SMOG SIMULATION OF THE AIR STREAMS IN DEEP CUTTINGS

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1. Abstract

The air flow near Earth surface might be observed by both qualitative and quantitative methods. Quantitative measurements are extremely important for structural design, giving fit information regarding wind stress or speed, and also about the amount of snow in turbulent diffusion.

Nevertheless, we still find an interest concerning the qualitative methods, especially for the wind streams very close to the Earth surface. This approach is quite important for the road designers, because quite often is very difficult to find the right alignement without any prior study in wind tunnel, in order to avoid problems that often occurs in winter for certains road sections.

At the Faculty of Civil Engineering of Iasi one realized some tests of smog simulation of the air streams for roads.The goal was to make appears the « self-cleaning streams », that usually occurs in the case of deep cuttings, streams that avoid the snowing up of such a cross section by a continous circular move of the snow. Rigid models have been done, for cut deep from 3 to 10 meters, at a scale of 1/100. The value of scale has been choosen in oder to make possible comparaisons with similar tests performed in wind tunnels using glass beads.

In order to perform the tests, a smog generator using paraffin was create. Pictures in dark have been also taken for every model.

2 Generalities

The air streams on the earth surface can be followed qualitative and quantitative methods.

Quantitative methods are mainly important especially for struture design for wind loadings, giving specific information about air pressure or speed, and also, for particular studies, about quantities of snow in air turbulent diffusion.

On the other hand, researh on wind effects on structures showen up different methods to bring to the fore, by qualitative methods, the turbulent flow of the air in boundary layer. For the road design, the importance of this approach it is proved by the fact that, in many occasions, designer should chose different sollutions of longitudinal road profile or cross section without previous studies in wind tunnels. This type of study couls largely anticipate the behaviour of different types of roads/highways during winter period.

Air stream viscosity in built environnement means one possibility to bring to fore some particularities of this phenomena, by qualitative means. This approach do not require high technology for recording and analizing datas.

Methods for air streams visualisation in the case of turbulences on boundary layer are largely used in wind tunnels all over the world. This visualisation might be done with smog, laser or powders., and recording could be done by taking pictures.

3. Air Stream Visualisation With Smog

The smog in an air stram is produced in a smog generator, equipment designed to supply a dense, non-toxic and non-floating smog.

In the Aerodynamic Laboratory at the Civil Enginner University in Iasi, Romania, the smog is obtained from paraffin (wax) oil.

The smog generator is shown in fig. 1.

In the equipment, the wax oil is taken by a stream of CO_2. The wax oil vaporize and, with constant pressure, is passing throgh a heating system, and goes on to the condensation box.

A compulsory condition is that the smog should not float. This has to be checked by longitudinal injection of the smog in the wind tunnel, without any vertical impulsion. More, one’s has to verify if smog spreading is totally horizontal.

The recording of air streams is done by taking picture in the dark. A special equipment allow the visualization of streams in the models (cross sections representative for deep cuttings, with deep from 4 to 10 meter)

