Internal Erosion of Clayey Soils Protected by Granular Filters

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I.- INTRODUCTION

Process of internal erosion in an embankment dam due to concentrated flow through a crack:

- formation of the crack through the core leading to a channel for water flow
- erosion of material from the crack walls due to the shear stress applied by flowing water
- transport of eroded particles to the filter
- retention or percolation of these particles within the filter
- continuation of erosion leading to piping failure, or sealing of the crack.

I.- INTRODUCTION

MAIN VARIABLES:

FILTER: PSD POROSITY ¿PERMEABILITY?

NO COHESIVE

BASE SOIL: PSD POROSITY ETC

COHESIVE

BASE SOIL: PSD POROSITY ¿PLASTICITY?

¿WATER CONTENT? ¿MINERALOGY? ¿DISPERSIVITY?

¿HYDR. GRAD.? ETC ETC ETC

NOMENCLATURE

The notation used in this paper is described in the following examples:

DxB = particle size of the base material for which x% by weight is finer, (in millimetres)

DxF = particle size of the filter material for which x% by weight is finer, (in millimetres)

Boundary filter = the coarsest filter that is able to protect the base soil in the No Erosion Filter test

$D15F_b$ = $D_{15}F$ of the boundary filter

NEF = No Erosion Filter Test

PI = plasticity index

PSD = particle size distribution

UGR = University of Granada

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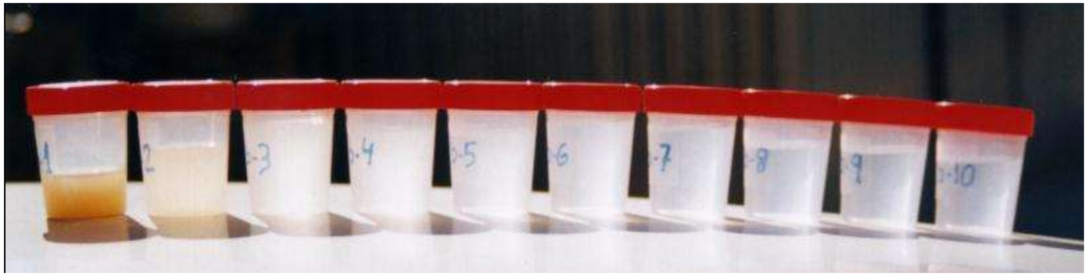
II.- MATERIALS AND METHODS

