WASTE MATERIALS IN CONCRETE PAVING BLOCKS

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SUMMARY

The use of waste material, in particular ashes from municipal waste incinerators, is of special interest in Rotterdam due to the amount produced annualy (more than 300,000 tons a year).
Application as a foundation material below concrete block pavement was investigated in the pilot-project Vondelingenweg in Rotterdam.
In this case the water infiltration behaviour of the pavement was important because of possible environmental effects on soil and groundwater. The paper deals with results of measurements of the infiltration capacity and water balance. Experiences with concrete pavings blocks with incinerator ashes in a demonstration project carried out in 1983 are discussed after four years of heavy traffic. Research and experiences on the use of mixtures of incinerator ashes and concrete and brickwork rubble as aggregate in concrete kerbs are described.

1. INTRODUCTION

The use of waste materials is the subject of much attention in The Netherlands, in particular in Rotterdam. Is it not true, that by reuse of materials, a saving of natural resources is achieved as well as an improved utilisation of the limited space of waste dumping facilities?

The annual quantities of waste material produced in the region of Rotterdam are approximately 500,000 ton of brick and concrete debris from building work and demolition, 350,000 ton of incinerator ashes, 200,000 ton pulverized fuel ash (PFA), 20,000 ton of old asphalt, 150,000 ton of reject soil, etc. (see table 1).
Various research projects in Rotterdam demonstrate that the use of these waste materials makes their application in road building a very real possibility. This paper deals with a test project in which concrete block pavement was laid on a variety of foundation materials, such as ashes, broken concrete and masonry rubble.
Water hygiene control is of importance here because of the nature of the foundation materials, from an environmental point of view, and has been the subject of large scale investigation in this project.

Table 1 waste materials in the Rotterdam area (tons/year)

demolition waste (concrete and masonry)	500,000
incinerator ashes	350,000
pulverized fuel ash	200,000
road asphalt	20,000
soil material	150,000

A few results are mentioned.

In addition to the application of waste materials in the road sub-base, a further application is also possible in the manufacture of concrete paving blocks, paving flags and kerbs. Following on from the paper presented at the second conference in Delft in 1984, this paper concentrates on the results of four years of intensive use in the test-project Keilehaven, where at least 300,000 concrete paving blocks made with ashes were applicated. Also, the investigation concerning the use of these paving blocks, is discussed from an environmental point of view.

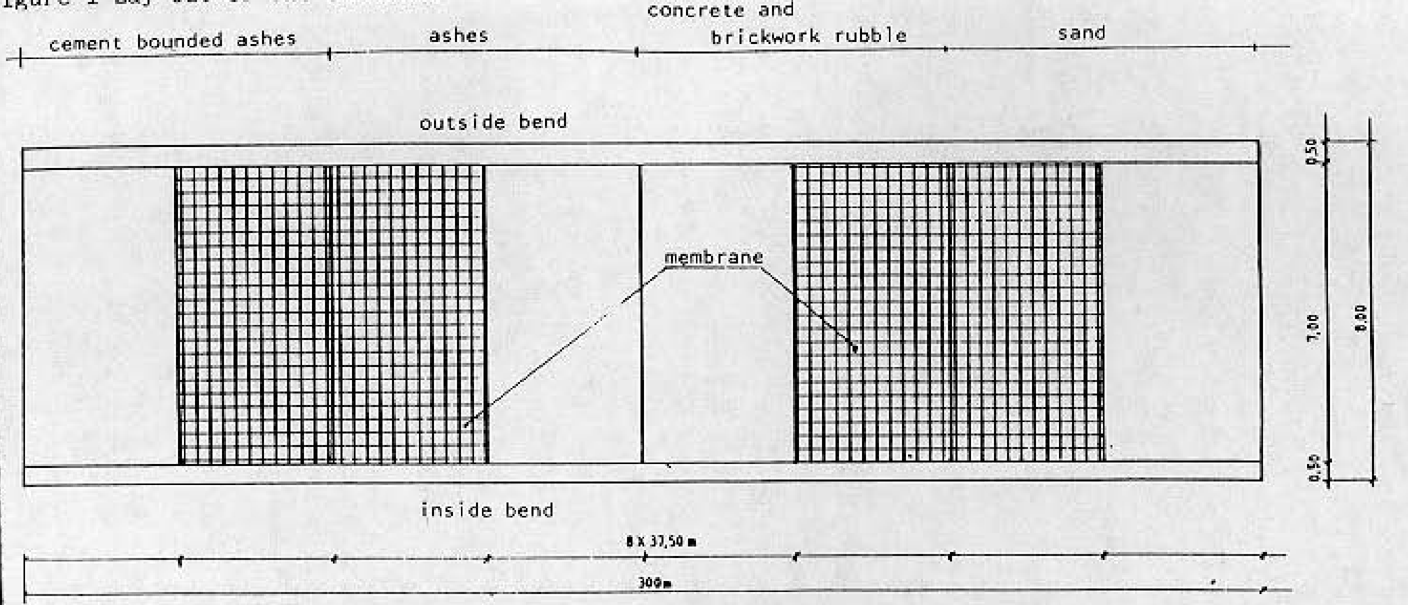
A recent development is the use of admixtures of concrete and brickwork rubble and ashes in kerbs. This paper discusses the results of the experiments.

