

DISCONTINUITY SURFACE ROUGHNESS MEASUREMENT TECHNIQUES AND THE EVALUATION OF DIGITAL PHOTOGRAMMETRIC METHOD

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ABSTRACT:

The development of the knowledge from classical photogrammetry to digital photogrammetry is provided simplicity on the works carried out either on the field or on the laboratory. As a result of this development, the application of the photogrammetry science on the various topics is increased its application to be used much more effectively.

Various means of discontinuity surface roughness determination methods have been developed for the isolation of the effects of discontinuity surface roughness on shear strength, dilation and friction properties of surfaces. In this study, measurement techniques used for modelling of the discontinuity surface roughness were defined and compared each other. The application of digital photogrammetry on discontinuity surface is determined and a case study is presented. Moreover, results obtained by the use of available measurement techniques were also discussed.

1. INTRODUCTION

On the earth surface, it is observed that discontinuities or joints do not have smooth surface structures and they are covered with random distributed roughness. Finding the effective role of surface roughness on the behaviour of discontinuities and on shear strength, made the surface roughness an important factor that has to be taken into account in underground and on ground projects such as tunnel, waste landfill, building, and slope, dam on which the effect of shear strength is seen densely. The new studies supported by new methods and technological advances will make contributions to take well-defining of surface roughness and effect of surface roughness on the behaviour of discontinuities.

In this study, techniques that are used in measurement of surface roughness are introduced briefly and these techniques are compared with each other in certain parameters. In addition, measurements were made by using different techniques on the same sample surface and with data acquired from these measurements three-dimensional model of sample surface are defined. These geometrical defined surfaces are analysed with numerical expressions and the results are discussed.

2. DISCONTINUITY SURFACE ROUGHNESS MEASUREMENT TECHNIQUES

Roughness of a discontinuity surface can be measured by enclosing the entire surface or an axis that is set in the direction of potential sliding and a line on the rough surface.

In the literature, it is well known that different kinds of techniques and methods are used in modelling and measurement of surface roughness. Mostly used techniques are listed and compared on Table 1.

As indicated by the Table 1, all techniques that are known to be used in measurements of surface roughness are compared. Among these techniques Digital Photogrammetry with its measurement sensitivity, practicability, functionality and cost taken together is seen advantageous as compared with other techniques [Unal, 2000]. But if laser device gets much cheaper by time, laser technique will have much more advantages.

Table 1. Comparison of techniques used in measurements of joint surface roughness [Unal, 2000]

<i>Roughness measurement techniques</i>	<i>Simplicity usage</i>	<i>Sensitivity of measurement</i>	<i>Scanning dimension</i>	<i>Flexibility of usage area</i>	<i>Measurement span</i>	<i>Usability of system for other purposes</i>	<i>Cost</i>	<i>Evaluation</i>
Profilometry	Usage is simple but it takes many times	Poor, used technology is also poor,	2-D	Good (Lab.) Poor (Field)	Short-Long, depends on the purpose of study .	Unavailable	Low-Fair	Suitable for 2-D measurements. But it is not functional adequately
Scanner (Type of profilometry)	Good, usage of it depends on the its technology	Fair-Good, depends on the sensitivity of mechanical and electronic system and change depends on the used technology	2-D 3-D	Good (Lab.) Poor (Field)	Medium-Short, depends on the used technology.	Unavailable, its accessory equipment can be used.	Fair-High	Suitable methods for roughness measurements.
Stringline	Simple, but it takes many times and needs hard studying	Poor, used in the field for rough measurements.	2-D	Poor (Lab.) Fair (Field)	Short – Long depends on the experience	There is no specific equipment	Low	It is not suitable method for sensitive measurements
Photogrammetry	Fair, needs experience and expertise.	Fair-good, change depends on the experience and expertise	2-D 3-D	Fair- Good (Field) Poor-Fair (Lab.)	Medium, depends on the experience and expertise	Main function is mapping.	High	It is not suitable method for sensitive measurements
Photograph	Fair-good, drawing and image software provides easiness.	Poor-Fair, change depends on the used technology.	2-D	Fair- Good (Lab.) Fair- Good (Field)	Medium, can be short , depends on the technological background	There is no specific equipment, all used apparatus can be used other purposes.	Fair-High	Suitable for 2-D measurements
Digital photogrammetry	Fair-good, depends on the sensitivity of used software	Good	2-D 3-D	Good (Lab.) Good (Field)	Good, depends on the software	It can be used in different purposes.	Fair-High	Suitable for roughness measurements. Especially for field study
Laser	Good	Very good	2-D 3-D	Very Good (Lab.) ----- (Field)	Good	It can be used effectively for different purposes	Very high	Very suitable for all type of studies

