Journal of **Kim Il Sung** University (Natural Science) Vol. 3 No. 4 Juche103(2014)

Meteorological Simulating for Design Windbreaks in Table Highland

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Abstract In this paper, for design windbreaks in research region, first we have calculated probability maximum wind velocities in region, and then use “$E-\varepsilon$” turbulence-closure model and microclimatic model “$Envi-met$”, simulated the effect of windbreaks [1－8] and suggested the effective ways to rationally distribute windbreaks under considering topographical conditions of this region, suitable for distribution of wind field.

Key words probability maximum wind velocity, “$E-\varepsilon$” turbulence-closure model, micro-climatic model “ENVI-Met”, windbreaks, wind field distribution

1. Calculating Probability Maximum Wind Velocities in Region

1.1. Primary data

Primary data are measured wind data during 40 years in research region from 1971 to 2010(height: 10m, 10min averaged data).

We have proved that among some known theoretical distribution functions the distribution function which explains well the probability distribution is Kambel distribution function.

The excess probability of Kambel distribution function is computed as

$$P = 1 - \exp\left\{-\exp\left[-\bar{y} - \frac{\sigma_y}{\sigma_x}(x-\bar{x})\right]\right\}$$

where $\bar{x}$ and σ_x are averaged value and standard deviation of annual maximum wind velocities , according to sample number *n*, also $\bar{y}$ and σ_y are calculated by following expression.

$$\bar{y} = \frac{1}{n}\sum_{i=1}^{n}\left\{-l_n\left[-l_n\left(1-\frac{1}{n+1}\right)\right]\right\}$$

$$\sigma_y = \sqrt{\sum_{i=1}^{n}\left\{-l_n\left[-l_n\left(1-\frac{1}{n+1}\right)\right]-\bar{y}^2\right\}}$$

When the excess probability is *P*, the maximum wind velocity X_p is computed is as follows.

$$X_p = \alpha \cdot y_p + (\bar{x} - \alpha \cdot \bar{y}) - g$$

where $\sigma = \sigma_x / \sigma_y$, $y_p = -l_n[-l_n(1-p)]$ is, n is sample number, i means the order of size of it.

The conformability estimation between experience distribution function according to the observation data and theoretical one-Kambel distribution is calculated is as follows.

$$\Delta V = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(u_i' - u_i)^2}$$

where u_i is the i^{th} value of maximum wind velocity on empirical distribution curve, u_i' is the i^{th} value of theoretical distribution one, for conformability estimation, we calculated the values of ΔV according to the several distribution functions by using the wind observation data of the research region and surrounding ones, and indicated in table 1.

Table 1. Values of ΔV calculated according to several distribution functions

Point	Distribution Form		
	Kambel distribution	Weibull distribution	Pearson distribution
1	0.71	0.86	1.05
2	0.55	1.16	1.19
3	1.00	1.46	0.97

As shown in table 1, in research region the values of ΔV from the Kambel distribution function are the smallest, the Kambel distribution curve is unanimous in the form of distribution passing through the between points on empirical distribution.

1.2. The calculation results and analysis.

We calculated the maximum probability wind velocities of 1, 2, 5, 10%, and 20% on three places in research region. The maximum probability wind velocities are indicated in table 2.

As you can see in table 2, the maximum wind velocities of 1% probability on the region is 19m/s or so, and therefore, the wind velocity with the 100 year-excess rate surely would be under 20m/s.

So using the wind velocity 20m/s of 1% probability for design of windbreaks as the design wind velocity can be secured in scientific way (These wind velocity values are 10 minute-averaged ones.).

Table 2. Probability maximum wind velocities during a year

Point	Probability/%			
	1	2	5	10
1	19	18	16	15
2	20	18	16	15
3	16	15	13	12

2. Using " $E-\varepsilon$ " Turbulence-Closure Model and "ENVI-Met" in Simulation on Windbreaks Distribution

2.1. " $E-\varepsilon$ " turbulence-closure model

It is well known that the turbulence-closure model is used in solving the fundamental equations of atmosphere phenomenon [1, 2].

As the one-dimension closure model (K-method) is simple one, it is widely applied, on the other side it has the defect that it can use only on the even topography and did not consider the effect of the topographical inequality and obstacle.

The multiple-dimension closure model, its physical base nearly approached on the practice, but it has the defect which is difficult to use in the practice because the amount of calculation is enormous.

Through a compromise between both sides, " $E-\varepsilon$ " turbulence-closure model was appeared; it is a 1.5-dimension model.

Using this model, the effect of the uneven surface of the earth horizontally and the course of advection can be correctly simulated. Also, in the model " $E-\varepsilon$ " the kinetic energy of turbulent (E) and its dissipation velocity can be used in order to obtain the coefficient of turbulent exchange.

Several kinds of the turbulence-closure model using in the practice were considered

2.1.1. The standard model "$E-\varepsilon$"

The simplest model on turbulent consists of two transport equations to calculate the turbulent velocity and the length scale. The typical one of them is the standard model "$E-\varepsilon$", and it is used in the wide field for its stability in calculating, economic effectiveness and correctness [4].

It is the semi-experienced model made of the transport equation about the kinetic energy of turbulent (E) and its dissipation velocity.

The transport equation on E is given under the correct leading of equation and one on ε is calculated by using the experienced values and an mathematic analogue. The standard model "$E-\varepsilon$" disregards the effect of the viscous molecule and can conclude under the full turbulent.

