5 GRADING INSPECTION

5-1 GRADING INSPECTION AND THE REVIEW PROCESS

Grading-code plan check and field inspection is a process of checks and balances in which approvals are granted by stages. The purpose of the grading review process is to provide quality assurance inspection intended to assure safe site development for public safety and welfare. This review process—at both rough- and final-grade stages—includes application of site knowledge during construction by:

1. grading staff professionals, inspectors, and supervisors, and
2. private consulting civil engineers, soil engineers, and engineering geologists.

In this chapter we will augment discussion of the review process where approval is granted in stages with numerous photographs and illustrations, as well as discuss the salient details of grading field inspection. Although we will discuss the techniques of grading-control inspection and fill-control testing, we will defer to available soil mechanics textbooks all technical discussion of soil testing, calculations, and analysis. This text is primarily intended for readers with limited knowledge about grading inspection and code enforcement. Experienced civil engineers and geotechnical personnel are assumed to have, or have available, the necessary technical expertise.

While the techniques described can be readily applied to public works projects, the grading-inspection discussions presented here are oriented toward excavation and grading on private property for residential, commercial, and industrial construction.

Effective grading-code enforcement requires public agency inspection of grading itself as well as critical review of work proposed or completed. The adoption of a grading code assures neither compliance with that code nor public safety and welfare. These objectives can only be accomplished through effective field inspection and review.

Some governmental agencies have tried to force code compliance by making professional consultants entirely responsible for field inspection; but this method seldom yields satisfactory results.

Implementation of grading codes creates a need for soil engineering and engineering geological consulting firms to provide geotechnical services required by grading codes. When an area develops sufficiently, the geotechnical industry and the construction trades set up business offices in that area. The services and skills they provide should prove healthy for the community as well as for the industries they represent. However, problems may develop when such growth accelerates unchecked.

Where the stage approvals are provided by experienced, capable staff, public safety and welfare are protected. However, many public agencies have no experienced grading inspectors, nor do they retain qualified consultants to provide responsible review and deputy inspection. Consequently, they are without professionals or field technicians able to determine the competency of geotechnical services or fill-placement control, or the authenticity of reports and field testing. This deficiency leaves open the door for unqualified and even fraudulent "soil testing laboratories" and "geologists" to operate virtually undetected. Outright charlatans compete with and displace competent geotechnical firms who have necessary experience in slope stability analysis and foundation soil investigations.

One soil testing firm operated for seven years in four California counties and numerous cities using a computerized typewriter to create soil reports signed by a licensed civil engineer (who had little if any training or experience in soil engineering) and by a "geologist" who wasn't a geologist. The reports, which contained the types of data required by the various codes, had been composed by a computer operator who selected appropriate data from the memory bank of the typewriter. The company was widely used because it produced "excellent" reports promptly and economically. As a result, thousands of false reports were accepted, thousands of building permits were issued for building and construction sites, and thousands of structures have been built upon "engineered" graded sites of questionable stability and safety. Finally, after numerous site and construction failures involving land settlement and slope failures, the company was detected to be fraudulent and was sued.

This firm was able to operate undetected for so long because the jurisdictions it served did not have staff professionals able to determine the authenticity of the reports received. This case is mentioned to document the need for experienced, qualified grading inspectors as a means of assuring safe construction. To assist readers of this text to learn how to recognize high-quality grading practice and to discourage or prevent approval of substandard work, we are including numerous photographs and illustrations.

There are three ingredients essential for the creation of dependable, serviceable building sites. These ingredients are: (1) a good design with a properly prepared set of detailed plans, (2) a capable contractor with the desire as well as the ability to construct a quality site according to the plans, and (3) some type of independent quality control over both materials and construction processes.

Many contractors do have the desire to build according to the highest prevailing standards. However, under competitive bidding procedures, the economic pressure to save time and expense wherever possible is always present. Adequate inspection and effective quality control during grading operations is essential if problems created either by "shortcuts" or inadvertent failure to comply in detail with approved plans and specifications are to be avoided both during grading and after the completion of grading.

Benefits of an adequate preliminary geotechnical investigation are lost if there is not enough control to make sure that recommendations are being implemented. If preliminary investigations are inadequate, or if unexpected field conditions become apparent during grading, it is essential that the problems are recognized during grading so that recommendations can be revised appropriately and work can be correctly completed according to the revisions. The time involved and the field exposures available during grading are usually much greater than during preliminary investigations. Therefore, the maximum field information is available during grading, and the inspection during grading provides the best as well as the last chance to make sure that all potential problems are addressed by standard performance. A good job doesn't just happen; it results from thorough preparation, knowledgeable effort, and conscientious attention to detail.

5-2 CALLED GRADING STAFF INSPECTIONS

Grading staff inspection includes site inspection, coordination, and stage approvals to assure compliance with specifications of a plan permit. Building officials should establish required called inspections. These inspections require the permittees to notify the proper building official as various stages of grading construction are completed, and require that the grading inspector be present on-site at various stages to inspect and approve portions of the grading construction. These called inspections may be a matter of enforced departmental policy or may be specifically written into the code under supervised engineering. Such inspections are required by the City of Los Angeles code, while in the County of Orange, California, a modified Chapter 70, Uniform Building Code (UBC) requires these inspections for approved permits. The County of Los Angeles has modified Chapter 70, UBC, to include called inspections under Section 7014, subsection C, Supervised Grading Requirements. The Prince George's County, Maryland, code requires called inspections at the initial, rough-grade, and final-grade stages.

A suggested addition to Section 7014(C), UBC, Engineered Grading Requirements, could include the following:

Inspection of Excavation and Fills. The permittee or his agent shall notify the building official 24 hours prior to the grading operation being ready for each of the following inspections:

1. *Initial inspection*—when the permittee is ready to begin work, before any grading or brushing is started.
2. *Toe of fill inspection*—after the natural ground is exposed and prepared to receive fill, but before any fill is placed.
3. *Excavation inspection*—after the excavation and placement is started, but before the vertical depth of the excavation exceeds 10 feet.
4. *Fill inspection*—after the fill and placement is started, but before the vertical height of the lifts exceed 10 feet.
5. *Drainage device inspection*—after forms and reinforcement are in place but before any concrete is placed.
6. *Rough grading*—when all rough grading has been completed, including installation of all drainage structures and other protective devices. The rough-grade stage includes submittal of the as-graded plan and final geotechnical reports that must be approved prior to issuance of building permits.
7. *Final grading inspection*—when all building site fine grading work has been completed, utility trench backfills are completed and approved by the soil engineer and final drainage of the building site is ready for approval.

The permittee need not wait for the inspector to arrive before proceeding with the above work, except for inspection 2. The building official approves the work inspected or notifies the permittee or his agent immediately if construction fails to comply with code requirements.

In addition to the called inspections specified above, the building official may make such other inspections, at intervals as he may deem necessary, to determine that work is being performed in compliance with the requirements of the code, and that adequate control is being exercised by the professional consultants. In-grading investigations and reports by the site soil engineer or geologist may be required. (This requirement is generally stated at the end of Section 7014(C), UBC.)

The above called inspections are the basic inspections needed by the grading inspector to assure compliance with specifications of the plan and permit. The building official may choose also to establish more detailed inspection requirements similar to the prescriptive code requirements in the City of Los Angeles, or similar to the required grading inspections by the County of Orange, California. A copy of County of Orange required inspections is found in Appendix B.

5-3 PRE-GRADING MEETING

The initial inspection, usually held on the site prior to any brushing and preparatory to actual grading construction, is generally referred to as the pre-grading meeting.

The Purpose of the Pre-Grading Meeting

The meeting provides an open forum for the discussion of the contractor's approved methods of construction; discussion of special problems such as buttresses or stabilization fills, existing landslide treatment, brush, tree, and rock removal and disposal methods, removal of alluvium and colluvium, subdrain locations and methods of construction, benching requirements, desilting basins, and rainy-season protection; and discussions concerning conditions of the permit.

By participants developing strong communication and an understanding of the conditions, requirements, and specifications of the plan and permit during the meeting, anticipated problems are resolved through careful planning for safe application of geotechnical and grading construction techniques prior to the actual commencement of grading work. Pre-grading meetings have been very successful in the County of Orange, California, in resolving potential on-site problems and in development of awareness and open communication among all segments of the industry involved.

Participants in the Pre-Grading Meeting

The project coordinator should request the presence of the following principals at least 48 hours prior to the pre-grading meeting: owner, soil engineer, engineering geologist, design engineer or architect, grading contractor, and representatives from the building and the road departments where applicable. The building department representatives may include the grading supervisor, staff geologist, staff engineer or supervising grading inspector, and the district grading inspector.

The building department representatives review the plan, specifications, conditions of permit approval, and any problems peculiar to the site prior to the actual grading. Questions relative to the site construction or differences of opinion should be discussed openly among all members present.

Activities of the Pre-Grading Meeting

During the pre-grading meeting, the grading contractor normally discusses the type of equipment he intends to use, the size of equipment spread, and the number of cubic yards of earth he proposes to move each day. This information allows the soil engineer to determine how many technicians will be needed to test and supervise the compaction and fill placement during construction. A "rule of thumb" on large grading projects may be one qualified technician for each 10,000± cubic yards of earth moved per day if the contractor operates one spread of equipment. If spreads are to be used in several different areas, the soil engineer may need to place a soil technician for each spread location. In addition, if the site conditions warrant geologic inspection and surveillance, a field geologist may be needed. A full-time field geologist often takes sand cone tests in addition to making the geologic inspections, or may perform other duties in cooperation with the soil technician.

5-4 IN-PROGRESS GRADING INSPECTIONS

The in-grading inspections include brush removal inspection, toe of fill key inspection, excavation inspections, compacted fill inspections, and drainage device inspections, which are discussed in detail later in this chapter. (See Figures 5-1 thru 5-20.) Daily grading inspections should continue during construction to ensure compliance with the permit and the grading ordinance. These inspections also help the operation maintain steady progress, and minimize holdups or stop orders. Much of the in-progress grading inspection is involved with making sure that the soil engineer's representative is on the site doing his job and that the grading contractor is complying with the specifications and requirements of the permit.

The grading inspector keeps communications open and coordinates work among the contractor, soil engineering representative, and engineering geologist, to assure that each stage of grading construction is properly inspected, tested, and approved by the geotechnical consultants. This process is appropriately called *grading control.* (See Figure 5-13.)

Specific requirements of the soil engineer and the engineering geologist are listed in the appendix as "Conditions of Permits." A building official usually requires the soil engineer to supervise testing and grading control full time, and the engineering geologist to perform periodic or weekly inspections, geologic mapping, and recording of geologic conditions. Adverse engineering or geologic conditions uncovered during grading construction, but which were not indicated or evaluated in the preliminary reports, would necessitate such evaluations at the time that such conditions were found. To assure safe construction under such conditions, geologists may have to make additional cross sections and soil engineers may have to re-test and reanalyze the soil as well as re-design the involved portion of the site.

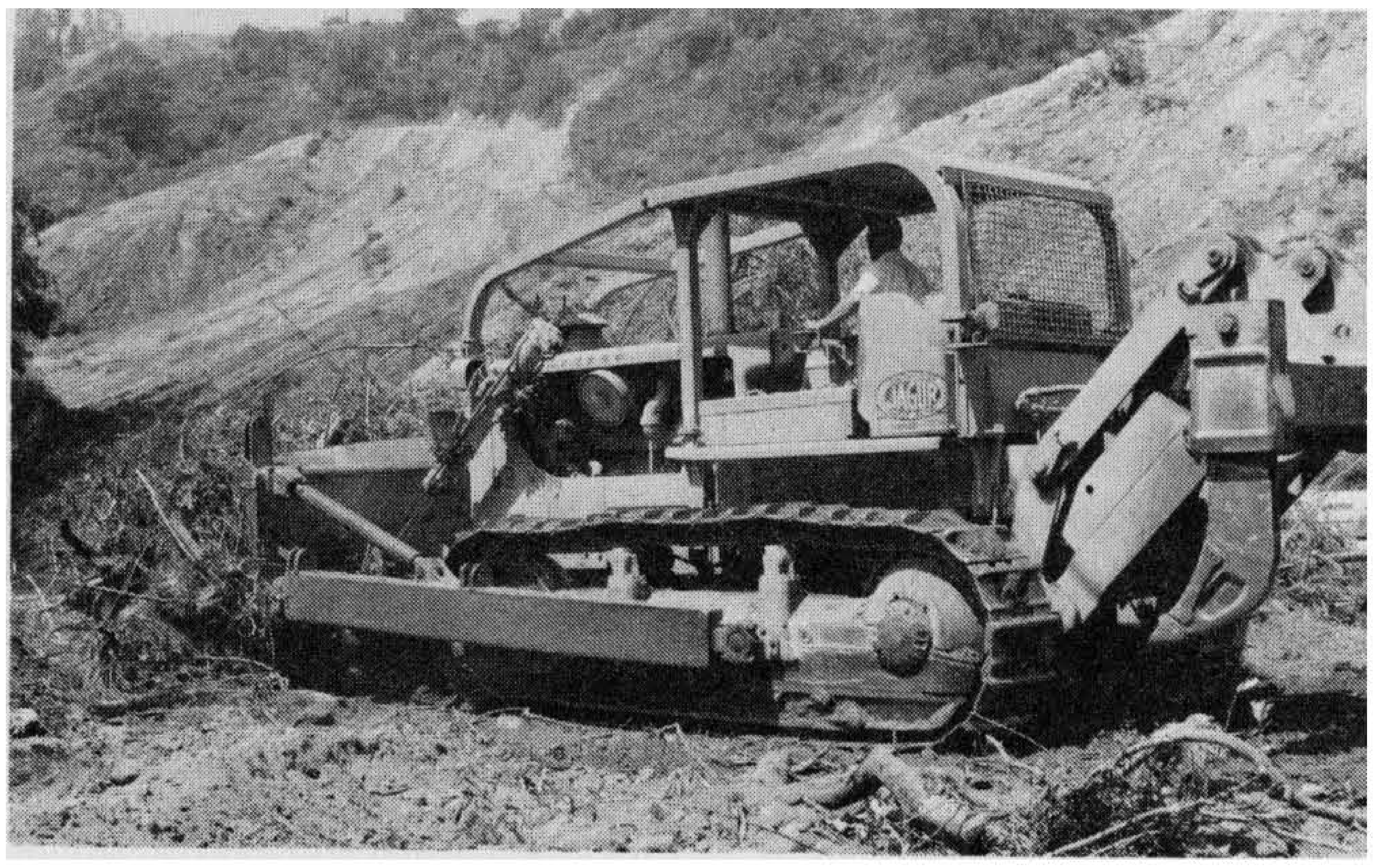


Figure 5-1 Stripping brush from the natural slopes. Brush stripping is accomplished sometimes with a brush-rake on the front of a bulldozer. The brush is loaded onto trucks and hauled to a dump for disposal. Photograph courtesy of the Dept. of Building & Safety, City of Los Angeles, staff photographer John Shadle.

Figure 5-2 Canyon bottom cleanout. The brush is removed, and compressible soils and alluvium are removed down to competent bedrock. Photograph courtesy of the Dept. of Building & Safety, City of Los Angeles, staff photographer John Shadle.

Figure 5-3 Canyon bottom clean-out continues, using ripper-cats and scrapers to remove compressible soils. Photograph courtesy of the Dept. of Building & Safety, City of Los Angeles, staff photographer John Shadle.

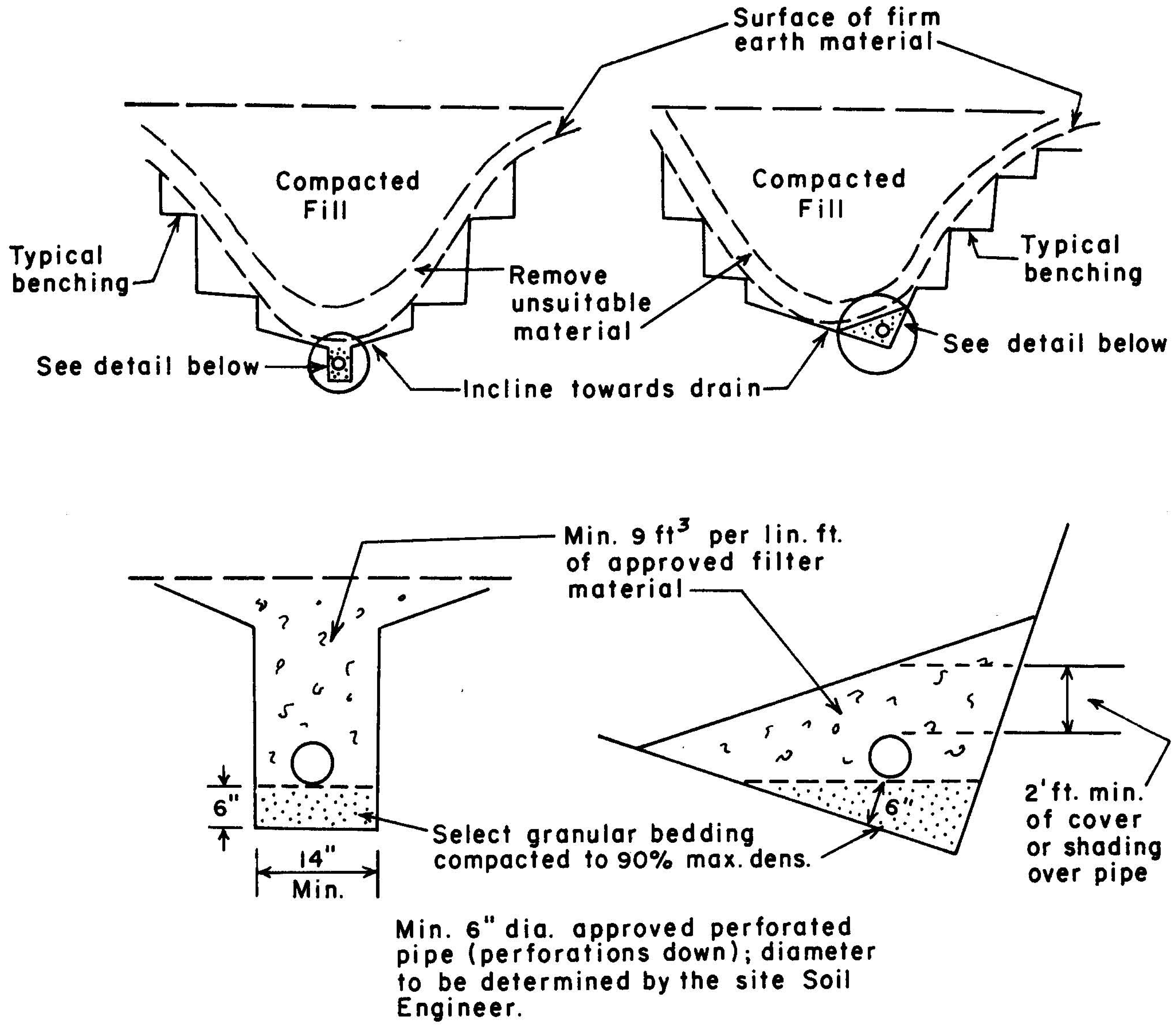
Figure 5-4 Lateral canyon clean-out. The push-cat is pushing the scrapers to assist them in loading. Photograph by and courtesy of Frank E. Denison, geologist.

