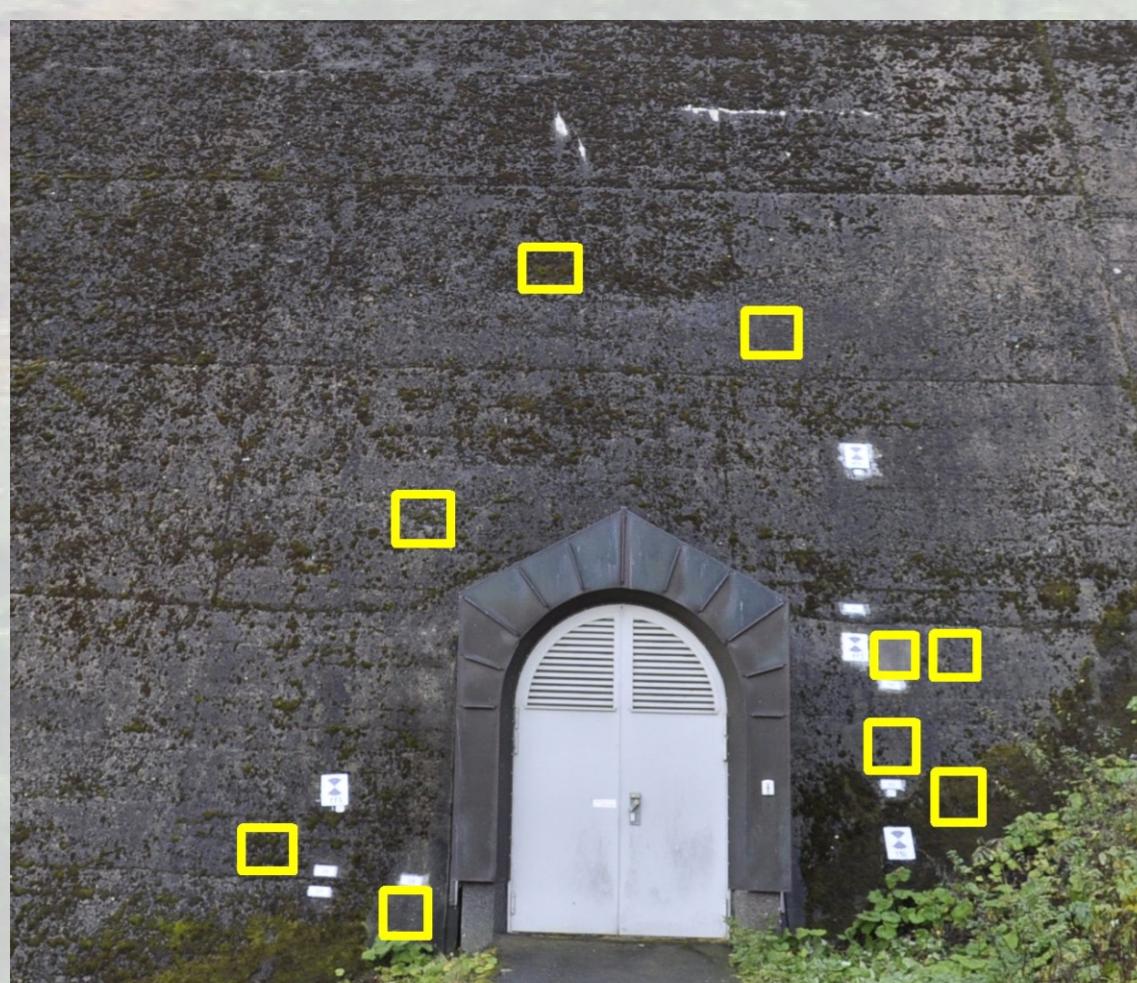


# ANALYSIS OF THE POSSIBILITY FOR USING THE RESULTS OF TERRESTRIAL LASER SCANNING (TLS) MEASUREMENTS AND CLASSIFICATION ALGORITHMS OF IMAGES FOR THE ENGINEERING STRUCTURE SURFACE CONDITION ASSESSMENT