The transport equation decided the kinetic energy of turbulent (E) and its dissipation velocity (ε) is as follows.

$$\left.\begin{aligned} &\frac{\partial}{\partial t}(\rho E)+\frac{\partial}{\partial x_i}(\rho E u_i)=\frac{\partial}{\partial x_j}\left[\left(\mu+\frac{\mu_t}{\sigma_E}\right)\right]+G_E+G_b-\rho\varepsilon-Y_M+S_E \\ &\frac{\partial}{\partial t}(\rho\varepsilon)+\frac{\partial}{\partial x_i}(\rho\varepsilon u_i)=\frac{\partial}{\partial x_j}\left[\left(\mu+\frac{\mu_t}{\sigma_\varepsilon}\right)\frac{\partial\varepsilon}{\partial x_j}\right]+C_{1\varepsilon}\frac{\varepsilon}{E}(G_E+C_{3\varepsilon}G_b)-C_{2\varepsilon}\rho\frac{\varepsilon^2}{E}+S_\varepsilon \end{aligned}\right\} \qquad (1)$$

where G_E is the production term of the kinetic energy of turbulent by the gradient of average velocity, G_b is the production term of the kinetic energy of turbulent by the buoyancy, Y_M is the contribution term of the disturbance volume expansion of compressible turbulent on the whole dissipation velocity, $C_{1\varepsilon}$, $C_{2\varepsilon}$, $C_{3\varepsilon}$ is the constant, σ_E is Prandtl number of the turbulent about E, σ_ε is Prandtl number of the turbulent about ε, S_E and S_ε are source terms.

When the E and ε are calculated, the viscosity coefficient of the turbulent μ_t is decided as follows.

$$\mu_t=\rho C_\mu\frac{E^2}{\varepsilon} \quad (C_\mu:\ \text{Constant}) \qquad (2)$$

Form the experiment about the turn flux of turbulent, the model constants can choose as following values experientially.

$$C_{1\varepsilon}=1.44,\ C_{2\varepsilon}=1.92,\ C_\mu=0.09,\ \sigma_E=1.0,\ \sigma_\varepsilon=1.3$$

2.1.2. The RNG "$E-\varepsilon$" model

This is obtained using the strict statistical method (the re-standardization method).

Their form is similar to the standard model "$E-\varepsilon$", but the following contents were added.

① The term to improve the accuracy of the rapid changing flux in ε-equation is added.

② The effort of turbulent rotation is added, so the rotation flux can be expressed more correctly.

③ Use the interpretational equation of Prandtl number of the turbulent.

④ Compute the effect of the low Reynolds number with the leaded equation about the efficient viscosity.

For these characteristics, the RNG "$E-\varepsilon$" is possible to calculate the more wide flux field more correctly than the standard model "$E-\varepsilon$".

The model RNG "$E-\varepsilon$" applies the re-standardization method in case of the calculation from the Navier-Stokes equation corresponding moment values, and also use constants which are different from the standard model "$E-\varepsilon$".

The transport equation using in the model RNG "$E-\varepsilon$" is as follows.

$$\begin{aligned}&\frac{\partial}{\partial t}(\rho E)+\frac{\partial}{\partial x_i}(\rho E u_i)=\frac{\partial}{\partial x_j}\left(\alpha_E \mu_{eff}\frac{\partial E}{\partial x_j}\right)+G_E+G_b-\rho\varepsilon-Y_M+S_E\\&\frac{\partial}{\partial t}(\rho \varepsilon)+\frac{\partial}{\partial x_i}(\rho \varepsilon u_i)=\frac{\partial}{\partial x_j}\left(\alpha_\varepsilon \mu_{eff}\frac{\partial \varepsilon}{\partial x_j}\right)+C_{1\varepsilon}\frac{\varepsilon}{E}(G_E+C_{3\varepsilon}G_b)-C_{2\varepsilon}\rho\frac{\varepsilon^2}{E}-R_\varepsilon+S_\varepsilon\end{aligned} \quad (3)$$

where α_E and α_ε are inverse numbers of Prandtl number of turbulent about E and ε.

In the RNG theory the modeling of the efficient viscosity is calculated by differentiating the viscosity equation of the turbulent.

$$d\left(\frac{\rho^2 k}{\sqrt{\varepsilon\mu}}\right)=1.72\frac{\hat{v}}{\sqrt{\hat{v}^3-1+C_v}}d\hat{v} \quad (4)$$

where $\hat{v}=\mu_{\text{eff}}/\mu$, $C_\mu\approx 100$. If the equation (4) is differentiated, it can be analyzed correctly how the transport of efficient turbulent would change according to the efficient Reynolds number.

And the inverse number of the turbulent is as follows.

$$\left|\frac{\alpha-1.392\,9}{\alpha_0-1.392\,9}\right|^{0.632\,1}\left|\frac{\alpha+2.392\,9}{\alpha_0+2.392\,9}\right|^{0.367\,9}=\frac{\mu_{\text{mol}}}{\mu_{\text{eff}}} \quad (5)$$

where, $\alpha_0=1$, under the condition about higher Reynolds number ($\mu_{\text{mol}}/\mu_{\text{eff}}\ll 1$) $\alpha_E=\alpha_\varepsilon\approx 1.393$ is provided.

In RNG "$E-\varepsilon$" R_ε term is added to ε-equation.

$$R_\varepsilon=\frac{C_\mu\rho\eta^3(1-\eta/\eta_0)}{1+\beta\eta^3}\cdot\frac{\varepsilon^2}{E} \quad (6)$$

where $\eta\equiv S_E/\varepsilon$, $\eta_0=4.38$, $\beta=0.012$.

Using the equation (9), ε-equation is also written is as follows.

$$\frac{\partial}{\partial t}(\rho \varepsilon)+\frac{\partial}{\partial x_i}(\rho \varepsilon u_i)=\frac{\partial}{\partial x_j}\left(\alpha_\varepsilon \mu_{\text{eff}}\frac{\partial \varepsilon}{\partial x_j}\right)+C_{1\varepsilon}\frac{\varepsilon}{E}(G_E+C_{3\varepsilon}G_b)-C^*_{2\varepsilon}\rho\frac{\varepsilon^2}{E} \quad (7)$$

where $C^*_{2\varepsilon}$ is calculated as

$$C^*_{2\varepsilon}\equiv C_{2\varepsilon}+\frac{C_\mu\eta^3(1-\eta/\eta_0)}{1+\beta\eta^3} \quad (8)$$

In the region of the big transformation velocity R term is a minus, $C^*_{2\varepsilon}$ is smaller than $C_{2\varepsilon}$.

Thus, in the rapid transformation flux the turbulent viscosity of the RNG "$E-\varepsilon$" is smaller, more completed result than standard model "$E-\varepsilon$" is given.