Figure 5-5 This lateral canyon has been cleaned out and staked for subdrain trenching. Photograph courtesy of the Dept. of Building & Safety, City of Los Angeles, staff photographer John Shadle.

Figure 5-6 Subdrain excavation in progress within the main canyon. Equipment in the background awaits completion of subdrain construction prior to filling the canyon. Photograph courtesy of the Dept. of Building & Safety, City of Los Angeles, staff photographer John Shadle.

Figure 5-7 The siltstone and shale bedrock are seeping water along the bedding planes. Some bedding planes are slickensided and polished, indicating past movement. Photograph courtesy of the Dept. of Building & Safety, City of Los Angeles, staff photographer John Shadle.

Figure 5-8 Seepage build-up during lateral canyon clean-out requires subdrain construction. Photograph by and courtesy of James E. Slosson.



Filter material to meet following specifications or approved equal:

Sieve Size	Percentage Passing
1"	100
3/4"	90-100
3/8"	40-100
No. 4	25-40
No. 8	18-33
No. 30	5-15
No. 50	0-7
No. 200	0-3

Approved pipe to be schedule 40 Poly-Vinyl-Chloride (P.V.C.), orangeburge, or dipped asphalted corrugated metal pipe (C.M.P.)

Redrawn from the County of Orange, California Standard for Subdrains.

Figure 5-9 Typical canyon cleanout and subdrain details. Redrawn from the County of Orange, CA Standard Sheets by C. Michael Scullin.

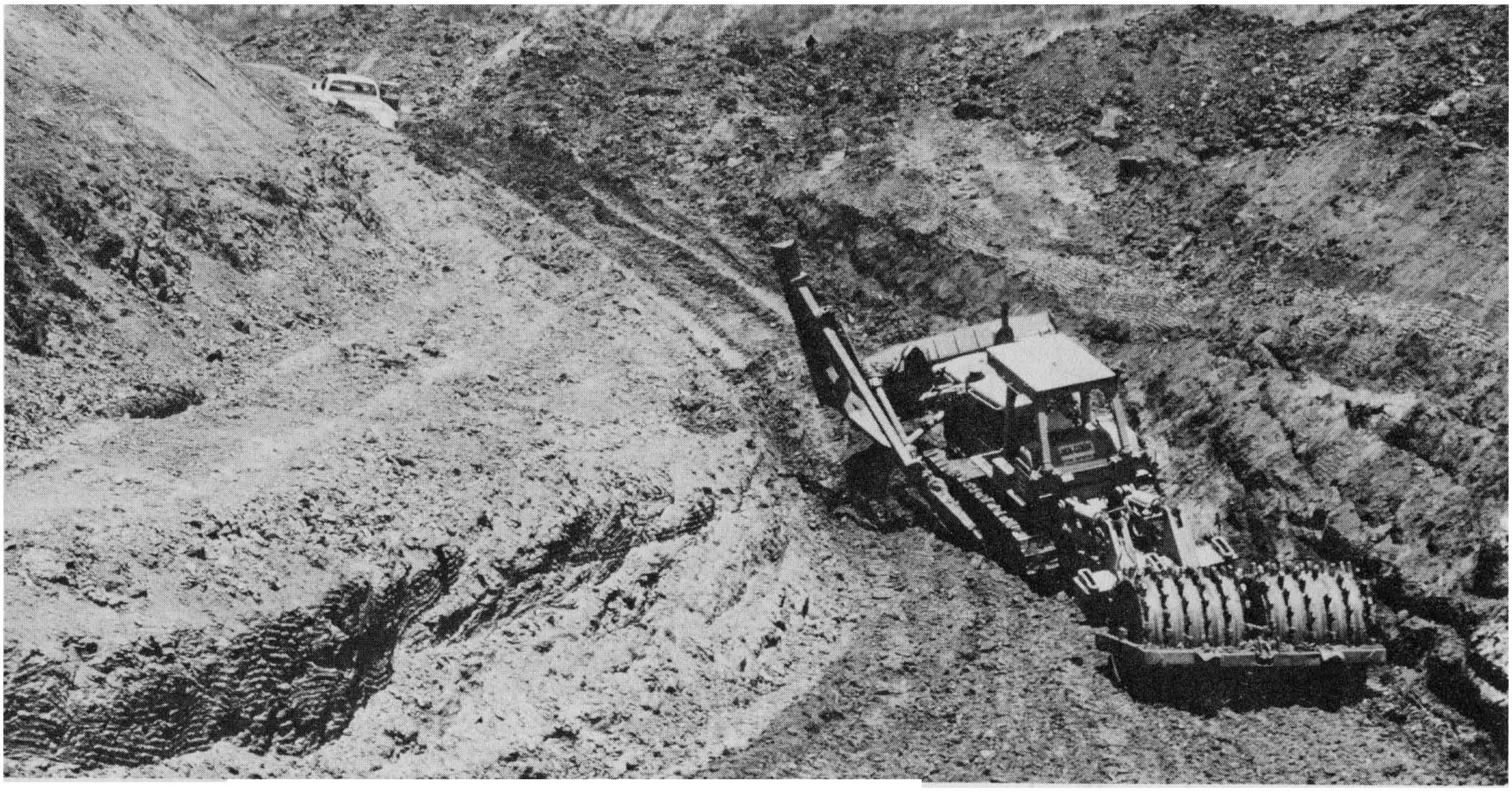


Figure 5-10 The toe-of-fill key backfilling after subdrain construction is completed. The sheepsfoot compactor is a double 5 X 5-ft. drum filled with water, and contains caps on the sheepsfoot points. Photograph by C. Michael Scullin.

Figure 5-11 Toe-of-fill key backfill in progress. A rubber-tired loader is spreading fill material while compaction is accomplished by a sheepsfoot roller as a soil technician watches. Photograph by C. Michael Scullin.

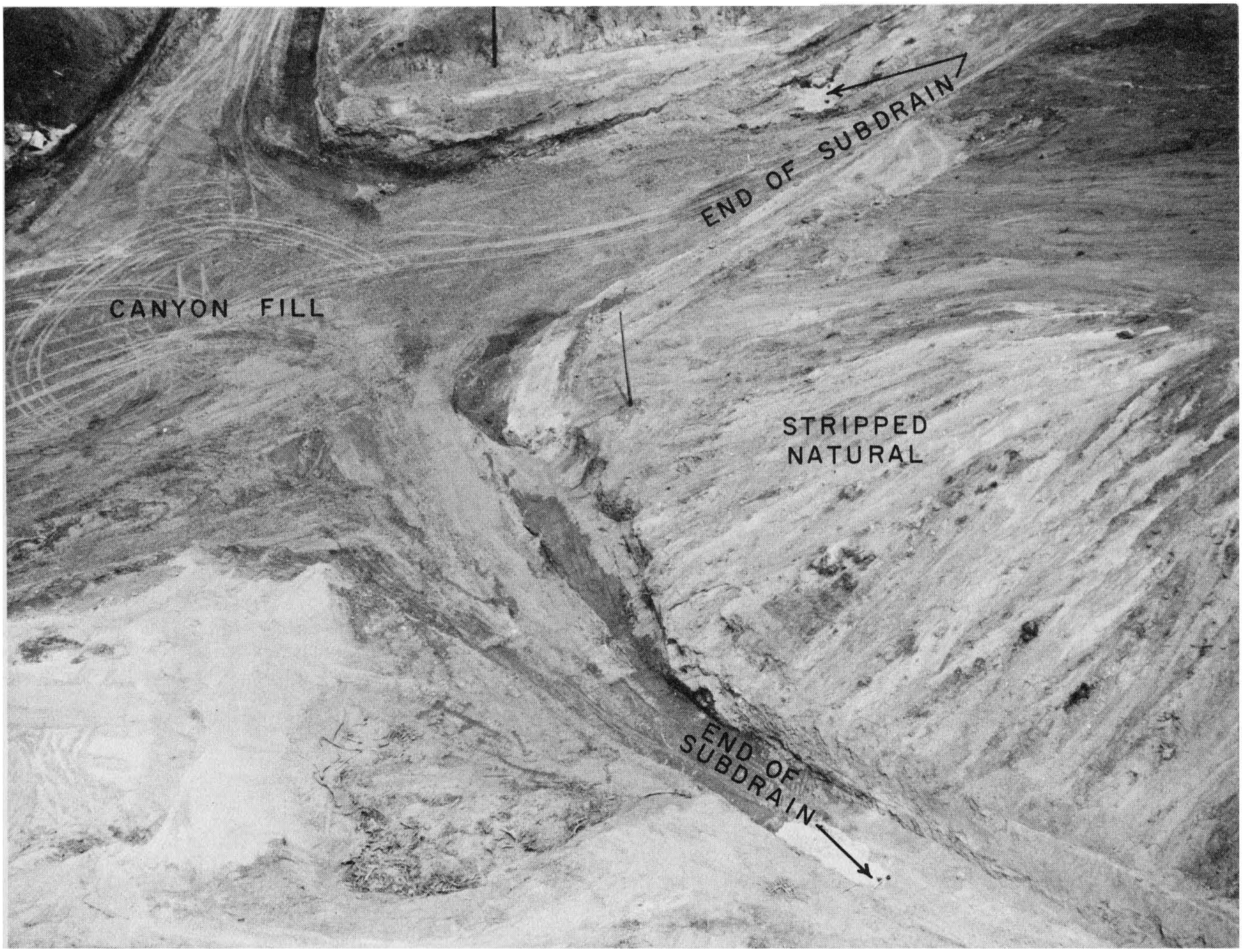


Figure 5-12 Filling lateral canyons. Construction of a subdrain is proceeding in each lateral canyon in advance of filling. Photograph courtesy of the Dept. of Building & Safety, City of Los Angeles, staff photographer John Shadle.

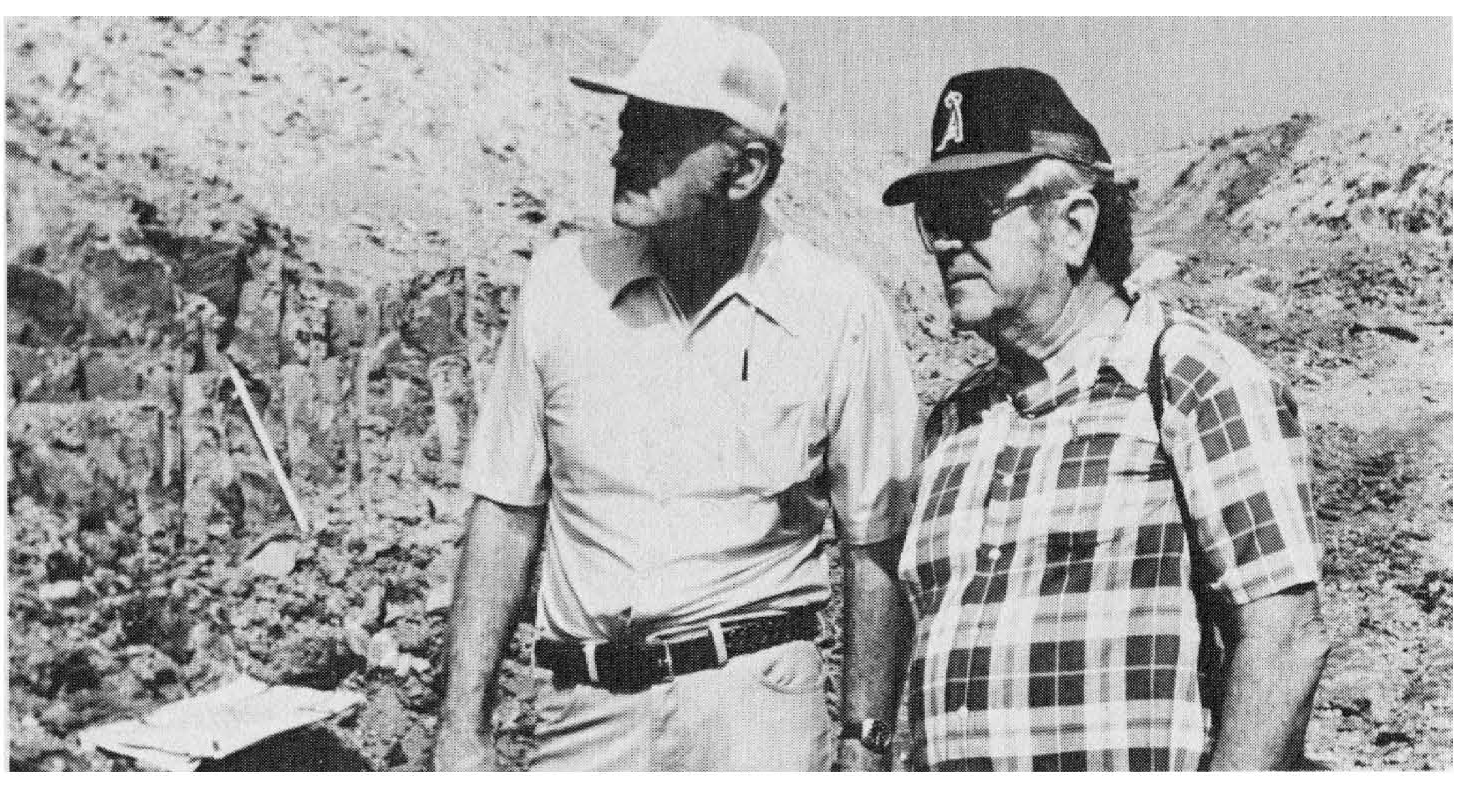
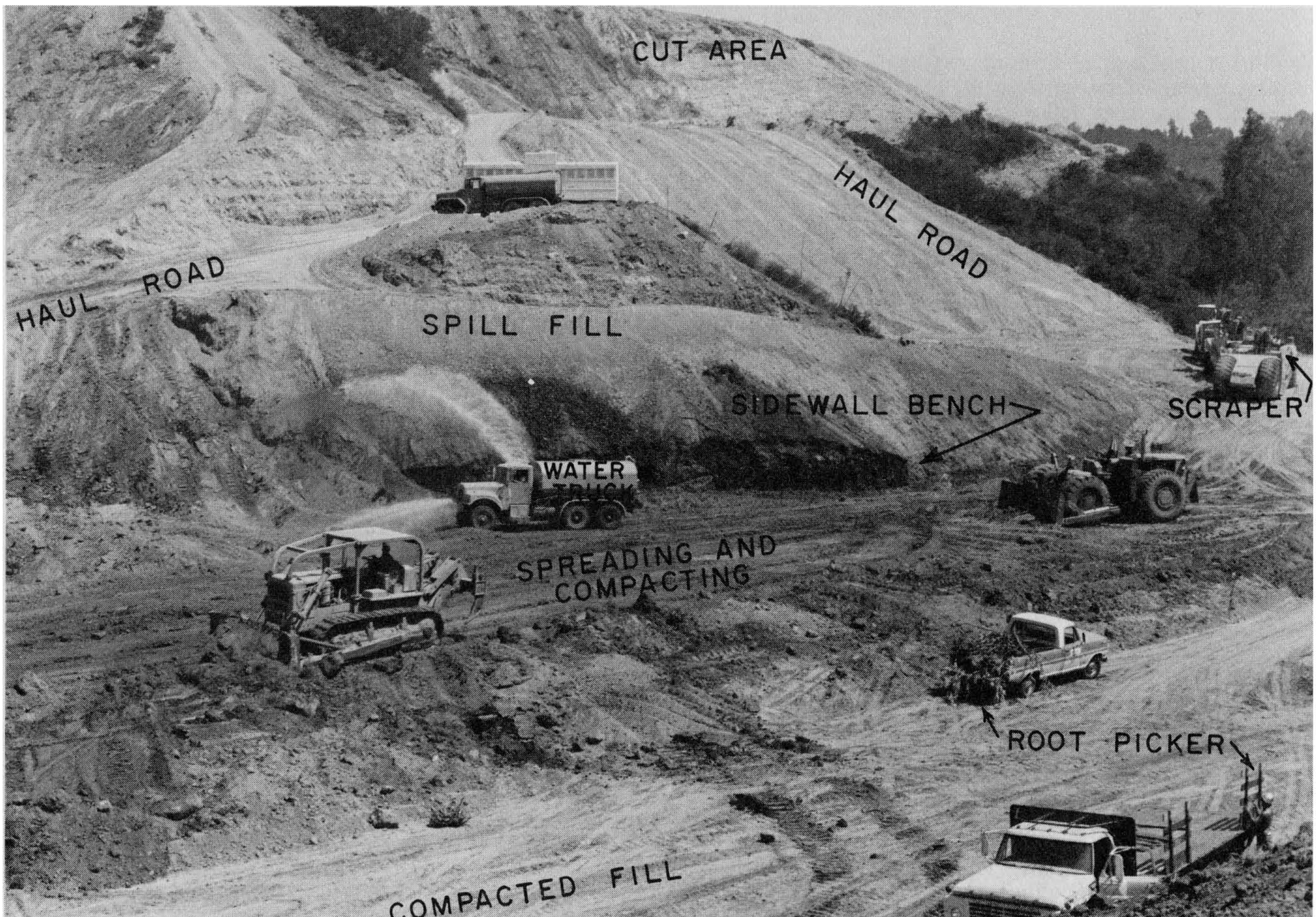


Figure 5-13 Robert B. Cassidy, project manager, and Robert W. Ross, supervising grading inspector, County of Orange, discuss the grading operation. Close communication between grading inspectors, geotechnicians, project managers, and supervisors is important. Photograph by C. Michael Scullin.