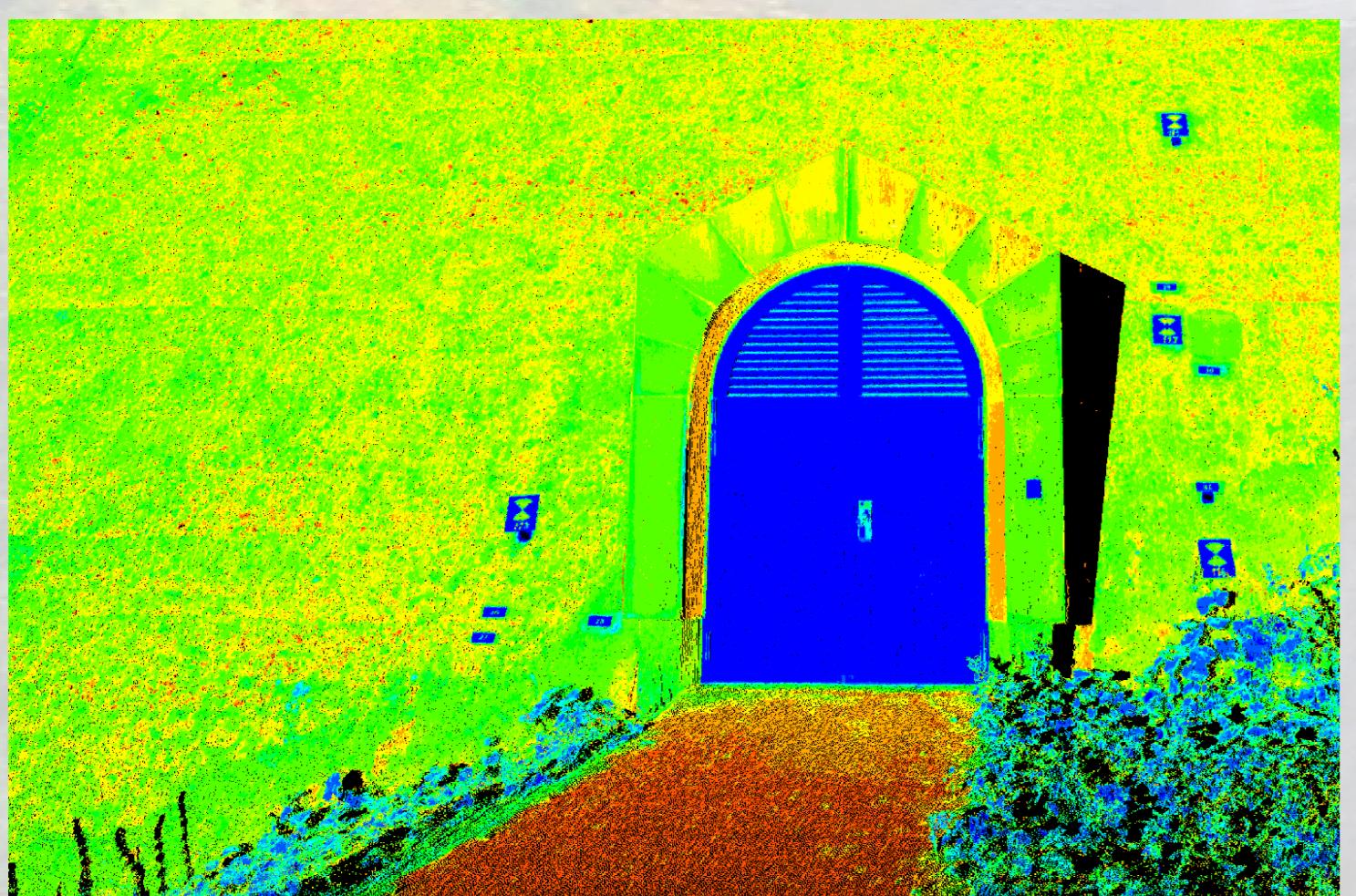
## Introduction

The paper presents evaluation of possibilities to utilise results of laser scanning for determination of conditions of outer surfaces of a water dam construction. Experimental measurements aim at comparison of results of analysis of laser scanning results - the intensity of reflection of laser radiation ( $I$ ) - and results of analyses performed with the use of other, non-destructive methods - visual evaluation and sclerometric measurements (using the Schmidt sclerometer) - not only with respect to results obtained, but also considering economic aspects, such as time, costs and involvement of the measuring team.