2.2. The microclimatic numerical model "ENVI-Met"

In the research on the local scale, climate the method based on the numerical simulation is more useful than observation [5].

The numerical simulation solves a number of the questions in analyzing complicated atmosphere phenomenon.

These models vary according to its scale, the physical base, and the time and space resolution. The principle and method of numerical calculation based on the non-static microclimatic model "ENVI-Met" is as follows.

2.2.1. The average flux field

In this model, we can obtain the three-dimension stream field by the non-static and non-compressible Navier-Stokes equation of Boussinesq approximation form and equation of continuity.

$$\left.\begin{aligned}
&\frac{\partial u}{\partial t}+u_i\frac{\partial u}{\partial x_i}=-\frac{\partial p'}{\partial x}+K_m\left(\frac{\partial^2 u}{\partial x_i^2}\right)+f(v-v_g)-S_u\\
&\frac{\partial v}{\partial t}+u_i\frac{\partial v}{\partial x_i}=-\frac{\partial p'}{\partial y}+K_m\left(\frac{\partial^2 v}{\partial x_i^2}\right)-f(u-u_g)-S_v\\
&\frac{\partial w}{\partial t}+u_i\frac{\partial w}{\partial x_i}=-\frac{\partial p'}{\partial z}+K_m\left(\frac{\partial^2 w}{\partial x_i^2}\right)+g\frac{\theta(z)}{\theta_{ref}(z)}-S_w\\
&\frac{\partial u}{\partial x}+\frac{\partial \upsilon}{\partial y}+\frac{\partial w}{\partial z}=0
\end{aligned}\right\}\tag{9}$$

where i =1, 2, 3, $u_i=(u, v, w)$, $x_i=(x, y, z)$, f is Coriolis parameter, p' is the pulsation component of the atmosphere pressure, θ is the potential temperature.

θ_{ref} is the temperature reflecting the average state of medium scale, and so we can calculate as first dimension model. S_u, S_v, S_w are the terms on local source and disappearance, and mean the effects of vegetation on wind velocity.

$$S_{u(i)}=\overline{\frac{\partial p'}{\partial x_i}}=c_{d,\,f}\mathrm{LAD}(z)\cdot W\cdot u_i \tag{10}$$

where $W=(u^2+v^2w^2)^{1/2}$ means the average wind velocity in height z, $\mathrm{LAD}(z)$ means the leaves area of vegetation index($\mathrm{m}^2/\mathrm{m}^3$) in height *z*, $c_{d,\,f}$ means coefficient of the physical friction on the plant area.

2.2.2. The turbulent course

The transport equation on kinetic energy of the turbulent E and its dissipation velocity used this model is as follows.

$$\left.\begin{aligned}
&\frac{\partial E}{\partial t}+u_i\frac{\partial E}{\partial x_i}=K_E\left(\frac{\partial^2 E}{\partial x_i^2}\right)+P_r-Th+Q_E-\varepsilon\\
&\frac{\partial \varepsilon}{\partial t}+u_i\frac{\partial \varepsilon}{\partial x_i}=K_\varepsilon\left(\frac{\partial^2 \varepsilon}{\partial x_i^2}\right)+c_1\frac{\varepsilon}{E}P_r-c_3\frac{\varepsilon}{E}Th-c_2\frac{\varepsilon^2}{E}+Q_\varepsilon
\end{aligned}\right\}\tag{11}$$

where $c_1 = 1.44$, $c_2 = 1.92$, $c_3 = 1.44$.

P_r and Th that are creation and annihilation term of turbulent energy by the wind swerve and thermosphere can be obtained as follows.

$$P_r = K_m \left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_i}{\partial x_i} \right) \frac{\partial u_i}{\partial x_j} \ , \quad Th = \frac{g}{\theta_{\text{ref}}(z)} K_h \frac{\partial \varepsilon}{\partial z} \tag{12}$$

$\theta_{\text{ref}(z)}$ is the potential temperature on the influx boundary. Under the stability condition Th would be ignored.

Q_E and Q_ε indicate the degree of turbulent is generated around plant corpus.

$$\begin{aligned} Q_E &= c_{d,\,f} \text{LAD}(z) \cdot W^3 - 4c_{d,\,f} \text{LAD}(z) \cdot |W| \cdot E \\ Q_\varepsilon &= 1.5 c_{d,\,f} \text{LAD}(z) \cdot W^3 - 6c_{d,\,f} \text{LAD}(z) \cdot |W| \cdot \varepsilon \end{aligned} \tag{13}$$

$c_{d,\,f}$ is the coefficient of friction on the surface of the leaf, W is the wind velocity in the viewing height.

In the second equation (13) ε is obtained by Kolmogorob relational expression ($\varepsilon = 0.16 E^{3/2} / l$).

From the calculated $E - \varepsilon$ field we can obtain the coefficients of turbulent exchange under isotropy assumption of local turbulent.

$$K_m = c_\mu \frac{E^2}{\varepsilon}, \ K_h = K_q = 1.35 K_m , \ K_E = \frac{K_m}{\sigma_E}, \ K_\varepsilon = \frac{K_m}{\sigma_\varepsilon} \tag{14}$$

where $c_\mu = 0.09,\ \sigma_E = 1,\ \sigma_\varepsilon = 1.3$.

To conquer the shortcomings of model forecasted too largely the turbulent on upper the boundary layer we have to use the result values of the one-dimension closure on the boundary surface.

2.2.3. The modeling of the plant

In the ENVI-met we think plant is not the simple obstruction on the wind and radiation, modeling it like the organism exchanges the temp and humidity with the circumstances (Fig. 1, 2).

In the model plant consists of the one-dimension row data according to the height. That is, we divided equally into 10 blocks according to the plant height, and input the value of density of the leaf area at every point.