Figure 5-14 Sidewall benches are being excavated during canyon cleanout. These sidewall benches are 15–20 ft. high and are well into competent bedrock. At right, the dozer with a slope-bar is cutting the sidewall benches while scrapers load the material. Photo by C. Michael Scullin.

Figure 5-15 Grading operation is shown in progress. Scrapers transport earth material from the cut area to the fill site where it is spread in lifts of 4–6 inches thickness, watered, and compacted. Photograph courtesy of the Dept. of Building & Safety, staff photographer John Shadle.



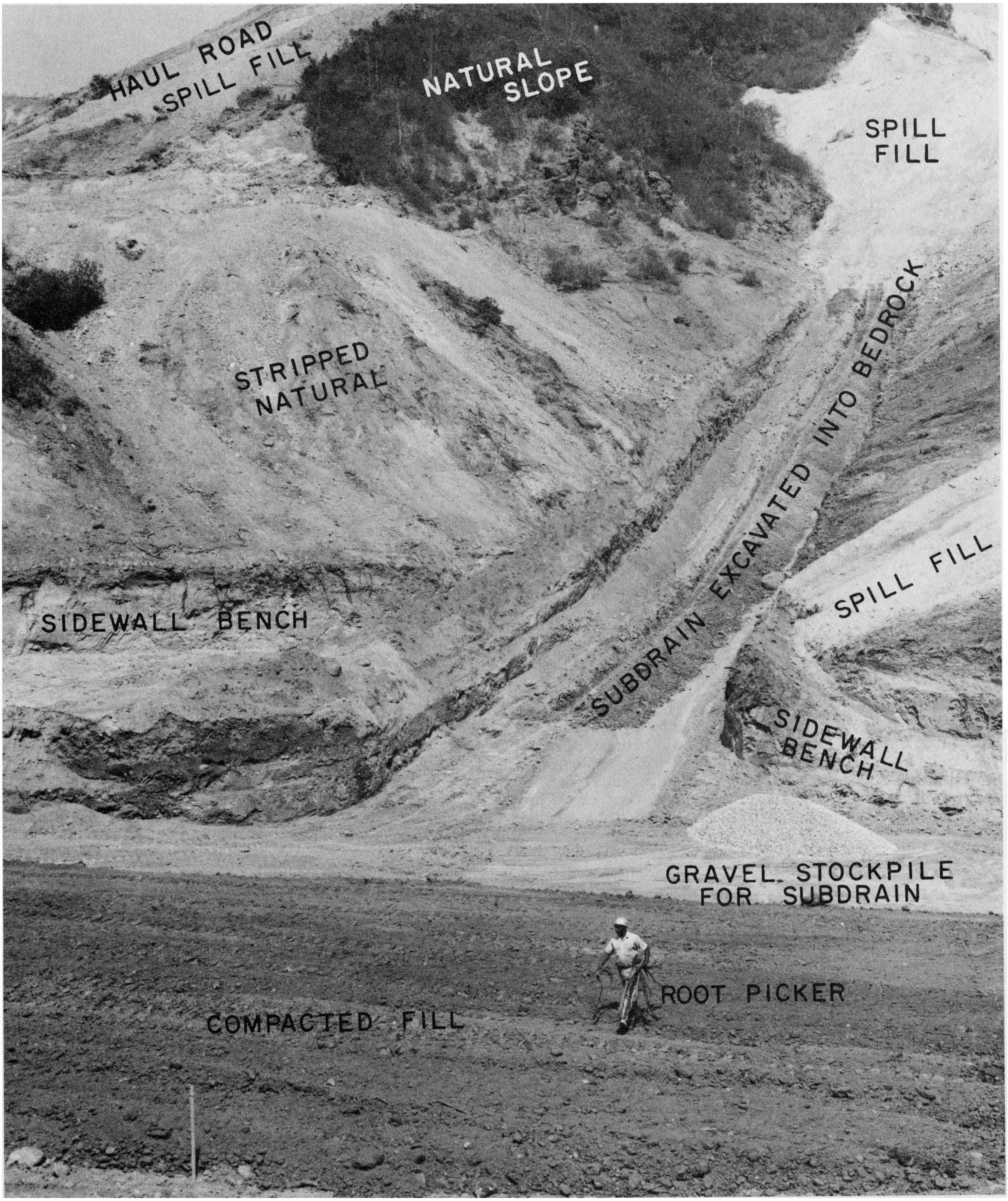


Figure 5-16 Here canyon fill is in progress. Brush, roots, and organic materials that are carried onto the compacted fill by the scrapers are removed by hand. Loose spill fills must also be removed as fill progresses. Photograph courtesy of the Dept. of Building & Safety, staff photographer John Shadle.

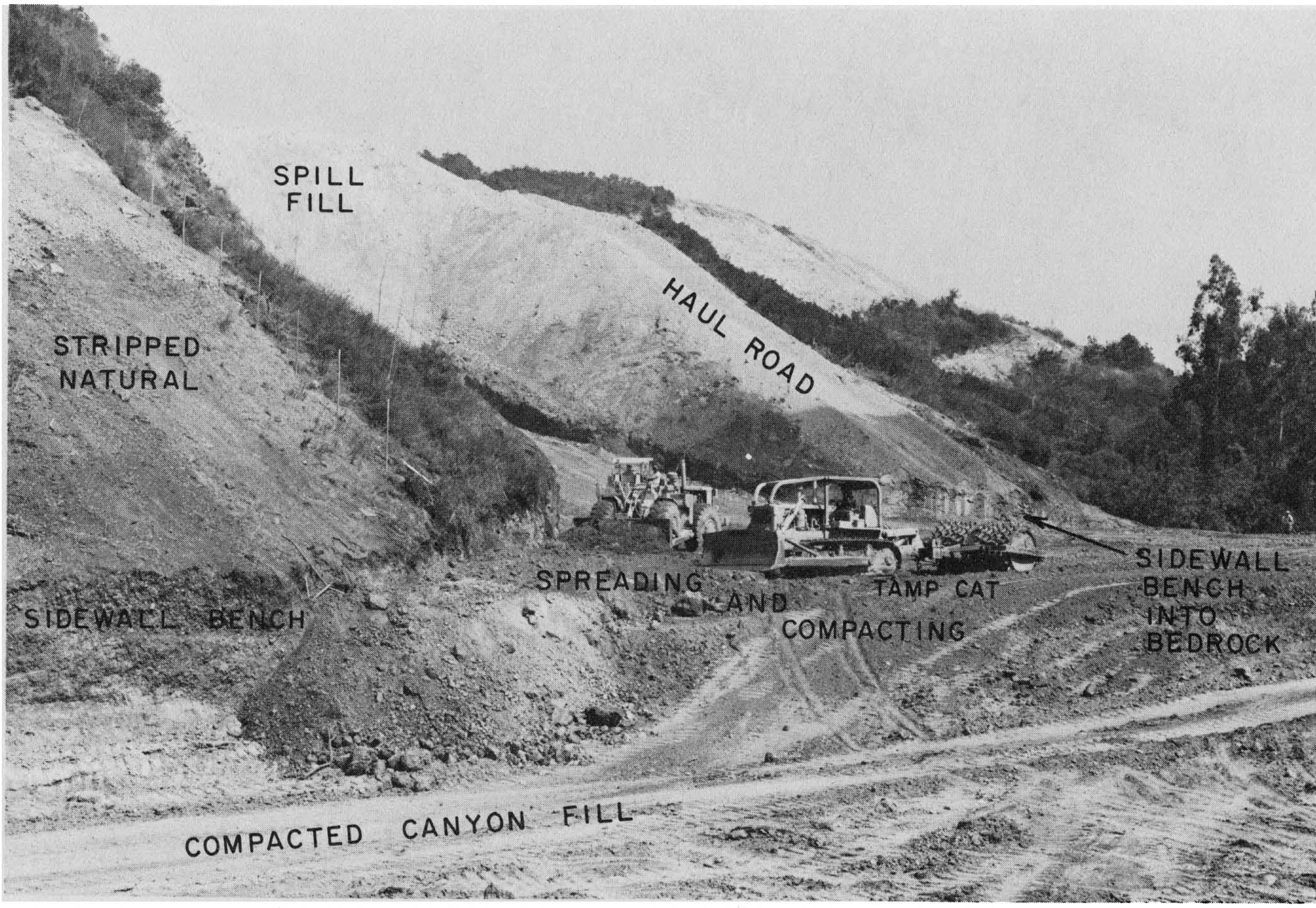
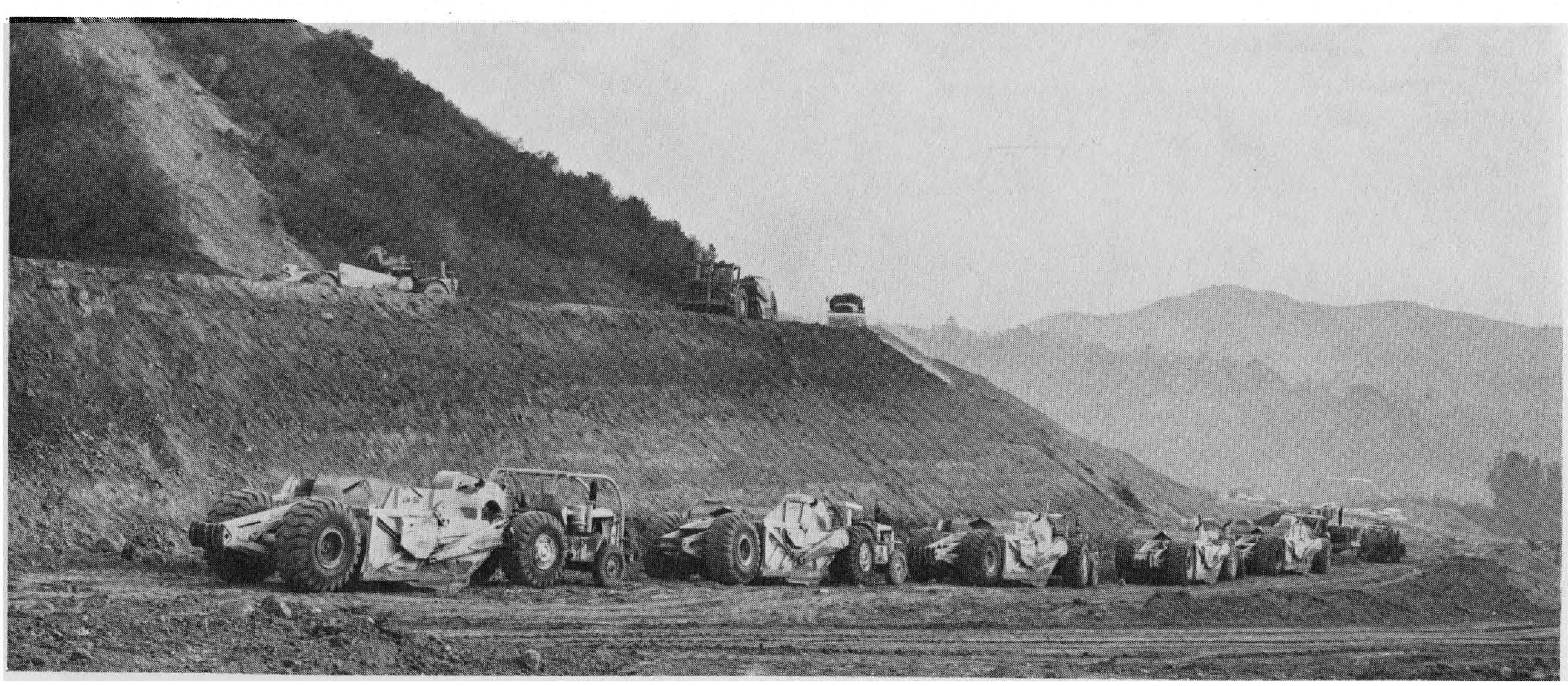


Figure 5-17 Canyon filling-in progress. The sidewall benches are narrowing as fill is almost lapping onto the near surface soils. The slope on the left needs to be rebenched. Notice the spill fills adjacent to the haul roads. These loose fills were inadvertently spilled during hauling and must be removed prior to fill placement. Photograph courtesy of the Dept. of Building & Safety, staff photographer John Shadle.

Figure 5-18 Fill-slope construction in progress. Scraper on the upper left is empty and is returning to the cut. The scraper upper center is hauling dirt to the fill site. The water truck is watering the slope. Photograph courtesy of the Dept. of Building & Safety, City of Los Angeles, staff photographer John Shadle.



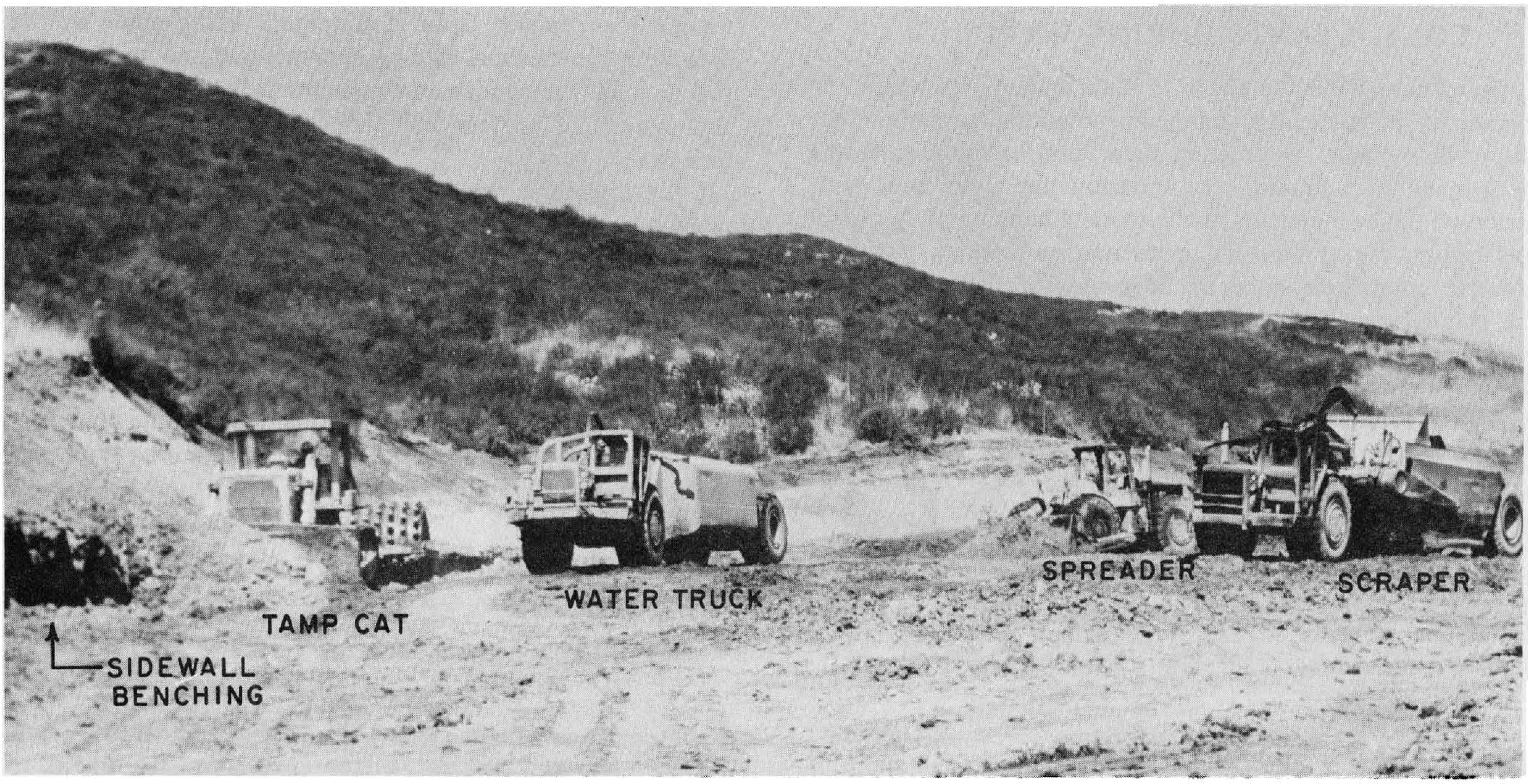


Figure 5-19 The compactor on the left is sidewall benching. The water truck, center, is spreading water on the fill. At right, rubber-tired spreader blade-spreads thin layers of fill while the scraper at far right dumps its load. Photograph by C. Michael Scullin.

