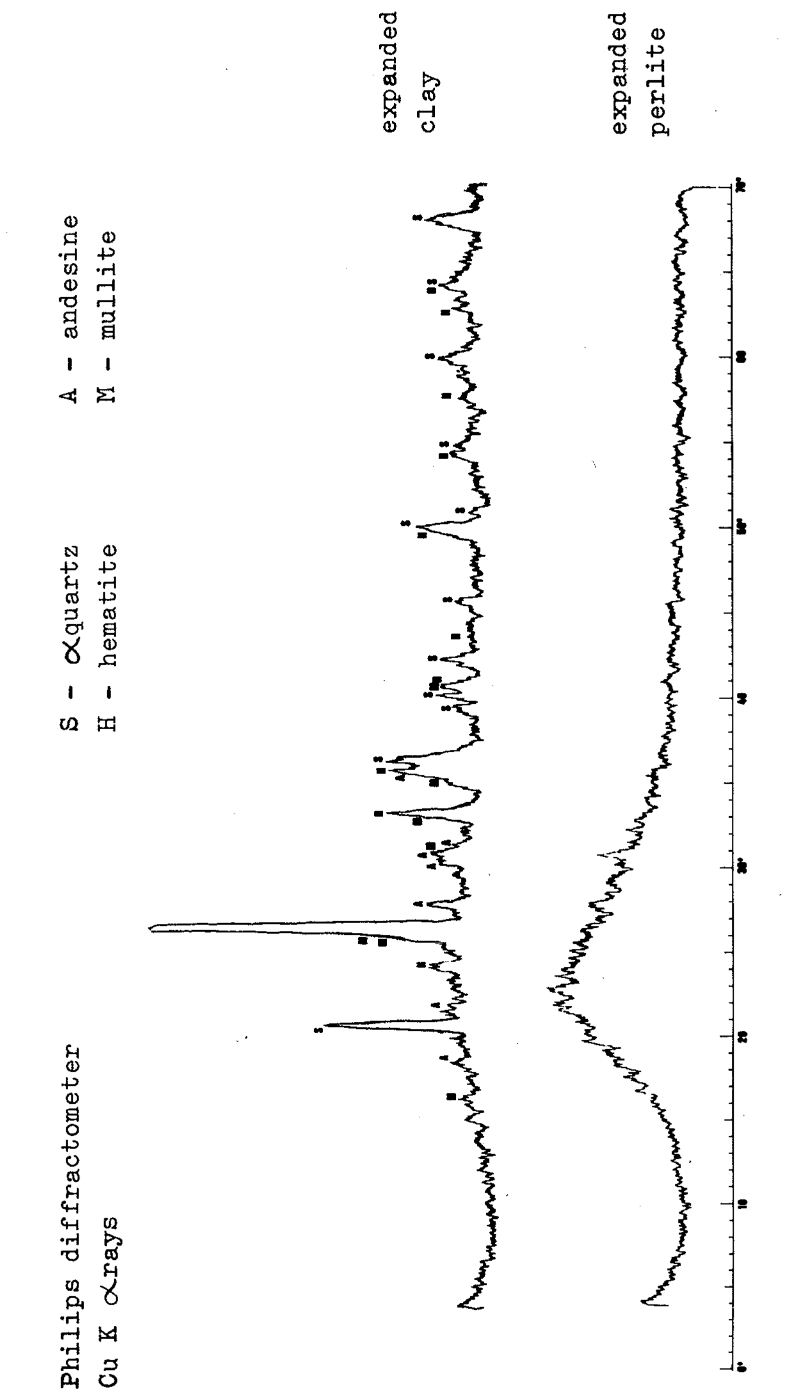
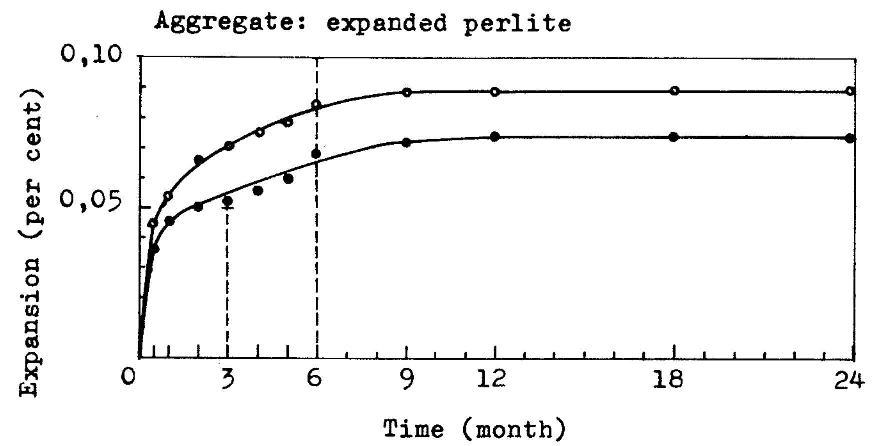


