〔韓國造景學會誌, Vol.24,No.4 pp.74~84, 1997年 11月〕

綠地空間別 土壤硬度變化에 關한 硏究

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A STUDY ON THE SOIL HARDNESS FLUCTUATION OF GREEN SPACE

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요 약

최근, 급격한 도시화 현상으로 인한 불투성 지표의 증가는 도시의 생태적 측면에 변화를 일으키고 있으며, 도시의 온난화 현상, 도시의 사막화 현상 등이 그 결과로 나타나고 있다. 특히, 불투수성 지표가 많은 도시에서는 그 수문학적 기능이 투수성 지표에 의존하고 있으며, 도시의 투수성 지표에는 오픈 스페이스와 주변의 생산녹지 등이 있다. 이러한 관점에서 투수성 지표에 관한 연구가 필요함에도 불구하고 많지 않았고, 대부분 포인트별 연구였다.

본 연구는 도시 내의 수문기능 환경변화개선에 관한 기초자료로 동경의 대표적 도시공원인 코카네이 (小金井) 공원과 동경 근교의 치바현 (千葉縣)에 위치한 치바(千葉)대학 부속 카시와 (柏) 농장을 대상지로 선정, 토양환경기능의 간접적 지표가 되는 토양경도를 나카야마식(山中式) 토양경도계를 사용하여 5120 Cm의 라인위에 10 Cm간격으로 512개씩, 코카네이(小金井) 공원에서 9라인, 카시와(柏) 농장에서 7라인을 공간별로 측정하고, 그 측정값을 다중비교검정과 Bartlett's 검정에 의하여 검정후에, 랜덤 데이타분석에 적합한 FFT(Fast Fourier Transform)를 사용하여 분석하였다.

본 연구의 측정값을 다중비교검정과 Bartlett's 검정한 결과, 유의차가 없었고, 각 데이터를 분석한 결과, 공원의 9라인과 농장의 7라인은 분석 그래프의 유형에 의해 각각 2가지로 분류되었고, 전체적으로는 3가지로 분류할 수 있었다. 특히, 공원과 농장의 분석 그래프에서는 수평방향으로의 변화에 대한 수직방향의 변화가 비슷한 스펙트럼이 공통적으로 나타났고, 각각 최대

값은 다르나 제1주기 부분에서는 답압과 같은 인위적인 요인에 의한 높은 수직방향의 스펙트럼 변화가 관찰되었다. 또한, 강우가 녹지의 경도변화에 미치는 가를 관찰하기 위하여 강우전과 강우후에 같은 라인(Line1 과 Line2)을 측정하여 분석한 결과, 측정값의 평균에서는 차이를 보였으나, 주기의 변화는 거의 없었다.

전체적으로 분석 그래프에서는 공간별로 스펙트럼의 수평방향에 대한 수직방향의 변화량의 차이는 보였으나, 비슷한 주기를 나타냈고, 각각의 유형은 공원을 녹지공간(lawn-area)과 나지공간(bare-area)으로, 농장을 녹지공간(lawn-area)과 경작공간(field-area)으로 분류할 수 있었다. 종합적으로 녹지를 지질학적 구조의 고유한 특징이 아닌, 답압 등과 같은 인위적인 요인에 따른 속성들에 의하여 나타나는 스펙트럼의 분석을 통하여 녹지공간(lawn-area), 나지공간(bare-area) 그리고, 경작공간(field-area)으로 분류할 수 있었다.

Ⅰ. INTRODUCTION

In recent years, an rapid urbanization has been developed rapidly economic growth, and population growth and is remarkable in a metropolitan area. It has many problems - city 's warming, green house effect, urban heat island and so on. One of those reasons is a change in environments of green space.[11] Definite indexes in the change are a diminution of open space in size and a fall-off in function. First, a diminution of open space means an increase of impermeable surface in size. In Tokyo, a change of open space has not been seen in the downtown area but in the outskirts. Second is a fall-off in function. The function of open space is classified in environmental preservation function and recreation function.[12]

The environmental preservation function is connected with the animate nature. The recreation function is connected with human environment. The environmental preservation function is environmental clarification, environmental regulation, ecologic main-tenance and so on. The recreation function is recreation, soundproof, prevention of sprawl, and so on. As mentioned above, if we take notice of the environmental preservation, the increase of an impermeable surface in city is due to, in a long term, green house effect[11][12], environmental dryness and ground subsidence, in a short term, urban flood and so on. The underground dam has been built in order to prove this problems the city 's problems, but it is not a perfect solution.