2. PILOT-PROJECT VONDELINGENWEG

2.1 Scope of the project

The project is located in an area in an industrial section of Rotterdam. The test road is used by heavy traffic (busses, lorries). The original road surface was made of rectangular paving blocks of 90 mm thickness, in herringbone bond.
The sub-base consists of minimal 2 meters of silty coarse to fine sand.
The test-project is 300 m long and subdivided into four sections of 75 m each and lies, for the greater part, in a bend. Each section has a different foundation: sand, a mixture of broken concrete and masonry (0-40 mm) and two types of ashes (0-22 mm) without and with sand and cement (see fig. 1). The surface of the complete test-project is paved with concrete paving blocks, bedded in compacted sand of an average thickness of 100 mm. The blocks were

Figure 1 Lay-out of the sections



he original blocks in the same road. The kerb dges are made of concrete, cast in situ. Half he length of each test section (37.5 m) has a ynthetic membrane between the sub-base and he foundation material. See figures 2 and 3. rainage pipes carry the intercepted water to ollection vessels at the roadside. See fig. 4 cross-section) and fig. 5.
he construction work for the test-project was ompleted in August '86. The various easurements were carried out from September 86 till October '87. The project was ordered Rotterdam Public Works. A significant part the cost of this project is met by vernment subsidies.

gure 2 Overview during execution

Research and measurements

part of this project, the various materials tested with an eye to both civil neering requirements and environmental straints. Further the quality of the local soil and groundwater was monitored. During construction phase, compaction measurements carried out. During the monitoring period, ember '86 - October '87, a large number of observations were made.

Figure 3 Membrane application

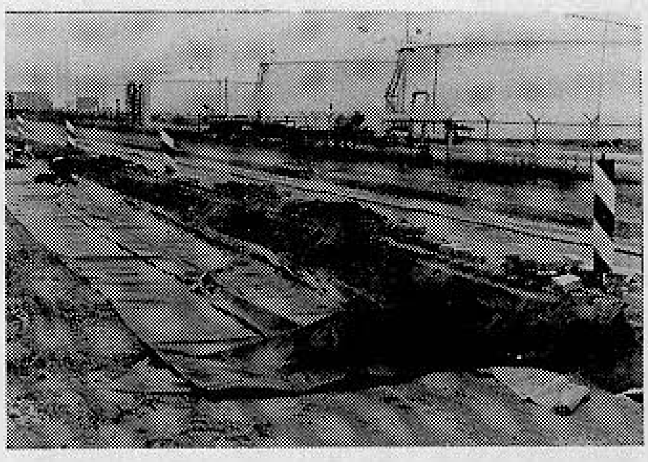
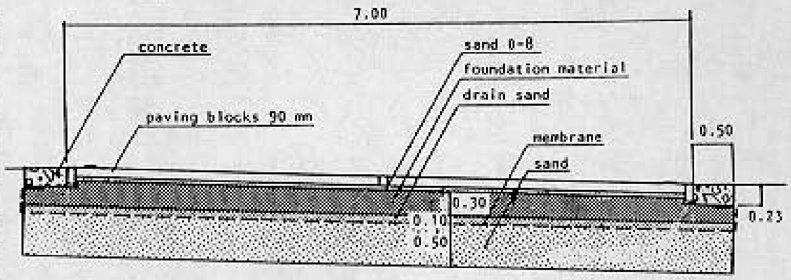


