CHAPTER 7

SUBGRADE PREPARATION AND TRANSITIONS FOR CONTROL OF FROST HEAVING AND ASSOCIATED CRACKING

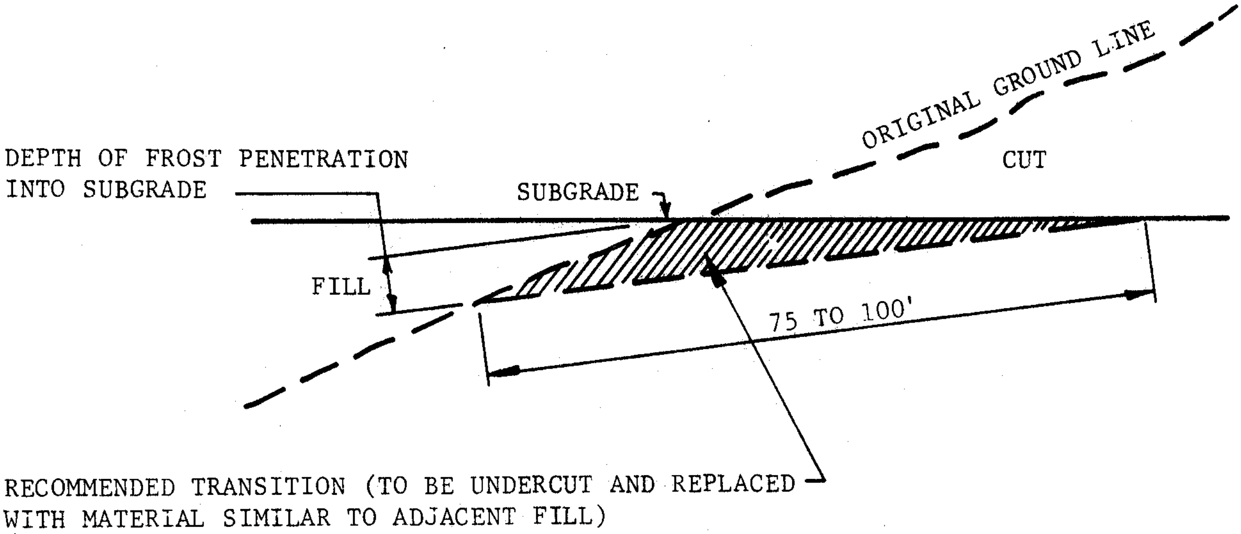
7-1. Subgrade preparation. It is a basic requirement for all pavements constructed in frost areas that subgrades in which freezing will occur should be especially prepared to achieve uniformity of soil conditions. In fill sections, the least frost-susceptible soils should be placed in the upper portion of the subgrade by temporarily stockpiling the better materials, cross-hauling, and selective grading. If the upper layers of fill contain frost-susceptible soils, the completed fill section should be subjected to the subgrade preparation procedures required for cut sections. In cut sections, the subgrade should be scarified and excavated to a prescribed depth, and the excavated material should be windrowed and bladed successively until thoroughly blended, and relaid and compacted. The depth of subgrade preparation, measured downward from the top of the subgrade, should be the lesser of either 24 inches, or two-thirds of the frost penetration given by figure 3-4 (except one-half of the frost penetration for airfield shoulder pavements and for roads, streets and open storage areas of Class D and E) less the actual combined thickness of pavement, base course, and subbase course, or 72 inches less the actual combined thickness of pavement, base, and subbase. At transitions from cut to fill, the subgrade in the cut section should be undercut and back-filled with the same material as the adjacent fill (fig 7-1). Refer to appendix E for field control of subgrade and base course materials.

a. Exceptional conditions. Exceptions to the basic requirement for subgrade preparation in the preceding paragraph are limited to the following:

(1) Subgrades known to be non-frost-susceptible to the depth prescribed for subgrade preparation and known to contain no frost-susceptible layers or lenses, as demonstrated and verified by extensive and thorough subsurface investigations and by the performance of nearby existing pavements, if any, are exceptions.