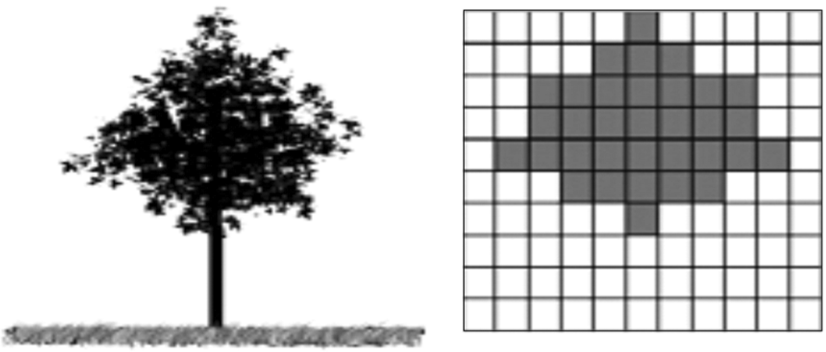

Fig. 1. plant factor constitution on the leaf area density

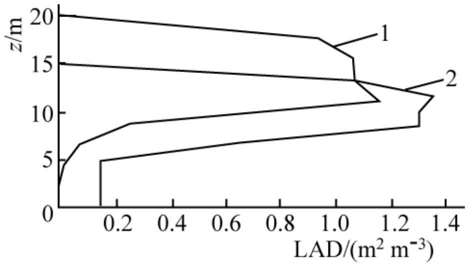

Fig. 2. Vertical distribution of the leaf area density
1－larch tree 20m, 2－an alder tree

The leaf area density (LAD) is decided by the ratio of the leaf area to a unit volume in the space of plant (m^2/m^3).

Also, the characteristics whether it is the broadleaf or coniferous, the air resistance of the leaf area, reflection level, and so on are in taken.

Using the microclimatology model to the regarding region we have experimented the simulation to estimate the windbreaks effect of the strips.

3. The Numerical Simulation of the Windbreaks Effects using “ENVI-Met”

In this paper we use microclimatic model “ENVI-Met” and had experiment numerical simulation of the windbreaks effect on research region.

3.1. Initial setting data and the result to calculate the windbreaks effect

3.1.1. Initial setting data

We simulate the windbreaks effects according to the structure of the strips in case of that zone of the strips lied is plain and the strips are vertical with the wind direction (Fig. 3).

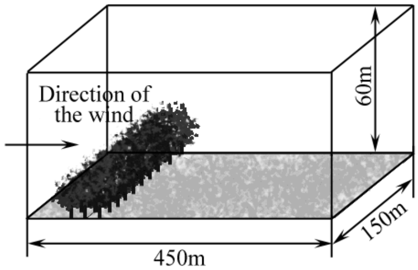

Fig. 3. Setting up of the simulation calculation zone

The environmental setting of the model for calculation is as follows.

① Setting up the strips

Height of the strips 20m, the width of the strips 10m, the death of the strips 2m, the leaf area density (LAD) · 0.473m^2/m^3, the root area density 0.1m^2/m^3.

② Environment setting up

The wind velocity 10m/s, the air temp 293K, air humidity 50%, the soil temp 293K, the surface rough height 0.05m.

③ Setting of the calculation net

The size of the calculation district 450m×150m×60m, Number of the lattice 90×30×20, the size of the lattice 5m×5m×3m, the number of the buffer net 3.

3.1.2. Results on the calculation of the wind field around the strips (Fig. 4－6)

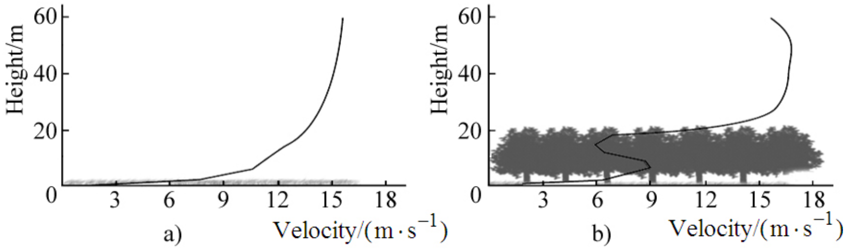

Fig. 4. Average wind velocity distribution on each height
a) Unsheltered area, b) Inside of the strips

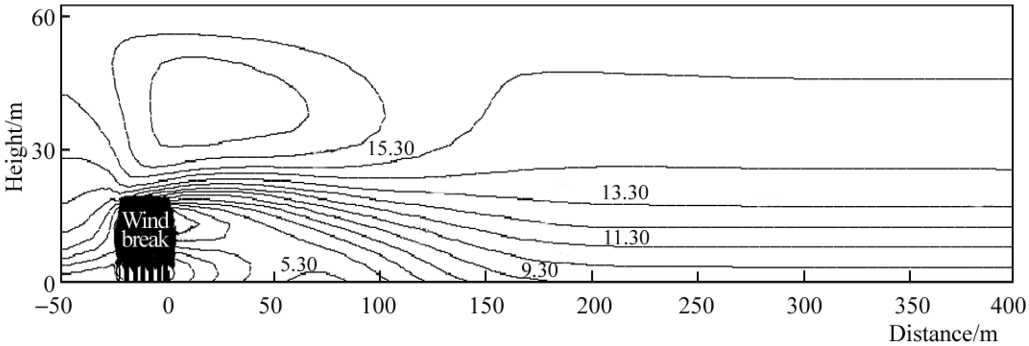

Fig. 5. Isarithm on the wind velocity(m/s) around the strips

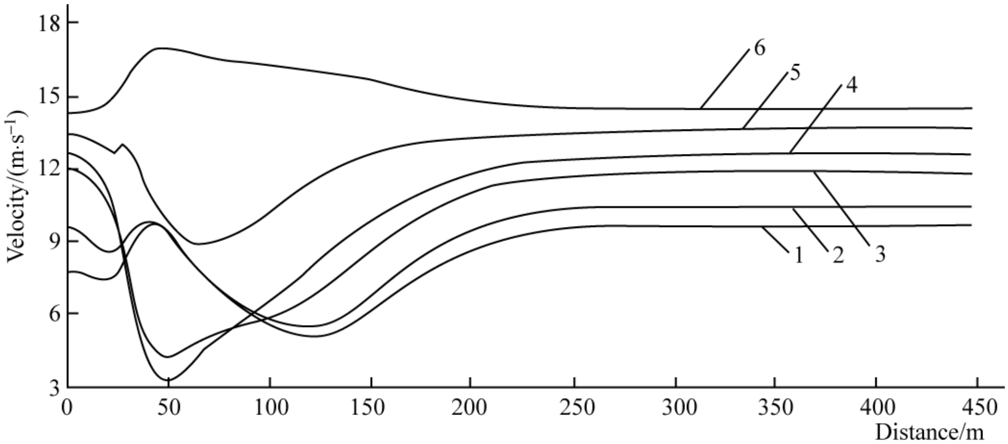

Fig. 6. Wind velocity distribution classified by the height behind of the strips
1－6 Height from ground surface 1, 6, 10, 15, 20, 30m