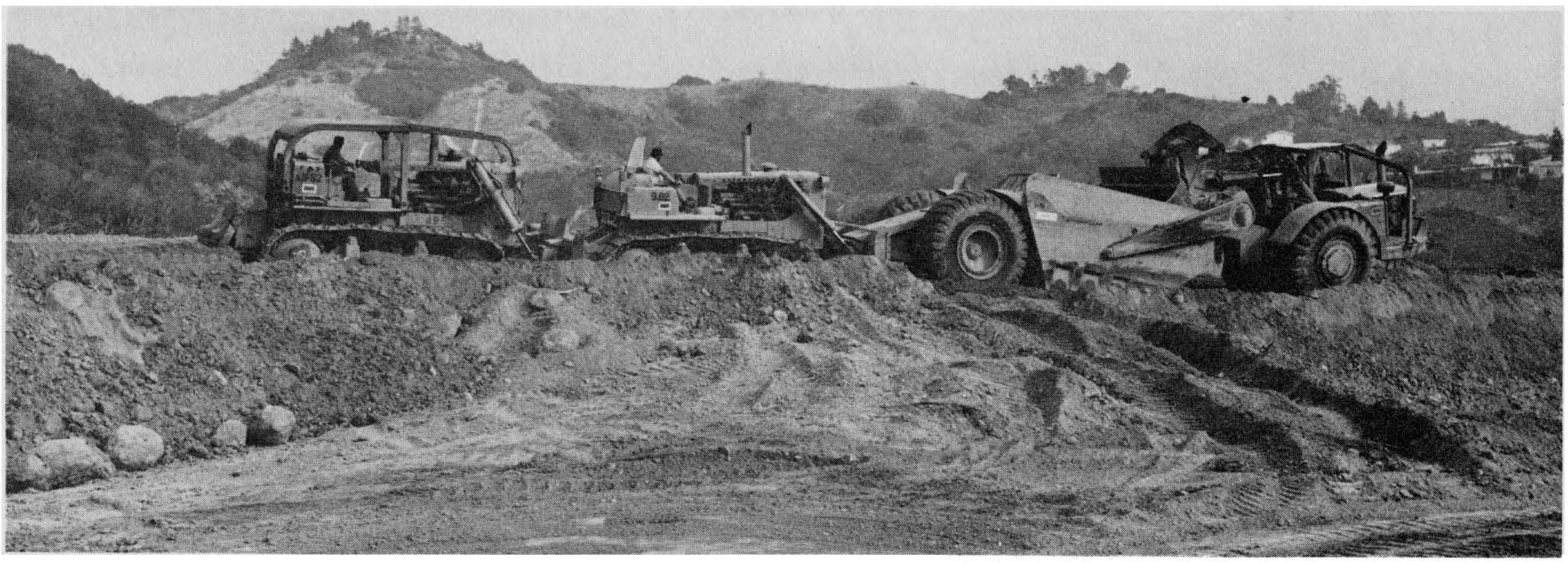
Figure 5-20 Ripping the cut area with double shank rippers. Photograph by C. Michael Scullin.

5-5 CHANGING PROFESSIONAL CONSULTANTS DURING GRADING

There have been instances in grading projects where the owner or permittee has changed professional personnel (the site civil engineer, the soil engineer, and/or the engineering geologist) after grading construction has commenced but prior to the completion of the work. Changing professional personnel during grading construction creates potential adverse conditions since the incoming professional cannot be totally aware of what has taken place prior to his involvement with the site, and since new problems may have developed during grading. Left unresolved, these problems may ultimately result in a settlement or subsidence or land failure that may bring about litigation. When it is necessary to change professional consultants during a project, the grading operations should be stopped until a complete report is prepared by the professional consultant who is leaving the project. Upon a statement being made by the incoming professional that he has reviewed and understands the data in the report and assumes full responsibility for that aspect of professional service, the operation may be resumed.

If the incoming professional cannot accept and approve the work completed prior to taking over, all or part of the previously completed work must be re-done so that portion of the project can be approved or a thorough investigation be conducted to assure approval. While such a requirement may present a hardship to the developer and the contractor, it is essential in order that the mass stability of the site can be continuously observed by professionals during construction in order to assure public safety through long-term performance of the stability of the site.

Figure 5-21 Two push-cats team up to shove a loaded scraper out of the cut. Photograph courtesy of the Dept. of Building & Safety, staff photographer John Shadle.



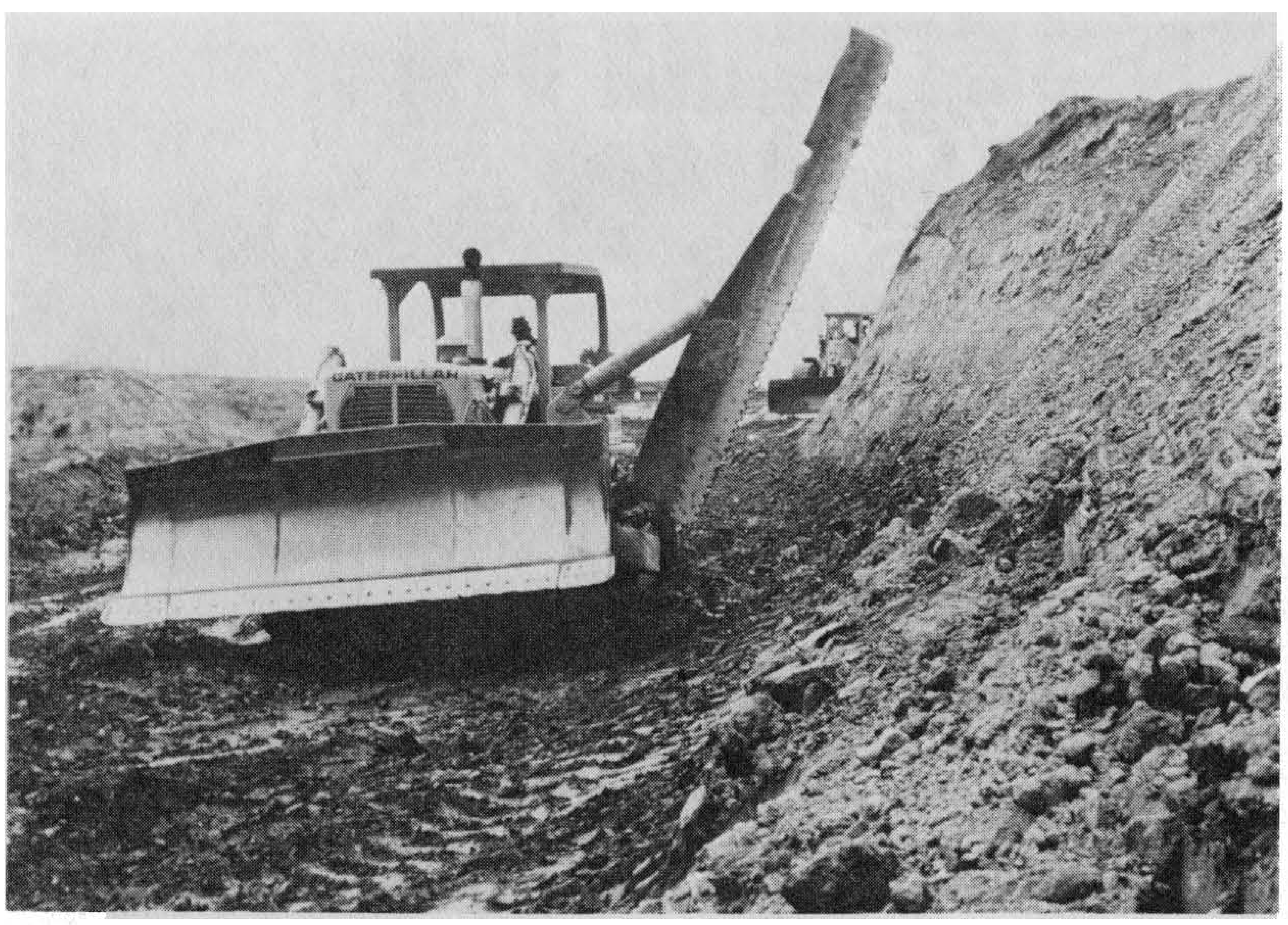
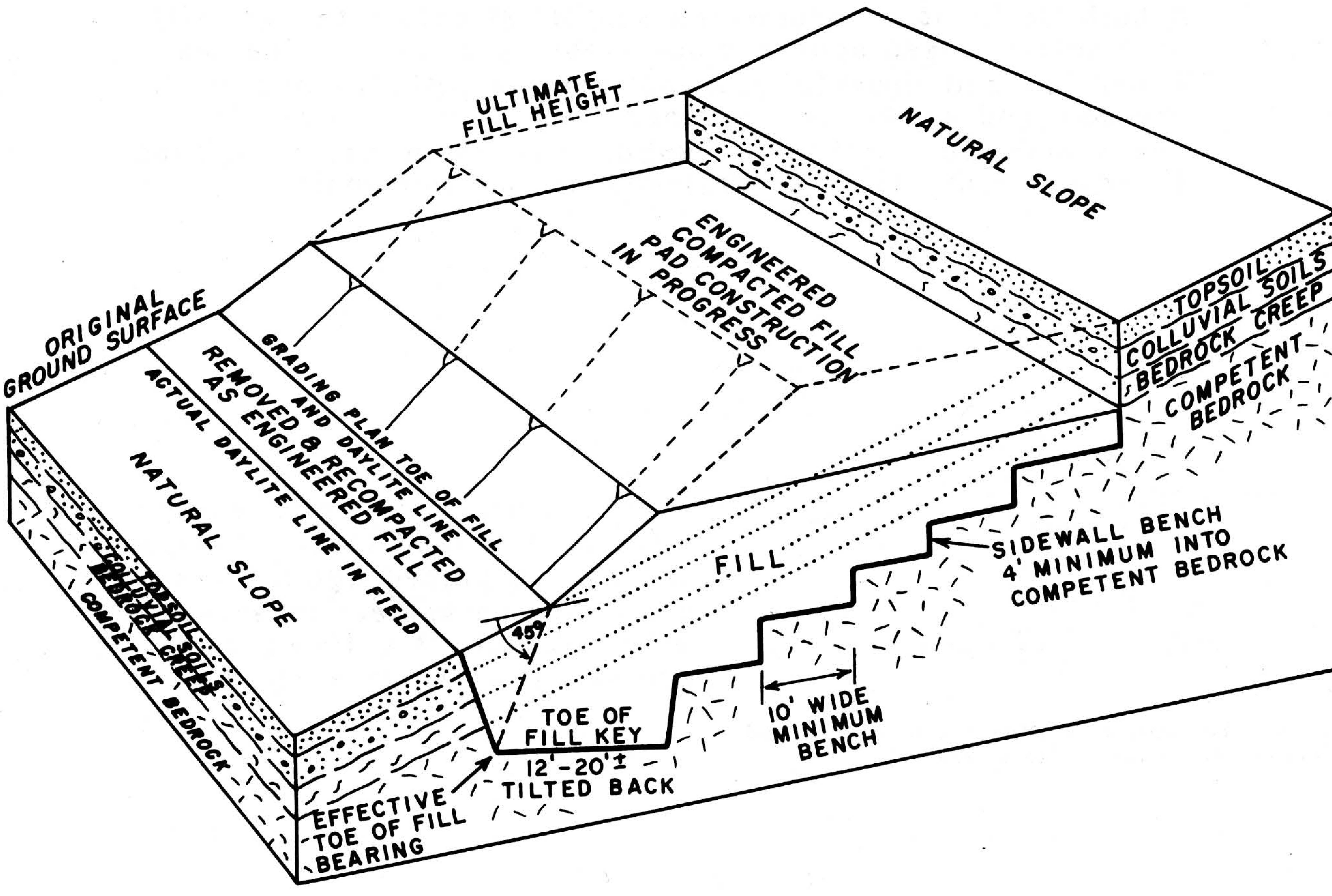
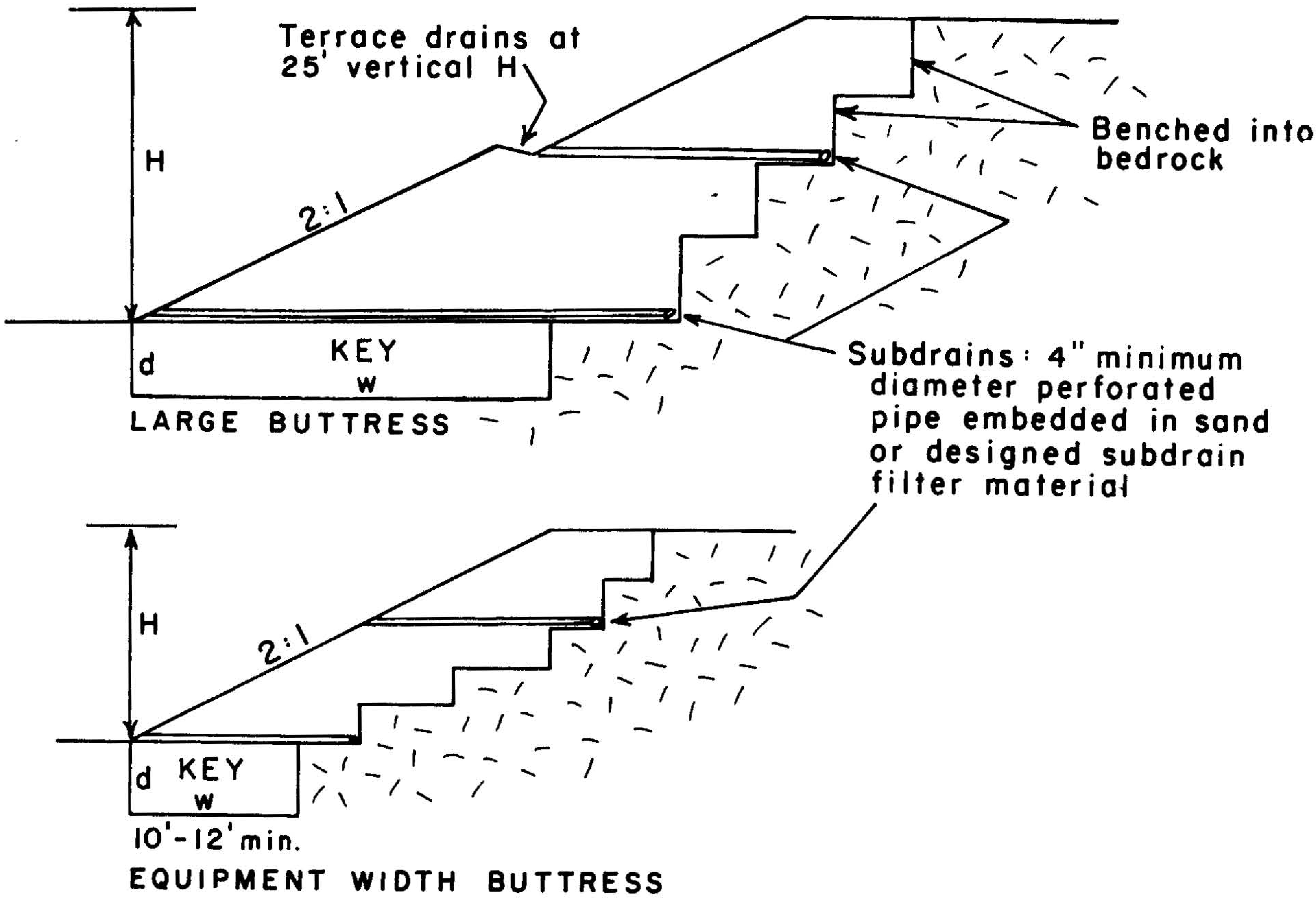


Figure 5-22 A ripper cat with a hydraulic slope board is shown here cutting slope angles. Photograph by C. Michael Scullin.

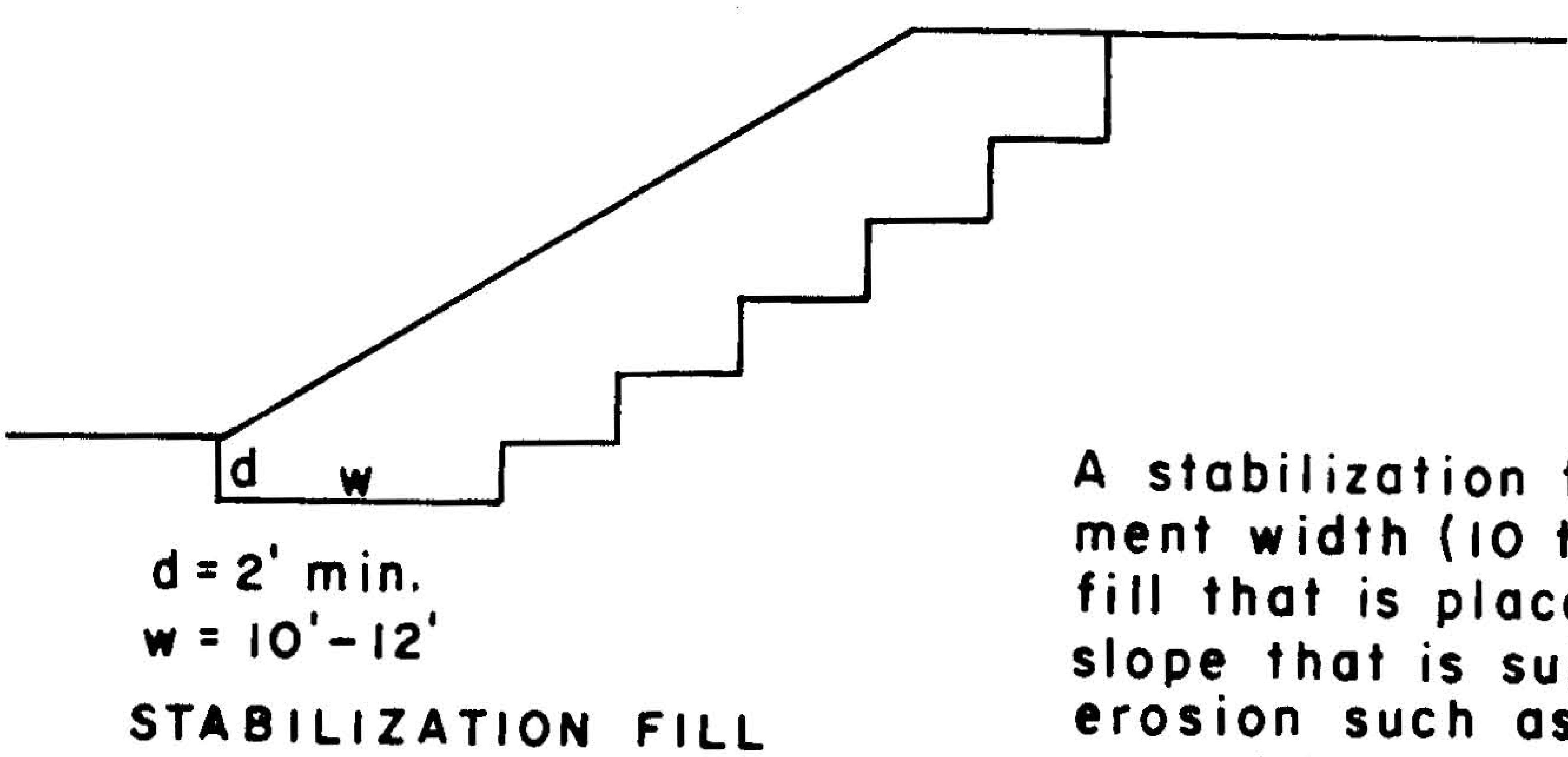
Figure 5-23 Robert R. Reece, senior grading inspector, and Robert W. Ross, supervising grading inspector for the County of Orange, California, inspect a cut slope that is starting to ravel along the bedding plane component in this siltstone. Photograph by C. Michael Scullin.

