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Soil Erosion Control Guidelines on Urban Lands*

by Romeo C. Bruce, Ph.D.**

Many hectares of agricultural and open space lands in the Philippines particularly near the cities are converted to urban uses (Fig. 1). These areas are used for houses, industries, shopping centers, schools, highways and other facilities.

A study in 10 major cities outside Metro Manila indicated that built-up areas in the city expand by 1.5 to 5 percent every year since 1972. In Metro Manila, at least 100 hectares of agricultural and open spaces are converted to residential subdivisions, industrial sites and other urban uses each year since 1970 (Fig. 2). A photo study of Quezon City-Novaliches area indicated that about 30 subdivisions are being developed at the same time in 1980. Field checks made during this year's rainy season showed the seriousness of soil erosion in these development areas.

Numerous areas developed for urban uses where damages on construction sites have been considerable, e.g. gullied slope on road banks, washed-out streets and debris-laden work area, can be cited. Damages occur not only on construction site but are also inflicted below construction sites-clogged drainage ditches, pollution to streams and beaches, etc.

Erosion occurs in many construction sites and off-sites in the Philippines. Construction of highways, dams, irrigation systems and other projects involving major earth-moving are going-on in numerous places in the country.

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Damages due to erosion resulting from these conversion are in most cases ignored by engineers and developers. Only when the damage becomes so disastrous to mean life and property loss that people start to react and focus their attention to such construction projects.

Many large landslides occur in nature even without man's intervention and a natural reaction of many uninformed persons is that all landslides are "acts of God" and something that cannot be avoided. But it can be shown that most landslides can be prevented and that many smaller landslides, particularly those on the road banks, would not have happened if proper precautions had been taken. Anyone who has seen the havoc brought about by landslides in urban areas and many mountain roads will appreciate that landslide study and prevention should be one of the most important concerns by urban development planners.

The shortage of suitable building land around many cities in the Philippines is forcing consideration of the use of steeply sloping land and natural hillsides with all the consequent problems, of which landslide is the most serious. Too much sloping land has been developed for urban uses without regard to slope, soil erodibility or for soil conservation practices which were necessary or even mandatory during or following development. Many residential subdivisions are being established on hillsides and steep slope areas for exceptionally dramatic setting and views. Streets and buildings are located without fitting them with existing topography. Extreme excavation and filling in the area increase soil erosion both on-site and off-site construction areas.

In many cases, the roads and highways appear to have been located more for convenience than with consideration of topography and stability of soil cover. It is quite evident that accelerated erosion and landslides have been induced as a result of road construction. Visual evidences show a much higher concentration of landslides immediately above and below roads. Where roads have been more stabilized, slides and deep gullies are frequently associated with poor or virtually non-existent road drainage. Better stabilization both structurally and vegetatively and particularly better provision for drainage of rain water off the roads will reduce erosion losses, lessen the potential for landslides, reduce road maintenance cost and provide a safer transportation system.

Objectives in the Formulation of Guidelines

The guidelines presented in this paper have been formulated with the following objectives in mind:

I. To provide planners, developers, architects, engineers, contractors and others with guidelines which when adapted will effectively reduce erosion and sedimentation in converting land for urban uses.

II. To provide soil conservation measures that will prevent controllable erosion and avoid off-site sediment damages.

III. To provide conservation and site management practices that can reduce or eliminate environmental hazard resulting from major earthmoving projects.

Principles of Soil Conservation in Urbanizing Areas

There are five principles involved in soil conservation in urbanizing areas:

1. Erosion and sedimentation commonly occur in construction projects involving major earth moving.
2. Erosion and sediment control problems begin with the removal of protective vegetation and continue until adequate cover is restored.
3. If an erosion control program is considered early in the planning stage and made part of a development plan, problems in soil erosion, runoff and sedimentation can be reduced.
4. Problems in soil erosion, runoff and sedimentation can be reduced by:
   (a) Planning techniques
   (b) Vegetative measures
   (c) Structural measures
   (d) Timely completion of the project.
5. Erosion and sediment control measures should be applied as part of the construction operation.

Wise planning can avoid or reduce many erosion problems in urbanizing areas. The development can be planned to fit the topography to keep the amount of earth moving to a minimum. Bulldozing and grading should be done during the dry season in small increments and bare land should be protected after grading. Temporary or permanent vegetation should be installed at the earliest opportunity. Good vegetative cover is the best protection against soil erosion. Permanent erosion control structures should be installed as early in the construction schedule as possible. Streets, if installed and paved early, can serve as diversions to reduce length of slope and convey runoff from the construction site. If sediment basins are needed, they should be installed before any major land clearing or grading is done. Timely completion of the project should be the main objective of any urban development.

