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Workshop Topic 4 EARTHWORK OR EXISTING ROADWAY PREPARATION

Workshop participants concluded that earthwork is a promising area for achieving improvements in the use of materials and energy. Since 30 percent or more of the highway construction dollar is invested in earthwork, significant savings can be achieved by more efficient use of materials and energy and more effective design and construction procedures. These savings can contribute to increasing the miles of highway construction in an era of shrinking transportation budgets and continuing inflation.

A rational assessment of earthwork considerations on a nationwide basis must proceed from initial recognition of the wide range of physical characteristics of the native soil and rock materials involved. These properties also can undergo extreme changes when the material is subjected to environmental changes of moisture and temperature. The range of physical properties is far greater than that of processed and manufactured materials used in the remainder of the highway facility.

Workshop discussions included all phases of design and construction beneath the pavement section including earthwork, appurtenances such as walls and drainage, use of waste materials, and geometric design standards.

EARTHWORK DESIGN

Every transportation project ranging from new facilities to improving existing facilities should include sufficient subsurface explorations, testing, and analysis to determine the adequacy of the in-place foundation soils to support the proposed embankments, structures, pavement section, and cut slopes. For major projects on new location, the investigation should commence in the planning phase in order to identify areas requiring costly foundation treatment. Line shifts to areas of more favorable soil conditions may allow significant savings in foundation treatment costs. Summaries of best current practices are available in NCHRP publications (1, 2, 3).

An important factor in achieving economy in earthwork is use of on-site materials to minimize energy expenditure. Sufficient explorations and test data should be provided to the contractor during bid preparation to adequately define the soil properties for excavation and compaction considerations. Sufficient explorations should be made to accurately define soil and rock quantities where unclassified excavation items are used. Complete and well-organized subsurface data will reduce the "risk factor" that all contractors must consider when preparing bids on earthwork items and will provide the means for selecting the most efficient equipment for construction operations. Maximum use of on-site materials for embankment construction, granular backfill, subbase, aggregate, and stone filling for stream-bank protection will serve to reduce the energy used during construction. In some instances standard specifications may require modification to allow maximum use of on-site material.

A suggested area for research is improvement of procedures for investigation of cut-slope stability problems in earth and rock. Landslides in the United States annually cost an estimated $100 million to repair. Groundwater is a factor in 95 percent of these failures. Improved exploration methods are needed to define the location and movement of groundwater since effective groundwater control is in many cases the most economical and effective corrective solution. Also, research is needed to develop improved procedures for design of rock cut slopes and improved remedial measures for stabilizing existing unstable rock slopes.

EARTHWORK CONSTRUCTION

Workshop participants concluded that a nationwide improvement of earthwork construction specifications is probably the most significant measure that could contribute to optimum use of energy and materials in the earthwork area. In the last 25 years the construction equipment industry has provided earth-moving equipment with improved capacity and improved compaction equipment of various types. This equipment evolution has resulted in more efficient earth-moving operations requiring less energy per cubic yard of material excavated, placed, and compacted. However, there have been few changes in earthwork specifications allowing the contractor to place thicker lifts with fewer passes and use the increased capacity of the compaction equipment. Most states still limit loose lift thickness to 6 to 8 in. (15 to 20 cm). It is obvious that earthwork specifications have not responded to technical improvements.

In 1973, New York State adopted new earthwork specifications designed to accommodate the increased capacity of present compaction equipment and to allow a greater efficiency in construction operations. Maximum allowable lift thicknesses were established for each type and size of compaction equipment along with maximum speed and pass requirements. Acceptance of each lift is based on conformance with the above requirements, density test criteria, and the requirement that there be no rutting under the final pass on the lift surface. Under the new specification, the contractors have increased the loose lift thickness for plastic glacial tills to 12 to 15 in. (30 to 38 cm) and for sands and gravels to 15 to 24 in. (38 to 61 cm). In many cases this was less than the maximum allowed for the equipment. The contractor is also responsible for controlling the moisture content to achieve the compaction requirements. Both the transportation department and the contractors have been satisfied with this specification.

Another area in which traditional conservative practices were examined was preparation of the existing ground surface. A number of states have eliminated stripping of topsoil and removal of stumps where gradelines are higher than 6 ft (1.8 m). No adverse results were reported. Other suggested practices were elimination of compaction of ground surface under high fills and elimination of the practice of excavating shallow organic deposits until soil investigations are made. Many shallow organic deposits contain a small amount of organic material and will rapidly compress and be stable under the embankment weight.

Topsoil has been traditionally used on earth cut and embankment slopes to aid in establishing turf growth. In many states the topsoil operation has been eliminated, and adequate turf has been obtained by applying mulch and fertilizer during the seeding operation. The exception to this policy is along urban expressways where landscaping is an important consideration.

Disposal of logs and brush has become a problem in many areas that have no-burning regulations. Allowing the contractor to place and bury this material in the outer portion of embankment is a practical solution in several states.

Workshop discussions directed emphasis on the need for a number of research investigations to improve the efficiency of embankment construction.

