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PARAMETRIC DEFINITION OF SANDBLASTED AND POLISHED CONCRETE SURFACES

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ABSTRACT

A lot of considerations have been developed on the influence of surface roughness on the adherence of a repairing systems on a concrete support : sandblasting, hammering, hydroblasting, acid attacks,... have been analysed by a lot of authors.
This presentation gives a parametric interpretation of a sandblasted surface in comparison with a polished concrete.
A stylus is walked along the surface to be analysed and the profile is continuously registered.
The filtration of the electric signal is realised in order to separate waviness and roughness.
The effect of the stylus/component profile contact on the validity of the measurement results is of prime importance.
Profilometry and surfometry are mathematically described by statistical and amplitude parameters. The analysis of surfometry profiles let us to observe and quantify the shape regularity and the isotropic effect of sandblasting. The bearing ratio curves permit to quantify the volume of voids able to absorb the slurry or the repairing mortar applied on the support.
The difference, between the two surface treatments is clearly quantified and related to adherence properties of some hydraulic binders.
Keywords: surface treatment, concrete, profilometry, surfometry, bearing curve.

1 INTRODUCTION

The geometric characterisation of the surface of the concrete support is of prime importance in order to explain the potential interlocking effect of the new layer – slurry , PC, PCC or CC mortars – laid on the concrete support or to discriminate the efficiency of different surface treatments (sandblasting, hammering, hydrojetting,...).
The roughness is a generic term that is of course variable, relatively to the scale that is chosen to qualify the surface : in civil engineering area, the millimetric scale permits usually to distinguish surface treatments like hammering and sandblasting for example.

A lot of authors tried to characterise the surface roughness by the ratio between the surface occupied by aggregate and the cement paste [1], by the maximal depth of roughness [2], adherence-traction tests [3] or the calculation of surface parameters determined by image analysis and microscopical observations [4]. The determination of Surface Rough Index [5] should also permit to differentiate the surface treatment but gives only a "global" view of the roughness.
The analysis of the profile obtained by profilometry or surfometry let us to observe and quantify the shape regularity and the isotropic effect of sandblasting and polishing treatments.

2 PRINCIPLES OF THE PROFILOMETRIC AND SURFOMETRIC MEASUREMENTS

A stylus is walked along the surface to be analysed and the profile is continuously registered. The originality in the signal treatment is coming from the possibility of distinguishing the effect of high and low frequencies.
Profile filters separate the roughness profile from the long wave profile components and the waviness profile from the roughness. Profile filters provide a mean line to the actual profile. They are the basis for the calculation of parameters for roughness and waviness.
This mean line also applies to the waviness and any other long wave profile components which are not associated with the surface roughness. The mean line is determined for any point of the actual profile by a weighted mean value derived from adjacent points.
The roughness profile represents the deviations of the traced profile from the mean line. It is determined by subtraction of the mean line from the traced profile.