3. MODELLING OF SURFACE ROUGHNESS BY USING DIGITAL PHOTOGRAMMETRY

Developments in computer (software and hardware) technology, as being in all other sciences, have produced important structural changes in photogrammetry. Systems known as digital photogrammetry minimizes workload, high costs and time loss, are created by using high tech (hardware and software). These systems resulted in variation of their application fields and are important step into especially core databases for information systems and digital map production.

The aim of this study is to measure the discontinuity surface roughness using digital photogrammetric method. For this, discontinuity surfaces are analysed as separate lands and the heights of hills and that fill the surface are measured digitally in 3-D environment. In the case study, a sample of andesite having 7,75 x 7,75 cm measures is used and these processes are carried out in three steps [Unal, 2000]. These are:

- Taking stereo photos by a digital camera
- Evaluation of digital photo pairs by computer software and determination of surfaces coordinates (Figure 1)
- Obtaining three dimensional roughness map of the surface (Figure 2) according to the acquired surface coordinates by using graphics software

Firstly, photo-taking conditions should be determined for 3 dimensional modelling of surface roughness by following the

scope of this study. These are briefly listed below as [Seker ve Tavlil, 1996: Unal vd.,2000]. This:

- Using a camera that is suitable to the aim of this study,
- Denoting and determination the object coordinates (at least at 4 points) on sample surfaces for the evaluation process,
- Arranging photo pairs by taking photos from different points for three dimensional modelling,
- Taking photos so as to take, to capture all the details of the surface.

Pictures acquired by a half-metric camera (Polaroid PDC 2000 /40) are appraised numerically according to the photogrammetric principles by the help of digital photogrammetric system. As a result, 3 dimensional map of the discontinuity surface is produced.

When arranging photo pairs in order to determine surface roughness, the care was taken for the range between camera and the object and also to the base interval regulations, because of the smallness of sample measures. Photo- taking were carried out in two different points. Distance between camera and specimen surface is 25 cm. In first and second camera positions sample is held constant and photo taking device is moved when finishing the photo taking. As the measures of sample decrease, photo device is held constant and sample was moved.