(2) Fine-grained subgrades containing moisture well in excess of the optimum for compaction, with no feasible means of drainage nor of otherwise reducing the moisture content, and which consequently cannot feasibly be scarified and recompacted, are also exceptions.

b. Treatment of wet fine-grained subgrades. If wet fine-grained subgrades exist at the site, it will be necessary to achieve equivalent frost protection with fill material. This may be done by raising the grade by an amount equal to the depth of subgrade preparation that otherwise would be prescribed or by undercutting and replacing the wet fine-grained subgrade to that same depth. In either case, the fill or



SOURCE: MAINE STATE HIGHWAY COMMISSION

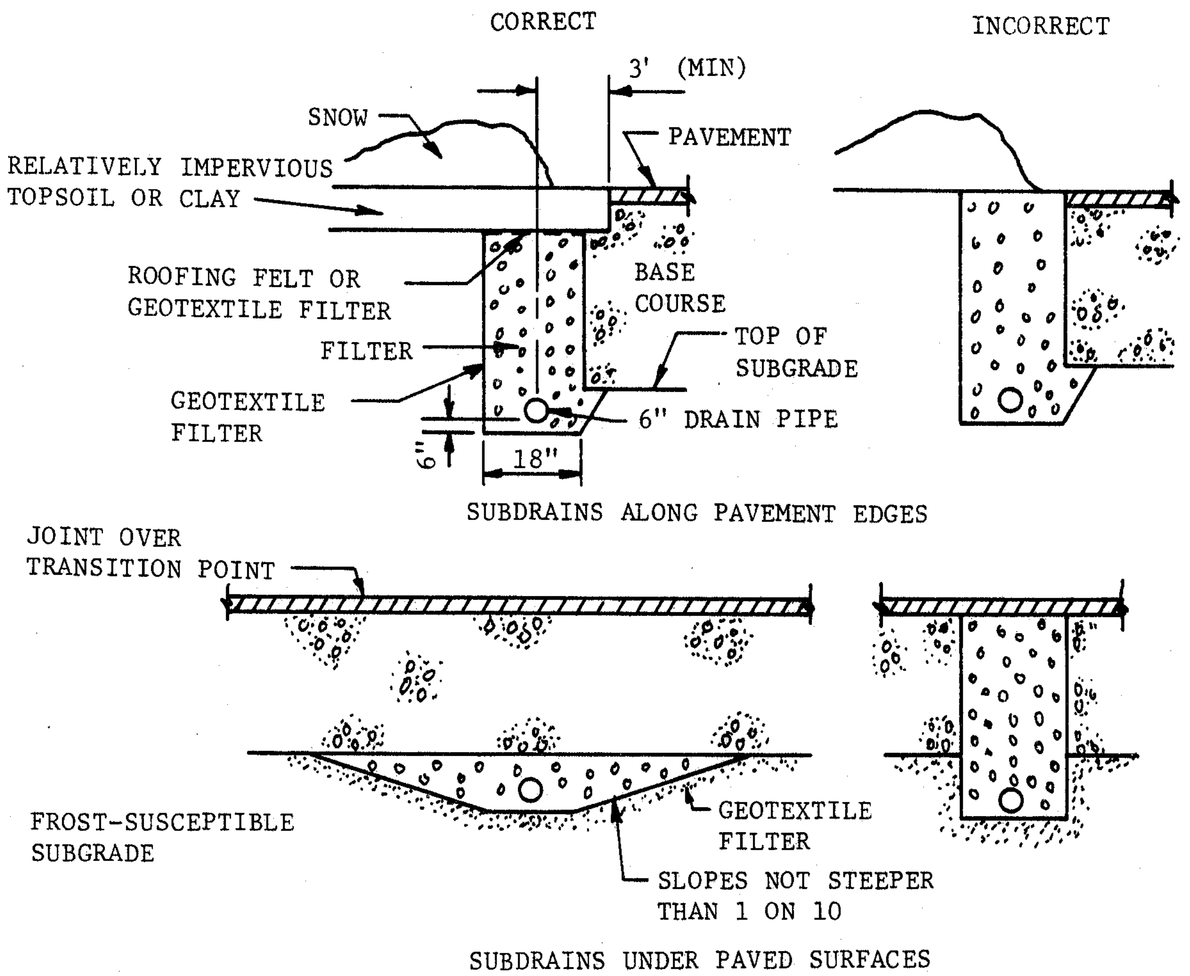
FIGURE 7-1. TAPERED TRANSITION USED WHERE EMBANKMENT MATERIAL DIFFERS FROM NATURAL SUBGRADE IN CUT backfill material may be non-frost-susceptible material or frost-susceptible material meeting specified requirements. If the fill or backfill material is frost-susceptible, it should be subjected to the same subgrade preparation procedures prescribed above.

c. Boulder removal. It is essential that all stones more than about 6 inches in diameter be removed from frost-susceptible subgrades to prevent boulder heaves from damaging the pavement. In the process of constructing fills, all large stones should be removed from subgrade materials that will experience freezing. In cut sections, all large stones should be removed from the subgrade to the same depth as the special subgrade preparation outlined in the preceding paragraphs.

