8

Environmental Considerations

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This chapter discusses some of the environmental issues commonly encountered during construction operations. It is a brief overview and does not include all the possible environmental issues that may be encountered on a specific project. Fortunately, most environmental construction problems are anticipated during the design phase and are adequately addressed in the contract documents and specifications. However, specifying how a contractor shall operate to withstand the forces of nature and getting the contractor to actually comply with the contract and achieve the project objectives can be a very difficult and drawn-out process. For example, prevention of erosion during and shortly after construction is particularly difficult. Achieving satisfactory results requires diligence and cooperation by both the contractor and the construction engineering team.

This chapter discusses general and site-specific environmental considerations, soil erosion, the influence of construction on the local environment, hazardous and objectionable materials, long-term issues and considerations, and frost actions.

GENERAL ENVIRONMENTAL CONSIDERATIONS

It is important to recognize environmental problems and know how to solve them in a prompt and effective manner. Failure to properly identify and mitigate environmental problems often leads to construction delays and increased costs. Environmental problems rarely go away by themselves and usually get worse with time. A severe environmental problem, such as malodorous or highly toxic waste material, could stop construction, and in an extreme case, even force the project to be abandoned. In recent years, growing public concern about the environment has exerted considerable influence on some construction projects. This trend is likely to continue.

SITE-SPECIFIC CONSIDERATIONS

Each construction site has its own unique environment. Some of the items that must be taken into account before the start of construction include the immediate local surroundings (schools, parks, airports, industrial plants, and the like) and special local events (county fairs, races, music and art festivals, and so on). Another consideration is the potential effects of construction on the local environment: strong winds blowing soil and dust, heavy rains causing temporary flooding and silting of streams and drainage structures, and excessive traffic delays due to construction operations.

Once potential problems have been identified, solutions and procedures should be incorporated into the contract.

Recognize the specifics of the local climate. For example, in areas of significant snowfall, recognize that drifting snow can potentially clog temporary drainage channels. Vegetation should be planted during a period when there will be adequate moisture, heat, and light. The plans and specifications generally cover project landscaping requirements. If questions arise, consult the resident engineer.

SOIL EROSION

The most common environmental problems encountered in construction are erosion by wind and water. Normal embankment construction activities require destroying the natural vegetative cover and the natural balance of environmental forces near the ground surface. The best way to prevent local problems is to reestablish the natural vegetative cover and natural environmental balance as quickly as possible after construction. There are several methods that can be used, and combinations and variations to fit local site conditions are usually the most effective. A number of new products are available that can help reduce the effects of wind and water during construction (see Chapter 5, section on Surface Water). Although some of these products can be very effective in local areas, generally they are quite expensive. Construction erosion may often be more economically taken care of by controlling the contractor's operations so that environmental damage is avoided. Be careful not to order the contractor to use various erosion control measures unless the items are specifically mentioned in the contract. Consult the resident engineer if there are any questions.

Many states specify in the contract documents the size of the area that may be opened to construction at any one time before the permanent erosion control treatment is applied. The contractor should not be permitted to destroy the natural vegetative cover on extended lengths of the site unless erosion control and prevention measures can be installed at about the same time. The contract may require the contractor to submit an erosion control plan. State and federal soil conservation agencies can often provide valuable information and guidelines. As part of each contract, many states include standard plans for temporary erosion control features and/or devices.

Water Erosion

As noted in Chapters 4 and 5, one of the first requirements of construction is to prevent damage to local water bodies by not permitting the construction runoff water to mix with any local stream, lake, or other nearby water body. This can best be achieved by reducing soil erosion caused by surface runoff where possible and by preventing unavoidable soil erosion from leaving the construction site.

Normal rainfall will cause erosion of exposed soil, if not protected. During construction, it is nearly impossible to prevent rainfall from eroding the work area. Therefore, to protect the environment, all the runoff and all the eroded soil must be kept on the project site until the sediment can be removed from the runoff water. Hay bales, sedimentation basins, and silt fences have been used effectively to protect local streams and water bodies. Such installations are generally shown in the standard plans or elsewhere in the contract. Refer to Chapter 5, section on Surface Water for a detailed discussion of these installations.

If roadway construction is in lakes or open water, use of sheetpiling or properly designed silt curtains has been very effective in keeping construction runoff from contaminating the open water. Such measures are incorporated into the project by designers and ordinarily are not left to field forces to develop.

Methods for controlling soil erosion should not be used in ways that contribute to other problems. For instance, while the use of mulching is very effective in holding seed in place until it germinates, the type of mulch must be appropriate for the area; otherwise a heavy rainfall could easily transport the mulch into local drainage channels, causing flooding and other damage.

Wind Erosion

When strong winds blow across unprotected land, they move the soil. Long-term wind erosion can be prevented by planting ground cover and establishing vegetation. The short-term local effects of wind erosion must be handled on a temporary basis by the contractor. One of the major contributors to wind erosion is construction traffic, which may lift large quantities of silt-sized particles high enough so only light breezes are needed to transport them great distances. Damage to crops and other vegetation, local residences, and vehicles may result.