II.1 TEST METHOD



II.- MATERIALS AND METHODS

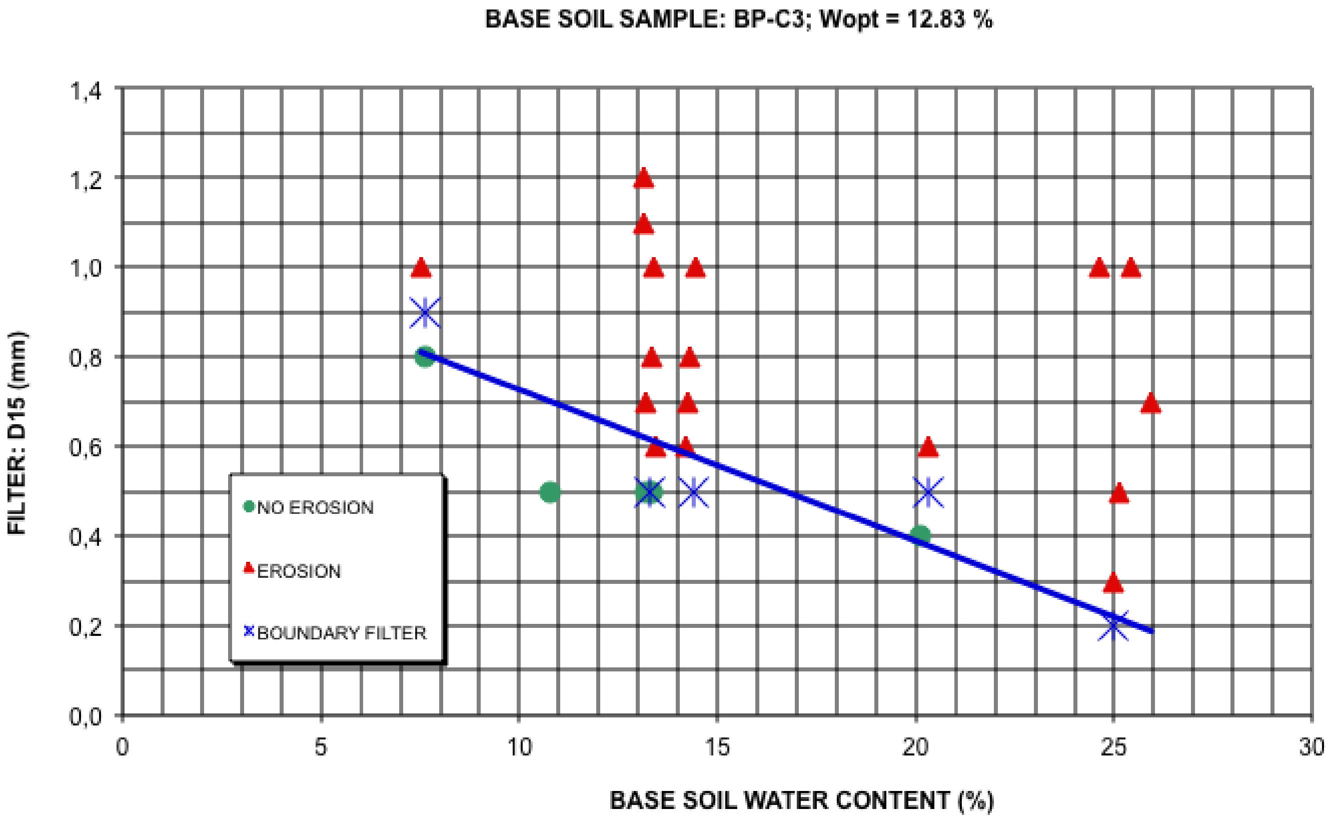
II.2.- SAMPLES TESTED

Name	Dam of origin	Liquid Limit	Plasticity Index	% fines <75mm	D85B (mm)	Pinhole Classif.
BBA-C1	Barbate	56	35	90.68	0.047	ND-1
BCA-C2	Canales	60	34	86.75	0.050	ND-1
BFA-C2	Francisco Abellán	32	14	67.75	0.606	ND-1
BJV-C1	J. del Valle	23	6	66.15	0.295	ND-1
BJV-C2	J. del Valle	31	12	90.76	0.052	ND-1
BJV-C5	J. del Valle	38	18	90.99	0.042	ND-1
BJV-C6	J. del Valle	30	12	88.88	0.061	ND-1
BJV-C7	J. del Valle	30	13	63.22	1.162	ND-1
BP-C2	Portillo	33	19	88.00	0.065	ND-1
BP-C3	Portillo	34	14	90.12	0.054	ND-1
BSC-C4	San Clemente	31	15	82.50	0.108	ND-1
BZA-C1	Zahara	66	33	93.94	0,004	ND-3

The filter material used in the UGR-NEF tests was obtained from “El Portillo” dam, (Spain). After washing on the 0.075 mm sieve, the filter material was split into distinct size fractions and re-blended to obtain different linear particle size distributions defined by the D15F and D100F sizes.