An impermeable surface is occurred from a diminution of open space. It is a change of the hydrological function in green space. The hydrological function of city depends on permeable area and open space. This dependance is emphasized now, so that we must turn our attention to farmlands and urban parks, also to investigate into the hydrological function of green space. From a ecologic function 's point of view, Soil Hardness Fluctuation,[13] An atmosphere and a soil 's moisture of circulation is one of subject materials. In this study , In order to be clear and accurate the hydrological function of green space, we studied on the soil hardness fluctuation of green space as a basic research of spatial fluctuation.

Ⅱ. MATERIALS AND METHODS

1. SITES INVESTIGATED

We selected three sites in two places; The places are Koganei park[10] and Kashiwa farm which have similar conditions and a similar size. We classified the sites according to eyes ; lawn-area, bare-area and field-area. Koganei Park is surrounded by Koganei City, Musashino City, Kodaira City, Tanashi City. It is the largest park that Tokyo regional government manages.

It is located on the Musashino volcanic Field which is adjacent to the Tamakiawajo-suii canal on south, and The Shakujii River on North. The size of Koganei Park is 719,402 m^2 (1987). The site is used for a playground, "KodomonoHiroba" (Children 's place) of which size measures 24,000m2. Koganei Park was a flat agricultural land but it was built as a result of the creation of Tokyo 's green space. A Playground which was used for a nursery before World War Ⅱ, but after World War Ⅱ it was changed to forest is the site of this measurement. Kashiwa Farm is attached to the horticultural school of Chiba university and is surrounded by Kashiwanoha Park and a residential area. Kashiwa Farm is located in the middle of the Kashiwa City 's green area and field area which is generating both agricultural and recreation activities. This site is composed of lawn-area (3,000m^2) and field-area (10,000m^2). Kashiwa Farm was the military communication facilities in 1987, but it was consolidated now horticultural facilities and bio-technology.

2. METHODS OF MEASUREMENT

1) Introduction of tools

The pocket penetrometer[8] is a hand-operated, calibrated- spring penetrometer[1], originally developed as an improvement on the thumb-fingernail technique for estimating the engineering consistency of cohesive, fine-grained soils. The maximum deformation of the spring as the piston needle is pushed into silty clay or clay soil has been correlated with unconfined compressive strength of soil in kilograms per square centimeter. The latter values are the scale on the piston barrel. Since correlations have been developed between root growth and point resistance, Nakayama (1962)[2] suggested converting the unconfined compressive strength scale to read in units of total probe resistance by calibrating the penetrometer scale against a load cell or set of known weights. The pocket penetometer is a simple operation. It can be pushed into the surface. The method is useful in comparing relative strengths among similar soil types or in determining hardpins, tones of compaction, or dense soil layers, if matric potential is jointly measured.

2) The procedure of methods

We measured nine lines for 3 days (1995. 8. 2.-4.) in the playground (lawn and bare) of the Koganei Park and seven lines for 2 days (1995. 7.19, 9.5.) in the lawn and the field of the Kashiwa farm. Exceptionally, the line1-1 was measured before raining and line1-2 was measured after raining, in order to find out whether the lines are related with the rain or not. We selected lines by the random method[7] and measured the hardness with the pocket penetrometer (total 512 points by 10㎝), data sheets and scale(50m). The procedure of method is the following[8]

1. Select the test location and determine the associated soil properties by referring to section ;

2 Move the indicator sleeve to the lowest reading (zero) on the penetrometer scale ;

3. Grip the handle and push the piston needle into the soil, with a steady rate of penetration, into the soil until the engraved line 6mm from the blunt up is flush with the surface of the soil ;

4. Remove the penetrometer from the soil and read scale ; and

5. Clean the piston and return the sliding indicator to it 's zero position.

3. METHODS OF ANALYSIS

1) Fast Fourier Transform[2),3)]

Fourier Series is often used for the most practical purposes in their digital computation. however only a Finite-range Fourier Transform can actually be computed with digitize data, and this finite range can always be considered as the period of an associated Fourier Series.

