X. SOIL SURVEYS

A. Sampling and Testing

The requirement in Field Section 21 of the Materials Manual for minimum numbers of samples applies only to classification tests. There is no specific requirement on number of moisture-density (M-D) relations tests. This is essentially between the soil surveyor and district construction. If the one-point M-D relations tests were being more widely used, there would be much less need, perhaps even no need, for including so many M-D tests in the soil survey. Soil surveyors are urged to become familiar with the one-point M-D test and to promote its use by construction personnel in their district.

B. NRCS Soil Series Names

The Natural Resource Conservation Service continues to publish 3 or 4 new countywide surveys each year. At this point they probably have a fourth to a third of the state covered. They are fairly easy to use and the soil surveyor is urged to use them where they are available. However, the new taxonomic system has soil series names which will not be familiar to the people who use soil survey reports. For that reason, the reports should be somewhat educational and fairly detailed with respect to origin, typical properties, and appearance. Many of the series names are now grouped in "associations" of several similar soils. There may be times when it will be simpler to report these soils as associations rather than attempting to differentiate each one individually.

C. Slope Selection Chart

A somewhat common source of confusion with the slope selection chart in the Materials Manual has been in selecting slopes for some CH residual soils. Note that the top column of the chart deals with geologic origin and this is the first division before looking at ASTM classification. A CH soil residual from rock with admixed chert or other rock fragments may be built on 2:1. However, 3:1 is indicated if it's a CH soil residual from shale and claystone - and without admixed granular material.

A soil series that has been especially confusing is the Union. The lower part of the profile is typically a cherty, residual clay and the upper part is of wind-blow origin, usually CL. Soil survey recommendations have ranged from 2:1 through 3:1. The 3:1 has been based on the CH classification, which is a misinterpretation since it's a CH residual from carbonates and is cherty. The slope selected should be based on the predominant phase. If it's mostly CL loess with only a few feet of residual soil, the 2.5:1 should probably be used. If it's almost all residual with a couple of feet of windblown then 2:1 should be adequate.

It should be emphasized that this chart is a guide. It's based on some theory and it's tempered by experience. It fits most situations, but there are exceptions. Some of the exceptions have been addressed in

research reports. For the most part, this chart is based on stability considerations, but in one area it's been shaded a bit for erosion control purposes. This is for the ML loesses. When dealing with a very tight right-of-way situation, it may be practical to steepen slopes in this material to 2:1 at the expense of some increased erosion problems or erosion control measures. If in doubt, shear tests can be done. To repeat, this chart is a guide - it's not carved in stone.

D. Spill Slopes

On grade separations, please consider if it's feasible to do selective grading with placement of better materials in fill spill slopes so that the spill slopes can be steepened. Some additional handling can certainly be justified if it results in reducing bridge length. This is not generally practical on stream crossings -- only on grade separations.

Note that the slope selection chart permits spill slopes to be 1.2:1 steeper than side slopes for several soil types, but no steeper than 2:1, where elevation differential is less than 20 feet between the toe of slope and grade at the bridge end. This recognizes that the effective height of the slope will be reduced by the abutment headwall by at least 6 to 8 feet. However, this gets a bit more complicated at stream channel crossings. Here it's necessary to consider the depth and condition of the stream channel and their effect on bridge end location. To give an example, one might have CL glacial soils and a height differential between grade and toe of slope of some 15 feet. The chart would indicate 2.5:1 side slopes for CL fill soils and 2:1 spill slopes. But, if the stream channel is entrenched in CL soil another 15 feet deep such that the total height differential is greater than 20 feet then the bridge ends should be stepped back to or beyond a point determined by projecting a 2.5:1 upward from the toe of the channel slope to intersection with grade. With typically steep channel banks, this would generally leave a substantial bench at natural ground level which would provide some room for bank sloughing without affecting the integrity of the spill slope. The spill slope would remain on 2:1 but the bridge end would be located as if it were at least 2.5:1.

Now things get even more complicated. To this point, we have not really considered some of the possible complications to the stability of stream and channel slopes. There is a caution in the text beneath the slope selection chart that, "Factors such as foundations, seepage, susceptibility to inundation, etc. may dictate flatter slopes." Even ignoring foundations, which call for a special investigation, there is no easy simple way of considering the effects of water that will fit every case. Determining proper slopes in such circumstances involves consideration of a complex intermingling of factors such as flooding rate, height and duration, rate of recession, water velocity, scour potential, soil strength, weight, permeability, swell potential, and seepage rates, all further complicated by considerations of costs and the risks and consequences of failure.

The following general comments and guidelines are offered, however, to supplement the Guide for Slope Recommendations. First, use the chart to determine the slope (spill or side) you would use if water were not a factor. This is the slope to which you will make adjustments based on the following considerations.

For moderate stream flows of average flood duration, about 1.2:1 flatter may suffice. For prolonged flooding followed by drawdown, 1:1 flatter may be appropriate. For intermittent or low-flow streams subject

only to flash flooding, no flattening may be needed. Always inspect stream slopes for evidence of slides and sloughs and inspect the condition of adjacent structures over the same stream. Consider the width of the embankment; a 4-lane roadway is more likely to fail into a stream channel than a narrow county road or railroad fill. Consider also the consequences of failure; be more conservative for heavily traveled arterial roadways than for minor or rural supplemental roads for example.

Keep in mind that many stream channel slopes are stable only because of mature tree growth along the banks and the reinforcement provided the banks by the root structure. Remember that trees will be destroyed by construction, the roots will rot, and maintenance will prevent their regrowth. The net result will be less inherent stability where most needed.

Channelization has led to much stream bank instability, particularly in the northwest part of the state. It is especially prevalent in Lafayette, Atchison, and Holt Counties. The invariable result is channel deepening, sometimes severe deepening. Careful examination of banks will often reveal massive slides, sometimes so massive as to resemble natural terraces. Always look at your county map; if the stream follows a straight line it has been channelized, the streambed will have deepened and the banks, if not already failed, will be in precarious condition.

E. SPILL SLOPES IN CUT SECTIONS

Cut slopes are based on the slope selection chart and are to be carried uninterrupted beneath structures regardless of the height of cut. No steepening or warping of cut slopes is to be done, including those of less than 20 feet in height. This has been discussed with and agreed to by the Bridge Unit.

F. ROCK SLOPES IN CUT SECTIONS

Normally rock slopes in limestones, dolomites, and sandstones are cut on vertical or with a slight batter. For cut slopes higher than 30 feet, 10 feet minimum width benches are provided. The benches may be provided at the contacts of different formations (not necessarily at 30 feet) and may vary in width. Shales, siltstone, and other soft rocks are normally laid back on a 2:1. For all rock cut slopes, a 10 feet minimum flat bottom ditch is required.