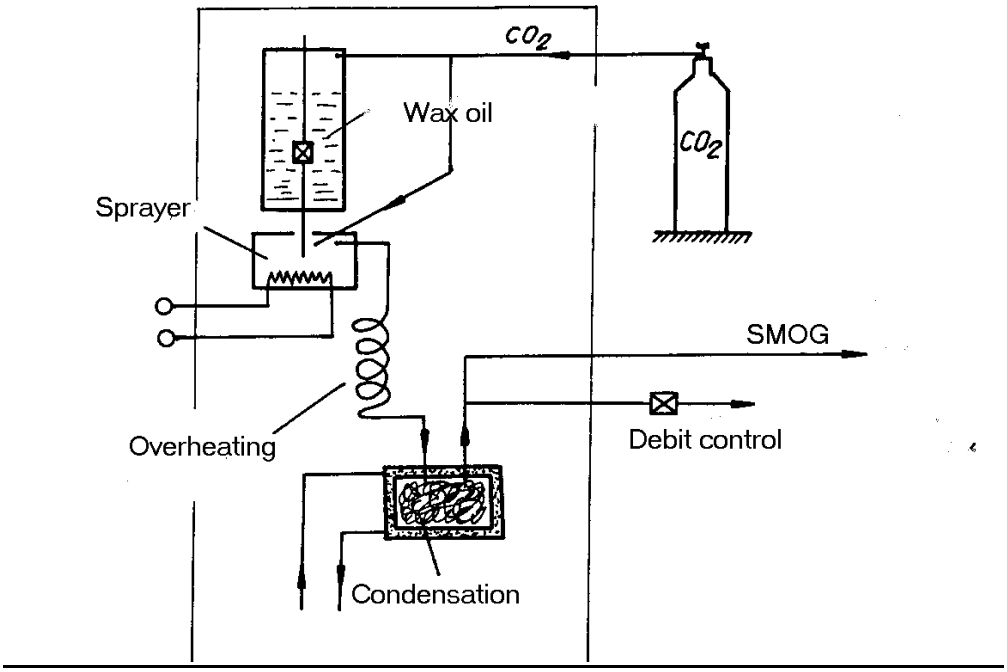


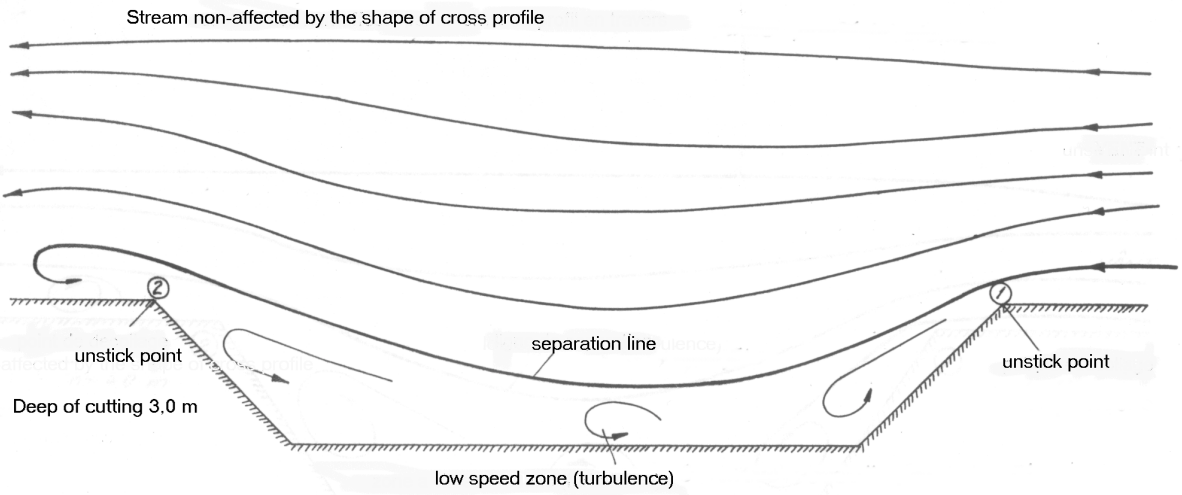
Fig. 1 – Smog generator

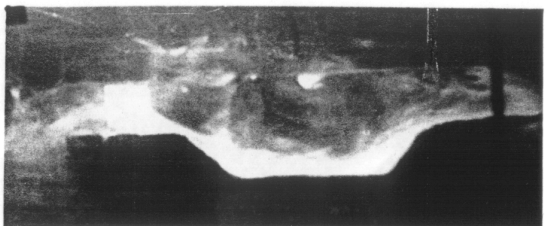
4. Visualization of Air Streams in Deep Cuttings