To prevent excessive construction dust in construction traffic areas, it is often necessary to use temporary pavements or chemical palliatives such as salt, calcium chloride, asphalt emulsion, tar, and numerous other chemicals. All dust palliatives are potential environmental contaminants. For example, salt is known to damage local vegetation, and it is undesirable for it to go directly into a water supply. Therefore, all proposed palliatives must be thoroughly evaluated before they may be used on construction projects. Most agencies usually have a list of acceptable dust palliatives for the contractor's use.

INFLUENCE OF CONSTRUCTION ON THE LOCAL ENVIRONMENT

Construction activities impose conditions on local environments that can be perceived by the public as ranging from slightly objectionable to completely intolerable. Controlling off-site trucking routes and limiting the hours of their use can often minimize inconvenience to the public caused by noisy truck traffic and soil spillage onto roadways. Close cooperation among the project engineer, local law enforcement officials, and contractor's personnel can usually prevent serious problems of this nature. Restrictions placed on the contractor's operations must, of course, conform to the contract.

HAZARDOUS AND OBJECTIONABLE MATERIALS

Although it is not uncommon to encounter waste materials from industrial operations in rural areas, they are much more likely to occur in urban excavations. Waste materials can vary from garbage dumps and paper mill wastes to mine and steel-making wastes (see Chapter 9, section on Waste Materials). Most of these wastes have concentrations of chemicals that can be harmful to the environment if not adequately handled. The excavation may even release gases that are harmful to humans, including the equipment operators and inspectors. Sometimes the gases have such noxious odors that they must be specially treated.

If there is any suspicion that the contractor has uncovered an area that might be environmentally obnoxious or hazardous, stop all operations and do not allow the contractor to transport the materials until a complete environmental assessment can be made. There are severe civil and criminal penalties if hazardous or contaminated materials are knowingly transported without proper permits, notification, and safeguards.

Occasionally the contractor may want to use waste products as part of the embankment construction (see Chapter 9, section on Waste Materials). Local industries are sometimes willing to pay contractors to haul away waste materials. Before accepting any of these materials on a project, have a complete evaluation made of the chemical constituents and of the stability of the materials when subjected to the local environment so that a long-term problem is not created. The contractor must also be alert to hazardous wastes coming from its own construction activities, for example, lead-based paint removed as part of the cleaning of bridges or asbestos from the demolition of old buildings. In these cases, applicable environmental laws must be strictly followed.

LONG-TERM ISSUES AND CONSIDERATIONS

Usually items that may have a long-term influence on the local environment are included as part of the contract documents. The engineer should be aware of the purposes of these long-term controls in the contract and make certain that the contractor's short-term activities do not negate the intent of any long-term environmental controls.

During construction, the engineer must be constantly aware of the need to prevent contaminants from reaching local water supplies. In order to grow vegetation on exposed soils, however, it is usually necessary to add fertilizers, lime, or other nutrients to the soil. These chemicals can cause concentrations that are very damaging to the local environment if they are improperly stored or misapplied. Certain contractor-produced wastes can cause permanent damage to the environment if not adequately controlled. The contractor's work yard needs to be constantly monitored for spills of fuel, oils, and chemicals, which should immediately be cleaned up. Crankcase oils, for example, should be collected and disposed of properly.

Unacceptable discharge from the project can produce permanent long-term damage to the environment if not adequately controlled. It may be necessary to separate runoff from the completed highway from local water supplies by salt berms, intercepted drainage, and other measures. However, when certain natural materials that are excavated and/or removed from their original location and used as construction materials are exposed to rainfall, harmful chemicals can be leached from them. These possibilities should be considered during the design phase and appropriately included in the plans and specifications. However, the engineer must be aware that any earthwork will be subjected to rainfall infiltration and possibly other materials, such as salts and oils, that might cause corrosion of structures under construction.

FROST ACTION IN EMBANKMENT DESIGN AND CONSTRUCTION

In areas where freezing temperatures occur, embankments and the facilities they support, such as pavements, rail lines, and so on, may be adversely affected by the freezing of the soil. This important factor has to be considered in the design of the project. The soils investigation should be done early in the location phase to properly prepare the specifications if problem materials exist. These problems should be noted in the contract documents so that the bidders are aware of unusual circumstances, requirements, disposal of unusable soils, and so forth.

Frost Effects

Frost heave is the upward expansion that occurs when certain soils freeze. Not only does the in situ moisture freeze, but more importantly, additional moisture flows to the freezing front. While the expansion of pore water upon turning to ice does contribute to heave, it is the additional water that moves to the freezing front that causes the dramatic heaving of road surfaces and railroad tracks (TRB 1974). Because heaving is seldom uniform over the area affected, road surfaces become very rough, resulting in cracked or damaged pavements. The distortion of road surfaces also leads to disruption of surface drainage.