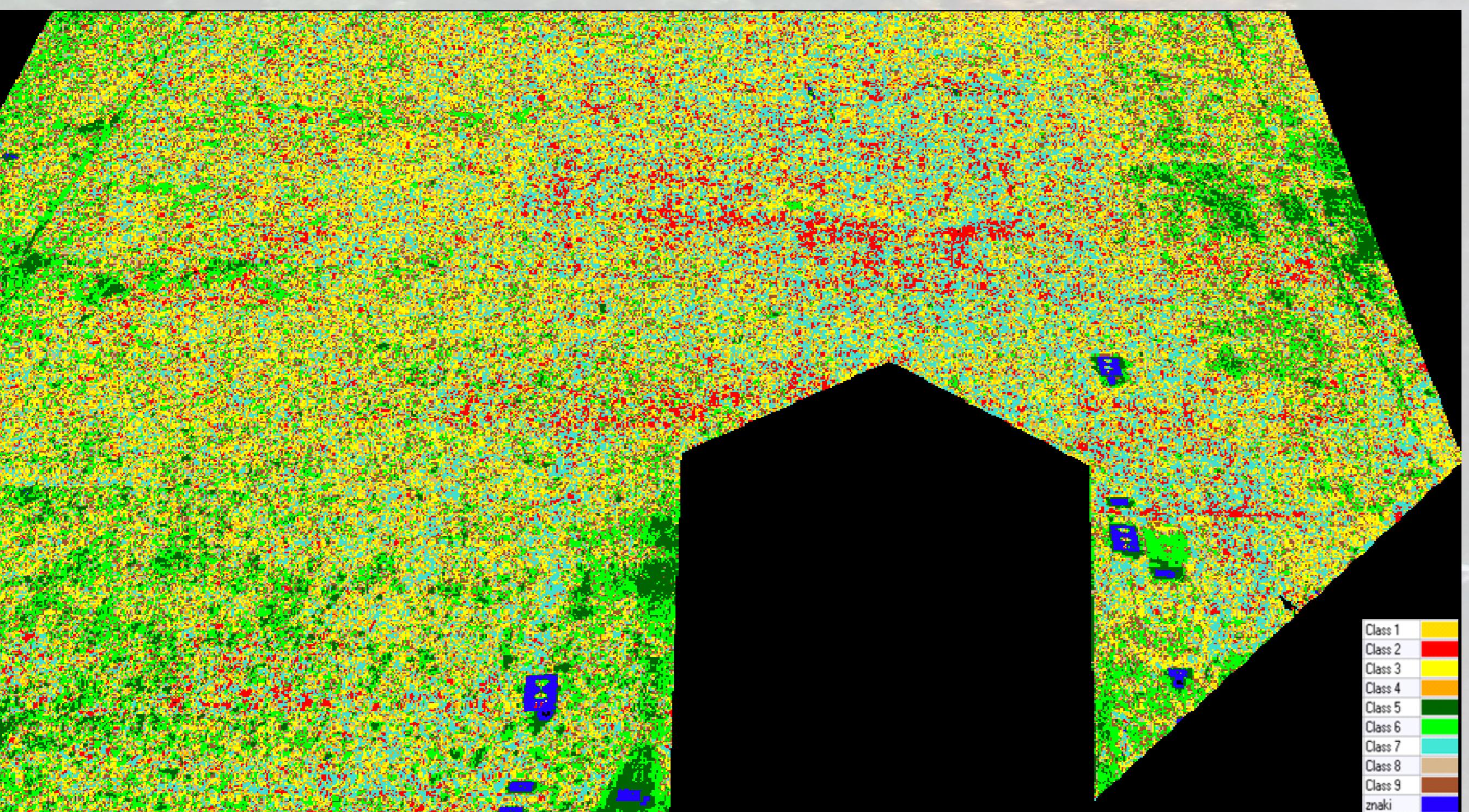
## Eckertalsperre



Selected reference sample areas for supervised classification



The results of the initial classification of intensity data captured by a TLS (un-supervised method, ISODATA algorithm) - station 501, the downstream surface



Eckertalsperre - the result of supervised classification algorithm using minimum distance method (9 classes) for bitmap representation of Intensity after the image filtration (mean)



## Conclusions

Preliminary results of the research indicate the possibility of using automatic image analysis techniques to identify areas of concrete structures with similar properties.

Works concerning preparation of an appropriate algorithm of technical conditions evaluation of the water dam downstream face concern: selection of a surveying instrument (scanner, scanning tacheometer), development of a method for control fields selection, methods of measurements, methods of measurements using the sclerometer, development of algorithms for filtration of measurement results (measuring errors detection, selection of points from a cloud of points measured using the scanner for a representative sample corresponding to the evaluated surface) and selection of methods of calculations and numerical analyses, interpretation of results - preparation of preliminary evaluation of the structure, specification of places for detailed inspection (works at heights on water dam sections, performed by contracted workers, trained to perform such tasks).