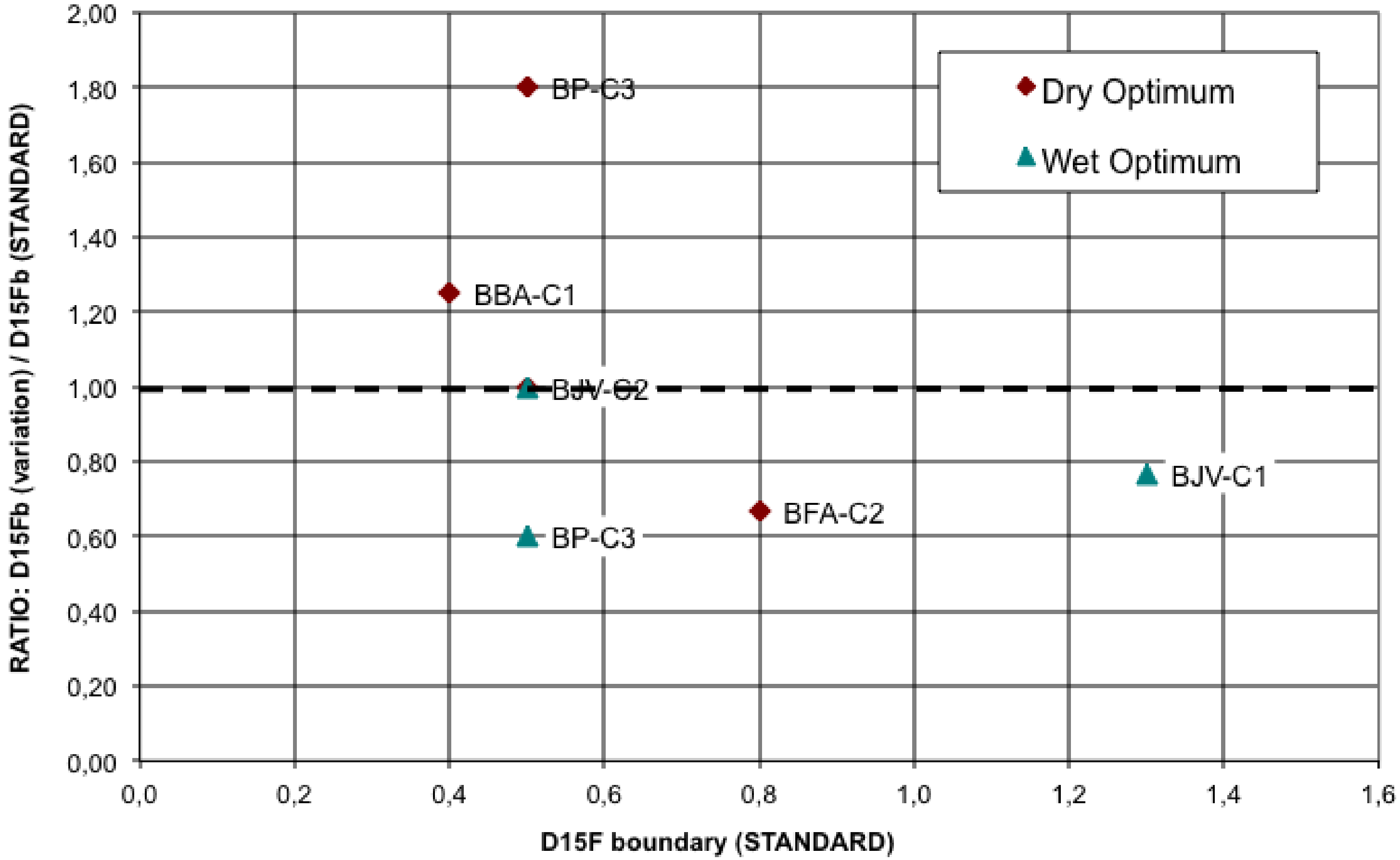
III.- RESULT AND DISCUSSIONS

III.1.- BASE SOIL MOISTURE CONTENT AND DENSITY



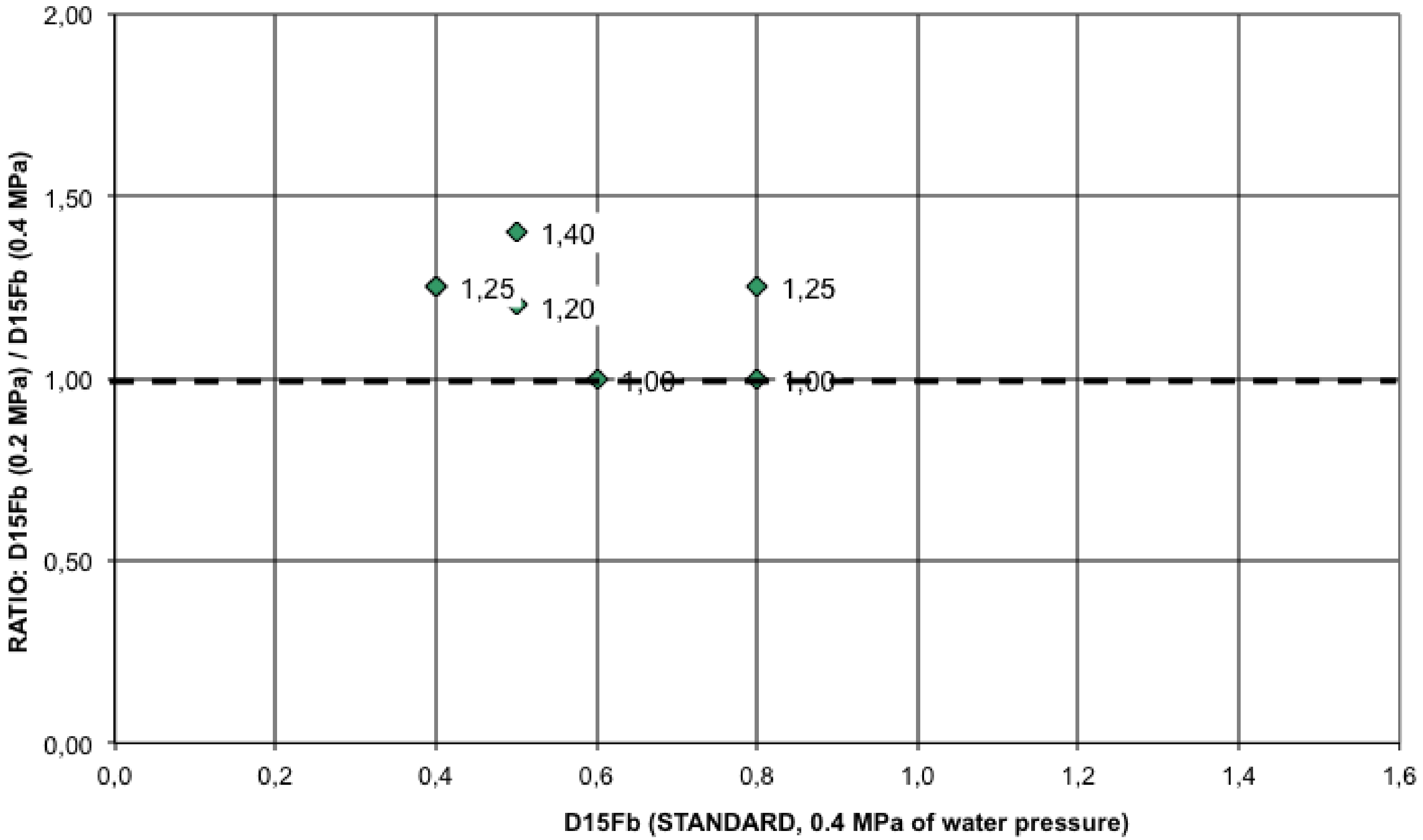
For BP-C3 base soil sample, the boundary filter $D15F_b$, decreases as the base soil water content increases, with a variation from 0.9 mm to 0.2 mm. This result is quite surprising.