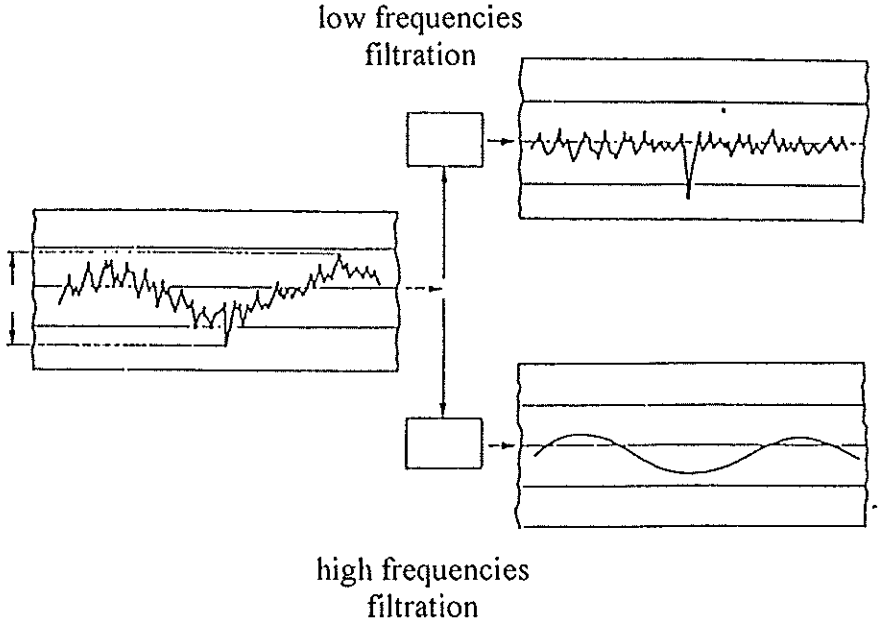


Fig. 1. Effect of the filtration of the total profile

The mathematical definition of the shape of the curve is usually given by statistical and amplitude parameters calculated from the total, waviness and roughness profiles [6]. The most commonly used are given in table 1.

Tab. 1. Profile parameters

Parameter	Definition
X_a	arithmetic mean of the departures of the profile from the mean line
X_q	quadratic mean of the departures of the profile from the mean line
X_p	maximum height of the profile above the mean line within the assessment length
S_m	mean spacing between profile peaks at the mean line, measured over the assessment length

The measurements are realised on a classical concrete support (limestone aggregates, quartz sand, cement CEM II B 32,5, W/C = 0.5) treated by sandblasting and polishing [7].

3 PROFILOMETRY

The profile of the surfaces was obtained by using a stylus ended with a sphere of 6 µm diameter. The path of measurement was selected as 300 µm and the length of assessment line was between 30 and 40 mm.
The maximum range of heights was 1000 µm. The total profile, as well as the filtered profiles are presented in Figure 2.