Simultaneous utilisation of test using damaging and non-damaging methods (including laser scanning) will allow to increase the accuracy and reliability of performed evaluations of the structure conditions. Proposed approach is the first example of such an application utilised for monitoring of high volume concrete structure surfaces.

Reference area	description/ reflection number/ comments	I	minimum	maximum	average	standard deviation
Besko Dam – Leica Scan Station 2						
Class I	Concrete covered with mosses and lichens	$I^{\text{avg}*}$	107.265	129.898	119.991	2.964
		$\sigma^{**}$	1.98	31.044	8.937	5.712
Class II	Clean concrete	$I^{\text{avg}*}$	87.469	121.082	102.569	7.035
		$\sigma^{**}$	4.746	23.556	13.045	2.904
Class III	Cracked concrete	$I^{\text{avg}*}$	121.367	148.143	132.17	3.489
		$\sigma^{**}$	5.373	25.12	11.735	2.884
Class IV	Concrete covered, slanting surface	$I^{\text{avg}*}$	107.755	149.347	133.612	6.661
		$\sigma^{**}$	2.687	55.227	18.651	12.681
Class V	Concrete covered, vertical surface	$I^{\text{avg}*}$	128.204	157.571	146.69	3.913
		$\sigma^{**}$	8.646	24.676	15.82	2.197
Eckertalsperre Dam – Z+F Imager 5006h						
Class 1,3,4,9	Concrete covered with mosses and lichens, slanting surface	$I^{\text{avg}*}$	0	87	33.382	15.608
		$\sigma^{**}$	84	168	164.153	17.56

\* Average Intensity value in 7x7 window, \*\* Standard Intensity deviation value in 7x7 window

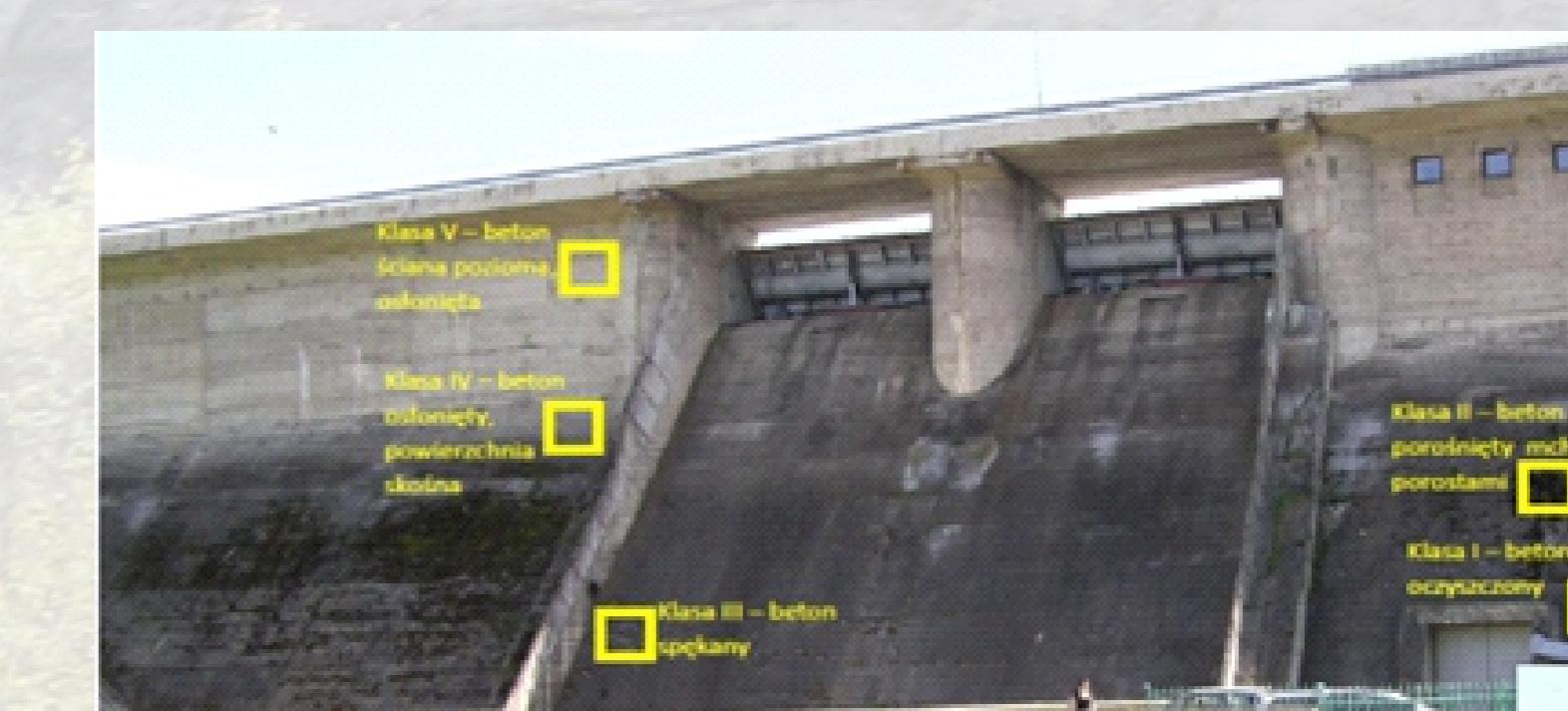
Table analysis show considerable variations of intensity values (after 7x7 averaging filtration) in individual reference samples. High variability of intensity standard deviation in a 7x7 window is also evident. Lower average values for standard deviation of picture calculated for 7x7 window occur in classes I, II and III, whilst higher for samples IV and V. Analogical relation can be spotted for combined classes (1,2,3,4) and (2,6,7). Distribution of reference samples in case of image with average intensity were close to normal, what makes correct operation of maximum likelihood algorithm. The results obtained using an algorithm ISODATA indicate the possibility of using image analysis techniques to separate classes of concrete surfaces with different properties. Quite a large compliance of the results of the classification using this method with the image of the reference samples allows you to evolve such a request.