Figure 1: X-ray diffraction patterns



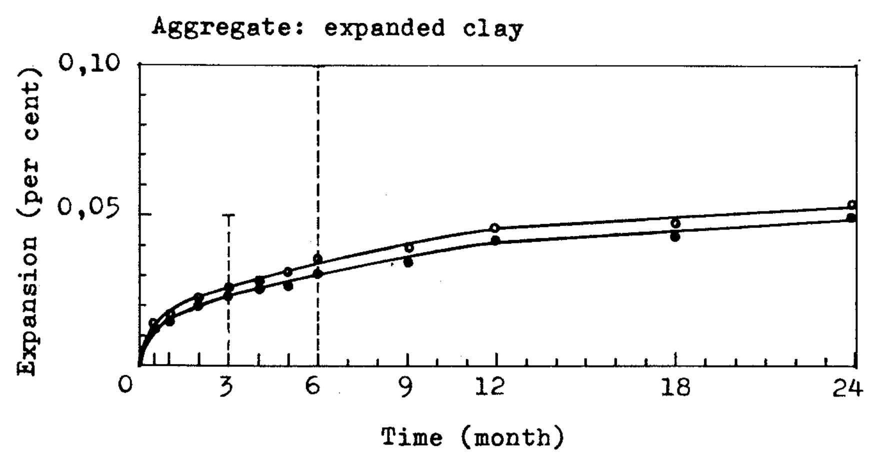
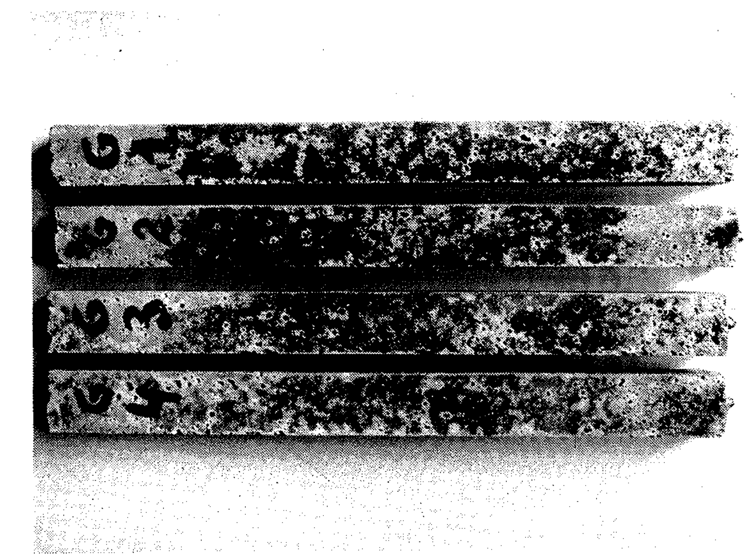