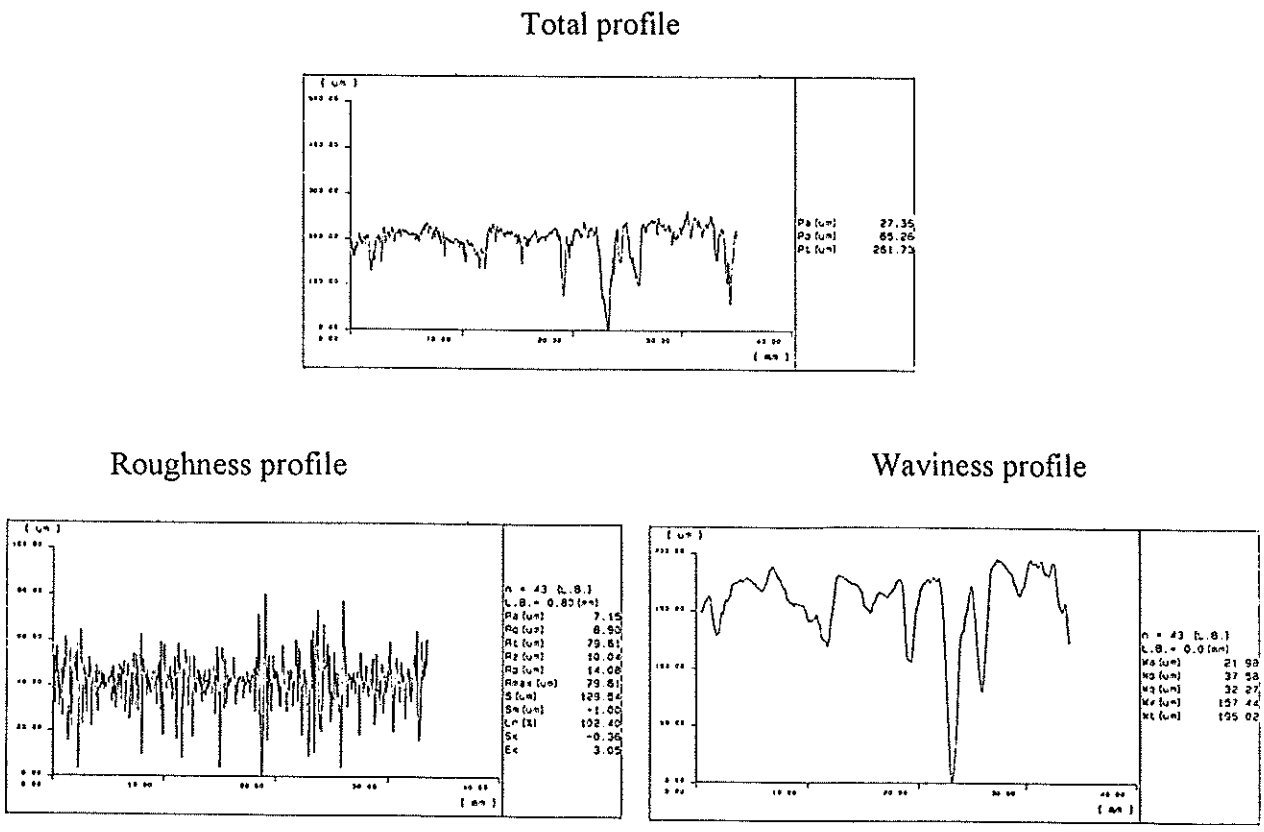


Fig. 2. Total profile, waviness profile and roughness profiles obtained on a polished surface of concrete

The total profile, as well as the roughness and the waviness profiles, may be defined by the three most effective parameters X_a, X_p and X_q.

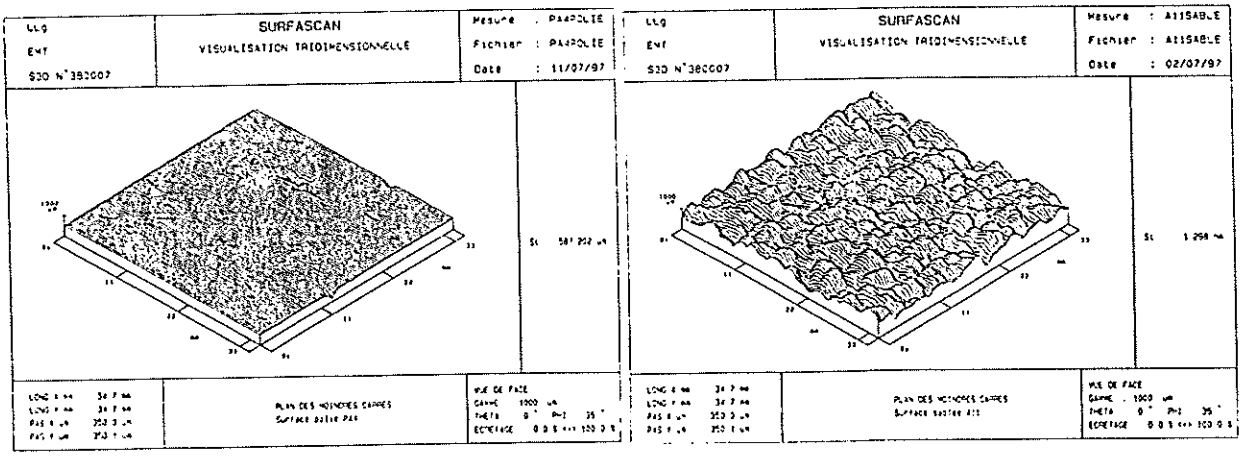
Tab. 2. Waviness and roughness parameters of sandblasted and polished surfaces (μm)

Parameter	Waviness		Roughness	
	Sandblasting	Polishing	Sandblasting	Polishing
X_a	130.49	19.5	16.22	8.38
X_p	395.63	42.2	29.06	17.03
X_q	162.47	26.61	19.79	10.43

The comparison between the surface treatments effects is quite clearly given by the values of the parameters defined hereabove. A statistical discriminant analysis specifies that the parameter X_a seems to be the more significant to discriminate the surface treatments. A first conclusion is also that the discrimination is more effective for the waviness than for the roughness. That let us to realise surfometry analysis with a new sphere of higher diameter (1,5 mm) in order to be able to display the waviness and the neglect roughness factors [8].

4 SURFOMETRY

The statistical and the amplitude parameters have been calculated for the sandblasted and polished surfaces.
The comparison of the parameters values between the original surface profile and the surface profile filtered in low frequencies (waviness) shows an evidence : the values are almost the same while the parameters related to the roughness parameters are low and non-significant, which that means to the roughness profile may be neglected.