One of the main reason for the importance of Fast Fourier Transforms is that they can be used to provide estimates of desired spectral density and correlation functions.

In general, a discrete complex Fourier transformation of signal $y(i)$ (i=0,1,2,...N) is executed by[6)]

$$Y(k) = \frac{T}{N}\sum_{i=0}^{N-1} y(i) \cdot e^{-j\frac{2\pi ki}{N}} \qquad (1)$$

where I designate a imaginary number, T a fundamental spatial period. And power spectrum is defined as[9)]

$$X = \lim_{T\to\infty} E\left[\frac{1}{T}\mid Y(k) \mid^2\right] \qquad (2)$$

This procedure requires a total of approximately N^2 real multiply-add operations. To greatly reduce these standard computational times, alternative methods have been proposed and developed,[3)]

Known as Fast Fourier Transform procedure, these methods will now be discussed in some detail because of their importance in digital processing of random data.[7)]

2) Autocorrelation Function [1)]

All of the derivations so far have assumed that individual observations were independent and uncorrected. This is likely to be a poor assumption for soils data since samples taken in close proximity to each other are generally more similar than more widely spaced sample. Data can be tested for spatial correlation using one of the autocorrelation function.

There are two ways to compute autocorrelation estimates. One is the direct method, involving the computation of average products among the sample data values. Another is the indirect approach of first computing an power spectral density estimate using FFT procedures, and then computing the inverse transform of the powerspectrum. We used the second way for this study because of saving the computing time. The autocorrelation function is computed by taking the inverse Fourier Transform of the powerspetrum estimate.

However, due to the underlying periodic assumption of the finite Fourier Transform, the autocorrelation function computed by this procedure is "circular" in character.[1)]

The autocorrelation function is taken by the convert transform of the powerspectrum.[15)]

$$C(\delta)= a \int_0^{\infty} \rho(f)\cos(2\pi f \delta)df \qquad (3)$$

The following diagram shows the summary of practices of FFT[14]

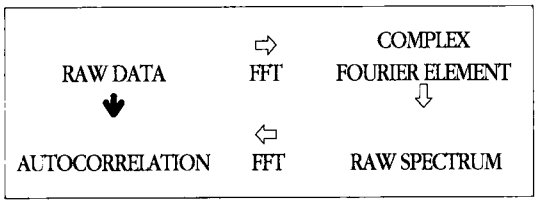


Diagram of the practice FFT

Ⅲ. RESULTS AND DISCUSSION

1. RESULTS

1) Hardness in green space

We selected nine lines in Koganei Park and seven lines in Kashiwa farm. Each of lines has 512 measurement points (51.2m and 10cm distance)

Individually, we obtained the total, the average, the variance and the standard deviation in lines. Table 1 and Table 2 are shown as the results.

The total average of Koganei park and Kashiwa farm are approximately 24.87㎜ and 15.69㎜ respectively in strength. In the Koganei park, We can find out little difference in the average. In the Kashiwa farm, we can divide lines into two groups. The first includes line 2-1, 2-2, 2-3 and 2-4 , the second has line 2-5, 2-6 and 2-7. The first group 's average is 19.725mm the second is 10.183㎜. The first is lines of the lawn-area and the second is lines of filed-area. Specially the biggest is the line1-9 (26.85㎜) and the least is the line1-3 (23.43㎜) in Koganei park. In Kashiwa farm, the biggest is the line2-2 (20.61㎜) and the least is the line2-7 (4.64㎜). The farm is less compacted than the park because the farm is not opened to the public and the traffic is less. Moreover, it is clear that the low value in the farm area is due to cultivation like this the hardness for the volcanic rock soil ranges so widely, depending on the