Figure 5-24 A typical toe-of-fill key for the construction of a sidehill fill in siltstone or shale terrain. The toe-of-fill key frequently requires keying and benching through several feet of topsoil, several feet of colluvium, and several feet of bedrock creep in order to key into competent bedrock. Toe-of-fill keys 10–20 ft. deep are common in such areas. Note that the effective bearing point of this toe of fill (45° from the horizontal) moves laterally downslope from the proposed grading plan toe. Source: C. Michael Scullin.



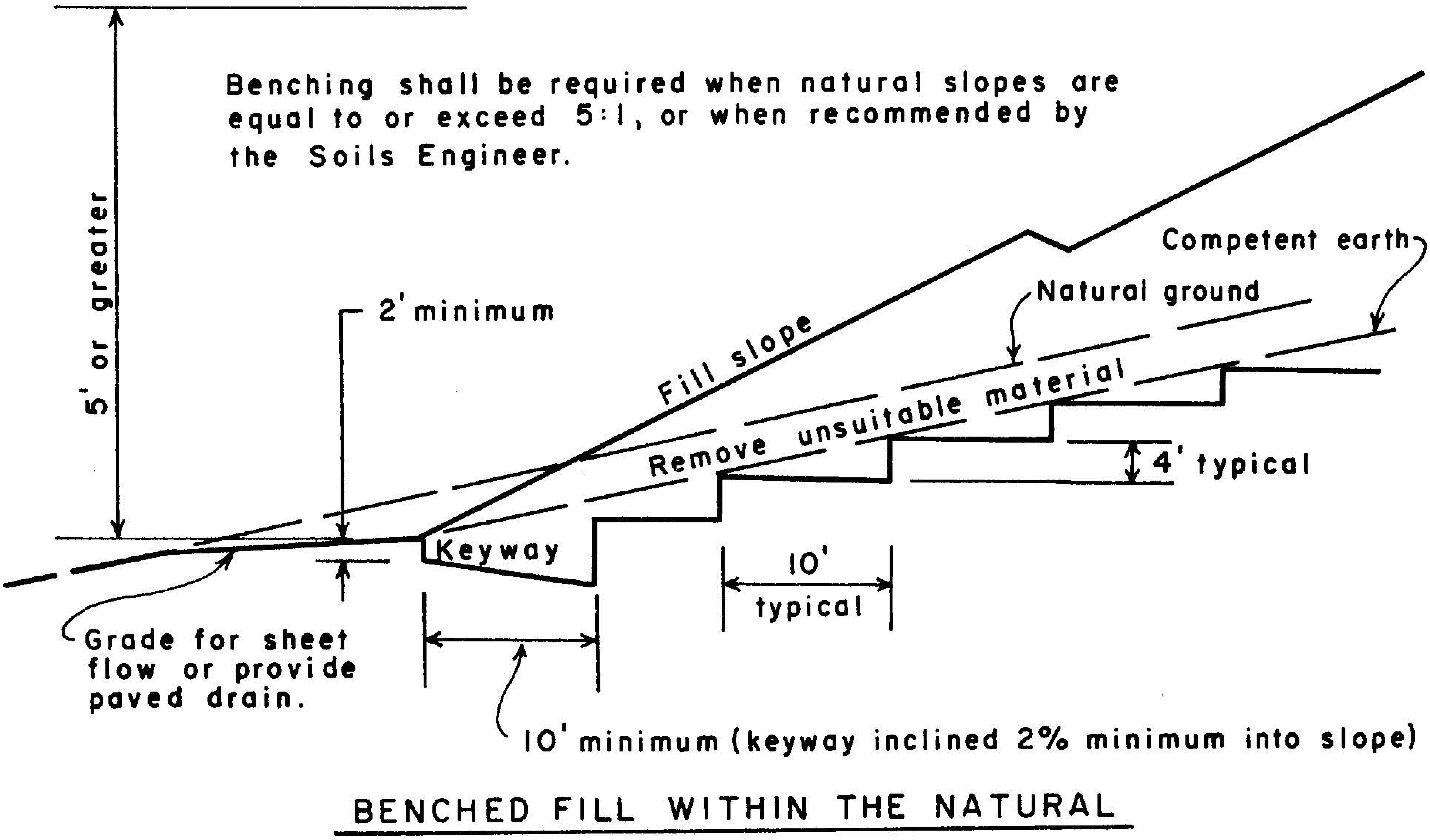


A buttress fill is an engineered support structure design with parameters based upon a slope stability analysis. The key width (w) and depth (d), the buttress heighth (H) and mass are designed by the soil engineer to support a slope that has a potential for failure. Subdrains are necessary and the filter material should be designed by the soil engineer.



A stabilization fill is an equipment width (10 to 12 feet) compacted fill that is placed against a natural slope that is subject to excessive erosion such as gullying or rilling caused by water or wind.

Figure 5-25 The difference between a buttress fill and a stabilization fill. Source: C. Michael Scullin.



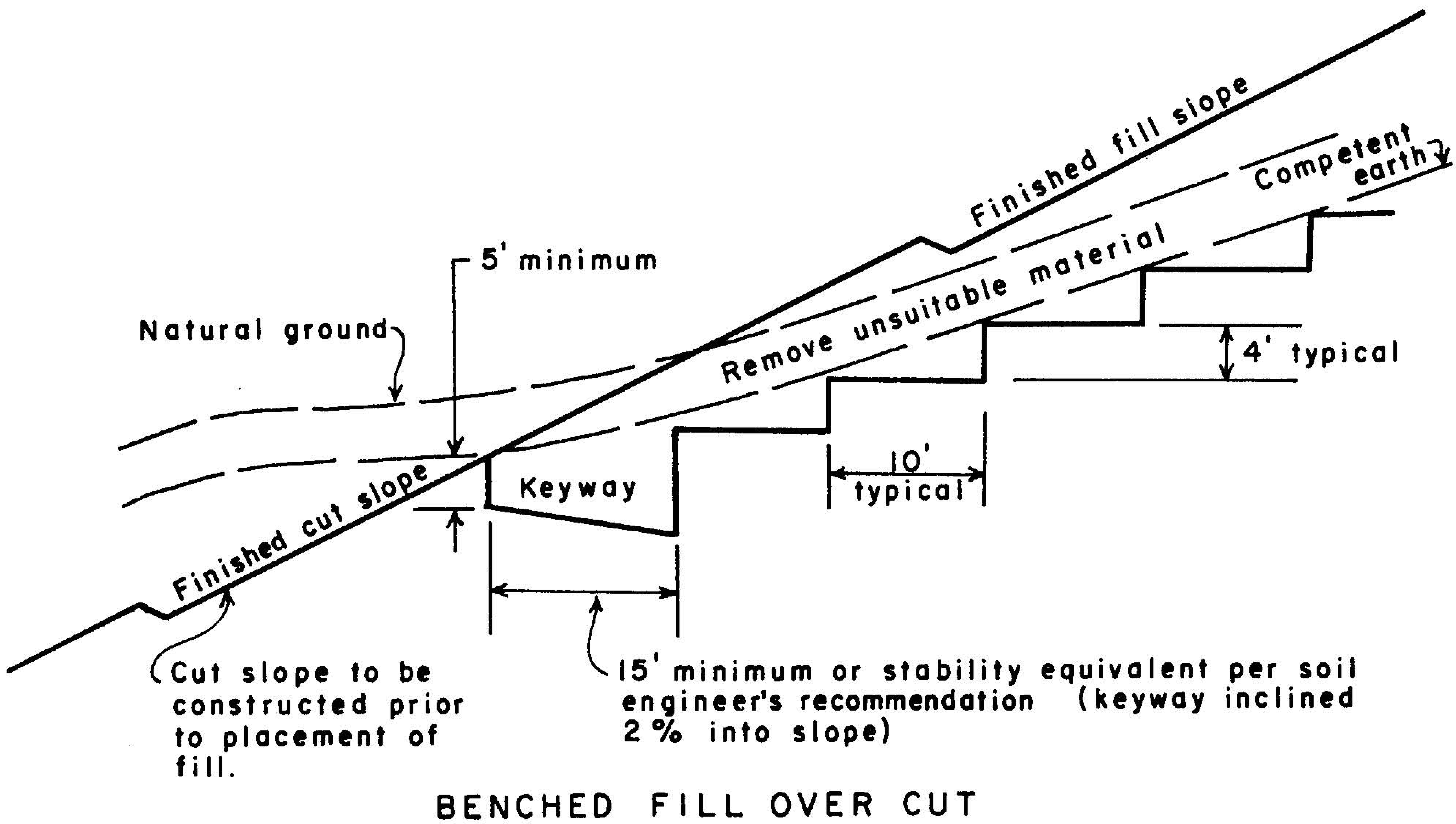


Figure 5-26 Suggested benching for compacted fill (altered from the Standard Sheet No. 322, County of Orange, California.)

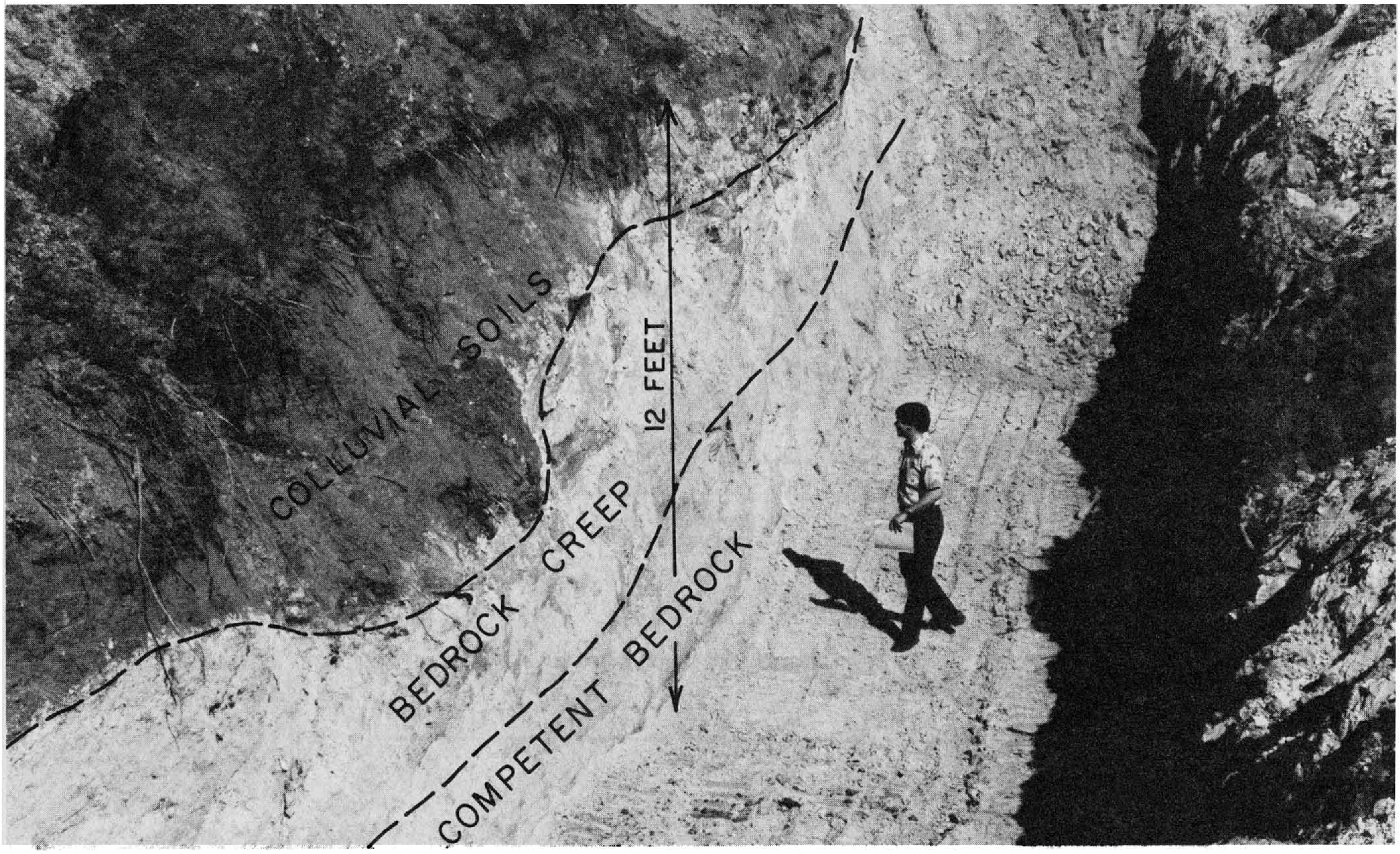
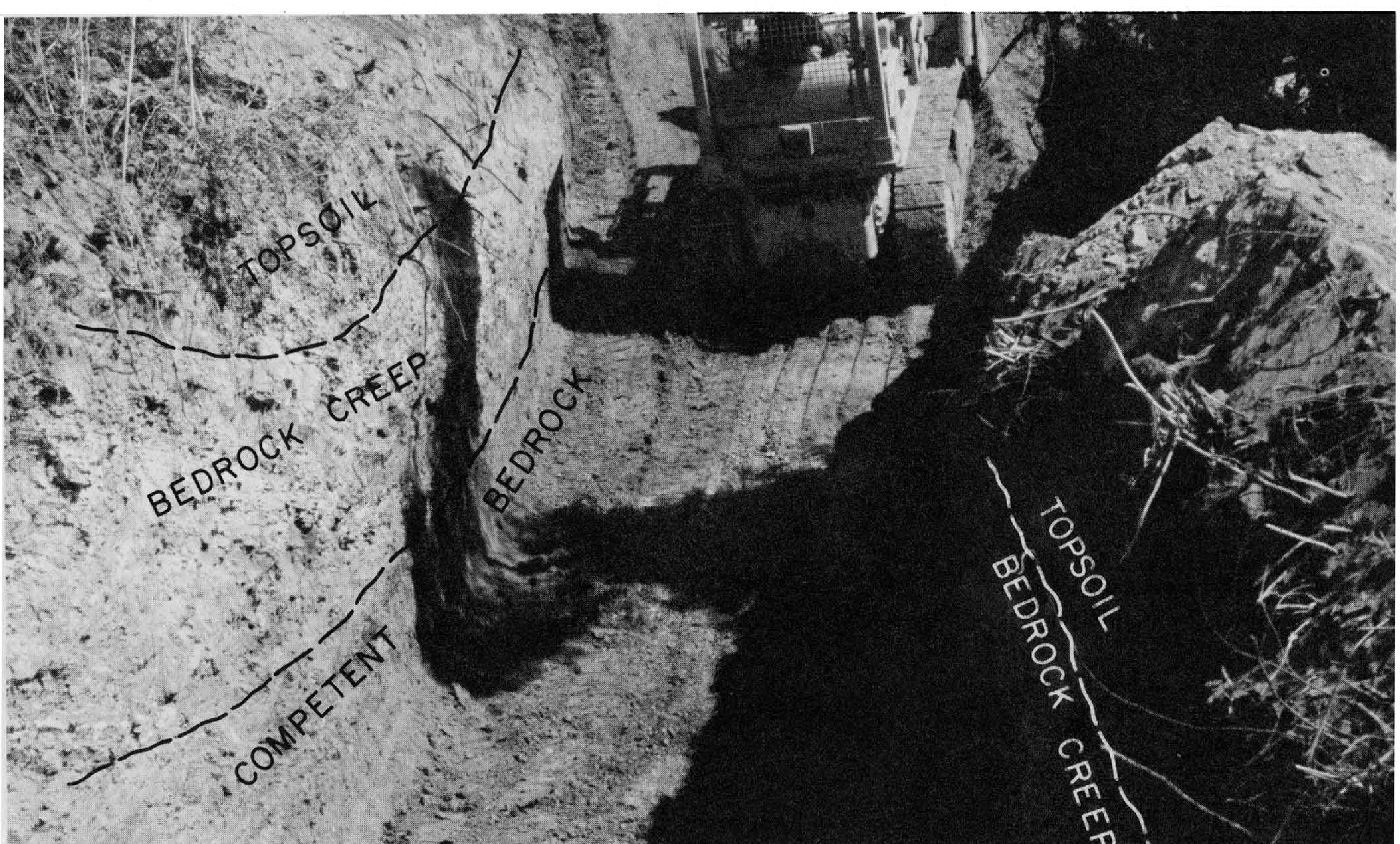


Figure 5-27 This toe-of-fill key backslope is 12-ft. deep in order to penetrate 3-ft. into competent bedrock.