Polished surface Sandblasted surface

Fig. 3. 3D visualisation of sandblasted and polished profiles

The comparison of the amplitude and statistical parameters measured on sandblasted and polished surfaces shows a significant difference (t Student analysis at the level of 95 %) and permits again to discriminate the surface treatment effects.

Tab. 3. Statistical and amplitude parameters for sandblasted and polished concrete surface – 3D analysis (μm)

Parameter	Polishing	Sandblasting
W_{tm}	79.3	434.9
W_{pm}	22.1	217.1
WS_{mx}	6290	6013
WS_{my}	5593	5949

However, it seems that the parameters S_{mx} and S_{my}, related to the mean path of the irregularities, present no significant difference, firstly following x or y orientation and, secondly, between sandblasted and polished surfaces. That means that, in our case, the sandblasting surface treatment has an isotropic effect.

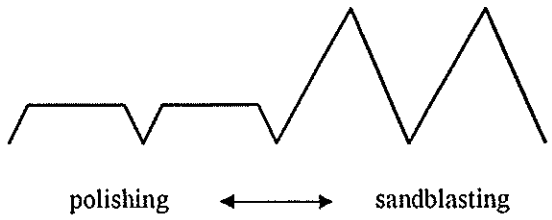


Fig. 4. Interpretation of the polishing effect on the concrete surface

Consequently, the analysis of the amplitude on waviness is more important and discriminating than the waviness frequency.

5 BEARING RATIO AND ABBOTT'S CURVE

The weighing function for the mean line indicates for each point the weights attached by the profile in the neighbourhood of that point. The transmission characteristic of the mean line is the Fourier transformation of the weighing function. The bearing ratio is a measure of the length of the bearing surface (expressed as a percentage of the assessment length), were the profile peaks have been cut off at a line which runs parallel to the mean line of the profile.

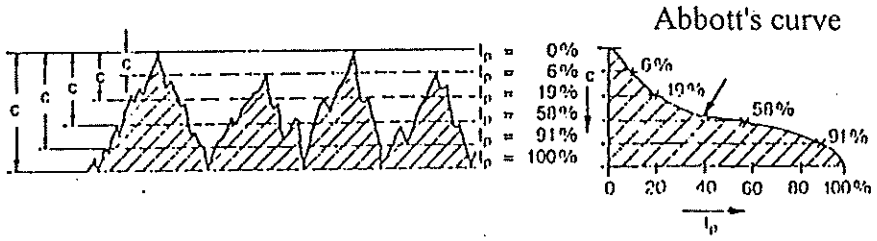


Fig. 5. Definition of the bearing ratio tp (%)

If the values of the bearing ratio are determined on the all height of the profile with a number of cut lines as great as possible, it is possible to define the curve of Abbott. The curve of Abbott is a graphic representation of the variation of the bearing ratio.

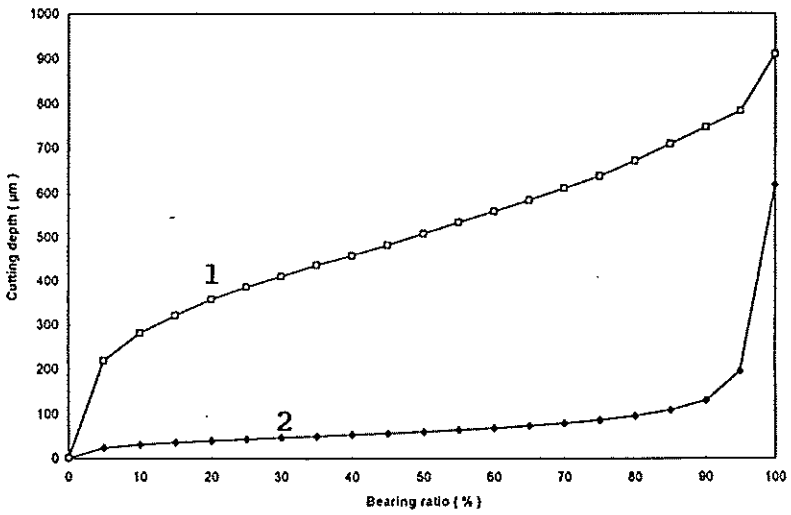


Fig. 6. Shape of the curves of Abbott for sandblasted surfaces (1) and polished surfaces (2)