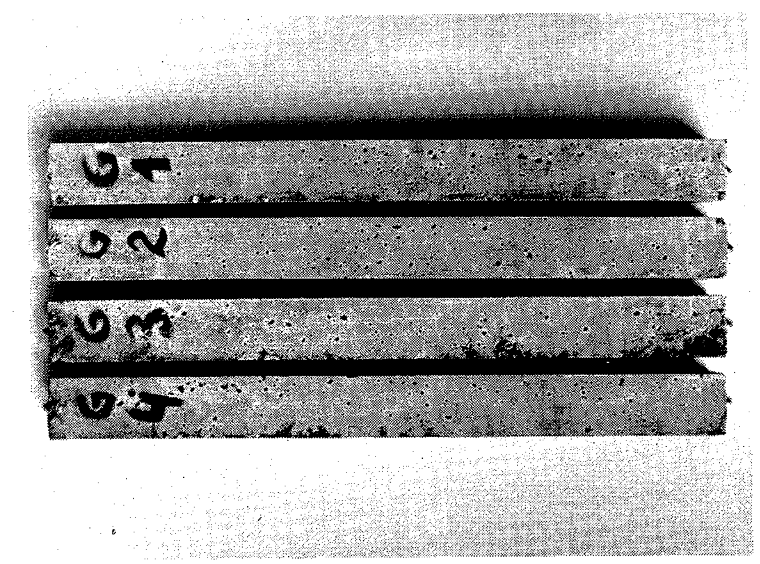
Figure 2: Expansion of mortar bars stored over water at temperature 38 ± 1 °C

Alkali content in cement : • 1 per cent
∘ 2 per cent

ASTM C-227 maxima guidelines: --------┤

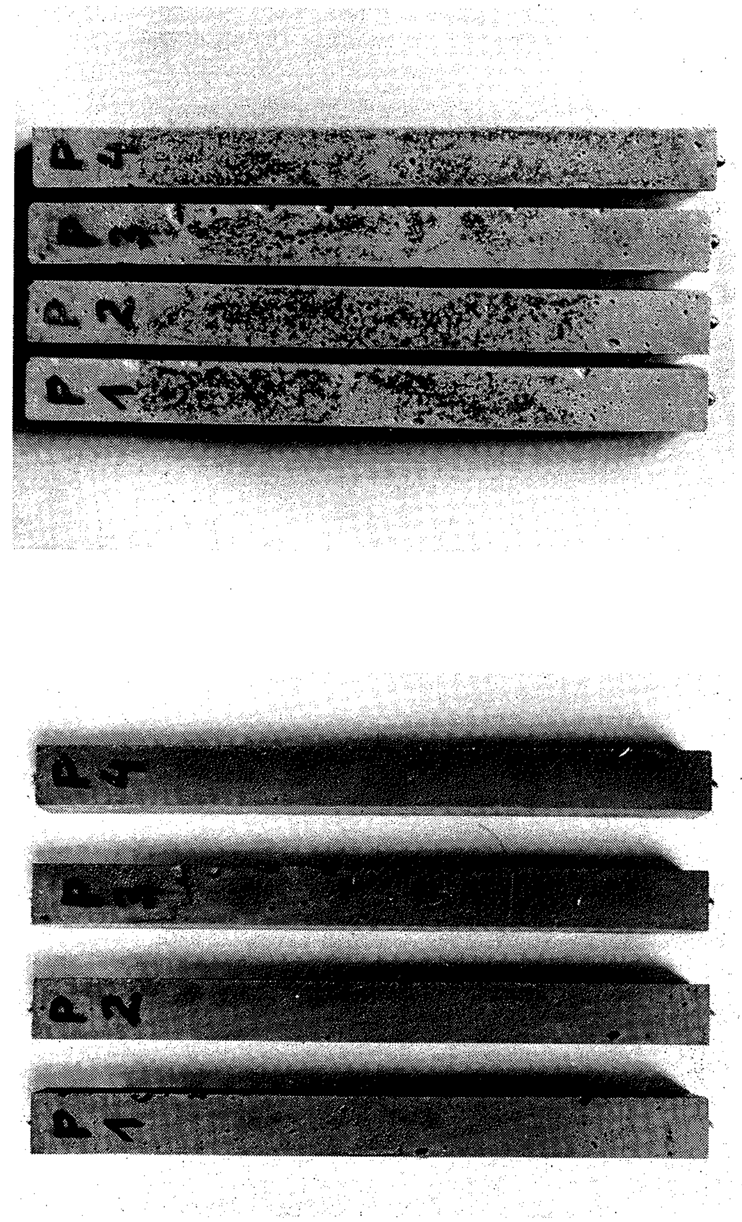


After five years.



