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SOLIDS IN URBAN DRAINAGES

LOS SOLIDOS EN EL DRENAJE URBANO

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Abstract
One of the frequent problems that may produce inadequate performance of urban storm systems is the occurrence of solid materials within the system. Usually, design of these systems is done under traditional calculating methods that do not take into account any amount of solids that might be carried by the water during high flows. This paper pretends to bring attention to the many problems that arise, specially in developing countries , by the fact that no consideration is given in the design stage to the damaging effect that solids (eroded material, solid wastes) may produce in the hydraulic behaviour of the systems by clogging or sediment deposition in curb inlets, pipes, canals, etc.
Key words: storm systems, solid materials, hydraulic behaviour.

Resumen
Uno de los problemas frecuentes, que pueden llegar a producir un comportamiento inadecuado de los sistemas de drenaje urbano, es la presencia de materiales sólidos dentro de los mismos. Usualmente estos sistemas son diseñados bajo métodos tradicionales de cálculo que no toman en cuenta la cantidad de sólidos que pueden ser acarreados por el agua durante la ocurrencia de grandes gastos o crecidas. Este trabajo pretende llamar la atención a los múltiples problemas que surgen, especialmente en los países en desarrollo, por el hecho de no considerar en la etapa de diseño los efectos potencialmente dañinos que los sólidos (material erosionado, basuras) pueden producir en el comportamiento hidráulico de los sistemas al taponarlos o mediante el depósito de sedimentos en sumideros, tuberías, canales, etc.
Palabras Clave: drenaje urbano, materiales sólidos, comportamiento hidráulico.

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INTRODUCTION

Sediment found in drainage systems usually comes from natural processes of erosion, decaying forestry, scour in river beds, etc. which are caused, among other factors, by weather changes like seasonal floods and droughts, unusual heavy rainfalls, seasonal fires and others.

As population grows, the need for more habitat space has created conditions that multiply many times over these natural phenomena. Especially in the early stages of urban development and construction, sediment loads increase by hundred-fold (Wolman, 1967) altering channel characteristics (shape, slope) which in turn modify flow regimes. For the river or stream to reach a new equilibrium is a matter of probably many years, when reforestation and the final settlement of homes will bring down sediment production and the system will probably reach a new flow condition.

In developing countries this fact is aggravated by uncontrolled development, a product of lack of regulations or of weak enforcement of norms and standards. Thus, sediment production is high whenever and wherever homes are built. This is not only from slash and burn activities in shanty towns, which could be expected, but also from established urban developers that take advantage of the lax official control.

Another source of solids that affect small creeks and drainage collectors, especially in developing countries, is the habit citizens have of throwing wastes into ravines and creeks, due to the poor management of solid waste collection. These wastes are carried away usually during the early rainy season, creating clogging problems in urban drainage systems, very especially in the smaller sized collectors.

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One Final cause of problems in urban drainage that has to be mentioned is the worldwide increase of mudslides caused by extreme weather events, but sometimes triggered by human intervention in urban basins. In these cases, loss of human lives and property are sometimes staggering.

Awareness of the aforementioned facts is rapidly increasing, prompting analysis of existing storm drainage systems under new land-use conditions, and the redesign of the infrastructure if it is required. Mapping of risk zones within urban areas is fastly becoming a requirement in megacities of developing countries to diminish flood or mudslide effects, a procedure that was once only used in earthquake prone zones for that sole purpose.

A part of urban drainage concerns is water quality and, although this papers deals more with solids in the system, it is considered important to mention the contribution to water quality from suspended or dissolved solids. Environmentally speaking, total solid reduction is part of the process to carry out in the recovery of a polluted stream, and its adequate water carrying capacity.

URBAN STORM DRAINAGE, DESIGN AND CAPACITY

When designing drainage storm systems, the practitioner usually estimates run-off peaks with the use of the many calculations and programs available. These methods pay little attention, if any, to the basin conditions that differ from slope, imperviousness, soil types or channel characteristics(vegetal cover , for example). Advanced computer simulation models do include more data, like infiltration rates, vegetation distribution and other factors. However, these models require extensive and detailed recorded data, rendering them useless in developing countries where records are usually short and data collecting is poor or unexisting. Lack of information is usually substituted by statistical methods (correlations, stochastic formulae, etc.).

None of these methods, however, give serious considerations at the design stage to future changes caused by future anthropogenic activities (especially appearance of shanty towns in unstable slopes) which could affect flow regimes and thus, channel sections, slopes and overall basin conditions. Even, in well design structures, flow conditions could change if an inadequate amount of debris and sediments, due to high rates of urbanization or deforestation are suddenly deposited in a small amount of time.

When elaborating master plans for cities, designers do look at future scenarios and take into consideration changing basin conditions overtime in order to delineate flood plains, adopt land use criteria and locate culverts, bridges and other structures to cope with water flows. This, however, is only done in the planning stage design. When actually going onto the smaller scale design of urban sectors (small culverts, curb inlets, and such) no consideration is given to upstream conditions, or future modified urbanization (like more densification) and the design is done straightforward. As a consequence, occasional flooding may occur in sites considered adequately designed under common engineering practice and standards, when changes set in. This shows there is areal need to take into account, when designing small urban storm drainage systems, especially in developing countries, the possible sediment loads that may come from future construction sites, as well as solid waste dumping from densely populated squatter areas (shanty towns with inadequate or unexisting solid waste collecting systems).