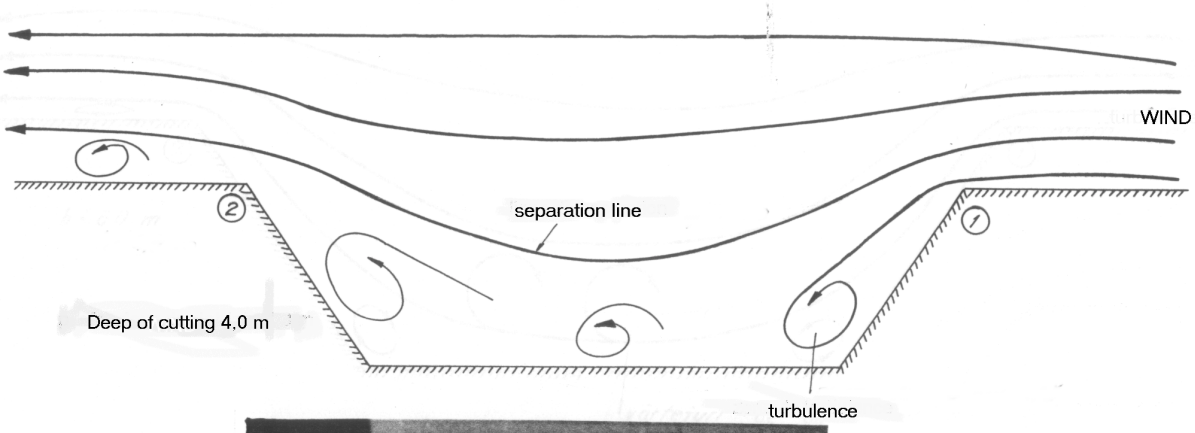
With the previous presented equipment, one's realized at the Civil Engineer University some vizualizations of air streams for the roads. We have tried to show the « self cleaning streams » for deep cuttings, streams that avoid the snowing for such cross section, by taking the snow in a permanent circular motion.

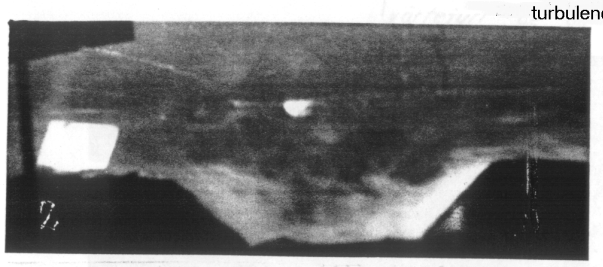
Fo this purpose, rigid models, 1/100 scale were done, deep of the cutting from 3 to 10 meter. The scale was chosen in order to make possible comparison with similar studies in wind tunnels using glass balls. The specific gravity of glass balls did not permit to show the circular strams, and the snowing of deep cuttings was similar with the snowing of cuttings of 1-2 meter.

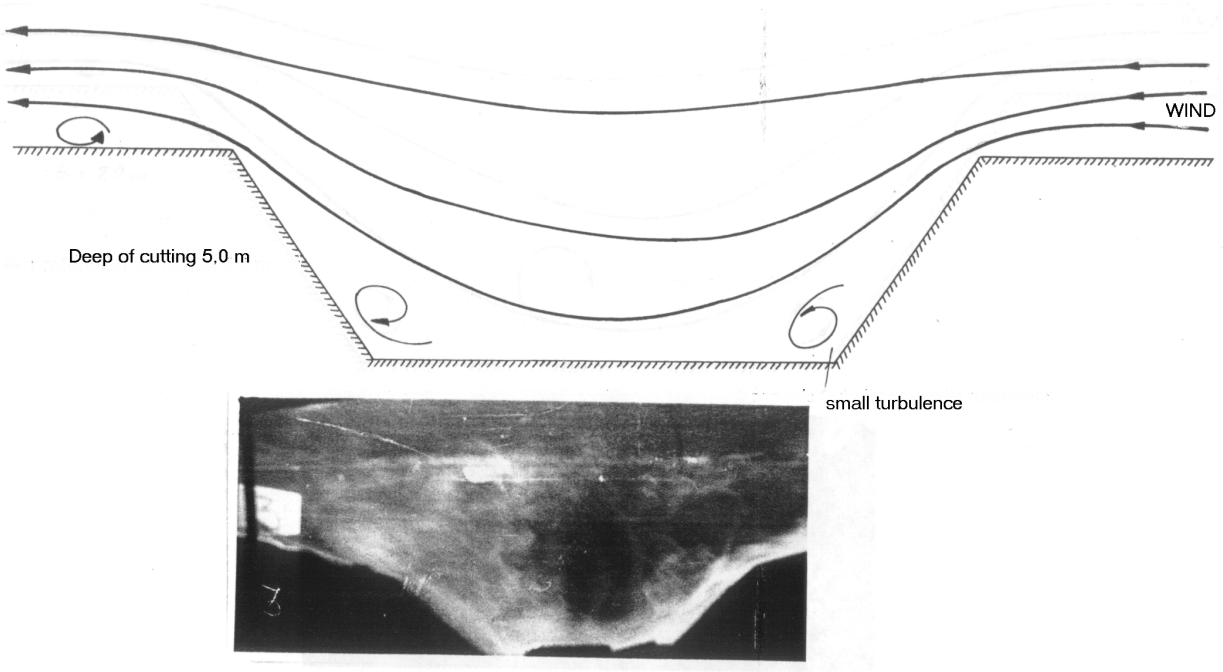
Hereafter, pictures taken for different deep and graphical considerations.