3.1.3. Result on the calculation effect of the protection against classified by the strips height

We had set up the various heights of the strips in case of the strips with 5m in width, the surface rough 0.05m, and calculated the recovery rate of the wind velocity behind the strips (Fig. 7).

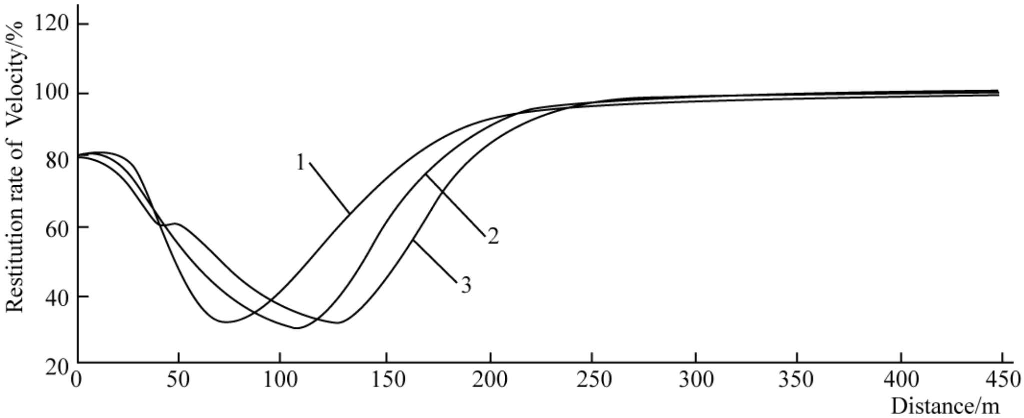

Fig. 7. Effect of a windbreak classified by the height
1－3 Height of windbreaks 10, 15, 20m

3.1.4. Wind distribution classified by the width of the strips (Fig. 8)

In case that the height of the strips is 15m, the wind velocity is 10m/s, the height of the surface rough is the 0.05m, we calculated the wind field according to vertical structure of the strip.

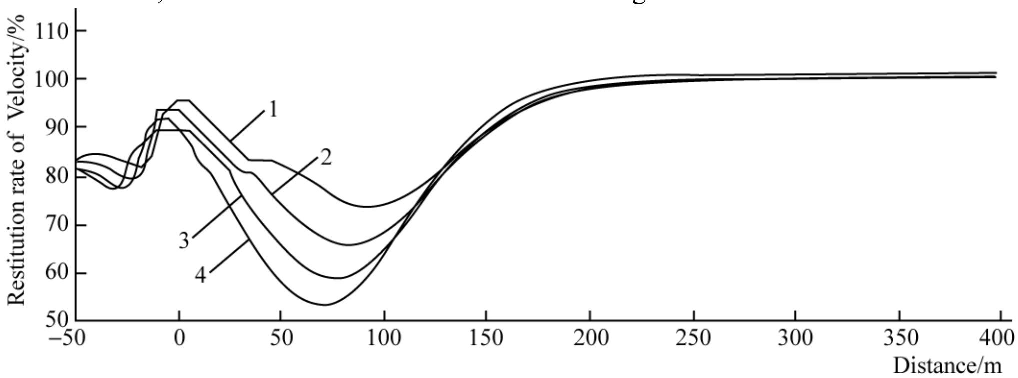

Fig. 8. Effect of a windbreak classified by the width of the strips
1, 2, 3, 4—Width of windbreaks 5, 10, 15, 20m

3.1.5. Wind distribution classified by the vertical structure of the strips (Fig. 9—11)

In case that the height of the strips is 15m, the wind velocity is 10m/s, and the height of the surface rough is the 0.05m, we calculated the effect of the windbreak classified by the vertical structure of the strips.

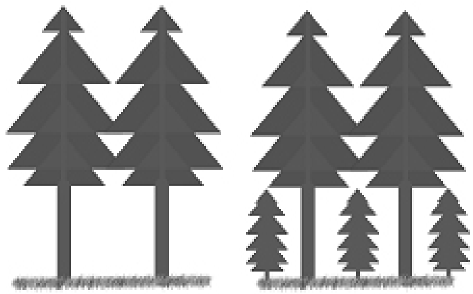

Fig. 9. the vertical structure of the strips
a) Downdraft shaped windbreak,
b) Non-downdraft shaped windbreak

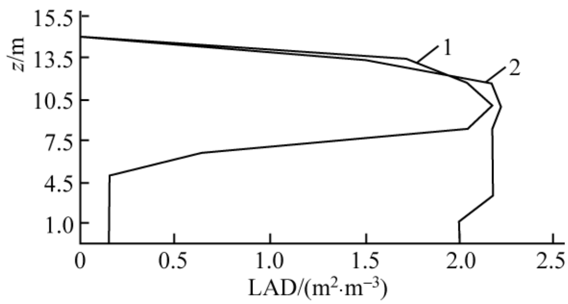

Fig. 10. Distribution of the leaf area density classified by the vertical structure of the strips
1—Downdraft shaped windbreak, 2—Non-downdraft shaped windbreak

