ALKALI REACTIVE COMPONENTS IN THE SAND AND GRAVEL OF THE RIVER DANUBE AND ITS TRIBUTARIES

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An overview is given of available data about the chert content of the sand and gravel found in the River Danube basin. Some more detailed data are provided about possible reactive components in the aggregates and cements of Slovenia. The question arises as to at what concentration of reactive components in concrete it is necessary, in everyday practice, to begin alkali - aggregate reaction (AAR) tests.

INTRODUCTION

The basin of the River Danube and its tributaries covers a large part of central and eastern Europe (Fig. 1). In this region sand and gravel are obtained form pleistocene sediments, in numerous sand and gravel pits (above and below water level).

It is interesting to note that in the proceedings of the more recent international conferences on alkali-aggregate reaction there are no reports aboux damage to concrete structures built using aggregate from deposits in the River Danube basin. Only laboratory findings for normal-weight concretes made from naturally occuring aggregates (1) and light-weight aggregates (2) can be found.

Thus, according to data in the literature this part of Europe is free of "alkali reactive" problems. But is this really so? The fact that new authors of papers about alkaline aggregate reactivity continue to appear should make us think carefully.

It could be asked what the right measure of prevention should be. It would be possible (by analogy to techniques used by international health organizations - although alkali aggregate reaction is not a disease (3)) to prepare maps which would indicate those regions where measures need to be taken against alkali - aggregate reactivity and those where such measures need not be taken.

THE QUANTITY OF REACTIVE COMPONENTS IN CONCRETE AGGREGATE

For most parts of the Danube river basin there are no published data about the composition of sands and gravels. The authors' proposal that such data be assembled and processed has not yet met with success, hopefully only due to the shortage of time for such work.

However, for part of the Sava and Danube river basins there are some data about the chert content in the gravel aggregate for concretes. These data, which were obtained by petrographic analysis and published by research institutes in Zagreb (4) and Belgrade (5, 6), are shown in Table 1.

Based on the results of aggregate quality assurance tests, petrographic analysis has shown that, in Slovenia, there are four types of mineral aggregate: crushed limestone, crushed dolomite, carbonate gravel (from the Sava river basin), and silicate gravel (from the Mura and Drava river basins). The composition of these different types of gravel is presented in Table 2.

By studying the composition of limestone and dolomite specimens, using petrographic, X-ray and chemical analysis, it was found that in Slovenia crushed aggregate cannot cause an alkali-aggregate reaction in concrete (7). This is because the crushed limestone and dolomite aggregate used for the making of concrete consists of relatively pure calcite and dolomite. These rocks contain less than 1 % of non-carbonate admixtures in the form of quartz, with traces of clay and organic material.

Table 3 shows the chert content in the gravel according to grain size and the location of the deposit. The maximum chert content is 4 %. Measurements of alkali-aggregate reactivity according to the method given in ASTM C-289 were carried out on those specimens which had the highest content of silicates (8). However, alkali-aggregate reactivity was not found.

DISCUSSION

Alkali-aggregate reaction has not yet been detected in Slovenia because the silicates in the aggregate occur mainly in crystalline form, and the total alkali content in the cements produced in Slovenia is small (Table 4).

Microscopic analysis of the chert grains (Table 3) has shown that they consist mainly of chalcedony, with less than 10 % of opaline.

CONCLUSIONS

To beginners in the field of AAR investigation, we suggest:

- that petrographic analysis of the aggregate can be accepted as a first-stage preventive step against AAR,
- that when the content of reactive components in the aggregate exceeds 3 % the usual, recommended reactivity tests (9) should be carried out.