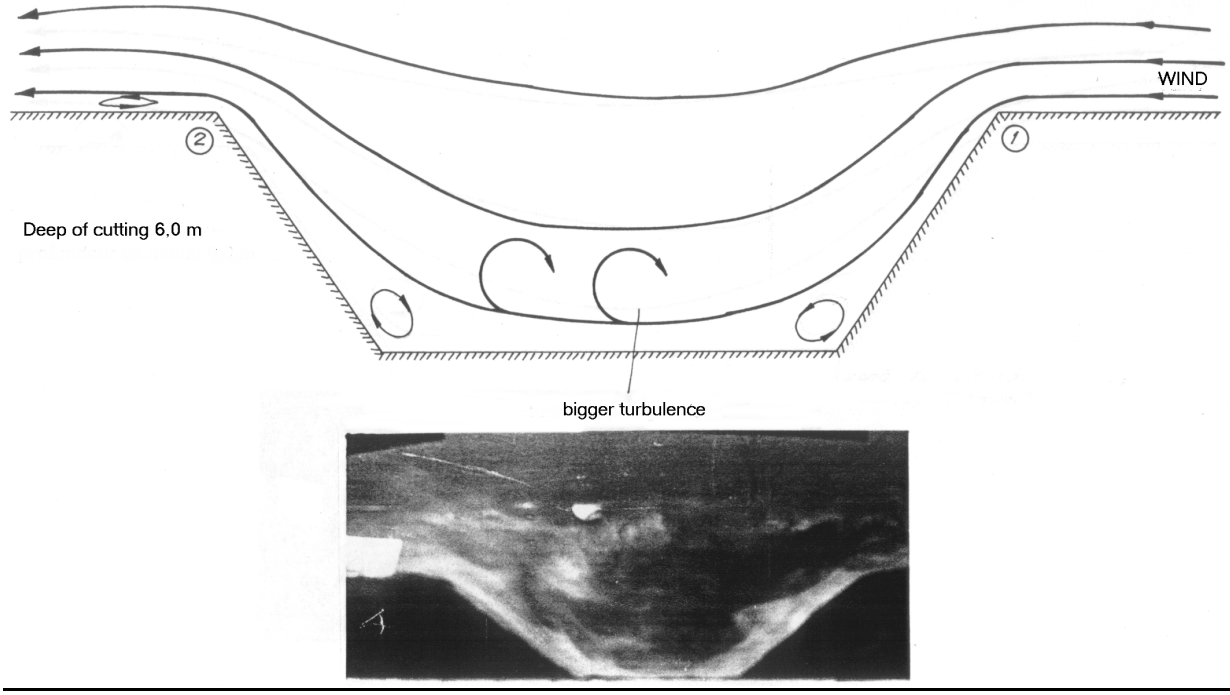

Stream non-affected by the shape of cross profile
2
1
unstick point
separation line
unstick point
Deep of cutting 3,0 m
low speed zone (turbulence)