Table 1. The analysis of soil hardness in Koganei Park (unit : ㎜)

Koganei	line1-1	line1-2	line1-3	line1-4	line1-5	line1-6	line1-7	line1-8	line1-9
Total	13143.0	12359.7	11996.2	12088.3	13004.8	12564.5	13235.2	12359.7	13747.2
Average	25.67	24.14	23.43	23.61	25.40	24.54	25.85	24.14	26.85
Variance	5.90	5.16	7.29	3.64	5.99	4.37	6.10	5.15	4.87
S.D	2.43	2.27	2.70	1.91	2.45	2.09	2.47	2.27	2.21

Table 2. The analysis of soil hardness in Kashiwa Farm (unit : ㎜)

Kashiwai	line2-1	line2-2	line2-3	line2-4	line2-5	line2-6	line2-7
Total	9548.8	10552.3	10583.0	9712.6	6103.1	7162.9	2375.7
Average	18.65	20.61	20.67	18.97	11.92	13.99	4.64
Variance	6.00	6.85	6.15	9.44	20.43	21.51	17.27
S.D	2.45	2.62	2.48	3.07	4.52	4.63	4.16

activities by human beings. than we must take account the differences among green spaces. It is expected that the infiltration capacity for the field area because higher than for the foot compacted areas. All these differences are checked by the multiple comparison tests and Bartlett 's test, and the result is little similarity.

2) RESULTS OF ANALYSIS

i) KOGANEI PARK

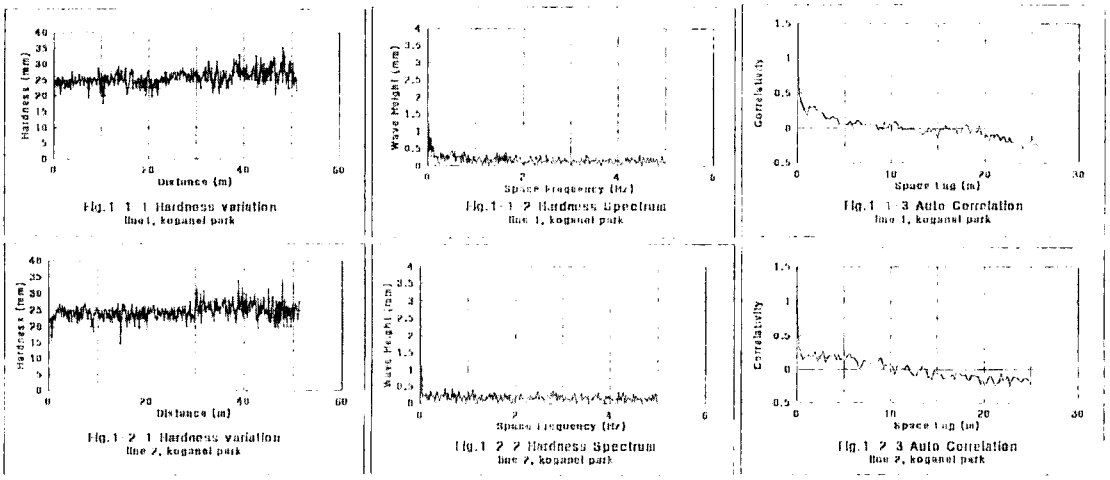
The results of Analysis are shown in Figures (from Fig1-1 to Fig1-9). The figures show the hardness variation, the hardness spectrum and auto correlation.

Accordingly We can assort lines two groups by Figures. The first is Fig1-1,1-2,1-4,1-5,1-6,1-7 and 1-8 , the second is Fig1-3 and 1-9. The first is the lawn-area which is classified the site accoding to eyes and the second is the bare-area.

The following analysis were derived from the results.