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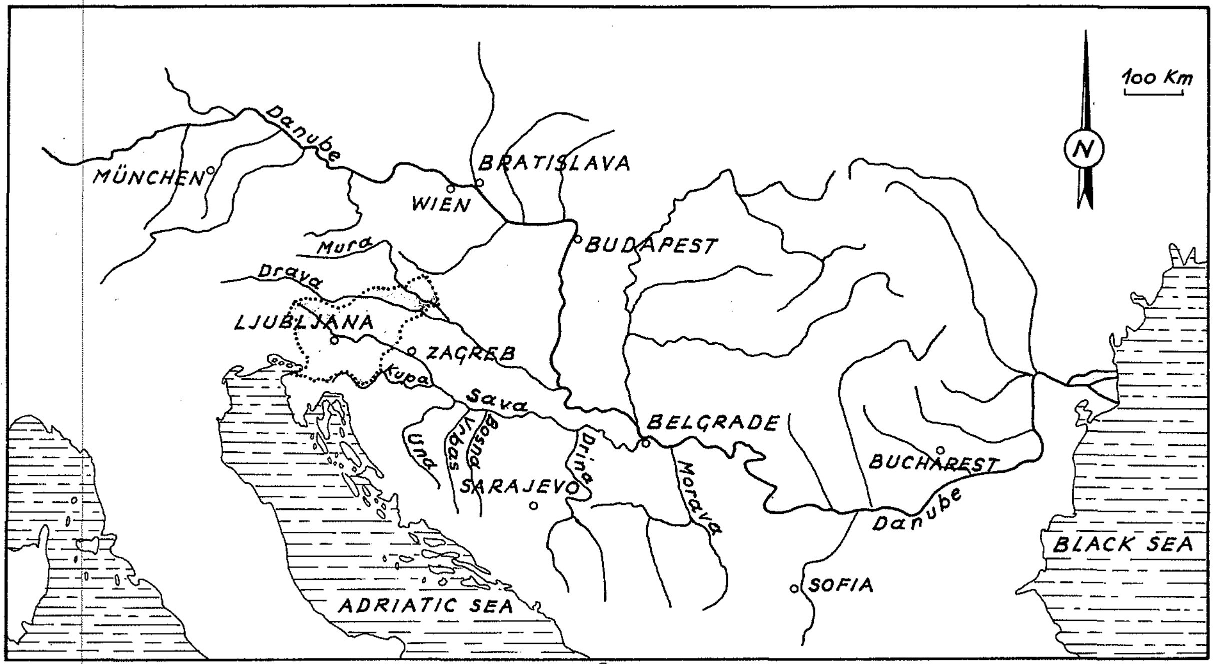

Figure 1: The River Danube Basin (area of 817.000 km^2)

Length of tributaries mentioned in the text (in km):

Mura	438	Kupa	292	Bosna	271
Drava	707	Una	214	Drina	346
Sava	945	Vrbas	240	Morava	483 (South + Great)

TABLE 1 - Chert content in mineral aggregate for concrete *

RIVER - Deposit	Chert content (%) Grain size (mm) 0/4 min.	0/4 max.	4/8 min.	4/8 max.	8/16 min.	8/16 max.	16/32 min.	16/32 max.	Coarse aggregate 4/32
KUPA									19
UNA									32
VRBAS	2.0	60.0	0.6	54.5	13.4	33.1	10.6	22.2	33
BOSNA	30.0	63.0	39.5	66.8	40.1	61.6	49.8	65.6	
DRINA - Popovi									8
- Zvornik									13
- Rača	5.0	30.4	9.6	20.8	10.5	24.8	6.3	16.7	
- Sremska Mitrovica	3.5	18.0	7.8	33.3	5.4	27.8	3.3	25.0	
MORAVA - Dubrovica	1.0	15.0	2.7	10.7	5.1	27.1	7.5	18.9	
- Bagrdan	2.5	7.0	4.3	10.0	7.2	8.0	5.2	9.0	
- Obrva	2.0	25.0	3.5	26.6	3.6	12.0	7.3	25.4	
- Aleksinac	1.0	4.0	3.3	21.4	2.4	7.2	1.0	6.4	
DONAVA - Negotin	3.5	8.0	6.6	17.1	3.3	13.5	3.8	12.9	

* Summary from published data /4, 5, 6/.