III.1.- BASE SOIL MOISTURE CONTENT AND DENSITY (other base soil samples)



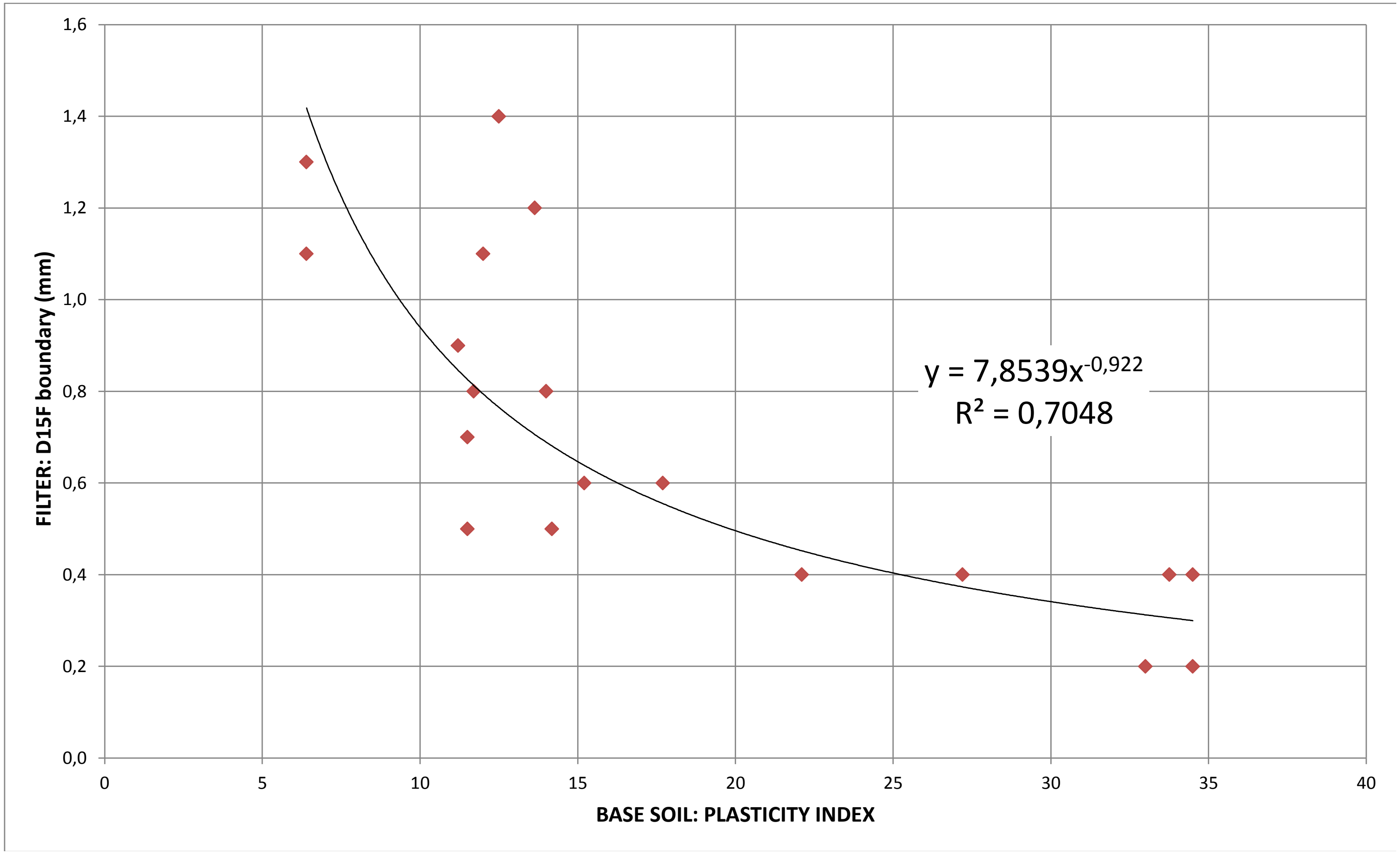
clay core should be compacted at the optimum water content. zones of higher moisture content and lower density than that expected during construction can be more susceptible to internal erosion.