1, line 1-1 and 1-2 (fine - rain)

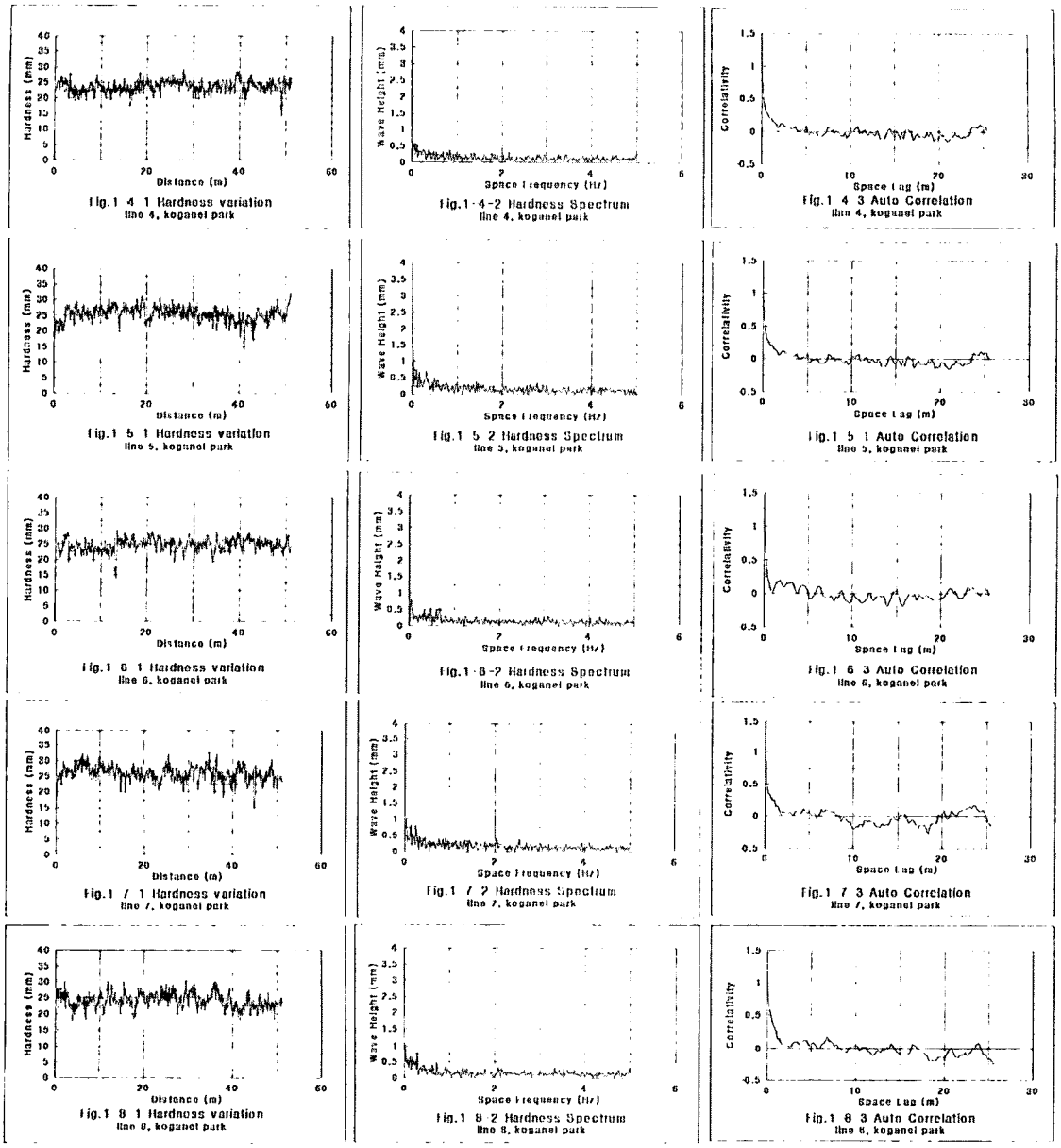
Average hardness is slightly decreased by rainfall. The tendency of auto correlation does differ by weather. That means hardness frequenting changes are basically not found. But, we found very small difference between the average (table 1).



2, line 1-4, 1-5 , 1-6, 1-7 and 1-8.

Average hardness ranges very narrowly between 23.61-25.85 in index hardness mm. Low frequency wave in hardness are found in hardness spectra that depends on the topographical features of landscape, for example of the history of pedestrian traffic. Short space lags are found in auto correlation that show the existence of some regular hardness waves, while long space lags are also found by means of topographical features.