Figure 4 Cross-section

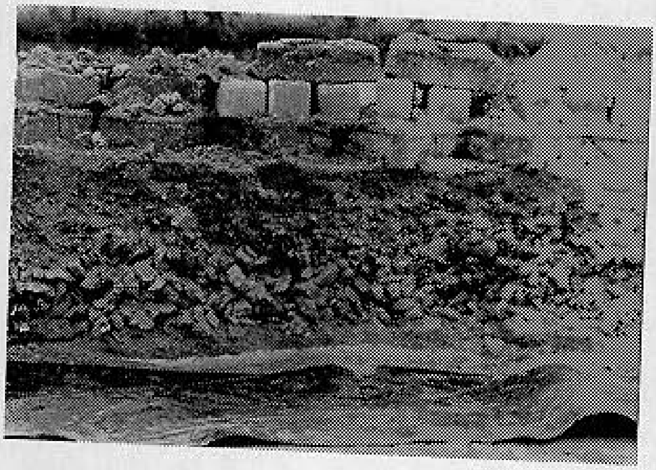


A. Civil engineering:
   - weight deflection measurement;
   - deformation measurements;
   - visual inspection.

B. Environmental:
   - quantity and quality of drain water;
   - quality of subsoil under the foundation;
   - quality of the foundation material;
   - rainwater quality;
   - infiltration capacity measurements.

In the context of this paper, waterbalance measurements at the test sections will be the main topic. For the results on other aspects one is referred to the final report of this project |1|.

Figure 5 Detail cross-section



2.3 Results

2.3.1 Infiltration capacity measurements

The water infiltration measurements were carried out on two occasions, in spring '87 in four locations and in the following autumn in three locations.
The method used is extensively described in |2|. In principle the method consists of measuring the fall of the water-level in a ring of 260 mm diameter, placed on the road surface. The measurements from the infiltration in ring are converted to the infiltration in street. See table 2.
The results show a relatively high infiltration rate of the project road surface. A relevant consideration is that the maximum rainfall intensity is approximately 6 mm/hour. The results show no decrease in infiltration rate with time, as might be caused by sealing of the joints between the paving blocks, on the contrary, the opposite seems to be the case. It has to be noted though, that the paving blocks used in the project have been used before and were damaged to a greater or lesser extent. Also visual inspection revealed that, as a result of traffic, in some places the

Table 2 results measurements of infiltration capacity

measurement	infiltration in ring (mm/h)	joint width (mm)	infiltration in street (mm/h)
1	60	3.5	114
2	60	5.5	78
3	12	6.5	17
4	220	3.5	462
5	90	4.5	124
6	155	5.5	208
7	88	6.5	104

*measurements 5, 6 and 7 carried out 6 months after measurements 1, 2, 3 and 4.

joint width between the paving blocks had increased. Further, it should not be dedu from the results that all the rainwater precipitation will find its way through t road surface. Reduction of infiltration i likely because of splash losses and surfa run-off due to road camber, and also, the saturation of material in the joints duri heavy rainfall and water absorption by th blocks themselves. This leads to a reduce passage of water through the road surface.

2.3.2 Waterbalance

The roadside collection vessels (figure 6) the test sections with a synthetic membran under the road foundation, allow the amour rainwater which has drained from under eac section, to be measured. The quantities ar determined by the amounts pumped out using flowmeter at the drain opening and syphon counting devices.

Figure 6 Collection vessels

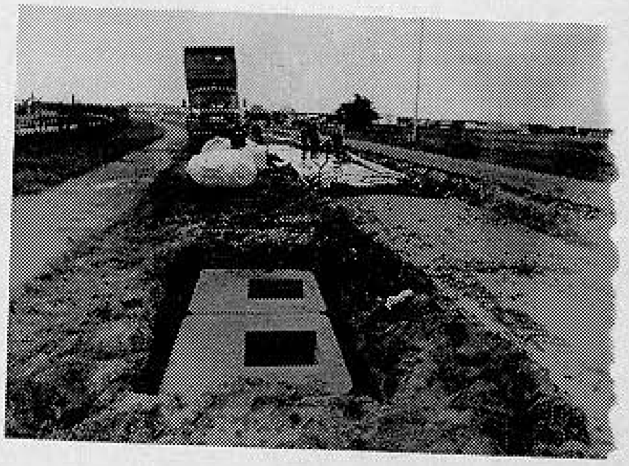
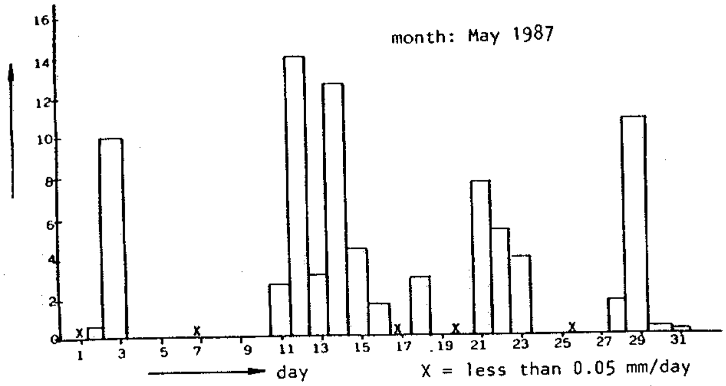


Table 3 results measurements drainage water rainfall (m3)

time period	section 1	section 2	section 3	section 4	rai fal
18/9 - 31/10	4.1	4.6	3.9	3.7	29.
3/12 - 13/1	8.2	8.2	7.7	6.4	38.
14/7 - 24/8	6.4	22.0	19.8	7.2	56.

