The Intense Rain and its Contribution to the Collapse of the Embankment at the Highway GO-213 of the city of Caldas Novas, in the State of Goias: a Contribution to the Studies of erosive dynamics.

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INTRODUCTION

One of the great changes which occurred in the social organization of this century was the accelerated growth of the cities. This unorganized growth caused serious problems in the urban space, mainly environmental impact caused by the urbanization, such as allotments, impermeabilization and others. With the increase of the level of urbanization there is a proportional increase in the environmental degradation due to the concentration of the population in the urban areas, as asserted by DEL GROSSI (1991):

"The 60´s, 70´s and 80´s were a time of various economic and political decisions which encouraged the great expansion of the urban district. (...) As a result of this expansion, geomorphologic processes were altered, and, in consequence, floods, ravines, landslides called "voçorocas", and collapses became problems that affected the whole community.

Besides the losses related to the degradation of the natural vegetation, causing thermal discomfort and disharmonic landscape, we also have the fleeing of the local "fauna", and the interference in the dynamics of the urban hydrographic micro basins, which has as a main consequence the development of hydric erosion like ravines, landslides and lateral erosion.

In the mid-west region of Brazil, where this study took place, the situation is not very different from the national picture, except for some particularities.

The region started to draw national attention, mainly because of the Brazilian deconcentration movement, necessitated by the expansion of the agricultural border and reinforced by the relocation of the federal capital in the 50´s, to the central plateau region. Furthermore, it is necessary to stress that, although the population growth in the mid-west region was linked to a governmental strategy, it had extremely limited developmental reasons, once it was evident the lack of establishment of efficient projects for the development of the region, only projects for simply occupying the area.

The challenges presented to the development of the mid-west region are complex and are of proportional size to the challenges of the country itself, in the search for economic development. Such development has gained a new profile, especially with the importance of and concern with the so-called economic, social and environmental sustainability.

Characterization of the area being studied.

Caldas Novas, location of the largest hydrothermal source in the world, faces similar challenges. The accelarated population growth, as shown in CHART 1, which occurred in part a unorganized manner, and added to the lack of sanitary drainage necessary for the appropriate disposal of waste, is causing the degradation of the environmental quality of the flowing water and of the underground springs of the city, which could affect in the future the environmental, as well as the economic and social sustainability.

ANO	NÚMERO DE HABITANTES
1842	200
1960	5.200
1970	7.200
1980	9.800
1991	24.900
2001	49.652

Source: IBGE

In addition to the rapid growth of the urban population, combined with, a unorganized settlement of the land, the city faces other complex issues related to the economic development and to the environment. The growth of the city was determined mainly by the discovery of the hot waters, which on its turn promoted the development of tourism and of hotel complexes in the municipal district, bringing along, the development of other enterprises, such as services and commerce. In this sense, we have a complex, unique situation, which has a wide ranging effect, for the city of Caldas Novas possesses essentially all the problems present in the majority of the cities in the mid-west region, but; as its main economic activity stems from the use of a very important natural resource (hot waters), the problems reach a much greater level, due to the fact that social factors distort the real necessities of the city and the wat to satisfy these needs.

Caldas Novas is located in the south mesoregion of the State, and locally in the micro region of "Meia Ponte" river, with the coordinates 17° 28` to 18° 05` south latitude and 48° 27` to 48° 56` west longitude, its altitude varying between 520 and 1043 meters, and having a total area of 1,604 km², while its urban perimeter adds 268.8 Km²

In the region of Caldas Novas there are crystalline rocks associated with the Paranoá and Araxá Groups, besides the superficial covers of the tertiary. In a more regional context, they belong to the south part of the

strip of bending rocks and the Brasilia group. The Paranoá Group appears in "Serra de Caldas" mesa, forming a topographic enhancement and composed of metasediments, metasilts with subordinate marbles, metarenites e quartzite.

The schistose rocks (micaxistos) from the Araxá Group form a greater group in terms of exposure. A more quartzous, sequence of quartzite lenses, predominates in the near regions of the Rivers Corumbá and Pirapitinga. Covering "Serra de Caldas", there is a layer of a more sandy nature and of a reddish color. Coluvial deposits less present and aluvial deposits at the bottom of the valley occur sparsely.