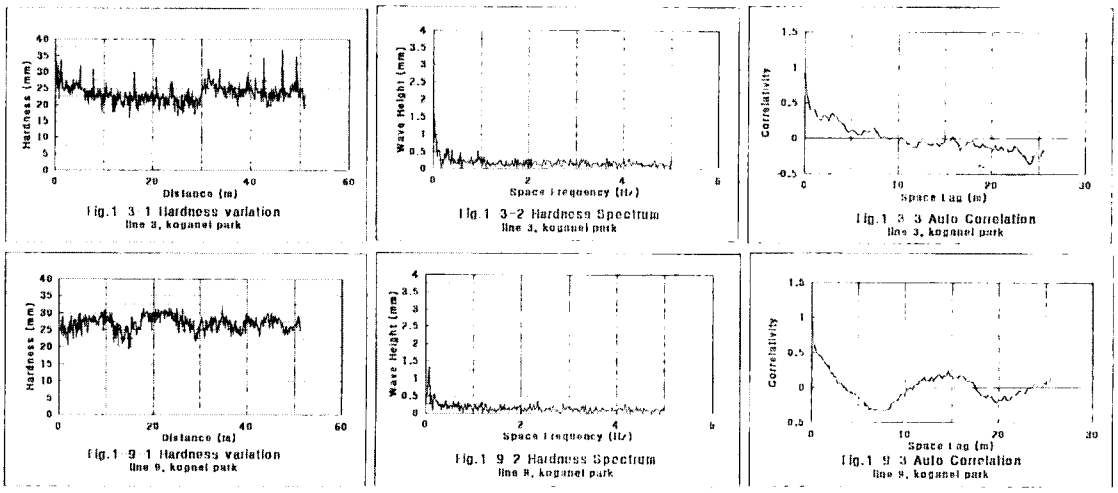
Generally saying, hardness fluctuations in lawn-area of public park are almost random, however weak periodicities are found in comparatively high space frequency.



3, line 1-3 and 1-9.

Basically the properties of spectra and auto correlation are similar to those in lawn-area, however the values sometimes records the maximum in bare soil area depending on the foot compaction.

Comparison of the features in Fig.1-9-3 with other features including lawn-area, both clear positive correlations in the figure are due to other reasons except the pedestrian traffic history (example, human's activities : football, picnic, walking and so on).