Table 3 gives the amounts per section for so of the periods. It also indicates the amount of rainfall for the relevant period for the area of a section. These rainfall data were supplied by a weather station situated about 10 km from the test site. For example, fig. 7 shows the data for the month of May 1987.

It has to be realised that there is a time la between the moment of rainfall and the sampling at the roadside collection vessel, igure 7 Rainfall in May 1987



due to the buffering capacity of the whole system. As a result it is possible that the drainage measurement at a given moment relates to the rainfall of the previous period. In this project, the amount of time lag was not determined. It is apparent from reference |2| that about 55% of the annual rainfall on a block paved surface, is lost through direct evaporation. Not indicated is, what proportion of the loss is due to run-off and splash and what proportion is due to evaporation from under the block pavement through the joints.

For the test project the results of the measurements during the complete test period are presented in table 4.
The conclusion may be drawn that these results of the percentage of the rainfall that finds its way into and through the road foundation fit in with the aforementioned literature, uncertainties included.

Table 4 infiltration rates pilot-project (% of rainfall)

section 1	25
section 2	42
section 3	23
section 4	13

2.4 The effect of the foundation materials upon the soil quality

From the results of the research into the composition of the soil exposed to the road foundation materials, it is evident that, after one year, no measurable change has occurred. A specially developed calculation model, for the soil quality in the unsaturated zone |3|, shows that in the long term, contamination out of the foundation materials will be limited to a soil layer of a maximum of about 200 mm below the foundation.

3. WASTE MATERIALS IN CONCRETE PAVING BLOCKS AND KERBS

In 1984 the construction work for the demonstration project Keilehaven was completed. Use was made of at least 300,000 concrete paving blocks and about 5,000 concrete paving flags.
Both these paving elements had part of their natural admixture substituted by ashes |4|.
After a period of four years of subjection to intensive use, it may now be concluded that there is no practical difference between concrete blocks and flags, made with ashes, and those without.
To cover the environmental aspect a leaching test series was carried out by KEMA in 1986 on blocks with and without ashes. The research consisted in subjecting one square meter of blocks to alternately wetting (rain) and drying. Similar research was carried out on broken blocks, with and without ashes |5|.
The resulting data permit the conclusion to be drawn that there is practically no difference between concrete paving blocks, complete or broken, with or without ashes. The application, all data considered, including the leaching tests, has been noted by the responsible authorities as environmentally acceptable |6|.

Waste materials in larger concrete units, such as kerbs, have been researched. Admixtures of ashes and broken concrete and masonry rubble have been used. Three mix types were used in the manufacture of 600 kerbs from mixes composed under laboratory control.

The mix types are listed in table 5. In the making of the kerbs the normal coarse aggregate was completely replaced by the mentioned mix types.

Table 5 mixtures tested for kerbs

	incinerator ashes (5/22 mm)	concrete and brick-work rubble (5/16 mm)
mix A	70%	30%
mix B	50%	50%
mix C	30%	70%

The results of research into the average flexural strength after 28 days are recorded i table 6. The results are below the values required by NEN 7015. Further research into this aspect is to be expected. Concerning this the idea is to adopt a reduced percentage mix i.e. adjust the size distribution.
The kerbs under review, show no deformation an no deviation in surface flatness. It became apparent during production that special attention needs to be paid to the moisture content of the ashes and to the presence of parts of steel, wood and paper.

Table 6 flexural strength of kerbs after 28 days (N/mm2)

mix A	4.4
mix B	4.6
mix C	4.4

rubble in and under concrete paving blocks, is possible; the application is technically and environmentally acceptable.

When using waste materials in road foundation, under concrete block pavement, account has to be taken of a limited effect on the soil under the foundation, by contamination carried by the rainwater infiltrated through the road surface. Tests in practice have shown that rainwater infiltration through the joints between the concrete road surface elements can amount to approximately 45% of the annual rainfall.

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