The observation of the curves permits to define the general shape of the surfaces : the polished surfaces are characterised by a full surface with not many holes while the sandblasted one are highly cracked.
The analysis of the surface parameters gives mathematical informations on the shape of the curves [6] :
C_R = relative height of the peaks
C_F = depth of the profile, excluding high peaks and holes
C_L = relative height of the holes

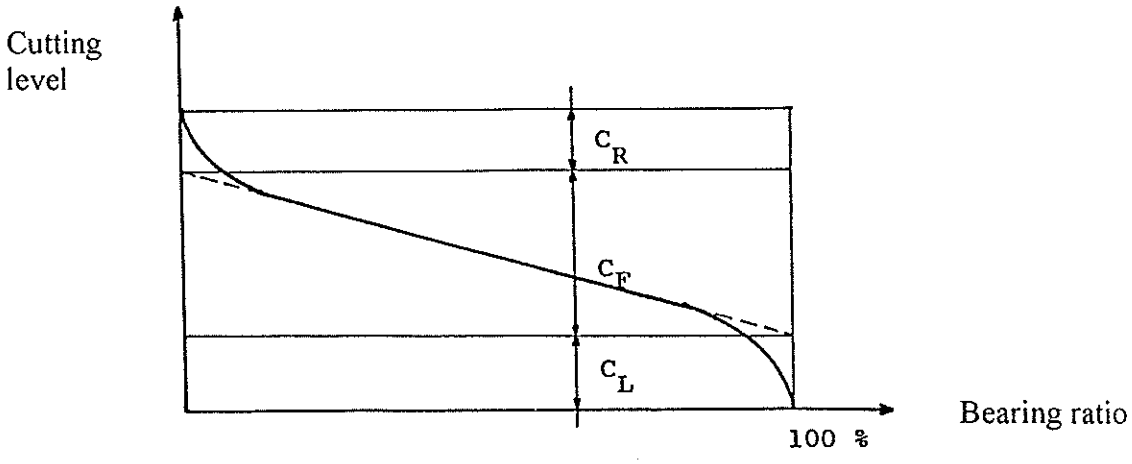


Fig. 7. Parameters of Abbott's curve

The parameter C_F gives information on the flatness of the surfaces : a lower value of C_F means an important flatness of the surface. The parameter C_L gives an idea of the importance of the volume of voids under the reference line. This parameter could be fundamental for the evaluation of the quantity of slurry, mortars,... necessary to fulfil the interface area between the concrete support and the new layer.

Tab. 4. Parameters of the Abbott's curves for sandblasted and polished surfaces

Parameter	Polishing	Sandblasting
C_R	18	173
C_F	32	268
C_L	47	254

The analysis of parameters C_R and C_L for polished surfaces shows clearly that there are more holes than peaks, which has already been determined by the observation of amplitude and statistical parameters. It permits also to calculate, for a given bearing ratio, the corresponding available volume of voids (Figure 8).

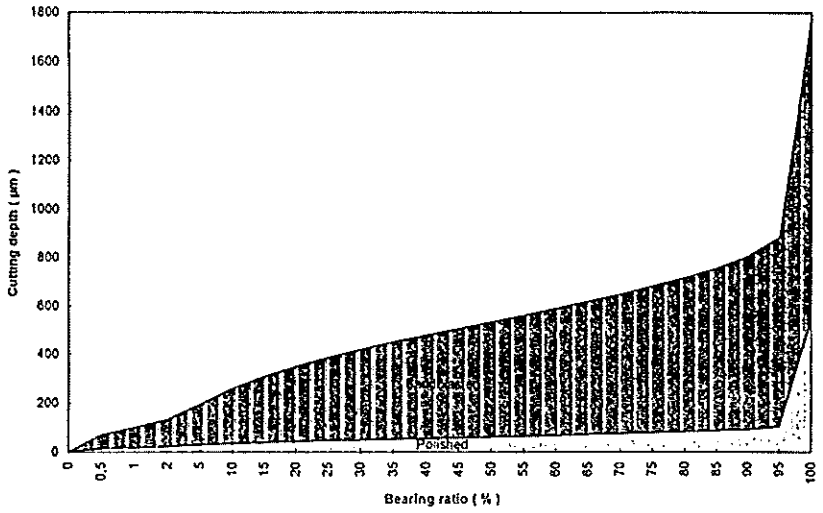


Fig. 8. Mean bearing ratio curves for sandblasted and polished surface – evaluation of the volume of voids