Figure 5-28 Toe-of-fill key excavation in progress for a sidehill fill. Both photos by C. Michael Scullin.



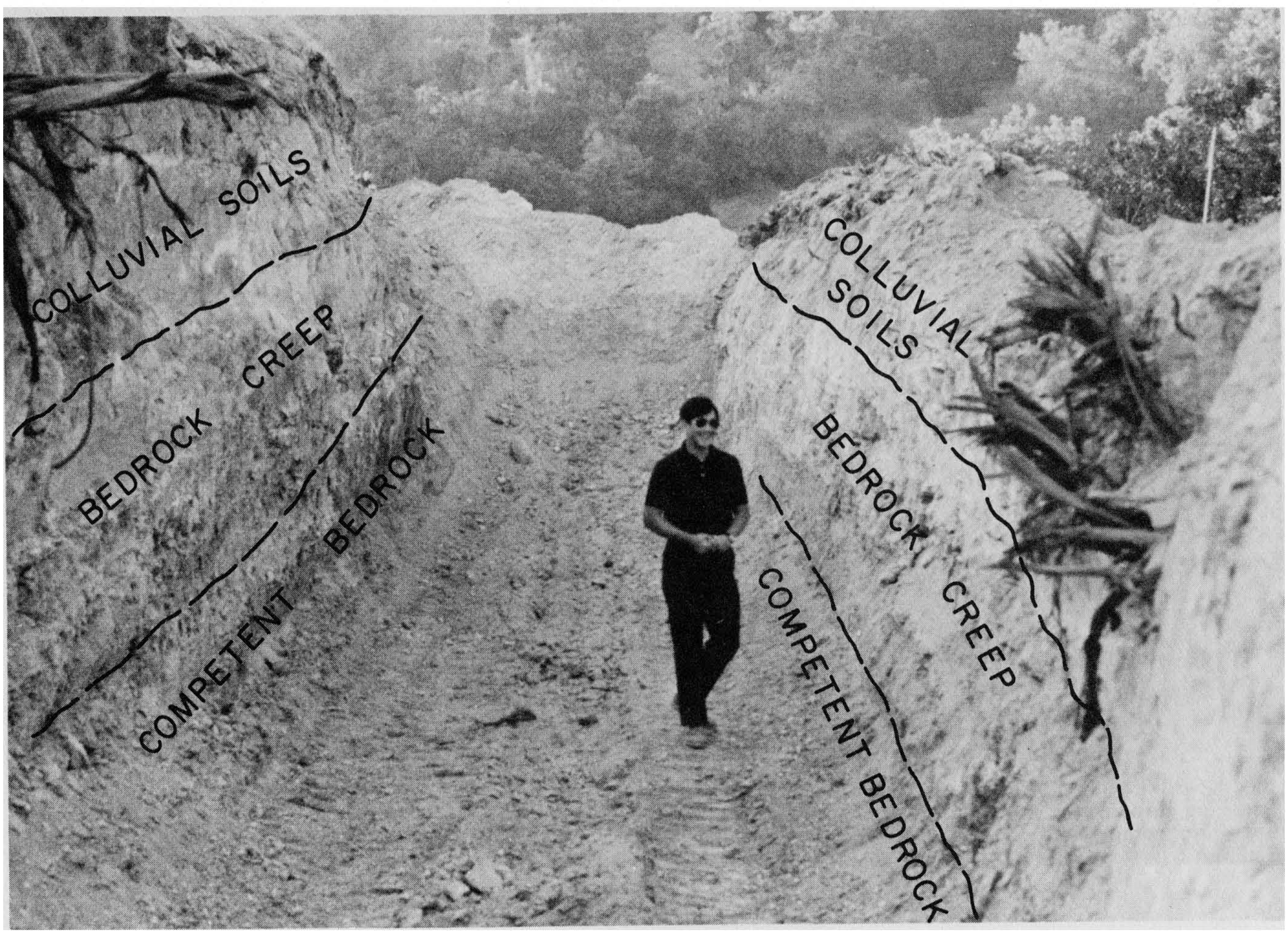
5-6 PROFESSIONAL REPORTS AND APPROVAL

Site consulting professional reviews and stage approvals occur continuously during the grading construction. No grading work should proceed without concurrent professional approval of both plans and construction for each step. Each of the special problems anticipated in the preliminary investigations and/or discussed at the pre-grading meeting are inspected, tested, and approved as they are graded. Additionally, any adverse soil or geologic conditions uncovered during grading must be corrected and approved as they are encountered during the grading. These are the primary means of effective grading inspection and quality assurance during grading construction.

Full-time soil engineering inspection is normally required during grading construction. The geologist should be available to make weekly inspections in order to assure that his recommendations are being complied with and to map in detail the geologic conditions as they are exposed by excavation prior to the placement of compacted fill. Bedrock is most exposed during rough grading, and detailed mapping during grading yields the most accurate data for the as-graded geologic map. (See Figures 5-7 through 5-34.)

The grading inspector and the soil technician should make sure that the grading contractor has *proper equipment on the job* to do the work specified in the permit. This includes excavation equipment such as earth-moving scrapers, compaction equipment such as sheepsfoot roller or vibratory compacter, water trucks, and dust control equipment. The 5 feet by 5 feet drum sheepsfoot should be filled with water and should have proper sheepsfoot caps on the spikes in order to obtain the desired compaction. The grading contractor may use other types of compaction equipment such as the Wagner compactor or a pneumatic roller. However, the soil engineering technician must test for proper compaction. If the contractor is unable to achieve desired compaction densities with existing equipment, he must use whatever equipment is necessary to obtain the desired result. (See Figures 5-11, 5-17, and 5-19.)

Figure 5-29 Shear keys, buttress keys, and toe-of-fill keys should be inspected both by engineering geologists and soil engineers to assure proper penetration of competent bedrock. David Hsu, T. W. Soil Engineering Consultants, Inc. inspects this engineer-designed shear key excavation. Photograph by C. Michael Scullin.



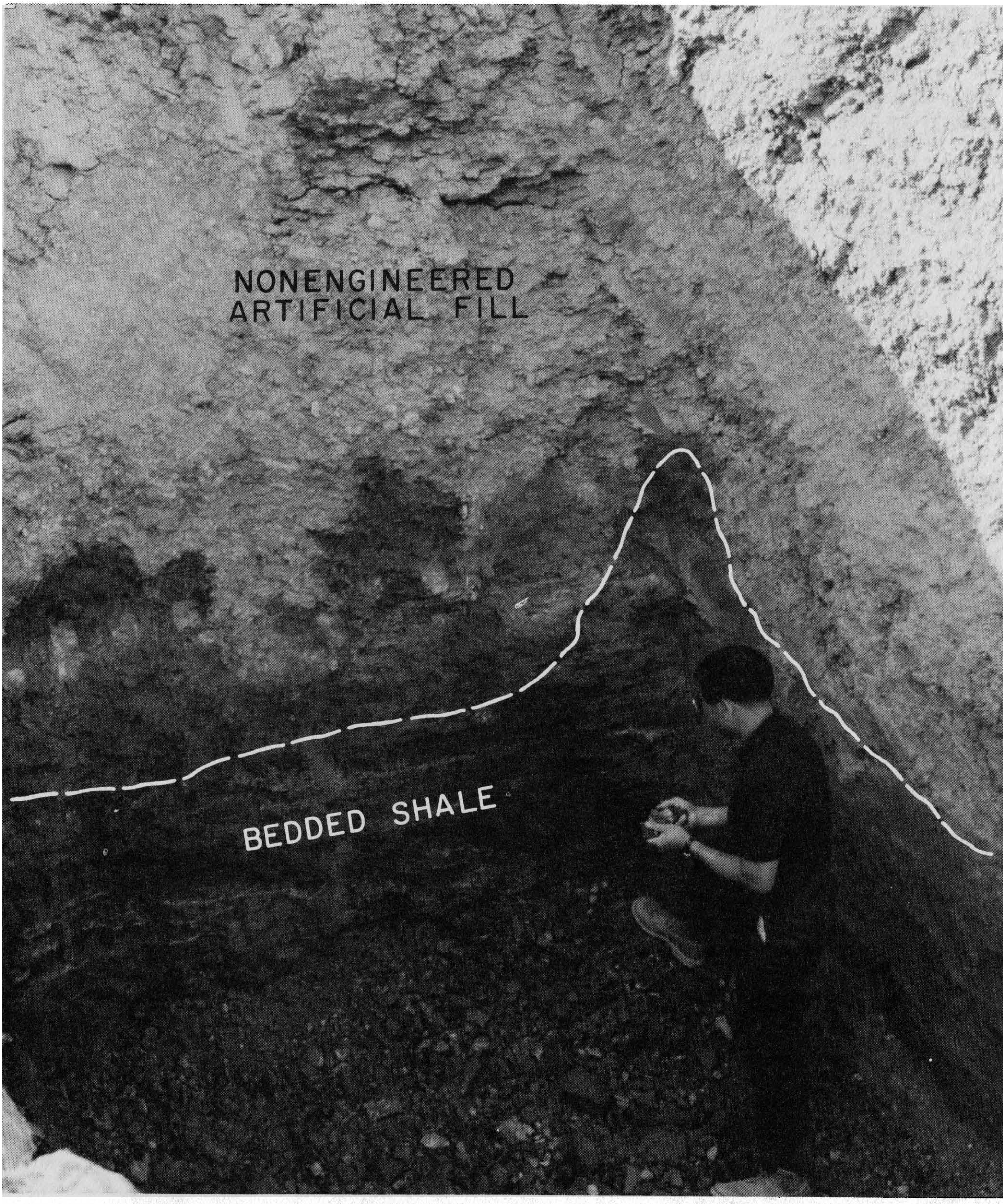


Figure 5-30 Toe-of-fill key through old loose artificial fill. Benching through this fill removes the loose material and keys into competent bedrock. Photograph by C. Michael Scullin.

Figure 5-31 A lime stabilization buttress key excavation in gypsiferous siltstone is shown here. Notice the white gypsum seams and the gypsum-filled joints. Grading inspector Burdette Sanders, dark shirt, is shown inspecting the key. Photograph by and courtesy of Robert W. Ross.

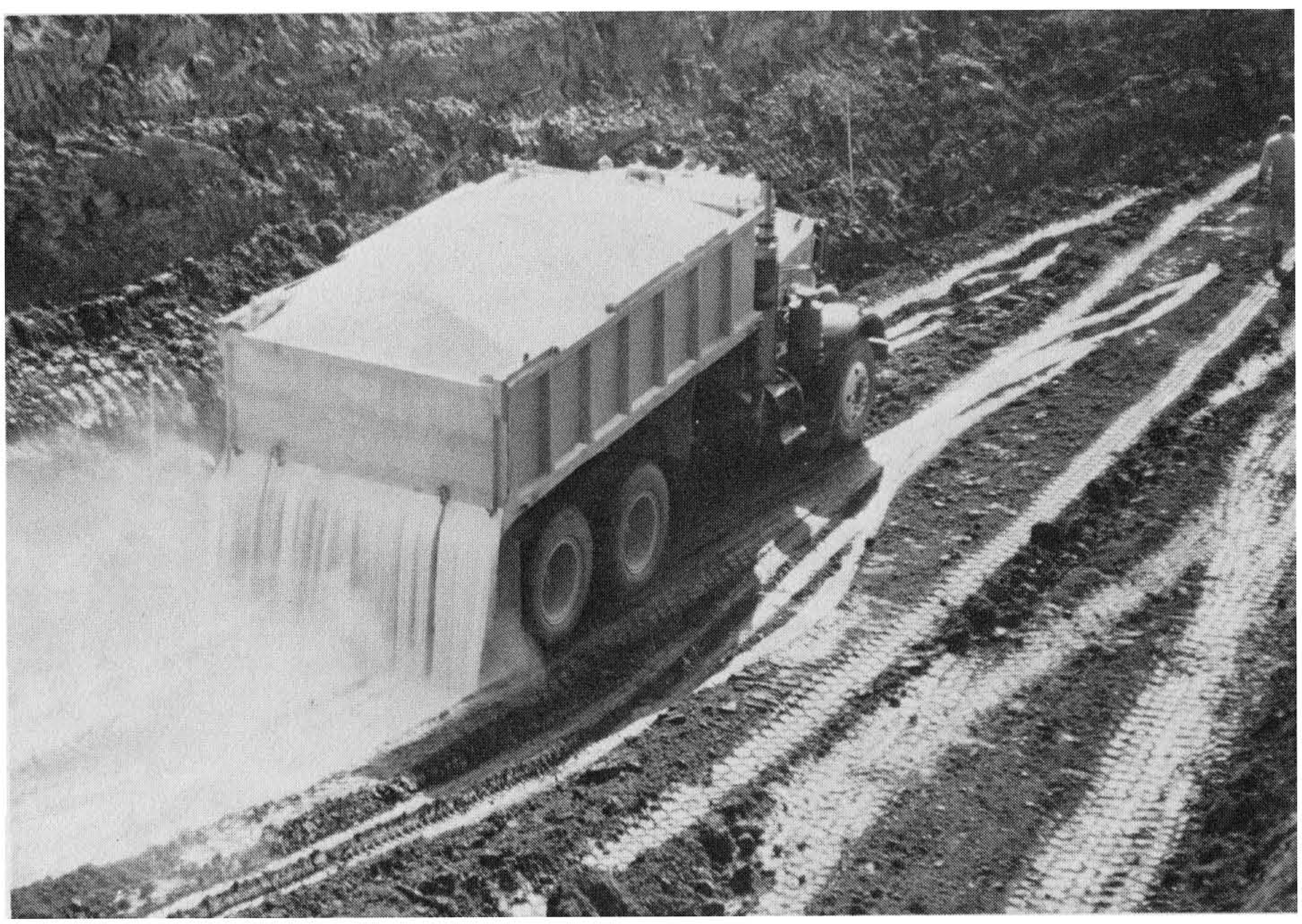


Figure 5-32 Laying lime in the buttress key. Photograph by and courtesy of Robert W. Ross.

Figure 5-33 Grading contractor, James E. Stephenson, Anaheim, CA, and the soil engineer check the thickness of lime in the key. Photograph by and courtesy of Robert W. Ross.

Figure 5-34 Mixing and compacting backfill and lime in the buttress key. Photograph by and courtesy of Robert W. Ross.

Removal of Organic Material and Debris

This is normally required by code and by the soil engineer. The grading inspector and the soil engineering technician must assure that all vegetation, roots, other organic material and inorganic debris is removed from the site, and that tree basins are cleaned out. The contractor may need to use laborers to pick roots, organic materials, and debris out of the fill areas for proper disposal off-site. (See Figures 5-1, 5-2, 5-15, and 5-16.)

Toe of Fill Bench and Sidewall Benching

These are necessary in hillside areas where compacted fill is placed. A bench at the toe of fill is a level area at least 12 to 14 feet wide that is established at the toe of fill slope for support. (See Figure 5-26.) This bench should be constructed within bedrock or competent soil that can support the weight of the proposed fill without undue settlement. The site soil engineer makes this determination. (See Figures 5-24 through 5-26.) The toe of fill bench is normally tilted back at 2%.

Sidewall benching is a term used to denote vertical cuts made into bedrock as the fill is being raised. Sidewall benching is intended to remove compressible soils and to establish a bond with bedrock or competent soils as approved by the soil engineer. The use of benching at the toe and along the sides of the fill as the fill is raised has been used to lock the engineered or compacted fill into the side slopes of canyon fill or to tie the fill into bedrock in a manner that assists in minimizing future settlement or subsidence. This provides vertical bearing on bedrock and stabilizes the side slopes. (See Figures 5-2 through 5-5, 5-9, 5-14 through 5-17, 5-19, and 5-24 through 5-26.) At all times during fill placement, the benching operation must expose competent bedrock in the vertical portion of the cut. The geologist and the soil engineering technician should determine the depth of colluvial soils on the side slopes of the canyon and of alluvium in the flow line of the canyons. They also evaluate the compressibility of the material and determine whether or not the soil should be removed, or may be re-used as compacted fill.

The grading inspector should verify that during fill placement the compacted lifts are within the tolerances approved by the soil engineer and that the density tests are being taken by the soil engineering technician. Any need determined by the soil technician for additional moisture or additional compaction should be supported by the grading inspector. Density tests should be taken in accordance with the American Society of Civil Engineers (ASCE) Geotechnical Engineering Group. (See Section 5-12 discussion of density testing.)

Rock placement in compacted fills requires supervision by the soil engineering technician. Rock placement generally involves spreading of rock and flooding to fill the voids around the rock. Normally the soil engineer does not allow clustering or stockpiling of rock as this forms cavities in the fill that may later shift to fill voids, causing settlement of the surface of the fill. (See Rock Disposal Detail, Appendix D.)

Primarily the grading field inspectors supervise all professional representatives on the job and support them in their efforts to assure compliance with the conditions and specifications of the permit.

In-Grading Professional Reports

These reports may be required in order to justify interim approvals for conditions like the following: approval to issue building permits for model lots, or approval to continue grading in cases that involve adverse geotechnical conditions uncovered by the grading. Discovery of previously unknown landslides and/or undetected compressible material require evaluation prior to continuance of grading.