7-2. Control of differential heave at drains, culverts, ducts, inlets, hydrants, and lights.

a. Design details and transitions for drains, culverts, and ducts. Drains, culverts, or utility ducts placed under pavements on frost-susceptible subgrades frequently experience differential heaving. Wherever possible, the placing of such facilities beneath pavements should be avoided. Where this cannot be avoided, construction of drains should be in accordance with the "correct" method indicated in figure 7-2, while treatment of culverts and large ducts should conform with figure 7-3. All drains or similar features should be placed first and the base and subbase course materials carried across them without break so as to obtain maximum uniformity of pavement support. The practice of constructing the base and subbase course and then excavating back through them to lay drains, pipes, etc., is unsatisfactory as a marked discontinuity in support will result. It is almost impossible to compact material in a trench to the same degree as the surrounding base and subbase course materials. Also, the amount of fines in the excavated and backfilled material may be increased by incorporation of subgrade soil during the trench excavation or by manufacture of fines by the added handling. The poor experience record of combination drains--those intercepting both surface and subsurface water--indicates that the filter material should never be carried to the surface as illustrated in the "incorrect" column in figure 7-2. Under winter conditions, this detail may allow thaw water accumulating at the edge of the pavement to feed into the base course. This detail is also undesirable because the filter is a poor surface and is subject to clogging, and the drain is located too close to the pavement to permit easy repair. Recommended practice is shown in the "correct" column in figure 7-2.

b. Frost protection and transitions for inlets, hydrants, and lights. Experience has shown that drain inlets, fueling hydrants, and pavement lighting systems, which have different thermal properties than the pavements in which they are inserted, are likely to be locations of abrupt differential heave. Usually, the roughness results from progressive movement of the inserted items. To prevent these damaging



NOTES:

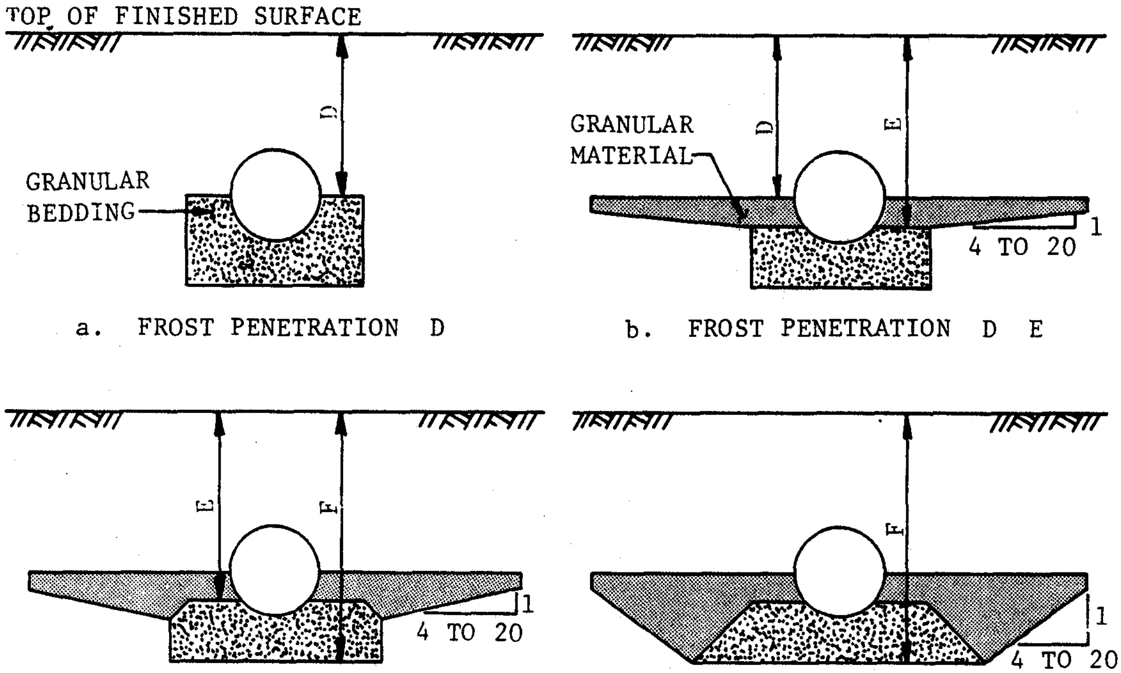
1. FOR ADDITIONAL DETAILS ON DESIGN AND DEPTH OF SUBDRAINS AND DEPTH OF SUBDRAINS AND FILTERS COURSES SEE EM 1110-3-136.