General Guidelines for Minimizing Erosion and Sedimentation in Areas Being Converted to Urban Uses

I. Consider the topography, natural drainage and soils for a given site.
   1. Urban development should be confined in areas not steeper than 20 percent slope.
   2. Avoid swampy/marshy areas.
   3. Avoid filling the natural drainageway.
   4. Avoid areas of shallow, slide-prone or extremely stony soil.

II. Keep land grading to a minimum. Prepare a land grading plan which will include the following:

1. Proposed cuts and fills and their slide slope.
2. Location of natural drainageways and adjacent properties.
3. Location and type of controls for drainage and water removal during and after grading.
4. Source and type of filling materials.
5. Location of topsoil stockpile.

The following operations should be done:

1. Divert water away from erosive areas.
2. Expose as small an area of land for as short a time as possible.
3. Temporary bridges or culverts should be used for crossing water courses.
4. Basins to trap sediments before it enters the streams or cause damage to other properties should be constructed.
5. Dust should be kept to tolerable limits by sprinkling with water.
6. Use mulch and/or temporary vegetation to protect bare areas during construction.
7. Where possible save trees and other existing vegetation particularly along the perimeter of the construction area to act as buffer for noise and dust to protect neighboring properties.
8. Maintain drainageways in natural cover when possible.

III. Establish and maintain soil conservation measures.

Permanent ground cover and landscape planting should be installed promptly after grading is completed in sections which will not interfere with the construction.

Guidelines for Soil Conservation in Subdivision Development

Whenever large open space land near or within towns and cities is ready to be sold to many interested buyers for residential purposes, private or public developers engage in the process of subdividing the land. They map out the lines of streets and divide the land into blocks. The blocks are further divided into lots to facilitate distribution of the land among individual property owners. They reserve some parts of the land as sites for parks, schools, offices, churches, hospitals and other public or semi-public buildings.

This is the process by which cities and towns are built and grow. Because initial decisions with respect to lot layout, street system design, sewerage systems, etc., have remarkably enduring effect to environment, no local planning program can be considered adequate which does not include public controls

over this process. One aspect is the policy towards conservation of soils with the purpose of controlling or minimizing erosion and sedimentation.

To minimize soil erosion and sedimentation, developers should consider the following guidelines:

I. Plan the developoment to fit the topography.
   1. Recognize the hazards if developing on slopes steeper than 20 percent.
   2. Plan streets and buildings to fit and utilize existing topography to avoid extreme excavation and fillings.
   3. Provide storm drainage to the street or to other areas where disposal does not induce landslides, erosion or flooding.
   4. Vary lot sizes and shape according to topography and slope.

II. Schedule grading during the dry season. Avoid grading during rainy season.

III. Practice small incremental development.
   1. Expose as small area of land at one time for as short a time as possible.
   2. Avoid removing topsoil and vegetation from large areas.
   3. Apply temporary or permanent erosion control measures immediately after grading.

IV. Maintain grading to a minimum.
   1. Excessive grading can be avoided by fitting the development to topography.
   2. Avoid deep cuts and fills. These can change the natural drainage pattern, create landslide and increase soil erosion.

V. Save top soil.
   1. Strip and stockpile topsoil for future use to landscape the site.
   2. Ccver the topsoil stockpile with temporary mulch—rice straw, twigs, etc.

VI. Save trees and other existing vegetation.
   1. Where possible save healthy trees, shrubs, and other existing vegetation.
   2. Plant trees, and shrubs on the perimeter of construction sites.
   3. Protect existing vegetation from construction equipment.
   4. Avoid filling around trees.

VII. Install street and storm drains early in the construction period. If installed early, streets can serve as diversions to control runoff water before land grading is started.

VIII. Provide for safe disposal of runoff water.

1. Grassed waterways.
2. Diversion
3. Sediment basins.
4. Grade stabilization structures.

Diversions can intercept and divert runoff at construction sites so it will not cause damage. A stable outlet is required to dispose water safely. Grow waterways is an effective erosion and sediment control. Sediment basins can detain runoff and trap sediment during the period when soils are exposed.

IX. Use vegetation to stabilize bare areas.

1. Provide temporary protection for cuts, fills, stockpiles of soil and sloping land with mulch such as rice straw, twigs, leaves and other materials.
2. Plant permanent vegetation promptly after final grading.

Guidelines for Soil Conservation in Road/Highway Construction

The building of roads is an important part of the building of cities. More than one-half of all the paved roads in the Philippines are located within urban areas. Roads are the greatest single cause of accelerated erosion and the greatest source of man-induced sediments in the country. It is not hard to believe this statement because a great number of landslides in the country takes place in road cuts situated in the mountain areas of Nueva Vizcaya, Mt. Provinces, Ilocos Region, Nueva Ecija and other areas.