Interim professional reports may also be required in cases involving on-site determination for the need of buttress support. Sometimes data available during preliminary investigations are insufficient for adequate site analysis because of subsurface changes in geology or soil conditions. In such cases, detailed investigation and analysis during grading are mandatory. These investigations may include false cut slopes in front of the planned cuts to determine buttress design parameters, or dozer pits excavated in the area of planned sidehill fills to evaluate the need for shear keys at the toe of fill. Geologic cross sections and soil engineering analysis should be submitted to the building official prior to continuation of grading in those areas under study. The frequent existence of such conditions substantiates the need for requiring full-time soil engineering inspection and frequent regular geologic inspections during grading. It is also justification for requiring the site geologist to map bedrock exposures in detail during grading construction so that he can identify changes in conditions that may indicate problems needing analysis during grading construction. (See Figures 5-20 thru 5-23.)

5-7 CANYON CLEAN OUT AND SUBDRAIN INSPECTION

Canyon clean out involves the removal of compressible soils such as topsoil, slope wash, colluvium, and alluvium in order to establish proper bedding of canyon fills. As this material is removed, the grading inspector should make sure that the soil engineering technician has specified in writing through either a field memo or an office directive that bedrock or competent soil that is left in place is suitable for the placement of the compacted fill without undue settlement of the fill prior to the actual placement of the fill. (See Figures 5-2 through 5-10, 5-14 through 5-19, and 5-24 through 5-30.)

Subdrains reduce or minimize the potential for hydrostatic build-up behind or beneath compacted fills. Soil engineers and geologists should determine whether or not given sites require subdrains since some fills may be constructed safely without them. Most deep canyon fills should have subdrains even if they are dry at the time of inspection, as future irrigation build-up or heavy rain seasons increase the infiltration of water into the subsurface.

Canyons often contain seepage or subsurface water that must be intercepted and drained, usually by a subdrain connected to a proper outlet. The canyon clean out and subdrain area should be inspected by both the soil engineer and the geological representative in order to determine the best locations for subdrains and the best subdrain designs for adequately draining seepage water. Normally the subdrains are tied into the bedrock where they most readily intercept water percolating down bedding planes or through joints, shears, fractures, faults, or other avenues for subsurface water. These subdrains must be designed both to carry anticipated water and to withstand pressures from heavy compaction equipment placing fill on top of the subdrain so that the subdrains are not compacted during remaining construction or use of the sites. Normally, the shading or gravel cover over subdrain pipes should be 18 inches to 2 feet to minimize the likelihood of compaction of the subdrain. It is essential that subdrains carry anticipated waters. (See Figures 5-6 through 5-9.)

The site civil engineer should survey the location of the subdrain as it is constructed in the field so that its location and outlets can be shown on as-graded or as-built grading plans. This is necessary in case either additional subdrains need to be tied into the originals, or it becomes necessary later to drill down to determine that the subdrains are still functioning. Subdrain outlets should be constructed prior to placement of fills in such a manner that they can be found easily upon completion of fill slopes or canyon fill construction. This is essential because it is often very difficult to locate subdrains when covered by backfill, and efforts to relocate subdrains often involve removal of lower portions of fill slopes, which endangers or reduces the stability or future performance of the fill slope. It is important that the grading inspector makes sure that the subdrain outlets are properly completed and surveyed for line and grade prior to backfilling. (See Figure 5-35.)

5-8 TOE OF FILL KEY INSPECTION

There is a difference between a toe of fill key and the toe of fill bench as discussed in Section 5-6. A toe of fill key is a slot cut at the base of a fill. It is excavated into competent bedrock and the key provides a more stable toe of fill than does the bench cut. A key may be used for a buttress, to support fill, or in an area where a normal fill slope is being built on a side slope adjacent to a canyon to lock the fill into competent bedrock. Note angle of toe of fill key, Figure 5-24, in comparison with toe of fill bench in Figure 5-25.

Building a fill key normally requires grading through and removing compressible soil and grading through the near surface bedrock disturbed by creep. The toe of fill should be established or keyed into competent bedrock.

To establish keys safely in competent bedrock in steep terrain where natural slopes vary from $1\frac{1}{2}$-to-1 gradients to 3-to-1 gradients, the toe of fill keys may be 5 feet to 10 feet deep on the downhill side of the keys, whereas toe keys on more level areas may only be 2 feet to 4 feet deep. The depths of these keys are somewhat dependent upon the thickness of compressible soils and bedrock creep that has to be penetrated in order to establish them properly in competent bedrock.

A fill over a cut slope requires a key (Figure 5-26). This key should be a minimum of 5 feet deep or 2 feet into competent bedrock, whichever is greater, to assure that future erosion of the cut slope or future surface creep will not remove lateral support of the overlying fill mass.

The toe of fill key is generally excavated for the full length of the key for short-length toe of fills. These keys are slot-cut in sections for long lengths of toe of fill. The soil engineer and geologist usually design toe of fill keys as a part of their recommendations made during their preliminary geotechnical investigation. During construction,

Figure 5-35 Subdrain outlet at the toe of a rough-graded fill slope. This fill slope needs to be finished; however, the subdrain outlet is properly exposed with an outlet above the toe of slope. Photograph by C. Michael Scullin.

the grading inspector must make sure these key sections are inspected by both the soil engineering technician and site geologist, and that they have the prescribed width and depth.

If the slot-cutting method is used, stockpiles of excavated materials will have to be located where the materials can be re-used as part of the compacted fill without causing loose fill problems or stressing natural or excavated slopes. The bedrock structure should be inspected and mapped by the project geologist, and if subsurface water or seepage is anticipated, subdrain construction should progress as designed.

The soil engineering representative should consider the toe of fill key backslope stability and whether or not it is safe to excavate the backslope at a steep angle for the length of key required. On large canyon fills these backslopes sometimes fail due to the vibration of the equipment used to complete construction, the steepness of the backslope, and the incompetency of the soil and bedrock material being excavated. (See Figures 5-4 through 5-12 and 5-24 through 5-34.)

5-9 BUTTRESS FILL, SHEAR KEY, AND STABILIZATION FILL INSPECTION

The difference between a buttress fill and a stabilization fill is illustrated in Figure 5-25. A buttress is a designed support structure based upon a slope stability analysis, while a stabilization fill is an equipment width compacted fill placed against a natural slope that is subject to excessive erosion as from water gullying or wind rilling. Running sands and loose silts subject to badlands-type erosion are normally stabilized. Stabilization fill is a blanket fill placed over or against a slope face to change the density and strength of the material to prolong its ability to withstand the erosive action of water or wind. Buttress fills, which should contain subdrains, vary in size depending upon the size of the slope requiring support. The actual calculations and design parameters of buttress fills will be discussed in detail by Richard T. Frankian in Chapter 10.

The grading inspection of buttress fills and stabilization fills is very similar to inspection of toe of fill keys. These inspections should all be based upon the design parameters established within the geotechnical report and as shown on the approved grading plan. Construction techniques are also similar, as both the buttress fill and stabilization fill have a toe of fill key. The width and depth should be accurately measured and surveyed, and the results should be shown on the as-graded plan. When subdrains are constructed, subdrain locations and elevations should also be surveyed. Stabilization fills normally do not have subdrains unless the sands and silts are subject to water recharge which may cause hydrostatic build-up behind. In such cases, subdrain outlets must be constructed and surveyed at the time of subdrain construction. Keys and backslopes should be inspected by both the soil engineer and engineering geologist, and geologically mapped for the permanent record in the final geotechnical report.

The actual toe of fill normally shifts outward, as shown on Figure 5-24, and the effective bearing point is located at the point where a 45° angle is projected downward from the grading plan toe of fill to a point where it intercepts the bottom of the key. These locations should be surveyed and staked in the field for accurate excavation of the key. Once excavated, the key should be surveyed again for the as-graded plan record. Sometimes these toe of fill bearing points shift outward further than the 45° plane intercept as the toe must bear on competent material. Poor-quality compressible materials must be removed from the toe key area. Mislocation of the excavated toe bearing point has sometimes resulted in costly removal and recompaction of toe keys. (See Figures 5-27 through 5-34.)

5-10 FACTORS INFLUENCING SOIL COMPACTION

The primary purposes of compacting fill soils are (1) to improve shearing resistance of the soils, and (2) to minimize the amount of subsequent settlement by controlling soil properties. Compaction side effects that may improve site conditions are the possible minimizing of the soil's expansive potential, the reduction of its permeability or infiltration potential, the increasing of allowable soil pressure or bearing capacity for foundations, and reduction of differential settlement caused by variations in supporting characteristics. Factors that influence soil compaction are:

1. type of material to be compacted,
2. type of equipment used to achieve compaction,
3. the amount of moisture present during compaction,
4. the depth of each lift being compacted, and
5. the number of passes required of the equipment to achieve the desired compactive results.

Soil Type

The soil type influences compaction technique since sandy "granular" soils and clayey "cohesive" materials differ in their properties and behavior.

During the preliminary investigation, the soil engineer determines which soil types can be anticipated. The contractor can determine what equipment is needed for compaction by reviewing the soil engineer's report, prior to making the cost estimate for construction. Granular fill with a small amount of clay binder for tightening will compact into a very dense structural fill with a plentiful application of vibration and water. Fine-grained, clayey soil that normally has a high moisture content may require only a small addition of water. Where the moisture content is too high, clayey and silty soils become "spongy" and pump water as the equipment passes over them. Such soils may require drying out prior to compaction. Lifts, or layers, of clayey soils are generally spread thin, or thinner than those of granular soils, and tamping-type rather than vibratory rollers are normally used for compaction. After a number of passes, when the soil-bearing capacity builds up, the sheepsfoot roller "walks out" or fails to penetrate further. At this point, the required compaction has probably been achieved and a density test would be appropriate for verification.

Compaction Equipment

This equipment can be classified as follows: (1) surface rollers, (2) tamping rollers, and (3) vibratory compactors. Surface rollers may include smooth wheels, grid-rollers, pneumatic tires, wobble-wheel rollers, supercompactors, and the heavy grading equipment such as dozers or scrapers. The tamping rollers may include a variety of sheepsfoot rollers and Wagner compactors. Vibrator rollers include the vibrating drum, the vibrating flat plate, and the vibrating sheepsfoot rollers of varying sizes. It is the responsibility of the contractor to determine the type, size, and amount of equipment necessary to achieve the density specified for a given site. Specifications should not dictate the type of equipment to be used, as variations in soil types and equipment available can lead to problems in field compaction. One type of compaction procedure may be more efficient on one soil than another. Since no laboratory test yet known can indicate which equipment will be most efficient for a given soil, the contractor must collaborate closely during grading construction with the soil technician.

Control of Moisture Content

This is important in maintaining uniform compaction. The gross stability of a fill requires that particular attention be paid to the soil moisture content during compaction. Excessive water in fine-grained, clayey soils usually results in low strength, high compressibility, excessive deformability, and poor performance of the slope. Clays of high plasticity are susceptible to excessive swell when wet and excessive shrinkage when dry. Potential expansion of soils may be minimized by compacting the soils at a higher-than-optimum moisture content resulting in a lower density so that there will be little or no tendency for expansion to occur under an anticipated surcharge load. A compacted clay can have a much higher permeability if compacted at a moisture content below optimum than if compacted to an equal dry density at a moisture content above optimum. Substantial benefits in strength, swell control, or permeability of compacted fills can be achieved by controlling their moisture content during compaction. Therefore, a soil engineer experienced in soil mechanics and slope stability analysis is extremely important in control of compacted fills. Professional supervision in addition to well-trained, experienced, and reliable field technicians is essential.

5-11 GRADING INSPECTION DURING FILL PLACEMENT

Grading inspection during fill placement is the most important aspect of quality control assurance during grading construction. Many fill control techniques, such as proper grading equipment on-site to accomplish the work, removal of organic material from the site, toe of fill benching and side-wall benching, rock placement, canyon cleanout, subdrain construction, and toe of fill key inspection, have been discussed in Sections 5-6 through 5-9. The placement of fill and the grading control procedures also involve operations other than those previously discussed. For example, the well-written paper, "Grading Control Procedures" by Mr. C. R. MacFadyen [1] explains many of the aspects of grading control.

Maximum Allowable Thickness of Fill Lift

The soil technician must make sure that the maximum allowable thickness of fill lift composed of the loosely spread fill material is kept within the limit of thickness that can be uniformly compacted by the equipment available on the site. Maximum compacted lift thicknesses of six to nine inches are normally desirable on subdivision grading. Generally, the lifts of fill spread throughout the fill areas are thicker and require additional spreading, mixing, watering or drying, or processing of some kind prior to accomplishing the desired compaction.

In some cases, "double dumping" takes place. This is a common term used to describe a practice wherein a lift of earth material is spread over a previously placed lift that has not yet been properly processed and compacted. This is an unacceptable practice. If the soil technician discovers a double dumping site, he should require removal, replacement, and recompaction of the improperly placed material.

The Soil Technician During Grading Inspection

The soil technician must be present almost continuously during the grading control process since he must assure that the fill processing necessary to attain the desired compaction results is being accomplished.

The Frequency of Soil Testing

This is prescribed by code, by specification, or by the site soil engineer. The soil technician must take as many tests as are required to be certain, on the basis of the results of the tests and on observations of the grading procedures, that the fills are being uniformly compacted to at least the specified density. A common minimum test frequency utilized in fill control is one field density test for every 500 cubic yards of compacted fill, but not less than one for every two feet of fill depth in each fill area. According to MacFadyen [1], "It is desirable to make at least one test in every lift of compacted material in massive fills. Thus a six-inch-thick compacted lift should be tested on approximately a 150-foot grid to meet the requirement of one test for every 500 cubic yards." Fill control test methods will be discussed later in this chapter.

Loose Spill-Fills or Tailings

These are earth materials that are dumped or spread onto the natural slopes or onto the compacted fill without the

Figure 5-36 Canyon-fill slope construction in progress. This fill appears to be 8–10 ft. above the lowest terrace drain. Loose spill fill overlays the surface and must be removed or compacted during finish grading. The inspector is walking along the toe-of-fill slope. Photograph courtesy of the Dept. of Building & Safety, City of Los Angeles, staff photographer John Shadle.

benefit of spreading, mixing, watering and compacting. (See Figures 5-15 through 5-17.) These loose, uncontrolled spill-fills or tailings usually accumulate along haul roads from cut areas to fill areas. They must be removed. The soil technician must control such conditions before the tailings become a massive removal operation, or before the compacted fill overlaps these loose deposits. If overlap occurs without correction, future settlement may result at that location.

Fill-Slope Compaction Requirements

These requirements are usually either part of the governing grading code, the grading plan or permit specifications, or are established by the soil engineer during his preliminary investigation. The primary criteria for proper fill-slope compaction involve the gross stability, the surficial stability, and the long-term performance of the slope. Our discussion of rain damage investigation in Section 7-2 treats the problem of the long-term performance of compacted fill slopes, particularly those constructed with expansive soils. Surficial failures have been most common, particularly those that have been subjected to extensive landscape watering prior to the rainy season. The soil engineer and the grading inspector cannot control slope maintenance or assure long-term performance due to improper maintenance. Most volume changes and changes in density with time will normally occur within the outer four to ten feet. Therefore it is important that the highest degree of compactive effort and grading skill be exerted in the construction of the outer ten feet of the fill slope or embankment.

Some of the more successful methods of fill-slope construction are: (1) over-filling and trimming back to the hard compacted core; (2) riding the outer edge of the slope in a horizontal manner with the heavy equipment that exerts more vertical compactive effort in the outer ten to twelve feet; (3) tractor-walking the dozer on the slope face and blading off the loose material (see Figures 5-36 through 5-38); and (4) after removal of the loose slough materials, using a grid-roller or a combination of sheepsfoot and grid-roller to finish the upper two to four inches of slope face. (See Figures 5-38 through 5-41.)

Figure 5-37 This grading operation is nearing rough-grade stage. Lot pad and streets are shown roughed out, slope terrace and down drains are paved, fill slopes are trimmed back and grid-rolled, and the desilting basin is roughed in. Photograph courtesy of the Dept. of Building & Safety, staff photographer John Shadle.

Figure 5-38 Here a bulldozer is "tractor-walking" the fill slope to trim loose material and compact the surface. This operation is followed by side-booming a sheepsfoot roller, then grid-rolling to tighten the surface of the slope. Photograph by C. Michael Scullin.

Figure 5-39 Jess Riddle, left, general superintendent of earthwork construction, Mission Viejo Company, and John H. Douglas, right, district grading inspector, County of Orange, California, inspect this slope-rolling operation. A sheepsfoot roller is cabled up and down the slope here prior to grid-rolling. Photograph by C. Michael Scullin.