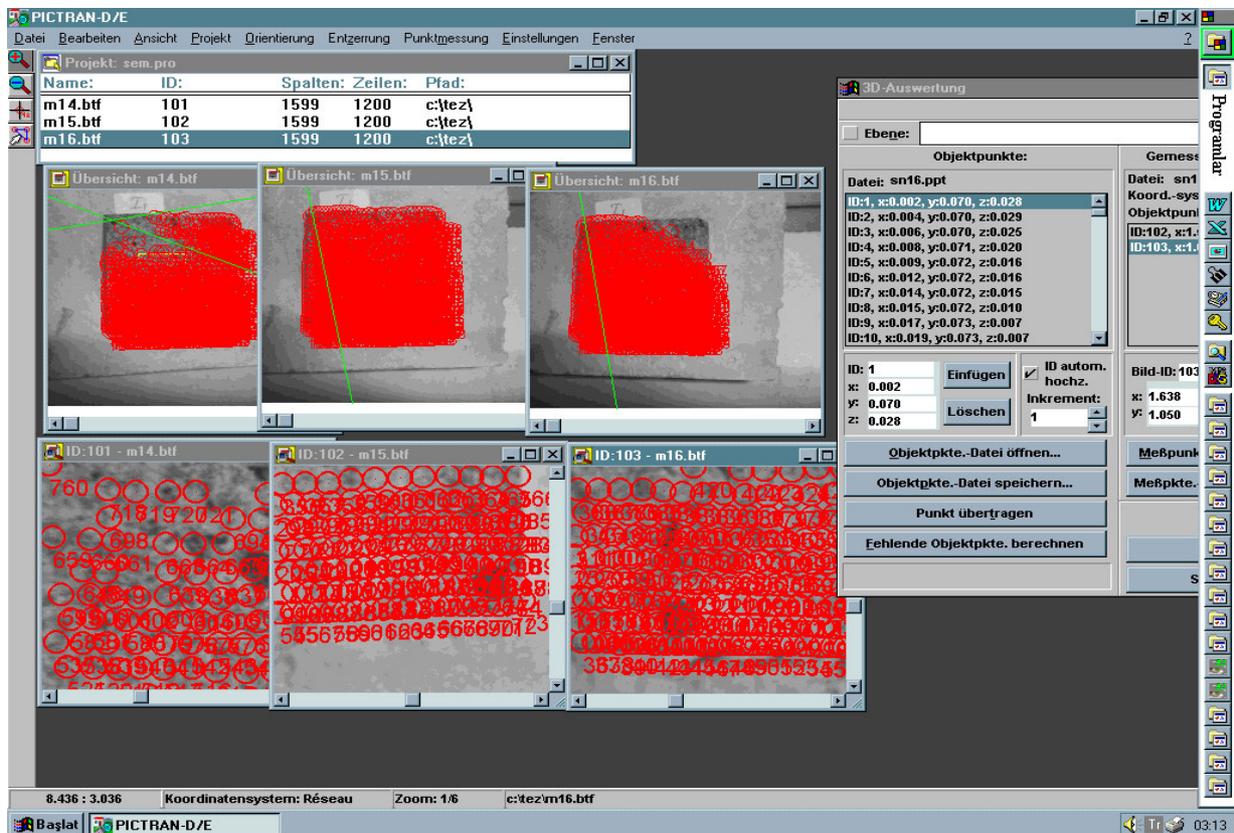


Figure 1. Description of the measurement of x ,y, z coordinates of joint surface by using PICTRAN software

Evaluation processes are carried out in a 0,25 cm interval by a software (PICTRAN) which is developed for photogrammetric purposes. These processes are carried out with arranging the pictures (photos) by inside and outside orientation of photos and by determining corresponding points in the result of comparisons. Acquired photo pairs are analysed as seen in Figure 1.

By using data acquired from photogrammetric evaluations and by using graphics software (SURFER) contour line curves of rough surfaces and three-dimensional models of these surfaces are obtained (Figure 3). For clear vision of the surface roughness, topographic drawing is shown isometrically.

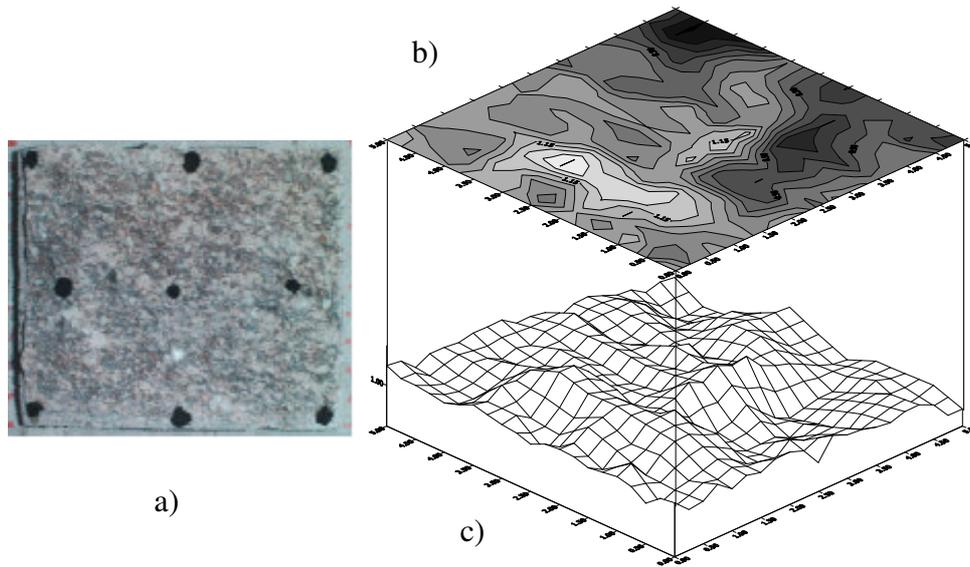


Figure 2. 3-D joint surface roughness model handled by using digital photogrammetry ; a) photography of joint surface, b) surface roughness contour, c) topography of surface roughness [After Unver and Unal, 1998].