III.2.- HYDRAULIC GRADIENT



The hydraulic gradient represented in the NEF tests is many times higher than the expected in a real dam. For the design of new dams, we do recommend using the modern filter criteria, but if we are assessing an existing dam, we possibly had to use less restrictive criteria.

III.3.- PLASTICITY



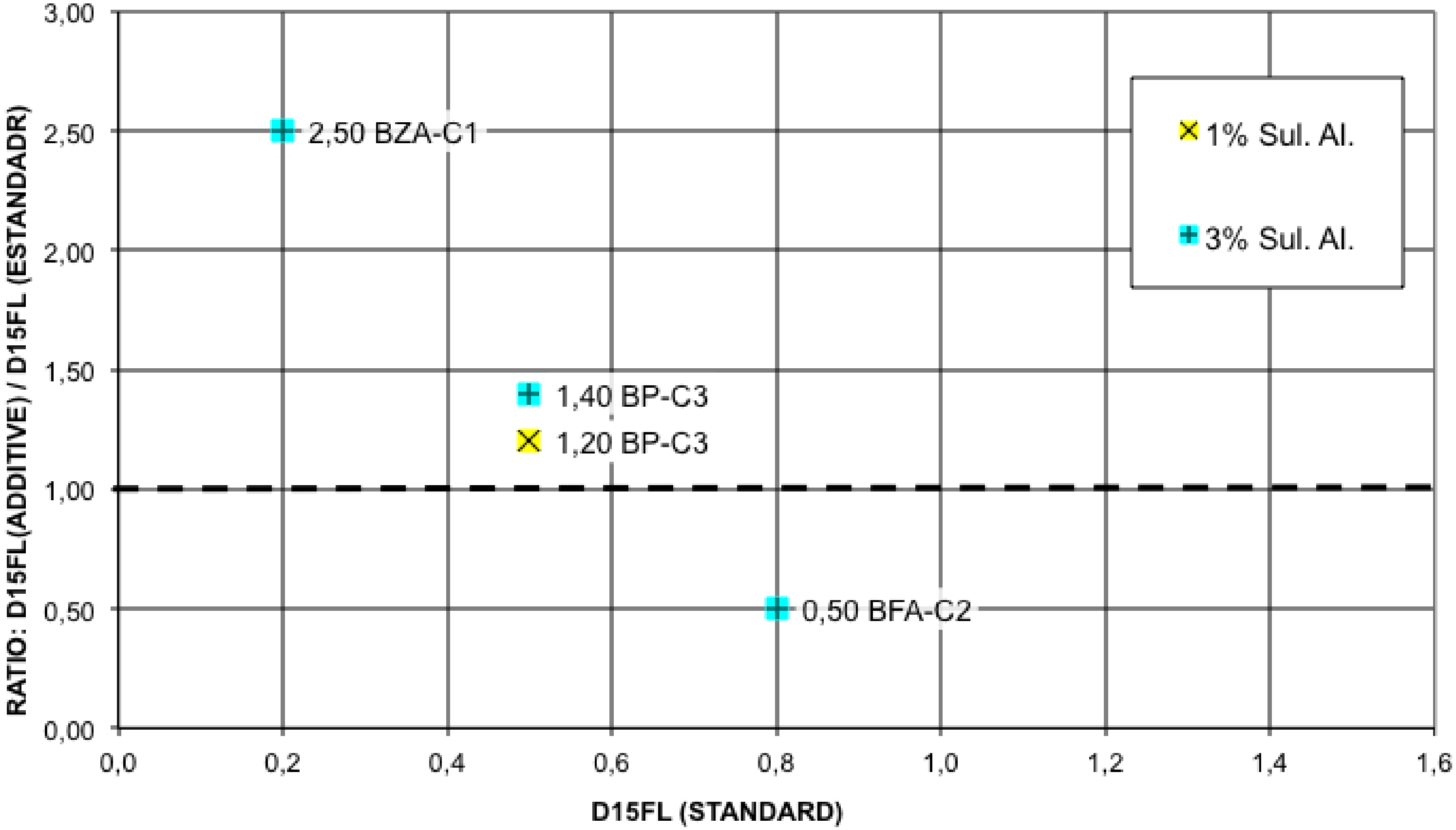
Base soil plasticity by itself has an important influence, BUT in our samples, a high base soil plasticity index also means a high base soil fines content. Therefore the base soil plasticity has influence in the boundary filter, but it is not as important as the PSD