To input some of these factors in the design, will undoubtedly increase costs, as bigger infrastructure will have to be built to carry the

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total urban sediment-loaded flows mentioned before. However, it is usually cheaper to prevent damage than to rebuild a damaged area. Of course, appropriate measures could be taken, like enforcing sediment control practices in construction sites, land use zoning to avoid poor people to live in risk-prone areas, appropriate solid waste collection systems in all urban areas and so on. But , the actual fact is that enforcement is still a problem for most developing countries, so it would be better to “overdesign” in many cases to guarantee the usefulness of the drainage structures that will protect property as well as , in some cases, lives.

QUANTITY OF STORM WATER FLOWS

Altering land use, as has been stated, brings many changes in channel conditions and regime flows. At a certain point, the increase in imperviousness changes these conditions so much, that present day performance of infrastructure is low or unsatisfactory as they can not manage adequately the hydrograph characteristics and the return period flows forced by the new land-use conditions. This means that for the existing data to be useful for future design, it needs to be adapted to the actual configuration of the systems. This is something that some practitioners fail to do, limiting their hydrologic peak flow design based on historic data, without much thought on how the new infrastructure will perform with some of the extreme events of the past, with the different roughness and flow parameters. The consequence could well be in the construction of a system with a lower capacity than needed. In a study done by William B. Reed (1991) on the effects of changing land use on urban peak flows, he states that an approximately forty to fifty percent increase in imperviousness, which reduces infiltration and time of concentration, will produce an increase as many as four times the two year peak event, and as much as twice for the 100 year event.

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Whenever extensive drainage improvements are made (Schueler 1987), decrease in time of concentration might go up to fifty percent of total time. Thus confirming that data has to adapt to present day situations, if appropriate drainage structures are to be built , or old ones modified, to handle the new higher peak flows.

Mc Luen and Thomas (1991) in a paper qualifying flood frequency analysis techniques for urbanizing watersheds, found adjustment factors that adapt old data to the new basin conditions up to 60 percent urbanization. Specific mention is made of bigger flows, especially when episodic changes occur. These are exampled as canalization of a stream, clearing a forested mountain slope for urban development, and others. As can be imagined, canalization will reduce time of concentration, producing bigger floods, a fact that needs to be analyzed when designing (with old data), as it might produce flooding downstream. One critical aspect is the urbanization of hillsides, as sediment production during construction is unusually high and the rise in peak flows could also be high afterwards,depending on the level of imperviousness. If single homes are built in those areas the problem is lessen, due to the fact that there will be gardens, trees, etc. If high density construction is done (low cost housing with big parking lots) the effect of imperviousness is high and the peak flows will also increase substantially. Once canals are built, bigger flows will be expected and, as a probable consequence, higher velocities. This means that bigger solids will be able to be washed out (a “desired” condition in developing countries). However, as soon as velocities diminish downstream, deposition will occur, causing damage like flooding by backwaters and such. This is critical in places where a drainage system was already in place, as it had not been designed to withstand the new imposed conditions. This has happened in partially canalized rivers, where water is discharged unto the original channel downstream causing deposition or scour, depending on the type of soil in the river bed.

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In urban areas, one sign of inefficiency of the drainage system is the continuous flooding of streets , sometimes even with low intensity rainfall. This might be a product of no maintenance practices or a change in upstream conditions (former non-urbanized areas that have been transformed into shanty towns or heavy impervious construction).

In 1999 Venezuela experienced intense mudslides due to severe weather conditions. River channels that had been concrete-lined to help flow under bridges, were suddenly filled with mud and rocks. In some cases boulders the size of a small home (3 meters in diameter) were stopped by these bridges damming the passageway and provoking more flooding on the river shores, with extensive loss of lives and property. Of course, an event of this magnitude cannot be avoided, nor design against its effect is economically feasible, but if proper respect had been had for the flood plain, and awareness of upstream geology, homes construction could had been limited and damage could have been avoided or minimized.

SOLID WASTE MANAGEMENT

In developing countries, middle and upper class developments in urban areas usually have adequate solid waste collecting systems. Poor sectors have very limited collecting (once or twice a week in some cases) and the most common practice for these people is to carry their own waste to a deposit, sometimes a certain distance from the homes. In certain cities, with high mountain slopes (like my home city of Caracas), these people might find it easier to dump everything (from mattresses to broken down home appliances) into the near-by creeks or ravines in the assurance that the following storm will carry it downstream. That is why an effort must be made by the proper authorities to work on two main lines: ***education***, to have people learn that dumping things into creeks might create an environmental hazard that might backfire on them (increase in the existence of flies, mosquitoes and such); and ***creating appropriate waste collecting systems*** that will make it easier and encouraging for people to use the system. Only these two measures will make solid waste materials in drainage systems become a minor problem, if any.

CONCLUSION

Total solids in urban drainage systems are a major problem in most developing countries, aggravated by the fact that when these systems are designed there is usually very poor or inadequate data to do a good hydrologic study. Furthermore, due to the high population increase rate, urban development(controlled or not) creates changes in basin characteristics that could multiply many times over the original flow in creeks and urban rivers, rendering the constructed drainage facilities unfit to handle the extraordinary flows, a fact that is aggravated if solid wastes are present. Future design of urban drainage systems should always take into account the whole basin characteristics and conditions, the possible future developments that might occur (urban master plans would help, if available and followed), delineation of flood –prone zones and an estimate that solid waste from upstream might contribute in a damaging manner(especially in cities with high and unstable slopes that the poor settle in), if there are no adequate waste collecting systems present.

Governments should foster environmental education in schools regarding proper disposal of solid wastes, as well as raise awareness amongst people from the poorer sectors of society to the hazards involved in risk-prone areas.

Involvement of people in decision making processes is essential at the design stage, if actual solutions are to be obtained at all.

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