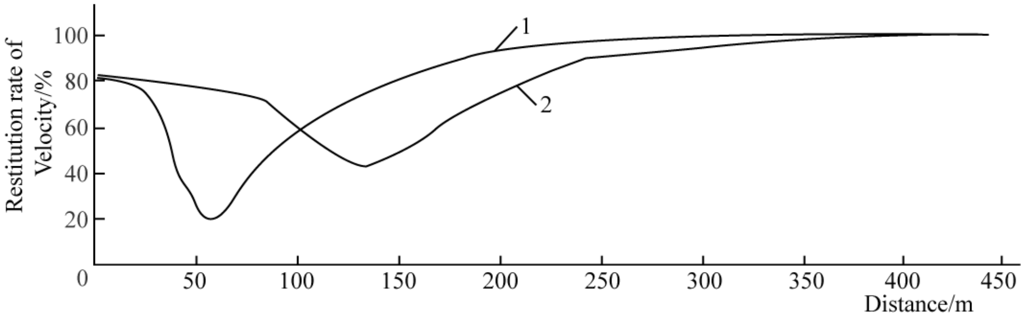

Fig. 11. Effect of the windbreak according to the vertical structure of the strips
1—Downdraft shaped windbreak, 2—Non-downdraft shaped windbreak

3.2. Estimation on the effect of the windbreak of the strips in special case

Generally, the grassland is not a plane, but a complex form of the land, and the wind direction is always out of plumb with the direction of the windbreaks distribution.

3.2.1. In case an angle between the major wind direction and the strips is an acute one

If you need to increase the windbreak effect of the windbreaks, you have to distribute it along a ridge.

But when the distribution direction of a ridge is out of plumb with the major wind direction and have an acute angle to it, the windbreaks distributed along a ridge form an acute angle with the major wind direction.

The effect on the windbreak of the windbreaks is varied by this angle, and thus we have to decide the space between the strips correctly.

When the strip width is 20m, the strips height is 12m, the draft level is 30%, wind velocity is 18m/s, the surface rough rate is 0.01m, the calculating results of windbreak effect according to the angle between the major wind direction and the strips are same as table 3.

Table 3. Windbreak effects calculation according to the angle between the major wind direction and the strips

No.	Angle /(°)	Wind velocity at several at position/m.s^{-1}			Mean wind velocity in several section/m.s^{-1}		
		100m	200m	300m	0～100 m	100～200 m	200～300 m
1	90	2.4	7.1	11.5	2.3	3.5	9.5
2	80	2.3	7.2	11.6	2.3	3.6	9.8
3	70	2.0	7.8	12.1	2.3	3.8	9.9
4	60	1.6	8.6	12.8	2.3	4.0	10.8
5	50	0.8	10.0	13.7	2.2	5.0	12.1
6	45	3	11.8	14.7	2.1	8.6	13.8

As you can see, in case of 90°, 80° and 70°, mean velocity of 200m to 300m, with the greatest velocity never exceeds 6th-grade.

From this point of view, we recognize that the windbreak effect on the vertical angle merely changes even when the windbreaks forms 70° with the major wind direction.

3.2.2. Wind distribution on the slide

In case the strips height is 12m, the strips width is 20m, the strips draft level is 30%, the wind velocity is 16m/s and the surface rough degree is 0.01m, the calculation result on the windbreak effect according to angle of inclination are same as Fig. 12, 13.

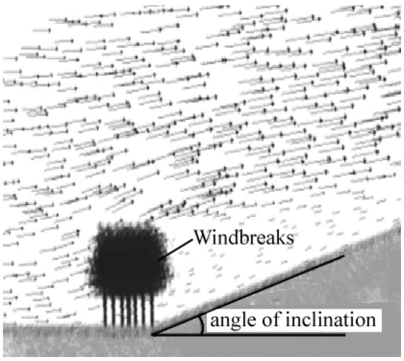

Fig. 12. Wind field of the strips around the slide

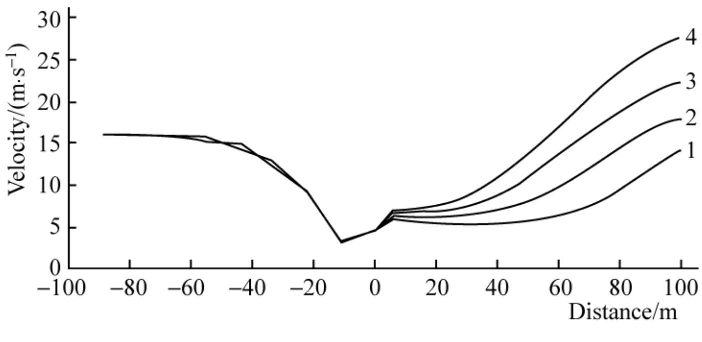

Fig. 13. Wind distribution curved line according to the slide angle
1, 2, 3, 4—angle of inclination 15, 20, 25, 30°

3.2.3. Wind distribution on the concave landform

In experiment, when the distance between a ridge is 500m, and the furrow depth is 10, 20, 30, 50m, we analyzed the effect of windbreaks (Fig. 14).

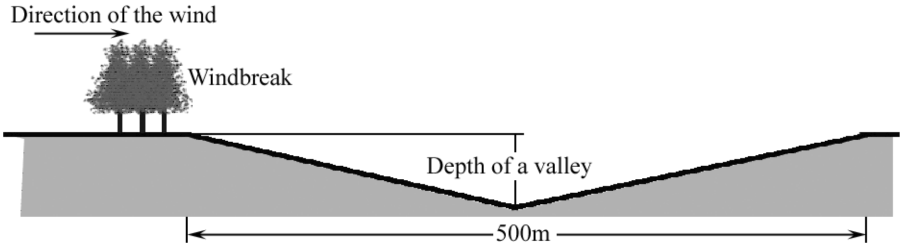

Fig. 14. Topographical accident used in the simulation

Table 4. Result of the calculation on windbreak effect in the concave land

Height /m	Position/m			
	300	400	500	300～500
Plane	11.0	13.0	13.5	13.8
10	10.0	12.5	14.0	11.5
20	2.5	11.0	16.5	9.7
30	1.0	6.0	18.0	8.7
50	2.0	4.0	19.0	8.5

In case the height of the strips is 12m, the width of the strips is 20m; the wind velocity is 18m/s, the wind distribution according to the volley deep behind the strips are same as table 4.