4. COMPARISON OF VARIOUS ROUGHNESS MEASUREMENT TECHNIQUES

In this study, a sample of andesite having 5 x 5 cm measures was used. For the aim of the study discontinuity surface is taken as if it is a some part of a land. Roughness measurements were made as to obtain 3-D map. Roughness measurements obtained by these techniques are illustrated in 3-D isometric maps in Figure 3.

As it can be seen from figure 3, measurement differences on the surface appears to be flue. Behaviour of contour line differences in a small interval decreased the visibility of differences on the picture. For this, comparisons are

made by using surface roughness coefficient (SRC) equation given as follows [Unal, 2000],

$$SRC = \frac{A_m}{A_n}$$

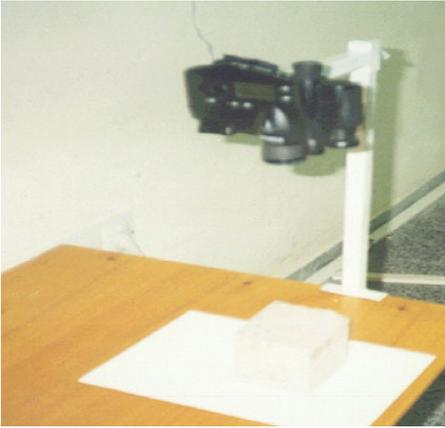
A_m = measured surface roughness area

A_n = nominal surface flat area).

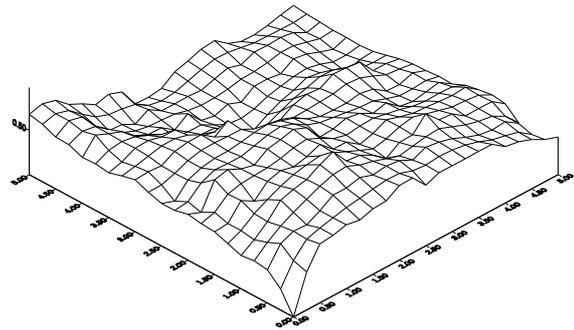
On the specimen surface, SRC values of roughness topography obtained by using different techniques are given in Table 2.

Table 2. SRC values of specimen measured by using different techniques [Unal, 2000]

	Dial gauge measurement system	drag measurement system	Digital photogrammetry	Profilometry
SRC	1.0768	1.061956	1.057128	1.037668



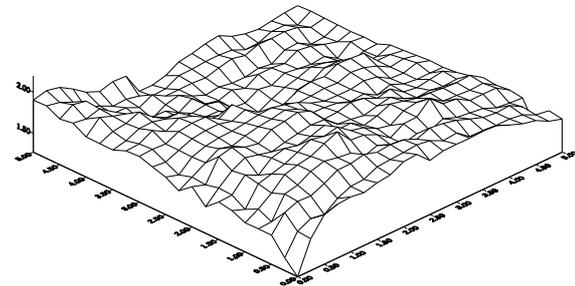
Taking stereo photo system for digital photogrammetry



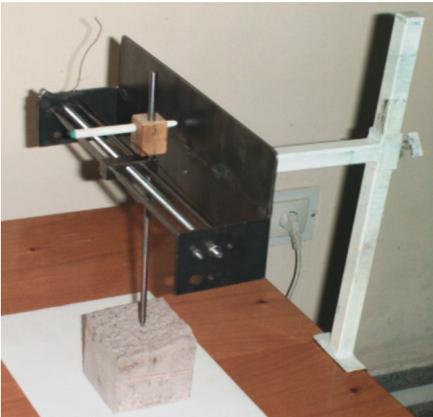
Surface topography measured with digital photogrammetry