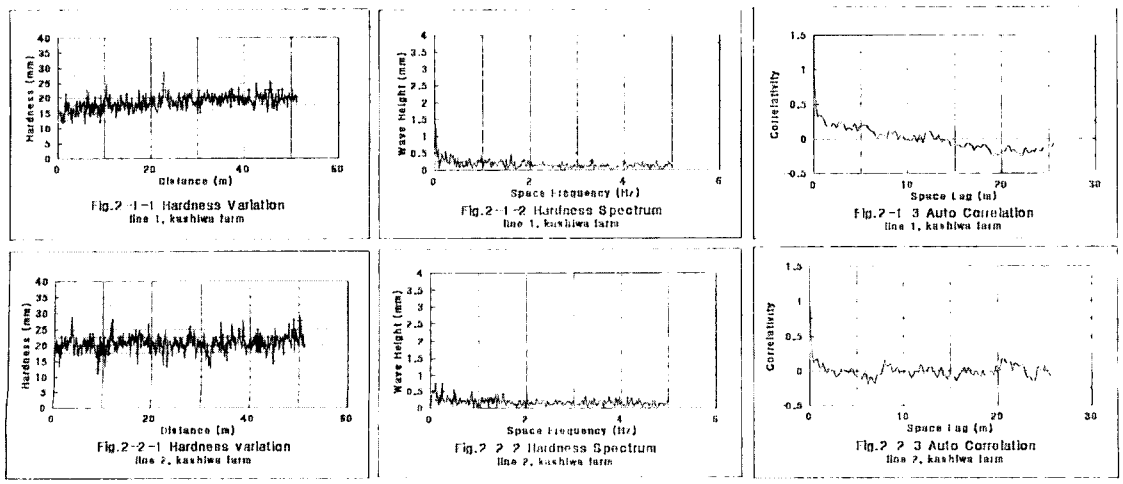
ii) KASHIWA PARK

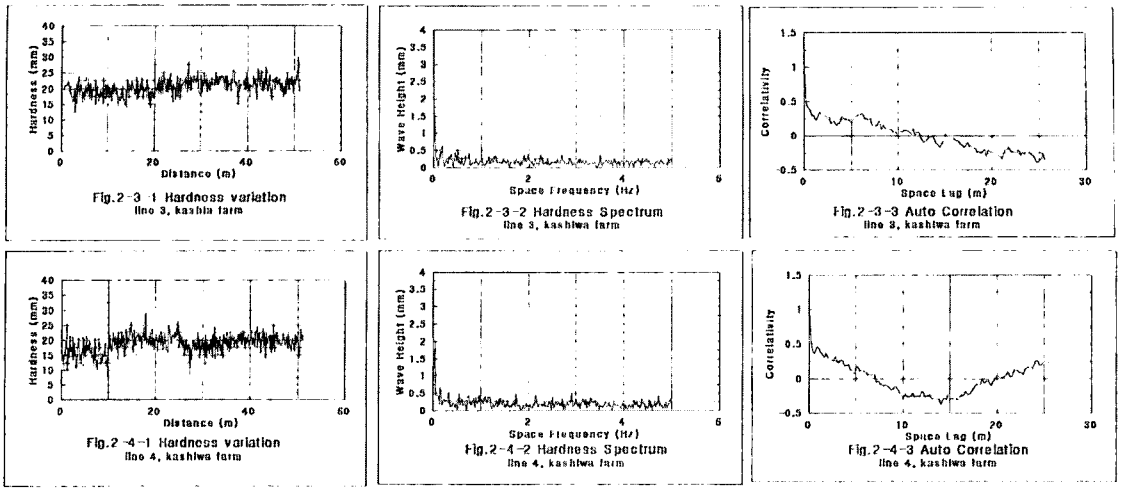
We can show the results of Analysis on Figures (from Fig2-1 to Fig2-7). The figures show the hardness variation, the hardness spectrum and auto correlation. Accordingly We can assort lines two groups by Figures. The first is Fig 2-1, 2-2, 2-3 and 2-4, the second is Fig 2-5, 2-6 and 2-7. The first is the lawn-area which is classified the site accoding to eyes and the second is the field-area. .

The following analysis were derived from the results.

1, line 2-1, 2-2, 2-3 and 2-4.

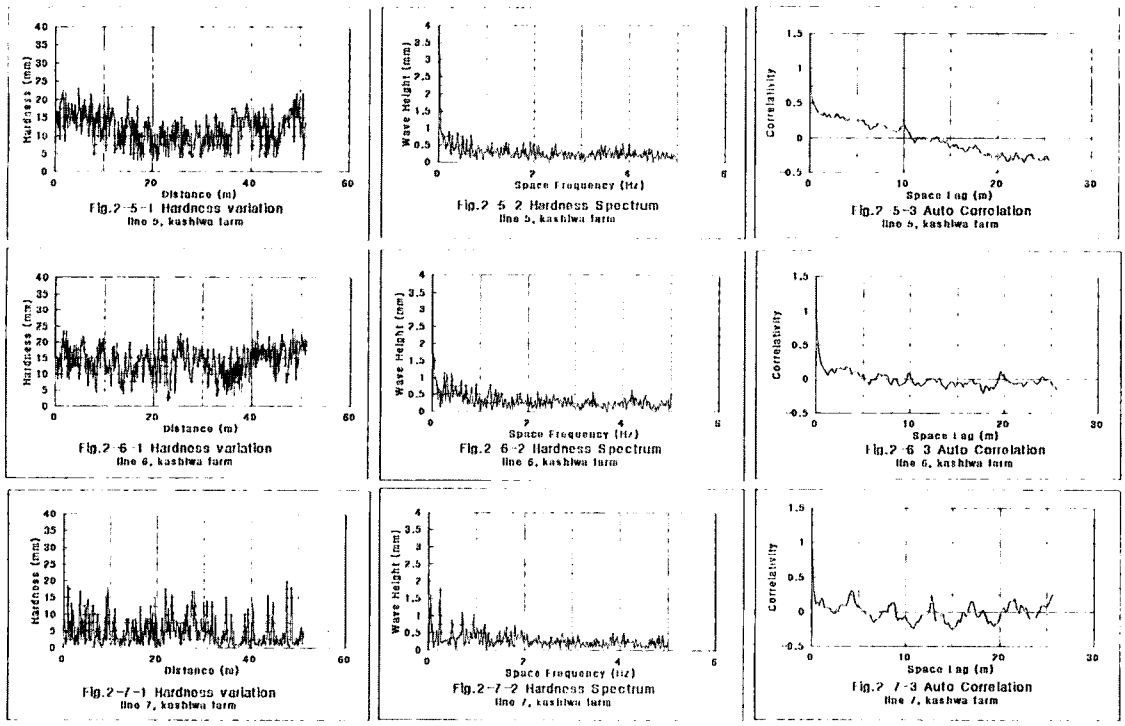
Average hardness in the lawn-area in the university farm in clearly less than those in the Koganei park that means the difference of pedestrian traffic quantity. However, the spectrum similarity with the Koganei park is found.