To avoid or minimize soil erosion, the following guidelines are recommended for road/highway construction:

I. Use drainage structures to divert or carry runoff water.

1. Install diversions at the top of cut slopes where the land slopes toward the roads.
2. Use diversion on all slope lengths greater than 50 meters including slopes at interchanges.
3. Plan diversions and drainageways to handle estimated peak flow for the design storm.
4. Control seepage in cut slopes with subsurface or vertical drains.
5. Discharge flow from lined channels, diversions, and closed conduits into outlets capable of handling the flow at non-erosive velocities.
6. Use temporary bridges or culvert structures for crossing watercourses.
7. Use coarse grained materials for road base to drain water.

II. Use vegetation to stabilize bare areas.

1. Species should be selected depending upon the existing local conditions. Among the species which can be used for roadside plantings are grasses like pangola grass, bermuda grass, Napier grass, star grass and Guinea grass; shrubs like wild sunflower, lantana, and dama de noche and fast growing trees such as giant ipil-ipil and eucalyptus.

2. Bring all cut and filled slopes to final grade as soon as possible and plant immediately.

3. Use temporary plantings or mulch on stockpile to topsoil, on spoil, and in borrowed areas.

III. In hillside subdivisons, it is desirable to build streets of less than normal width to avoid excessive cut and fill and undue damage to trees and other natural features.

1. Land to be cut or filled should be cleared of trees, stumps, roots, brush, boulders and debris.

2. Steepness of cut slope will depend on the soil and design. Cut slope of 30 percent is about the steepest for erosion control and stability.

3. Cut slopes 10 meters or more in vertical height should be benched to keep water from flowing down the face of the slope.

4. Fill material should be spread and compacted in a series of horizontal layers (usually 20 to 30 cm. thick) to attain the designed compaction. Filling should start at the lowest point.

Erosion Control Plan

The problem of soil erosion and sedimentation in urbanizing areas in the Philippines need immediate solution. It demands no less than cooperative effort between government and the land users particularly subdivision developers. Government policies regarding the utilization and development of open space land for urban uses is of paramount importance.

To make soil erosion control program for land intended for urban uses effective, subdivision developers should be required to submit an *Erosion Control Plan* as a separate document or incorporated with other maps and plans for the development. In any case, the plan shall be identified as *Erosion Control Plan* for the Project. Like an architectural plan, ECP should be approved by the appropriate agency before any earth moving operation starts.

An Erosion Control Plan should include the following:

1. Construction schedule showing the sequence and timing of operations. It should show areas to be opened up or exposed and dates proposed for beginning and completing clearings, grading, drainage facilities, as well as vegetative and structural measures for erosion control.

2. Topographic map at scale and contour interval appropriate for the area.
3. Slope map showing areas with slope:
    (a) 0 — 10 percent
    (b) 10 — 20 percent
    (c) 20 — 30 percent
    (d) 30 + percent
4. Soil map showing different types of soil occuring in the area.
5. Types and location of temporary erosion control measures to be installed.
6. Types and location of permanent erosion control measures to be installed.

Erosion Control Plan should be required when the development area exceeds a certain size (suggested limit 1 to 3 hectares), or is near a lake or stream (suggested within 100 meters). ECP should be approved by the municipality or city having jurisdiction prior to construction activity.

Important Policies Which Can be Enacted to Prevent/Minimize the Occurrence of Landslide in Urban Areas

1. The practice of constructing nearly vertical cuts and unusually high fills should be eliminated.
2. The slope of exposed surfaces of cuts and fills shall be no steeper than 1:1 and 1.5:1, respectively; although deviations from these standard values are permitted as local conditions warrant.
3. Drainage from individual lots must be conducted to streets and away from cut and fill slopes.
4. Erosion protection devices and/or vegetative planting must be incorporated in all grading plans before construction permit will be granted.
5. All subdivision developers must be required to complete the grading work and pertinent improvements within a reasonable length of time and in accordance with an approved plan or in a manner that will not constitute a hazard.
6. Preparation of a master plan for safe integrated development of the remaining hillside areas within the city.
7. Inspection and surveillance of development sites by agency implementing the soil erosion control program would be the basis for the enforcement in urban areas.
8. When the development areas exceeds certain size (suggested limit 1 to 3 hectares) or is near a lake or stream (suggested within 100 meters) the developer should be required to obtain an earth-disturbing permit conditioned

upon an Erosion Control Plan approved by the Municipality or City having jurisdiction prior to construction activity.

9. Agencies that continuously undertake large earth-disturbing activities such as highway construction companies or land developers for residential subdivisions, industrial complex, etc., should be given the option to develop a policy for erosion control that they would follow on all operations. An approved policy would exempt the company from obtaining earth-disturbing permit on a project by project basis. However, the sites would remain subject to inspection for compliance with standards.

Figure 1

Figure 2