The Intense Rain and The Collapse of the Highway GO 213: Some Comments

The fragility of the highway system and the precipitation that occurs during the rainy season have caused serious problems every year, mainly in those locations within or near the urban perimeters of the cities which, due to the accelerated increase in the population along with the changes caused to the environment, have been causing irreversible environmental damage. Thus, in consequence, the data indicate that, in succeeding years rain with equal intensity now has greater potential for impact and increased destruction in comparison to the rains of previous years.

In Caldas Novas, the rain which occurred mainly in the summer months, has been causing a lot of problems for its population. On January 17th, 2005, after a long period of rain, the embankment under highway GO-213 collapsed (Picture_1), taking the lives of three people. One of the hypothesis proposed out by the authorities to explain the causes of this accident was the great intensity of rain on the 17th. Nevertheless, the observation of the data on the precipitations, as well as the location of the collapse and its surroundings, reveal that not only these factors, but other

natural elements and human actions in the nearby environment have contributed to this catastrophe.

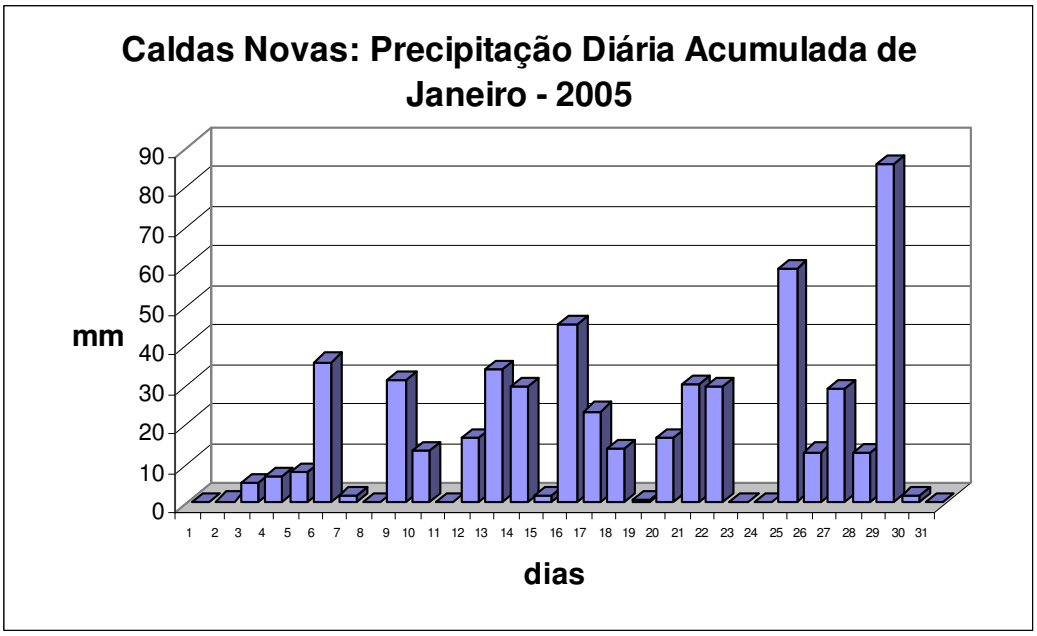
Picture 01_Open crater on the highway GO-213.
(Source: Journal O Popular)

The climate of Caldas Novas and, consequently the rain it produces, is classified, according to Köppen, as Aw, characterized as having a dry winter and a rainy summer, dominated predominantly by the inter-tropical and polar systems which spawn some of the most concentrated pluvial events, mainly in summer. In this season, the weather conditions over the city are controlled mainly by systems which produce instability, such as the Atlantic Polar Front (APF), The Tropical Instability Line (TI) and the Tropical Continental air mass (TC) responsible for the precipitations that occur during this time of the year. On the other hand, there are other active systems over Caldas Novas during this time of the year; the systems that produce stability: the Atlantic Polar air mass (PA) and and Atlantic continentalized tropical air mass (Tac) concurrently, which cause the reduction of the sky covering, of the nebulosity and of the relative

humidity. As noted, this pattern of behavior is related to the seasonal action of the air masses over the city.

In January, 2005, as shown in the graphic below, the rain was distributed in three big episodes, which correspond to the period of time between the arrival and action of a cold front and its replacement by a new cold front. The first started on the 3rd. and ended on the 11th, the second began on the 12th. and came to an end on the 22nd, and the third that commenced on the 25th. and finished on the 30th.