The volume of repairing material necessary to fulfil the "waviness" of the sandblasted surface is so 8 times higher than for polished. This is a global volume that does not take into account the "shape" of the holes that, considering the bearing curves, seem to be more narrow for the polished surfaces and have an ink-bottle shape for the sandblasted surfaces.
However, the wave amplitude factors are of such a large value that the penetration of the new layer should be due more to the pressure of application than to the capillar absorption.

6 CONCLUSIONS

The analysis of statistical and amplitude parameters given by profilometry and surfometry gives information necessary :

- to discriminate concrete surface treatments;
- to evaluate the shape of the profile;
- to quantify the potential interlocking effect;
- to quantify the volume of material (new layer) that will fulfil the waviness profile.

The most important interest of this method is the opportunity to distinguish waviness and roughness. Finally, it has been established that the difference between sandblasting and polishing is more coming from the waviness than the roughness.

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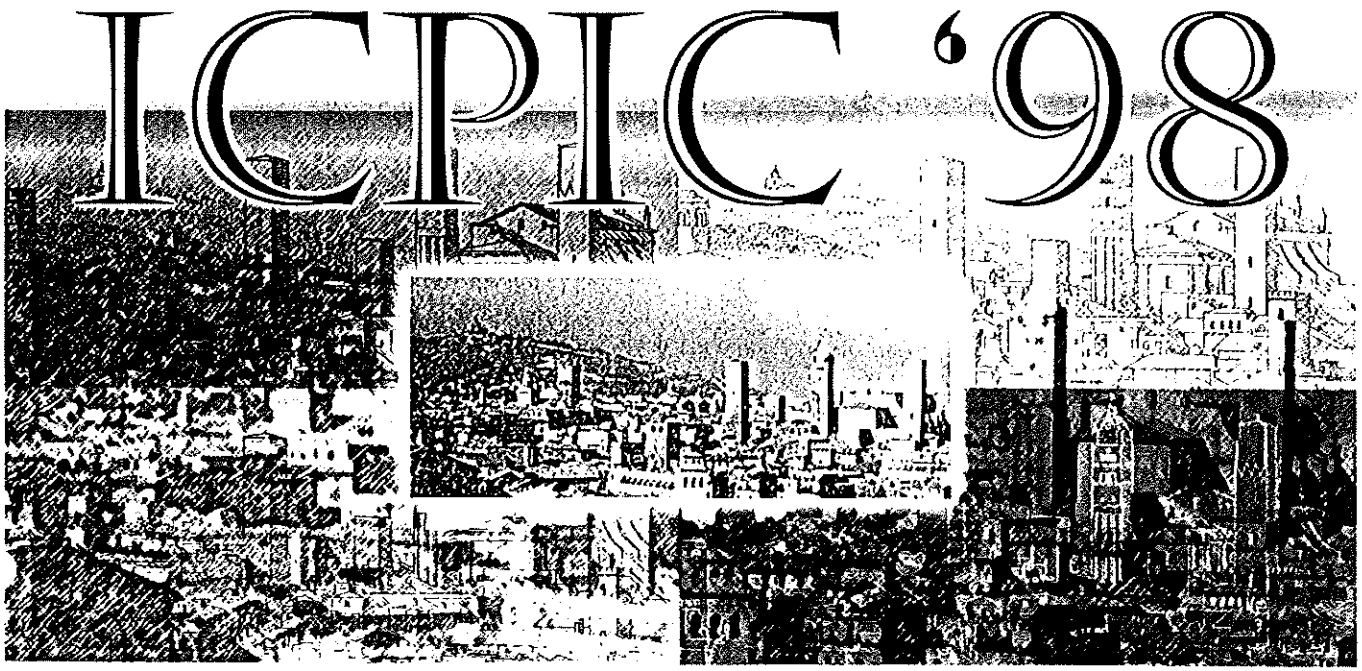

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