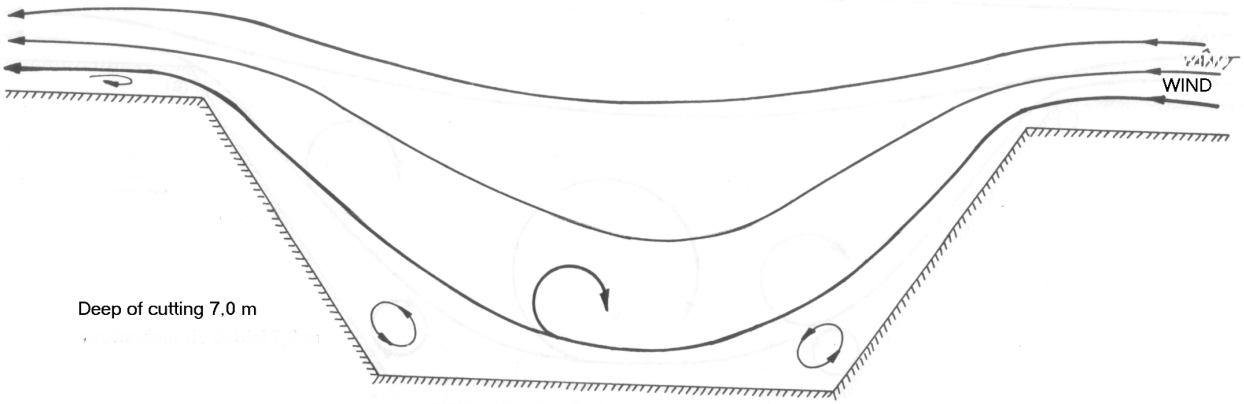



WIND
2
separation line
1
Deep of cutting 4,0 m
turbulence

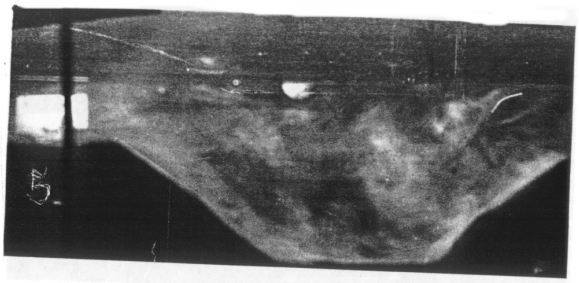


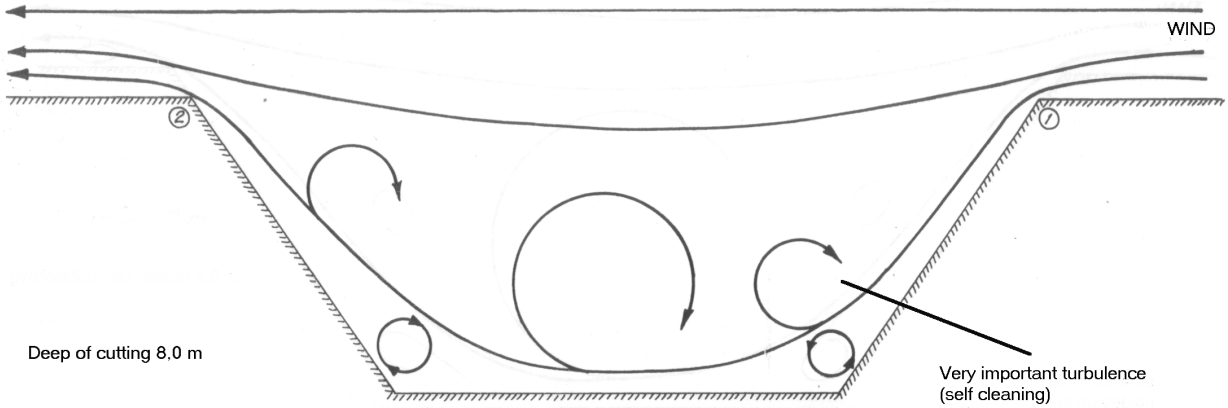

WIND
Deep of cutting 5,0 m
small turbulence


WIND
2
1
Deep of cutting 6,0 m
bigger turbulence



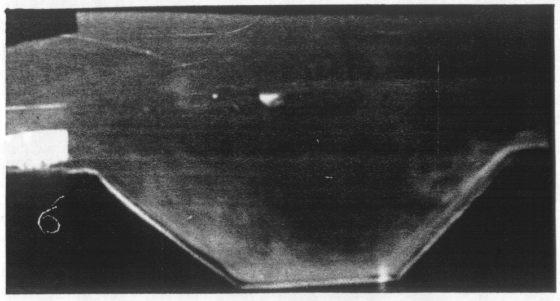
Deep of cutting 7,0 m

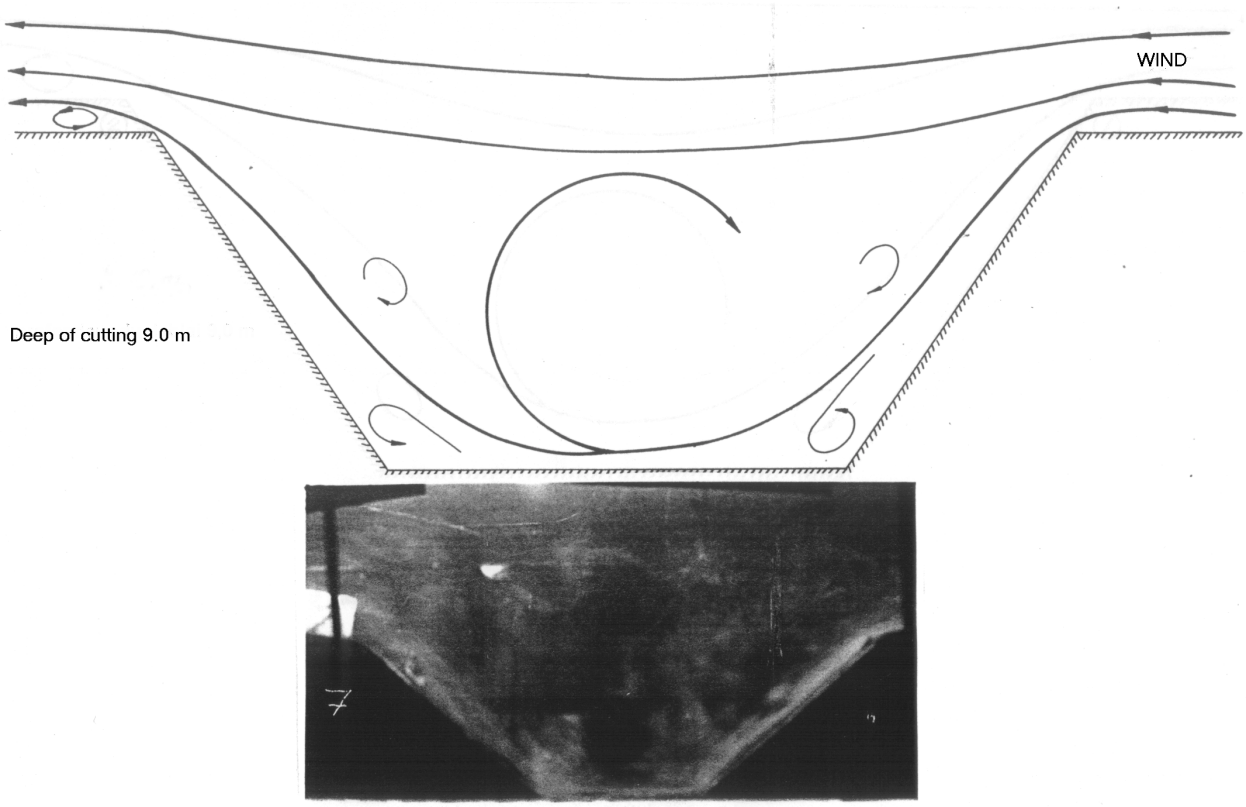


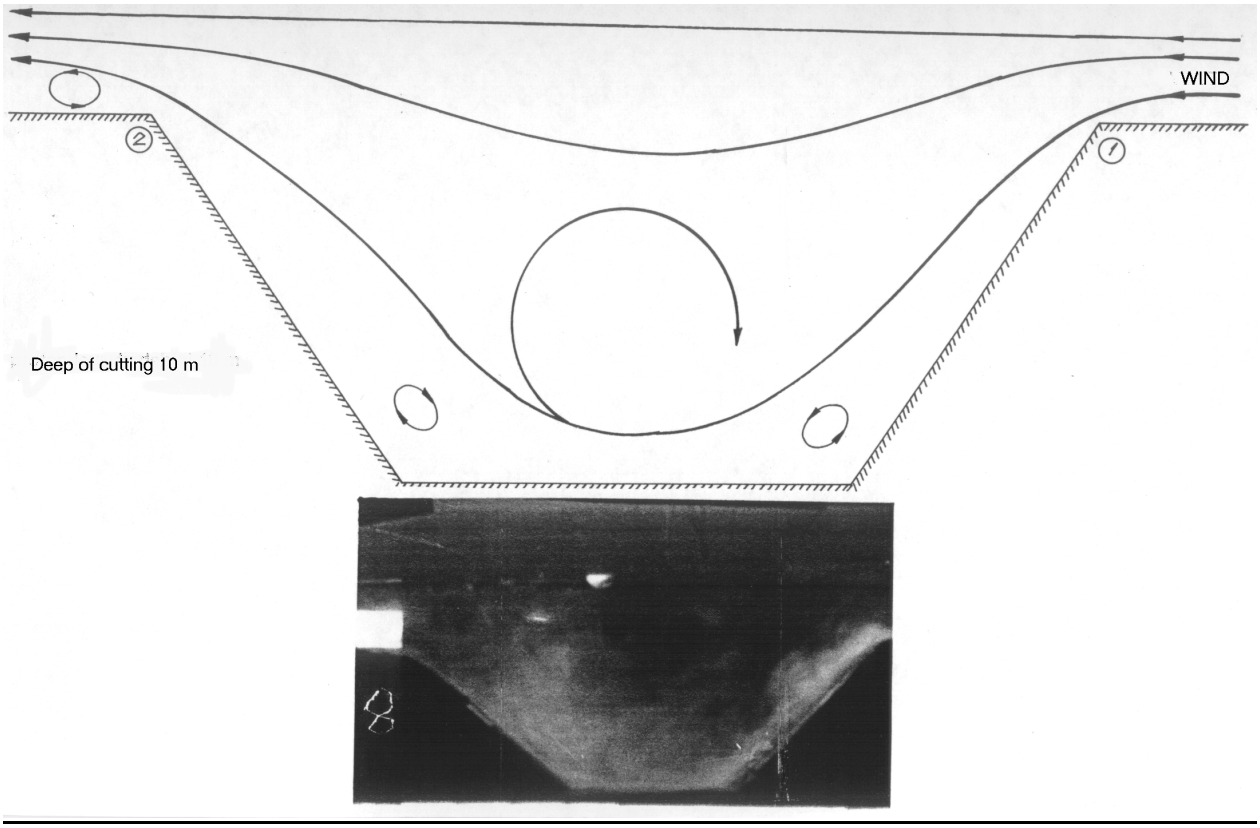


Deep of cutting 8,0 m

Very important turbulence
(self cleaning)




WIND
Deep of cutting 9.0 m
7


WIND
2
1
Deep of cutting 10 m
8

5. Conclusions

- For cuttings between 3-5 meter, the separation lines of the boundary layer unsticked on point no.1 are going down to the road axis, and are going up on the slope to finnally create a new boundary layer in the point no. 2. Under the separation line there is turbulence due to the decrease of the air speed, and the snow lay on the road surface. The main quantity of snow lay laterally, because the thickness of the boundary layer is more important in these areas. The snow deposit is not similar in the both sides of the road.
- Increasing the deep of the cutting, the separation line for the boundary layer unstucked on point no. 1 is going down to the road surface, producing circular currents transporting the snow to the edges. This phenomena is quite clear startin with 7 meter deep.
- If the deep is more important, the main circular stream will increase it’s volume, and the snow transportation to the edges of the road becomes higher and higher.
- It is generally accepted that the « self cleaning streams » occurs for cuttings of 10 meters deep or more. By the mean of smog simulation in wind tunnel, we show that this phenomena should be considered starting from 7-8 meters deep.