2. GRANULAR OR GEOTEXTILE FABRICS FILTER MAY BE NECESSARY BETWEEN BASE COURSE AND SUBGRADE (PARA 5-4).

3. UPPER 4 INCHES OF BASE COURSE MUST HAVE FREE-DRAINING CHARACTERISTICS (PARA 5-1).

U.S. Army Corps of Engineers

FIGURE 7-2. SUBDRAIN DETAILS FOR COLD REGIONS



a. FROST PENETRATION D

b. FROST PENETRATION D E

c. FROST PENETRATION E F

d. FROST PENETRATION F

SOURCE: MINNESOTA DEPARTMENT OF HIGHWAYS

FIGURE 7-3. TRANSITIONS FOR CULVERTS BENEATH PAVEMENTS movements, the pavement section beneath the inserts and extending at least 5 feet radially from them should be designed to prevent freezing of frost-susceptible materials by use of an adequate thickness of non-frost-susceptible base course, and by use of insulation. Consideration should also be given to anchoring footings with spread bases at appropriate depths. Gradual transitions are required to surrounding pavements that are subject to frost heave.

7-3. Pavement thickness transitions.

a. Longitudinal transitions. Where interruptions in pavement uniformity cannot be avoided, differential frost heaving should be controlled by use of gradual transitions. Lengths of longitudinal transitions should vary directly with the speed of traffic and the amount of heave differential; for rigid pavements, transition sections should begin and end directly under pavement joints, and should in no case be shorter than one slab length. As an example, at a heavy-load airfield where differentials of heave of 1 inch may be expected at changes in combined thickness of pavement and base, or at changes from one subgrade soil condition to another, gradual changes in base thicknesses should be effected over distances of 200 feet for the runway area, 100 feet for taxiways, and 50 feet for aprons. The transition in each case should be located in the section having the lesser total thickness of pavement and base. Pavements designed to lower standards of frost-heave control, such as roads, shoulders, and overruns, have less stringent requirements, but may nevertheless need transition sections.

b. Transverse transitions. A need for transitions in the transverse direction arises at changes in total thickness of pavement and base, and at longitudinal drains and culverts. Any transverse transition beneath pavements that carry the principal wheel assemblies of aircraft traveling at moderate to high speed should meet the same requirements applicable to longitudinal transitions. Transverse transitions should be sloped not steeper than 10 horizontal to 1 vertical. Transverse transitions between pavements carrying aircraft traffic and adjacent shoulder pavements should be located in the shoulder and should not be sloped steeper than 4 horizontal to 1 vertical.

7-4. Other measures. Other possible measures to reduce the effects of heave are use of insulation to control depth of frost penetration and use of steel reinforcement to improve the continuity of rigid pavements that may become distorted by frost heave. Reinforcement will not reduce heave nor prevent the cracking resulting from it, but it will help to hold cracks tightly closed and thus reduce pumping through these cracks. Transitions between cut and fill, culverts and drains, changes in character or stratification of subgrade soils, as well as subgrade preparation and boulder removal should also receive special attention in field construction control (app E).

7-5. Pavement cracking associated with frost action. One of the most detrimental effects of frost action on a pavement is surface distortion as the result of differential frost heave or differential loss of strength. These may also lead to random cracking. For airfield pavements, it is essential that uncontrolled cracking be reduced to the minimum. Deterioration and spalling of the edges of working cracks are causes of uneven surface conditions and sources of debris that may seriously damage jet aircraft and engines. Cracking may be reduced by control of such elements as base composition, uniformity and thickness, slab dimensions, subbase and subgrade materials, uniformity of subsurface moisture conditions, and, in special situations, by use of reinforcement and by limitation of pavement type. The importance of uniformity cannot be overemphasized. Where unavoidable discontinuities in subgrade conditions exist, gradual transitions as outlined in preceding paragraphs are essential.