As you can see in table 4, while the volley deep is 10m, in the block of 300m to 500m the mean wind velocity is 12.5m/s, and thus we do not need to distribute the support windbreaks.

3.3. Wind distribution in the research region

In the research region "ㅅ", for the windbreaks distribution we simulated the wind distribution field classified by the major wind direction numerically.

3.3.1. Making the calculation district net (Fig. 15, 16)

The size of the calculation district: 2.5km×2.5km×500m

The discrimination of the DEM data: 17m

The net discrimination: 100m×100m×10m, The number of the factor: 250×250×50.

The net pattern: 3-gon (tetrahedral net)

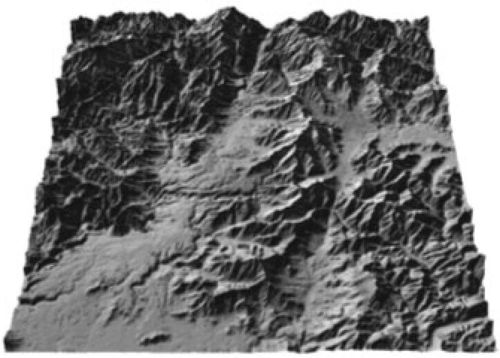

Fig. 15. Topographical accident of the research region

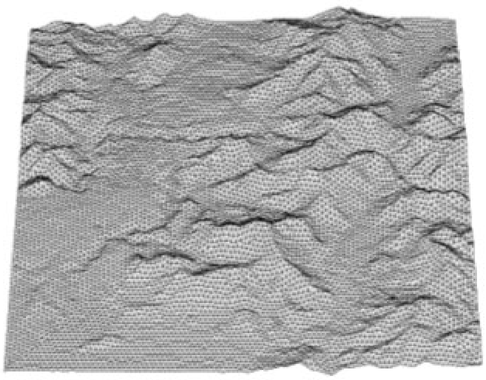

Fig. 16. Net formation in the calculation district

3.3.2. Setting up for the calculation on numerical simulation

① Setting up interpretation.

Solver: Pressure Based, Space: 3D, Formulation: implicit scheme, Time: normalcy course, Gradient option: Green-Gauss Cell Based

② Setting up turbulent flow model

Model: k-epsilon, k-epsilon Model: Standard, Near-Wall Treatment: Standard Wall Functions, Model Constants: C_{mu} =0.09, C1-Epsilon=1.44, C2-Epsilon=1.92, TKE Prandtl Number=1

③ Setting up medium

Density: constant: (1.225kg/m^3); Viscosity: 1.789×10^{-5}

④ Boundary condition

Surface boundary condition: Wall boundary, Roughness Height=0.1m

Entrance condition: Velocity-inlet (19m/s). Exit condition: pressure-outlet

Aberration limits: velocity: 0.001m/s, k: 0.000 1, epsilon: 0.000 1

3.3.3. Result of simulations (Fig. 17－19)

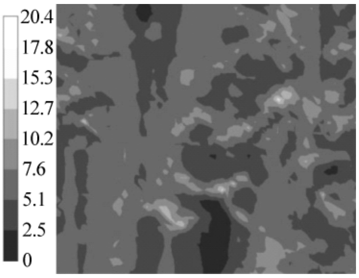

Fig. 17. When Northern wind blows, a wind velocity isopleth field

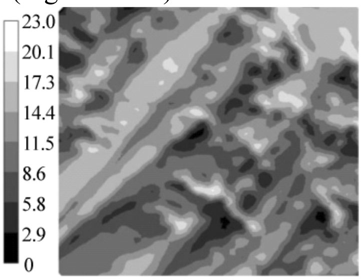

Fig. 18. When Northern east wind blows, a wind velocity isopleth field

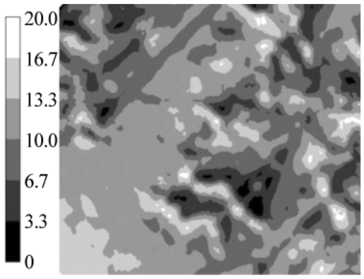

Fig. 19. When Southern west wind blows, a wind velocity isopleth field

The grass distribution status of the research region is as follows (Fig. 20).

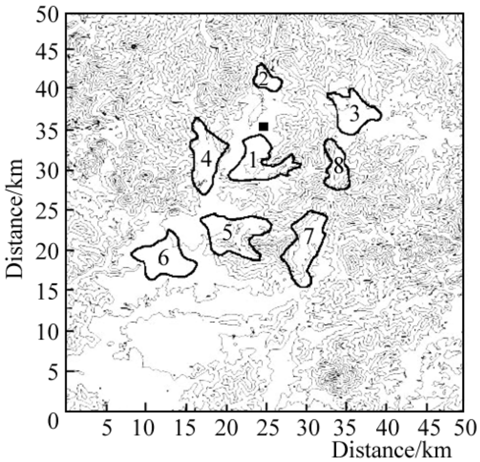

Fig. 20. Grass distribution plan in the regarding region

1－8 grass number, thick line: grass boundary, thin line: contour line, ■-meteorological observatory

The wind velocity classified by the grass district are same as table 5.

Table 5. Wind velocity classified by grass district.

Grass district	Wind velocities/($m\cdot s^{-1}$)			
	Northern	Northern east	Southern west	mean
1	19.3	21.2	20.2	20.2
2	21.8	18.5	18.3	19.5
3	17.3	18.8	18.2	18.1
4	18.2	17.8	16.5	17.5
5	19.2	20.5	19.5	19.7
6	17.8	20.2	19.8	19.2
7	18.5	19.8	16.3	18.2
8	18.8	20.0	15.3	18.0

The wind velocity calculated in each grass district is more than 6 levels, and we have to form the windbreaks well.