2, line 2-5, 2-6 and 2-7.

The hardness between lawn-area and field-area in Kashiwa is quite different. Hardness in field becomes quite small owing to the cultivation and the average value is scattered. Spectral features are similar to those of lawn-area except the case in Fig.2-7 that is measured normal to the direction of ridges.



Ⅳ. CONCLUSION

The soil hardness of green space has been measured in the Koganei park and the Kashiwa farm, and the results of measurement have been tested by FFT. Besides, I did multiple comparison test and Bartlett 's test in order to find significance level of results. the result is little similarity.

Average hardness magnitudes are different among the lawn-area with or without pedestrian traffic history and the farmland. however, high frequency but weak periodicity in hardness is observed in every case that is considered due to pedestrian traffic.

This is common except the special features as construction treatment of green space. Then we can conclude that the surface properties with pedestrian traffic history may be considered almost at random. measure it in comparatively small area to know the surface properties.

We can show the results of Analysis on Figures (from Fig1-1 to1-9 in Koganei park, from Fig2-1 to Fig.2-7 in Kashiwa farm). Accordingly We can assort lines three groups . The first is Fig1-1,1-2,1-4,1-5,1-6,1-7,1-8, 2-1,2-2,2-3 and 2-4 , the second is Fig1-3 and 1-9 , the third is Fig2-5, 2-6 and 2-7. The difference in soil hardness between before and after the rain is pretty small, however we can not find the difference in spectral properties. That means hardness frequenting changes are basically not found. But, we found very small difference between the average (table 1),

It is matter of course that the spectral difference between parallel and normal direction of the measured lines exists, however the spectral feature in the parallel direction is similar to other data.

The park and the farm in lawn-area differ from average. (Table1 and 2). Generally saying, hardness fluctuations in lawn-area of public park are almost random, however weak periodicities are found in comparatively high space frequency. Average hardness in the lawn-area in the university farm in clearly less than those in the Koganei park that means the difference of pedestrian traffic quantity. However, the spectrum similarity with the Koganei park is found.

Basically the properties of spectra and auto correlation are similar to those in lawn-area, however the values sometimes records the maximum in bare soil area depending on the foot compaction. Comparison of the features in Fig.1-9-3 with other features including lawn-area, both clear positive correlations in the figure are due to other reasons except the pedestrian traffic history. The hardness between lawn-area and field-area is quite different. Hardness in field-area becomes quite small owing to the cultivation and the average value is scattered. Spectral features are similar to those of lawn-area except the case in Fig.2-7 that is measured normal to the direction of ridges. The farm differs from the park, because the farm is not opened to the public and the traffic is less. In the field-area, the exiting of plant and the degree of growth are important things.

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