## Survey

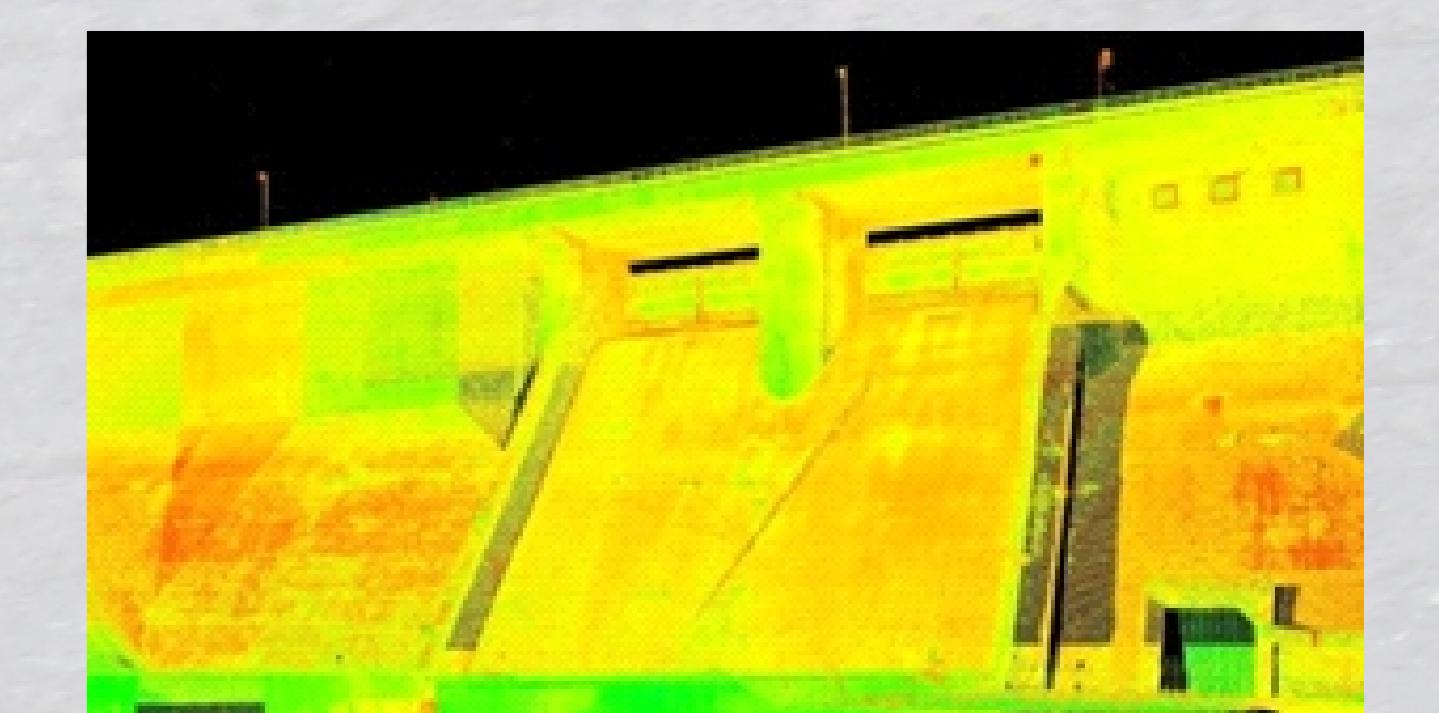
Development of Automatic Multisource Images Analysis method used the following data:

- results of terrestrial laser scanning,
- optical images,
- thermal images (Thermography),
- results of Schmidt hammer tests for assessment of designated reference samples
- conditions from the downstream surface of the dam,
- tacheometric measurements.

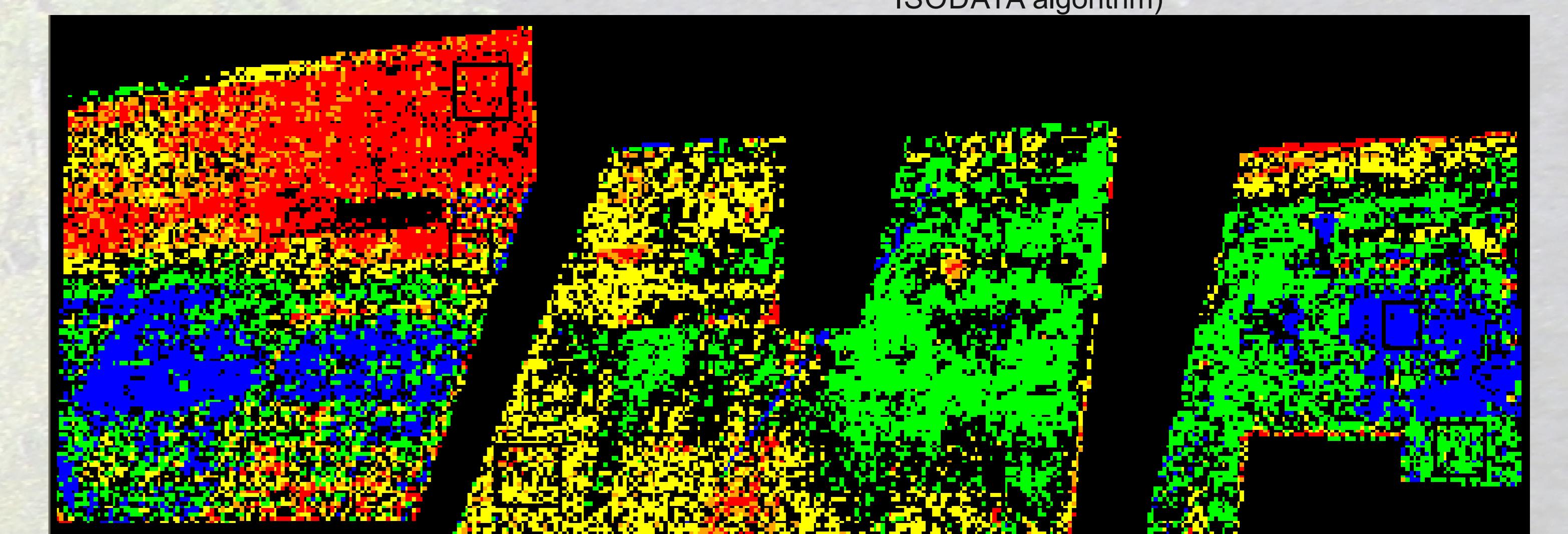
## Besko



Selected reference sample areas for supervised classification



The results of the initial classification of intensity data captured by a TLS (un-supervised method, ISODATA algorithm)



Besko dam - the result of supervised classification algorithm using maximum likelihood method (5 classes) for bitmap representation of Intensity after the degradation pixel size, in black fragments of the concrete dam are presented, which cannot be assigned to any of the classes because of the low probability of belonging to a specified class