1. Is there a more practical method of measuring soil densification than the moisture-density relation used for 50 years? A possible area that may be worthy of investigation is the modulus of elasticity. A rapid economical field test is needed to minimize delays to the contractor.

2. What degree of embankment densification is required to adequately support pavement and imposed loads? Can density requirements be varied with vertical elevation in the embankment section?

3. What cumulative changes occur in strength properties of in-place embankment soils that undergo annual cycles of environmental changes? What is the effect on pavement performance?

4. How feasible and efficient are earthmoving methods such as conveyor belt systems?

Participants emphasized the importance of providing a stable embankment surface at subgrade elevation. Sufficient strength must be provided to adequately support equipment for construction of the pavement. Adequate year-round subgrade support is a requirement for successful pavement performance as demonstrated by projects such as the AASHO Road Test.

When fine-grained soils are placed in the embankment at subgrade, they often have insufficient stability to support construction equipment. A number of states incorporate additives such as lime, cement, and fly ash or mixtures of lime and cement within the upper 6 to 12 in. (15 to 30 cm) of the embankment to increase the strength of the subgrade soil. It was concluded that the increased strength of stabilized subgrade soils could be considered in the total pavement design analysis in order to reduce the thickness cost of more expensive layers in the upper portion of the pavement.

Most pavement designers select subgrade support values prior to construction. Because of the variability of soils that could be found at final embankment or cut subgrade elevation, pavements could be overdesigned or underdesigned. In Colorado, strength tests are made on the soils from, or near, subgrade elevation during construction, and the pavement thickness is adjusted in the subbase layer to achieve a total pavement strength consistent with the pavement design procedure.

In some areas of the country, embankments are constructed with expansive clays. To reduce postconstruction swelling they are placed at moisture contents higher than optimum moisture. This causes difficulties in compaction and results in deep rutting. As a construction expedient, lime, fly ash, or cement is added in small quantities to increase stability and workability. Also, additives may be considered as a means to use on-site soils rather than haul borrow material from distant sources.

ROADWAY APPURTENANCES

Since nearly 10 percent of the highway construction dollar is invested in drainage, savings in materials and energy should be considered. Recently long-span corrugated plate structures have been introduced nationwide as a cost savings substitute for rigid structures. Since a portion of the strength of these structures is obtained from the pressure of the surrounding soil, there is a reduction in the amount of manufactured material needed.

Recent research findings in the area of pavement performance have emphasized the need for improved subdrainage in the pavement section. The use of plastic filter cloth and small-diameter pipe should be investigated from the standpoint of reducing trenching excavation quantities, underdrain filter quantities, and conduit material.

The introduction of reinforced earth wall construction in the United States has provided a positive method for reducing the materials and energy input for construction of earth-retaining structures. Horizontal metal strips incorporated into the backfill increase the internal strength of the earth mass and practically eliminate the horizontal pressure on the vertical wall component. Cost savings of this design compared with conventional wall designs have been in the order of 30 to 50 percent (6). Another recent innovation is the development of interlocking precast concrete units for wall construction.

In the last 5 years, temporary erosion controls have become an important consideration in highway construction. Plastic filter cloth can be efficiently used to replace stone for slope protection of temporary diversion channels. This material can also be used in temporary sediment retention structures to allow passage of water and retain soil particles as a replacement for graded filters composed of processed sand and stone materials.

The use of recharge basins in areas of permeable soils and low water table can provide a means of disposing of highway runoff with a savings in drainage pipe (4, 5).

USE OF WASTE MATERIALS

Municipal waste is the largest and most universal source of material that could be considered for use in highway earthwork. On a project in California, several hundred thousand cubic yards of sanitary landfill material has been successfully incorporated into earthwork grading by alternating layers of earth and refuse material. Sandy soil was blended with 6-in. (15-cm) layers of refuse and compacted by sheepsfoot compactors (7). Proposals have been developed in the New York City area to compress and bale municipal waste and haul the bales by rail to distant disposal sites. These wastes could be considered as a material source for embankment construction, based on a further investigation of the compressibility characteristics of the baled material. Fly ash has been successfully used as embankment material in Illinois. Consideration must be given to moisture control during placement. An earth protective layer is essential on the outer slopes to prevent water and wind erosion (8). Many other industrial waste materials that are hard and inert can be used for embankment material where they are economically available.

GEOMETRIC DESIGN STANDARDS

Workshop panels concurred that the volume of earthwork could be reduced significantly by modifying current geometric design standards. It is obvious that the major policy factor in this problem is safety; however, these considerations are included as a means of reducing materials and energy. Specific suggestions were (a) using steeper side slopes than those mandated by current safety standards and (b) altering grade and sight distance requirements to reduce earthwork volumes.

SUMMARY

The earthwork portion of the highway facility comprises probably 90 percent of the volume of material used in construction. More effective use of on-site materials, improved construction procedures, and use of new materials and methods for the construction of appurtenant structures will make a significant contribution to conservation of energy and materials in future highway construction.

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