TABLE 2 - The petrographic composition of river deposits in Slovenia

RIVER / Components (%)	SAVA				DRAVA				MURA			
	gravel		sand		gravel		sand		gravel		sand	
	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.
MAGMATIC ROCK												
Queratophyre, porphyry	0.0	1.0	0.0	0.4	0.0	1.3	0.0	0.4				
Andesite			0.0	1.1	0.1	0.8						
SEDIMENTARY ROCK												
limestone, dolomite	80.4	91.9	71.2	84.7	15.0	37.7						
sandstone	4.8	11.4	4.1	7.9	4.1	19.9	5.5	10.7	3.5	9.7	1.4	5.3
siltstone	0.8	3.8	1.7	4.3	0.2	3.7	1.5	4.6	0.0	6.5	0.0	3.5
shale	0.0 -	1.1	0.0	1.8								
marl	0.0	1.5	0.4	2.2	0.0	1.7	0.4	1.0				
chert	0.0	1.4	0.3	2.5	0.1	2.4	0.8	2.5				
conglomerate					0.0	3.4						
tuff	0.5	3.5	0.6	3.1								
METAMORPHIC ROCK												
quartzite	0.0	0.4	0.0	0.9	3.0	10.5	2.0	6.3	1.3	12.5	1.5	3.6
gneiss					4.9	10.3	1.3	4.4	13.7	26.6	6.6	19.7
amphibolite					1.0	6.8	0.8	3.5	0.0	2.5	0.0	2.4
phyllite					0.0	1.1	0.0	1.0	0.0	0.5	0.0	0.2
mica-schist					0.0	2.9	0.1	1.7	0.1	2.9	0.0	1.6
serpentinite					0.0	0.2	0.0	0.3	0.0	0.5	0.0	0.5
MINERALS												
quartz	0.3	3.2	3.2	7.8	29.3	51.7	53.6	61.8	56.0	75.1	71.5	82.4
mica			0.0	0.9	0.2	0.8	0.6	4.8	0.1	0.4	0.7	3.0

TABLE 3 - Chert content in river deposits in Slovenia

RIVER Deposit	Distance from the source (km)	Chert content (%) Grain size (mm) 0.125/0.25		0.25/0.5		0.5/1		1/2		2/4		4/8		8/16		16/32	
		min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.
SAVA																	
Hrušica	25	0		0		0		0		0		0.0	0.1	0.0	0.6	0.6	1.6
Hotič	107	0.9	4.1	1.0	2.6	0.7	2.0	0.6	1.4	0.7	1.0	0.2	0.5	0.2	0.4	0.0	0.3
Drnovo	182	1.3	3.3	1.0	3.3	0.1	3.2	0.3	2.9	0.0	2.7	0.7	2.9	0.5	0.8	0	
DRAVA																	
Šentvid	215	1.3	2.4	1.3	2.0	1.1	2.5	0.4	1.7	0.4	1.3	0.0	0.5	0.0	0.9	0.0	0.6
Hoče	262	0.3	2.0	0.5	1.8	0.5	2.1	1.0	2.9	0.8	3.6	1.0	3.3	0.4	2.7	0.5	3.0
Hajdina	287	2.5	2.9	1.3	2.3	0.9	2.3	0.5	1.8	0.4	1.6	0.0	0.4	0.0	0.4	0.0	0.2
MURA																	
Babinci	220	0		0		0		0		0		0		0		0	

TABLE 4 - Alkali content in cements produced in Slovenia

Cement Type	Cement Class	Cement plant	Na_2O content (%) min.	Na_2O content (%) max.	K_2O content (%) min.	K_2O content (%) max.
PC	45	Trbovlje	0.32	0.37	0.77	0.81
PC 15z	45	Trbovlje	0.34	0.38	0.82	0.85
PC 30dz	45	Trbovlje	0.37	0.46	0.77	0.85
PC 15z	45	Anhovo	0.26	0.30	0.86	0.97
PC 30dz	45	Anhovo	0.39	0.42	0.83	0.89
SPC	45	Anhovo	0.16	0.24	0.62	0.72

PC - Ordinary portland cement

PC 15 - Portland cement with 15 % granulated blast furnace slag

PC 30 dz - Portland cement with approx.10 % granulated blast furnace slag and approx. 10 % natural pozzolana

SPC - sulphate resistant portland cement