Thaw settlement and instability occur with the advent of warmer temperatures in the spring. Thawing occurs from the surface downward, with the result that moisture is trapped between the surface and the still-frozen soil below. This results in greatly reduced bearing capacity. While most modern high-volume roads can withstand this condition, the typical pavement thickness on low volume or older roads is insufficient, and seasonal load restrictions may have to be imposed. At the end of the thaw season, the surface may not settle back to its original level, so there may be residual pavement roughness (TRB 1974; Armstrong and Csathy 1963). Permanent rutting often results in water ponding, leading to the danger of hydroplaning.

Damage to and disutility of buried facilities is another possible hazard. Culverts may be heaved either temporarily or permanently, resulting in sharp bumps in the road, disrupted surface drainage, and eventual complete destruction of the culvert (Fredrickson 1963). Stormwater drains and outfalls for subgrade or pavement underdrainage systems may be rendered ineffective as well.

Mechanism of Frost Heaving

Three factors are necessary for detrimental frost heaving to occur (TRB 1974; Linell et al. 1963): (a) freezing temperatures for a sufficient duration of time, (b) a water supply sufficient to support the growth of ice lenses, and (c) a frost-susceptible soil, that is, one with a texture favorable to the upward movement of water to the freezing front.

Design to Control Frost Heaving

If any one of the above three factors can be eliminated during design, frost heave and instability during the thaw period can be essentially eliminated.

A soil subgrade, subbase, or base course material is considered to be frost susceptible if it contains more than 3 percent by weight of particles smaller than 0.020 mm (Linell et al. 1963). For convenience and practicality, and depending on local soils and climate, many frostbelt states specify an equivalent limit, typically ranging from about 8 to 15 percent of the maximum allowable percent passing the No. 200 sieve. Therefore, if any frost-susceptible soil within the depth of frost penetration can be removed and replaced with non-frost-susceptible soil, heave can be largely prevented. Alternately, it may be more effective to simply cover the frost-susceptible soil with a sufficient thickness of select non-frost-susceptible soil. This has the effect of raising the gradeline above natural ground, which often has side benefits in drainage and in areas of heavy snowfall.

The availability of moisture depends primarily on the permeability and the height of capillary rise of the subgrade or embankment soils. Some agencies consider that if the water table is more than 10 ft below the surface, frost will present little problem. On the other hand, an effort is made to keep the gradeline at least 5 ft above the water table, depending on the specific soils at the site, and to use select granular material to construct the embankment (Erickson 1963). It will be noted that this results in an ambiguity where the gradeline is from 5 to 10 ft above the water table. Engineering judgment is required in this case.

Cuts are likely to be troublesome, especially when they are deep enough to approach the groundwater table. The cut will typically drain toward the cut-to-fill transition, and thus localized heaving problems can be created unless effective drainage is provided to keep the seepage out of the fill (TRB 1974; Armstrong and Csathy 1963).

It might seem that freezing temperatures would not be amenable to treatment, as they are inherent to the site. However, there has been considerable success in controlling frost heave by the use of foamed insulation boards placed on frost-susceptible subgrades. They are then covered by a foot or so of base course and pavement materials. Unfortunately, there have been cases where differential icing of the pavement surface occurred as a result of the interruption of the heat flow from the earth. As a result, many early installations of thermal insulation were removed (TRB 1974). At present there is a renewed interest in the use of insulation. Concerns for liability still remain, however.

Other Design Considerations

In general, frost penetration will be greater (although frost heave will be significantly less) for free-draining cohesionless soils, dry soils, and soils of greater dry density than for silts, clays, and wet soils. The project should be reviewed to determine the relative frost-susceptibility of the various soils that may become part of the embankment. Selective placement should be considered so as to place the least frost-susceptible soil nearest the top of the completed embankment (NCHRP 1974). If clean sands or gravels are conveniently available, they should be used to facilitate the drainage of the embankment.

Cold Weather Construction

Since basically all soils will heave when frozen, some more than others, uniformity of the soil in the embankment is an important objective of the contractor and construction inspectors. Having a uniform embankment will help eliminate differential heaving when freezing occurs. Methods to accomplish this are discussed in Chapter 4, sections on Embankments and Compaction.

Care should be taken during construction to see that design features intended to counteract frost action are not altered by construction operations. For example, clean cohesionless materials used at the top of the embankment may sometimes be difficult to traffic by earthmoving equipment, and there may be pressure to add a little cohesive material to correct the "problem." This, of course, would be counterproductive to the frost-prevention purpose of the materials.

In general, construction during winter or freezing temperatures is avoided by most highway agencies. As noted in Chapter 4, section on Cold Weather Construction, it is very difficult to compact frozen soil to the densities which are typically specified, with the result that when spring comes, there is excessive settlement, especially differential settlement, of the embankment.

Where the work involves rock fill or clean, free-draining sands or gravels, however, and the work can be planned to avoid using frozen soil, it is possible to obtain satisfactory results (Haas 1988; Haas et al. 1988). The key is to prevent the soil from freezing before it is compacted and to suspend operations if it becomes too cold to do so.

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