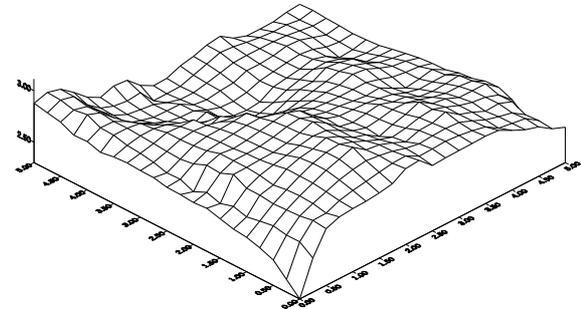
Measurement system by using dial gauge



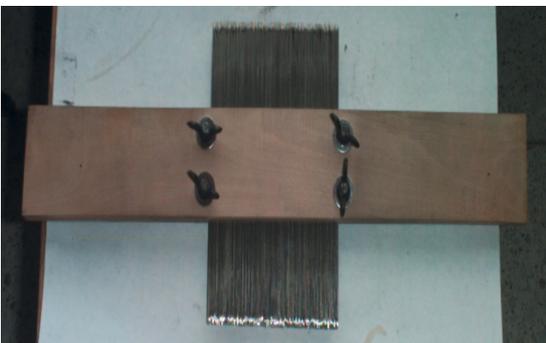
Surface topography measured with dial gauge system



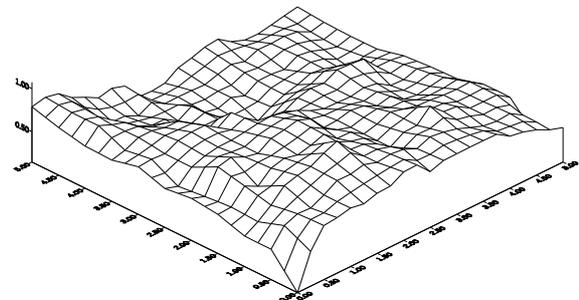
Profilometry



Surface topography measured with Profilometry



Drag measurement system



Surface topography measured with drag system

Figure 3. Measurement techniques and Isometric topographical perspectives of the used specimen [Unal, 2000].

In Table 2, although it is seen that measurements that use comparator are more sensitive than other measurements using different techniques, there are not much differences between them. It can be concluded that if disadvantages of the other techniques are taken into account, the photogrammetry is one of the most appropriate techniques in this purposes.

However, sensitivity of all measurements obtained by different techniques varies according to the degree of surface roughness. To avoid this factor, a camera having a high resolution should be used in these kind of studies in which a photo camera is used. As the resolution of the camera increases, naturally sensitivity will also increase.

5. CONCLUSION

It's known that in the measurement of discontinuity surface roughness, in addition to the photogrammetric method, different kinds o methods are used. Evaluations and measurements made in this study show that the photogrammetric method s a better method then others in many aspects. Especially, success obtained from the laboratory practices show that the digital photogrammetric method will be providing a lot of advantages in field studies. Observed features and advantages of digital photogrammetric method are summarized as,

- Having enough measurement sensitivity in defining the surface,
- Evaluation analyses are made in an easy way and in a short time without a need of special expertness,
- Avoids unnecessary work load, time loss and high costs,
- Much more data is obtaining in a short time interval,
- Because of measurements are held (except short period measurements) in pictures instead of fields (land), the time spent for field studies decreases in a big amount,
- Because of the pictures are permanent, changes are seen easily and rapidly. If needed measurements can be controlled and repeated.

REFERENCES

Seker, D.Z. & Tivil, A.Ü., 1996, Evaluation of Exterior Building Surface Roughness Degrees by Photogrammetric Methods, *Building and Environment*, Vol.31, No.4, pp.393-398.

Unal, M. 2000. *Modelling of discontinuity surface roughness and investigation of its effects on shear strength*, PhD thesis, Hacettepe University, Ankara, 219p.

Unal, M., Unver, B. & Tercan, A.E. 2000, Modelling of discontinuity surface roughness by digital photogrammetry and geostatistical methods, *Proc. of 9th Int. Symp. On Mine Planning and Equipment Selection*, Athens, Greece, pp. 391-396.

Unver, B & Unal, M., 1998. The modelling of joint surface roughness by using digital photogrammetry, Progress report, Hacettepe University, Ankara (Unpublished study).