At age of one day.

Figure 3: The expanded clay mortar bars (1x1x10 inch)



After five years.

At age of one day.

Figure 4: The expanded perlite mortar bars (1x1x10 inch)

EXEMPLES OF DETERIORATION BY ALKALIS IN ITALIAN CONCRETE STRUCTURES

Giulia Baronio, Dr.
Department of Structural Engineering, Technical University, Milan, Italy

1. INTRODUCTION

The so-called alkali-aggregate reaction (AAR) constitutes a serious problem in several countries, being normally related to anomalous expansion of concrete, causing fissuration, loss of strength and, in some cases, complete destruction of the concrete itself. As it is well known, this reaction takes place between alkali cations and hydroxyl ions from concrete pore solutions and amorphous or cryptocrystalline silica from some grains of aggregate /1/.

Fortunately, such phenomena are very infrequent in Italy: the only exemples reported by technical literature concern some industrial pavements situated in the regions bordering on the Adriatic Sea, as Romagna, Marches and Abruzzi /2/.

Recently, however, some parts of an 8 years old concrete structure were found highly fissured. The cracking pattern, caused by the growing of expansive gel inside the concrete, together with the results of chemical and petrographical analyses, carried out respectively on the aggregate, the reaction products and the concrete, led to the hypothesis of AAR. It has to be remarked that the building is situated in Lower Molise, slightly south of the area considered by /2/.

Keywords: aggregate; alkali-aggregate reaction; deterioration of concrete.

2. OBSERVED DECAY OF STRUCTURAL CONCRETE

The building appeared degraded after about 8 years since the casting of concrete structures; on the other hand, it is known that AAR can produce its negative effects only after about 5 or 6 years /3/.

The cracks assumed a different pattern according to the fact that restrained or unrestrained concrete were affected by AAR. Deep cracks, more or less parallel to reinforcing bars, could be seen in reinforced concrete colums; typical, randomly distributed, map cracks had formed on the surface of unrestrained massive concrete blocks (fig. 1).

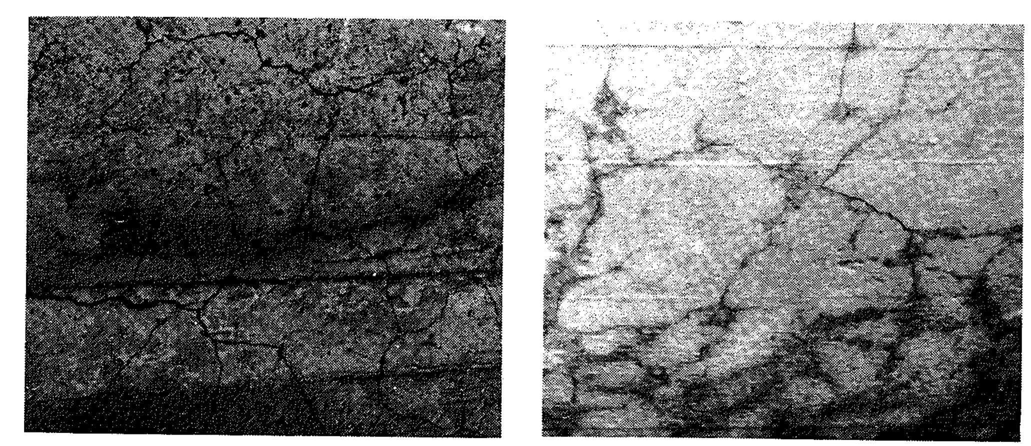


Fig. 1: left, right. Two aspects of map cracking on massive concrete blocks.