III.4.- MINERALOGY

Base Soil	% Quartz	% Calcite	% Dolomite	% Feldrs	% Clay		CLAY FRACTION MINERALOGY % Smectite	% Illite	% Kaolin	% Chlorit	% Parag
BBA-C1	38	3	0	3	56		82	0	18	0	0
BCA-C2	17	11	10	0	62		51	36	13	0	0
BFA-C2	30	0	9	9	52		22	63	6	9	0
BJV-C2	48	5	20	5	22		40	50	6	0	4
BJV-C6	19	4	51	4	22		46	44	0	10	0
BJV-C7	41	13	20	4	22		45	41	7	7	0
BJV-C8	48	6	25	1	20		38	52	0	10	0
BJV-C9	41	5	24	4	26		47	40	5	8	0
BP-C3	45	11	0	5	39		53	30	12	5	0
BSC-C4	9	82	0	0	9		63	21	16	0	0
BZA-C1	30	0	0	0	70		72	4	24	0	0

Many different statistical correlations have been studied between $D15F_b$ and clay mineralogy and NO SIGNIFICANT relationship have been found.

III.5.- ADDITIVES



Apart from possible practical application for modifying the design of filters; this conclusion demonstrates that the dispersivity and, more certainly, the water chemistry and composition of the clay are variables that influence the design of granular filters.

IV.- CONCLUSSIONS

In order to investigate the variables which influence the function of a base soil – filter system, 410 NEF tests have been performed at the University of Granada (Spain) with 11 base soils from 7 different dams.

The water content of the base soil seems to have a negative effect on its behaviour, since materials at higher moisture content require finer filters. This conclusion is not very clear, but if it is confirmed will have important consequences.

The hydraulic gradient has a negative effect. For this reason it is not sufficient to suppose that at high velocity erosion always occurs and therefore the hydraulic gradient stops having an effect. Therefore, for the design of new dams, we do recommend using the modern filter criteria, but if we are assessing an existing dam, we possibly had to use less restrictive criteria.

The plasticity of the base soil showed influence on the results, but it can be noted that there is a strong correlation between plasticity and the particle size distribution (more plastic materials are generally finer), and this leads to a general trend of materials with higher plasticity requiring finer filters. PI do not offer additional information than PSD

IV.- CONCLUSSIONS (cont.)

No significant relationship has been found between mineralogy and filter design.

The addition of aluminium sulphate to the base soil tends to flocculate the clay and reduce dispersion; this permits the use of coarser filters. Regardless of possible practical applications, this observation confirms that the dispersivity of clays affects the functioning of the base soil – filter system.

THANK YOU VERY MUCH

MERCI BEAUCOUP