Caldas Novas: Daily Accumulated Precipitation of January 2005.



Source: Meteorological Station of FURNAS CENTRAIS ELETRICAS, 2005.

Org.: BIELLA, C.A. & COSTA, R.A., 2005.

The geographical location and the morphology of the south region of Goiás, allow, specially, during the summer, the meeting of the cold air mass from the south with the hot, humid airmass, mainly from the systems of equatorial region. This atmospherical dynamic creates kinds of weather

characterized by cloudy skies and successive precipitations which last for days or even weeks, similar to what occurred during December and January in the region, increasing significantly the level of soil moisture and consequently the level of water in the pluvial channels

As observed in the graph, from the data collected in the FURNAS station, the rain which occurred on the 17th. was not the highest level of January, but that of the 29th which registered up to 85.5 mm. But, if this rain was not as heavy as believed nor the highest of the month, what might have caused the damage at GO-213? The problem is that the precipitation occurred in a concentrated way, that is, almost all of the precipitation occurred in a short period of time, right after a long period of rain that lasted approximately two weeks. This precipitation encountered a soil very close to reaching its field capacity, which resulted in a rapid superficial drainage to the Jacu stream, causing a sudden elevation of its water level and thus contributing to the collapse of the embankment built over the GO-213.

The damage caused by this precipitation can also be observed by the steep slopes of "Serra de Caldas", near the district of Rio Quente, where there are several landslides, mainly due to, the hydric saturation of the area, that were occurring intermittently during the days preceeding the event.
The great pluviometric volume on the day of the event and of the previous days prompted the elevation of the water volume of the streamlet, what can be seen some days after the incident, when the other great pluviometric marks (according to the graphic chart, from the data collected from the FURNAS station). The pluviometric rates show us that the precipitations which occurred in January of the present year are double the average registered in the previous years, in the same period. According to information gathered from the 10th. District of Inmet, the rain in the state was caused by the encounter of cold fronts originating in the South region of the country, with unstable zones, coming from the North Region, which bring wind, humidity and heat.

The region that the streamlet courses, from its headwaters to the studied area has a highly saturated soil, what can be easily demonstrated in the work done on the banks of the stream. Deforested areas, especially along the river in the micro basin of the Jacu demonstrate that the area shows a reduction of its water absorption capacity. Deforested areas contribute greatly in a large portion the erosive process and increase the process of sand accumulation in the bottom of the of the Jacu basin. Other noted environmental damage, besides the deforestation, are some areas of illegal exploration of the clay (soil) of the streambed, and the presence of collapsed dams probably due to the great volume of water during the studied period.

Picture 02 - Destroyed dam near the area of the collapse.

The sum of these elements: high pluviometric rates, the geomorphology of the region, the sand accumulation in some parts of the streambed, the collapse of dams and deforested areas contributed to the creation of atypical situation, with a great increase of the water volume that would normally pass through the water pipeline built under the highway GO-213, the location of the accident.

The steel pipeline built for the passage of the Jacu stream under the highway could not hold in the great volume of water and refuse carried through the stream basin, causing the water to be trapped to the point that the water had to flow over the highway. The presence of such a great

volume of water caused the infiltration and destruction of the embankment, for the pressure of the highway lane and of the trapped water forced its collapse, creating a crater of approximately 40 meters long and 15 meters deep, engulfing three vehicles that were passing by at that very moment, taking the lives of three people.

Picture 03 - Vehicle involved in the accident at GO-213
(Source: Journal O Popular)

FINAL OBSERVATIONS

The pluviometric rates of the month of January indicate a great quantity of rain that was concentrated in three well-defined episodes, which contributed to the accumulation of water in the steel pipeline. These episodes, added to the less heavy rains that occurred almost throughout the whole month in question, contributed to the accumulation of water in the embankment which held the pipeline and, consequently, part of the road was washed away. This can be observed with the many interruptions which occurred during the attempts to redirect the river as an immediate remedy, due to the increase of the water level of the stream in the days following the event.

Additionally, there is a lack of maintenance of the highways by public departments, especially in the areas of steel pipelines and embankments, the geomorphologic conditions of the region and also the environmental

damage, culminating in a rapid and violent erosive process, having as a result a tragic ending.

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