Table 6. Windbreak effect distance of the strips classified by the grass district

Grass district	Wind velocity /(m·s^{-1})	Effect distance of the strips/m	Grass district	Wind velocity /(m·s^{-1})	Effect distance of the strips/m
1	20.2	311.0	5	19.7	303.8
2	19.5	300.8	6	19.2	296.2
3	18.1	279.2	7	18.2	280.7
4	17.5	269.9	8	18.0	277.6

From here, we can know that the distance between the each strip in the research region is 300m.

Because the topographic accident is different in each grass district, their wind distribution feature appears variously.

3.3.4. Wind field calculation in the grass district No. 1

The result of the numerical simulation on wind field classified by major wind direction is as follows (Fig. 21－23).

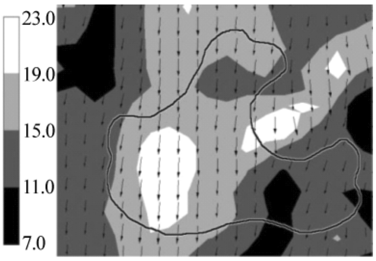

Fig. 21. Wind velocity isopleth In the northern wind

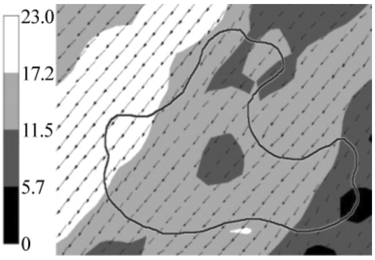

Fig. 22. Wind velocity isopleth field under northern east wind

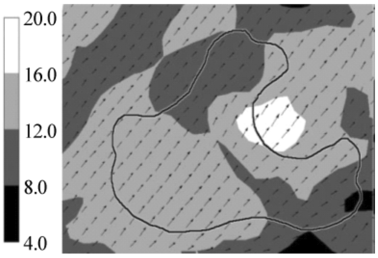

Fig. 23. Wind velocity isopleth field under southern west wind

3.3.5. Wind field calculation in the grass district No. 2 (Fig. 24－27)

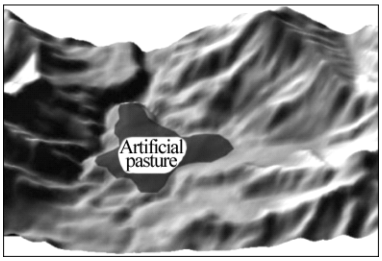

Fig. 24. Topographic accident in the grass district No. 2

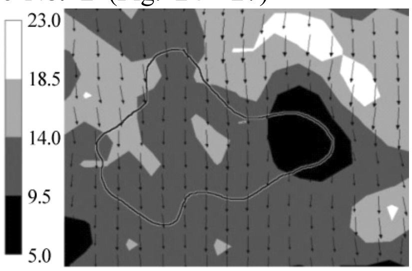

Fig. 25. Wind velocity isopleth field under northern wind

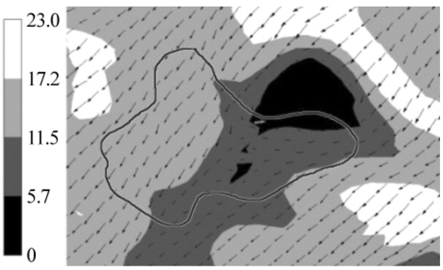

Fig. 26. Wind velocity isopleth field under the northern east wind

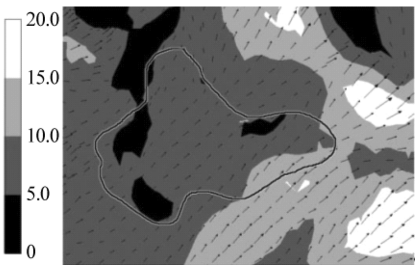

Fig. 27. Wind velocity isopleth field under the southern west wind

3.3.5. Wind distribution pattern in the grass district

From the calculation result the windbreaks distribution in the grass district are same as Fig. 28, 29.

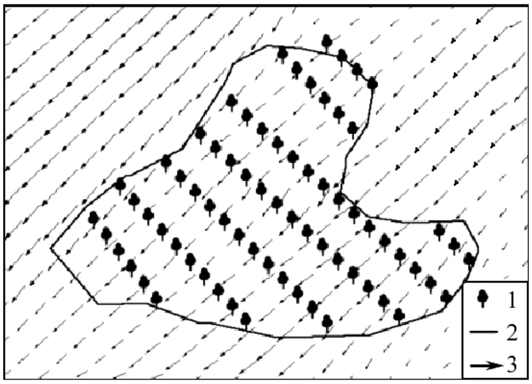

Fig. 28. Windbreaks distribution plan considered the topographical conditions in the grass district No. 1 (Northern east wind)
1－main windbreaks, 2－boundry of grass district, 3－vectors of wind velocities,

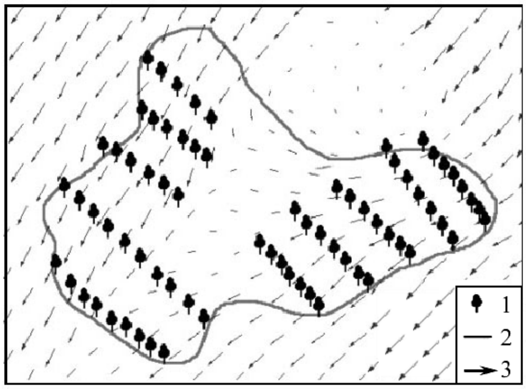

Fig. 29. Windbreaks distribution plan considered the topographical conditions in the grass district No. 1 (Northern east wind)
1－main windbreaks, 2－boundry of grass district, 3－vectors of wind velocities,

Conclusion

In this paper, we analyzed the characteristic of maximum probability wind velocities and calculated maximum wind velocity of 1% probability is 20m/s for design windbreaks in table highland. We also suggested “$E-\varepsilon$” turbulence-closure model for simulate wind fields in the windbreaks disposition and we gained wind distribution fields in the research region, then assumed dispositions of windbreaks by major wind direction and wind velocity isopleth field under the conditions. As you can see in this paper we provided meteorological foundations for maximum effect of windbreaks in the table highland.

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