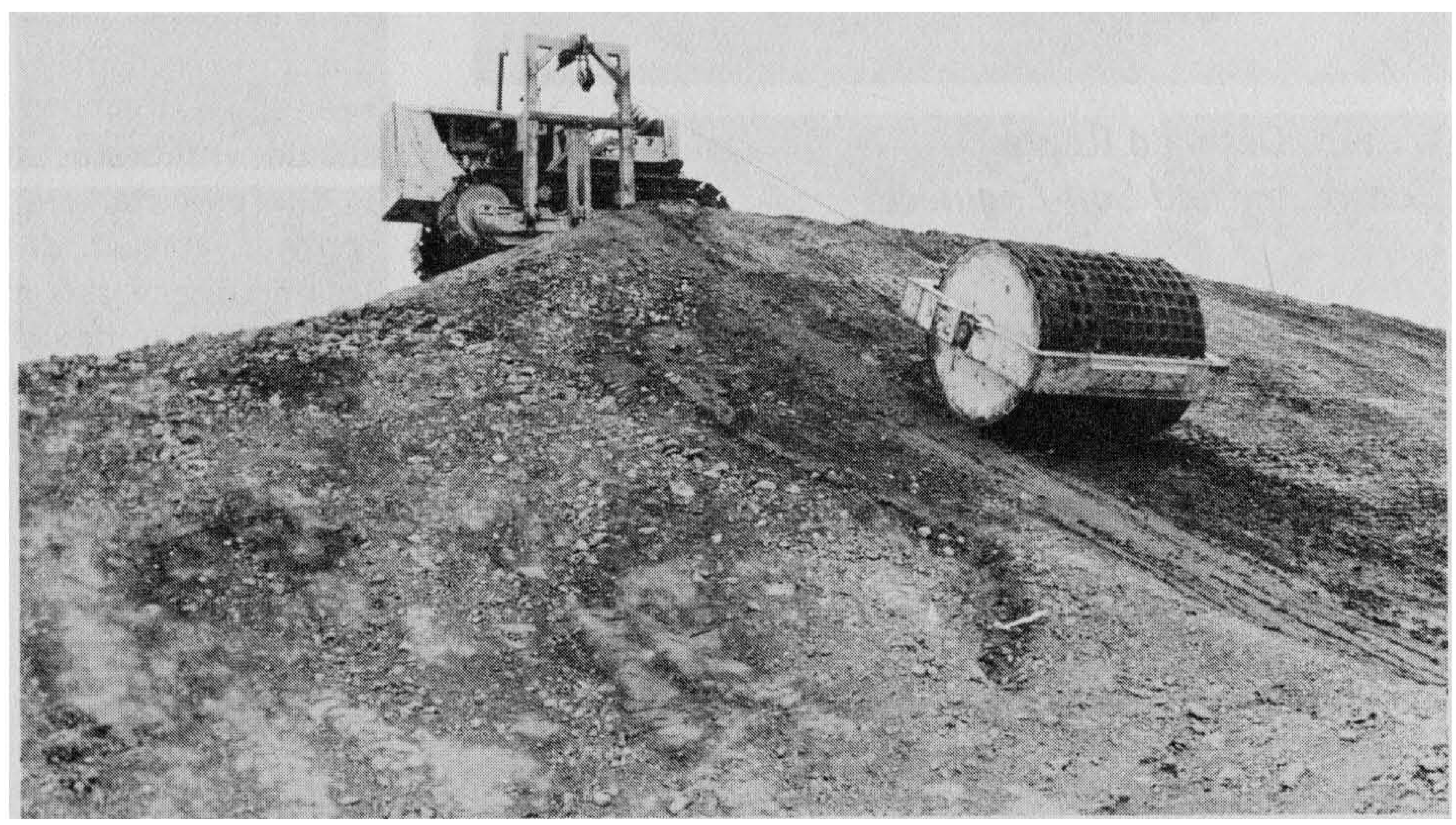


Figure 5-40 Gridrolling the fill slope after tractorwalking or sheepsfoot rolling compacts the outer 2-3 inches of the slope to form a crust which helps shed water rapidly. Photograph by C. Michael Scullin.

Figure 5-41 Notice the wide berm at the top of this fill slope. A wide berm is constructed to prevent drainage from going over the slope and to channel drainage away from the slope. Photograph by C. Michael Scullin.

The most effective method of fill-slope compaction appears to be overfilling and trimming back to the hard compacted core. Some of the large developers in Southern California who have been forced to pay high costs for repairs of surficial fill-slope failures have gone exclusively to the over-filling and trimming back method, which provides for a longer term performance. Some developers argue that they want the top foot of soil loose for landscape purposes; however, this practice encourages surficial slope failure.

The hydromulch method of application of seeds has given good results for sustained growth within a tightly compacted fill slope. The seeds utilize the compaction moisture as well as the applied water for growth. Thus, it is beneficial to seed as soon after completion of the slope as possible, before the near surface moisture evaporates out of the slope face. This method does not preclude landscape planting required by planning commissions. Planting and slope maintenance will be discussed further in Chapter 9.

Written, Detailed Reports (*Contractor and Soil Engineer*)

A report should be prepared by the contractors describing the methods they will employ to obtain the required slope compaction. This report should be submitted to the site soil engineer for review and comments prior to the pre-grading meeting, and discussed during the meeting.

The contractor should be required to obtain a minimum relative compaction of 90% out to the finished face of the slope. If a method of finishing a fill slope other than by overfilling and cutting back to the compacted core is to be employed, *slope tests* should be conducted by the site soil engineer during the slope construction to determine whether or not the required compaction is being achieved.

Each day, the owner, the contractor, and the grading inspector should receive a copy of the soil engineer's "Daily Field Engineering Report," which should indicate the results of field density tests for that day. Where failing tests occur or other field problems arise, the contractor should be notified by way of a written field report or conference memorandum, and the problem identified should be corrected immediately. If a problem is brought to the contractor's attention orally, and he corrects it promptly, the correction should be noted in a field report for the site record.

All work or rework necessary to bring the fill compaction into compliance with the specifications should be conducted immediately. Delays should be discouraged. However, if a legitimate delay is necessary, the grading inspector should write a stop-work order prohibiting additional work in the problem area until the corrective work is satisfactorily completed. Daily communication between the soil technician and the grading inspector is important in order to achieve the desired grading control. A close teamwork relationship often develops where the soil technician serving as deputy inspector of quality control, and the grading inspector, using the power of code enforcement, combine their efforts to assure public safety.

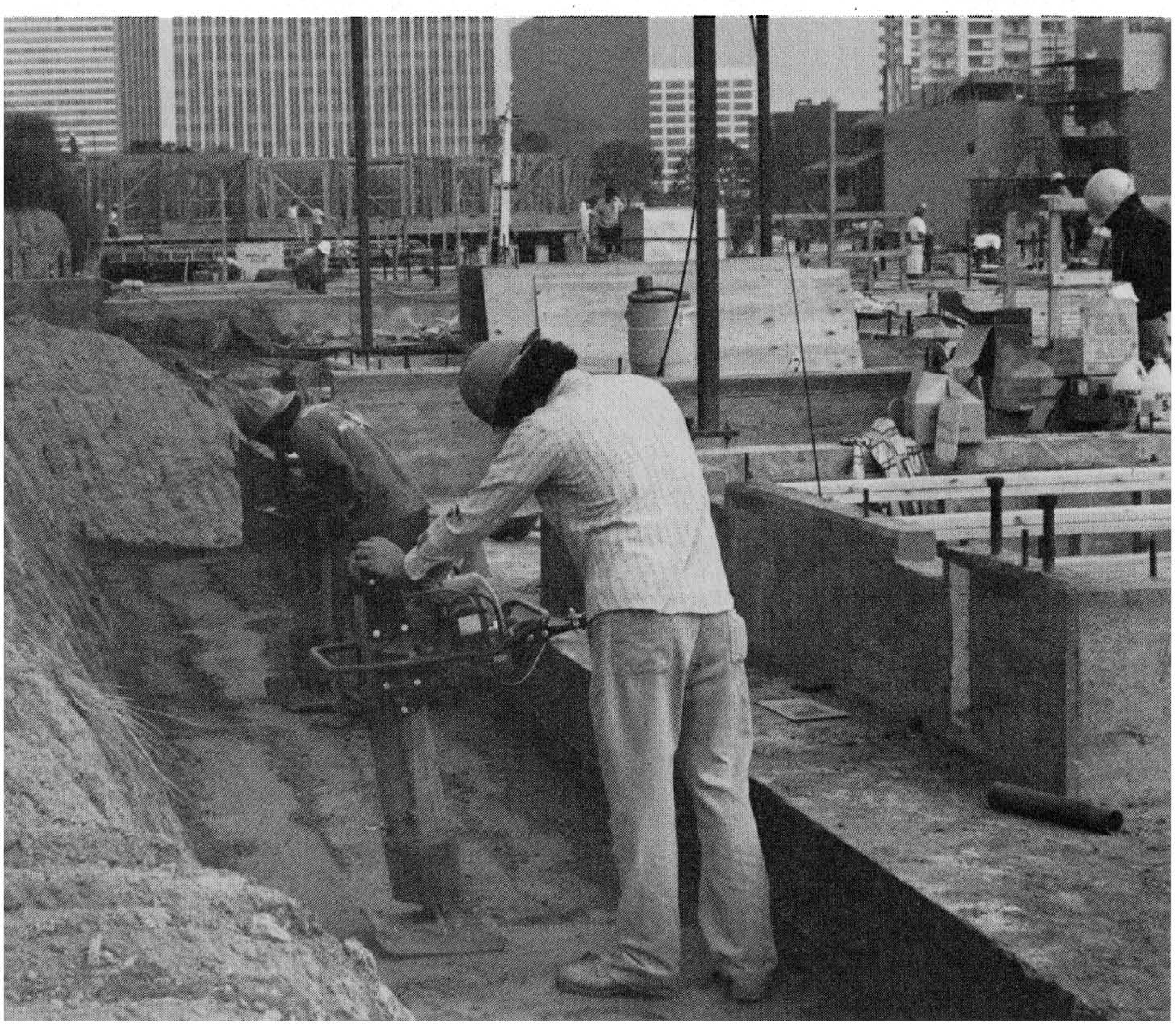


Figure 5-42 A Barco compactor is used here to compact or "tamp" backfill at the rear of a basement-wall. Photograph by Leopold Hirschfeldt, courtesy of LeRoy Crandall & Associates.

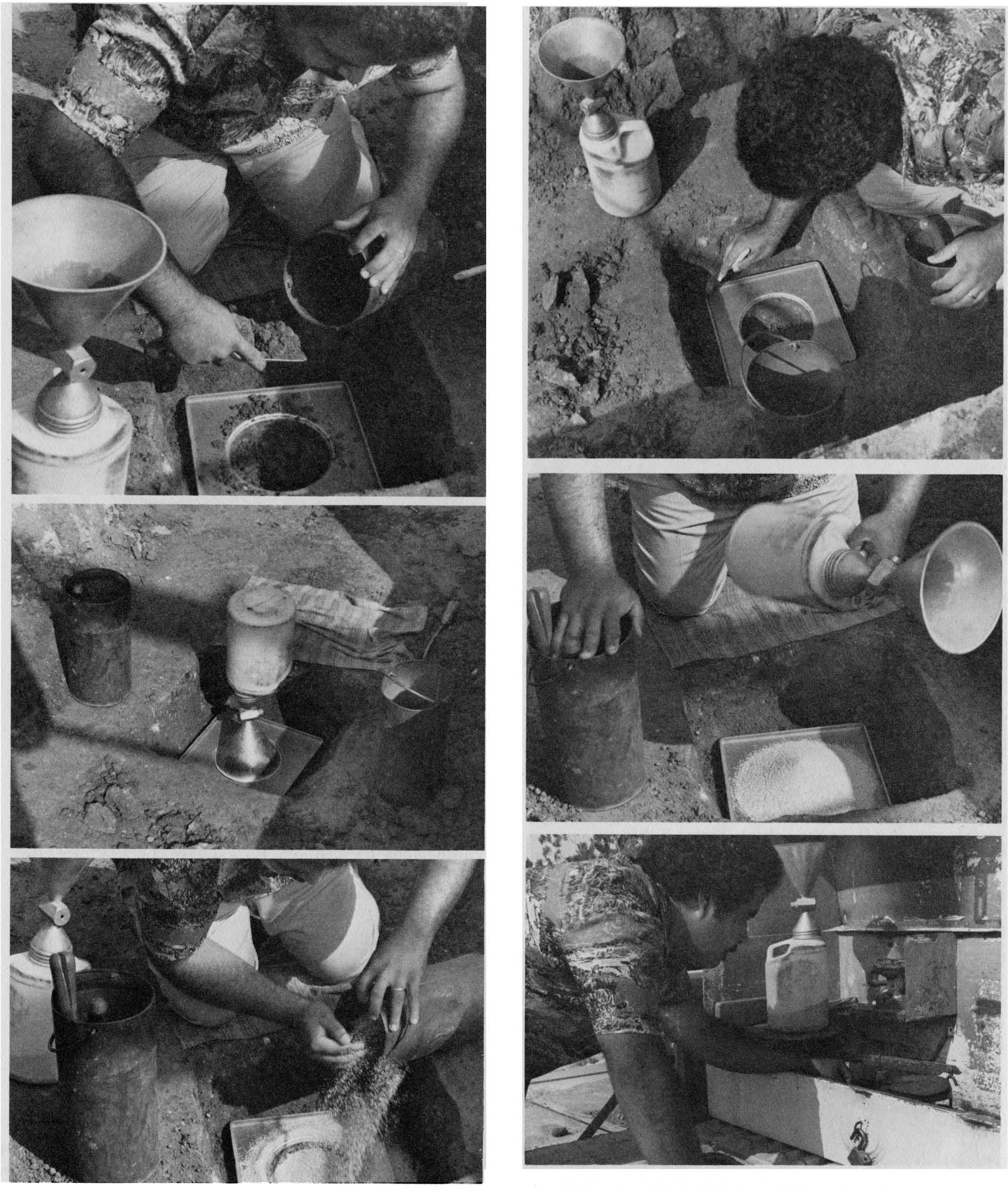


Figure 5-43 (a) A soil technician digs out compacted soil at a test site. Notice the baseplate, bottle, and sand cone atop the bottle. (b) The soil technician removes all soil dug from the test hole for complete weighing. (c) Next, the sand cone is set atop the baseplate, and sand is poured into the hole. (d) The soil technician closes the valve and removes the sand cone from the baseplate. (e) As much "clean" sand as possible is retrieved. (f) The volume of sand that has replaced the excavated soil void is weighed and the results are recorded. Photograph by Leopold Hirschfeldt. Courtesy of LeRoy Crandall & Associates.

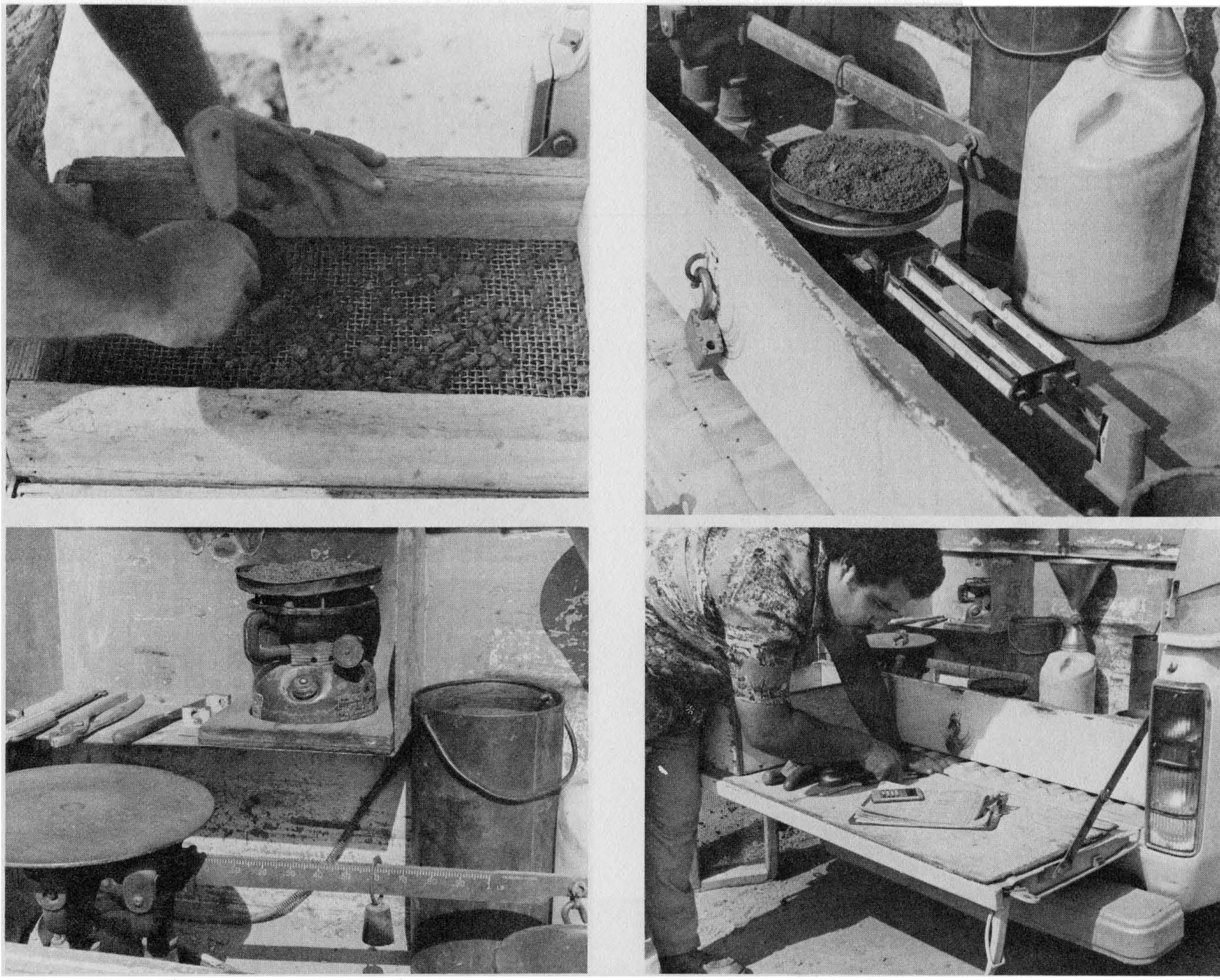


Figure 5-44 (a) The soil technician breaks down the soil sample removed from the hole by forcing it through a coarse sieve. This removes gravel particles, which are weighed separately. (b) The soil sample is weighed. (c) Burning out the moisture from the soil sample, after which the sample is weighed again. (d) The soil technician calculates the moisture content, dry density, and percent compaction. Photographs by Leopold Hirschfeldt, courtesy of LeRoy Crandall & Associates.

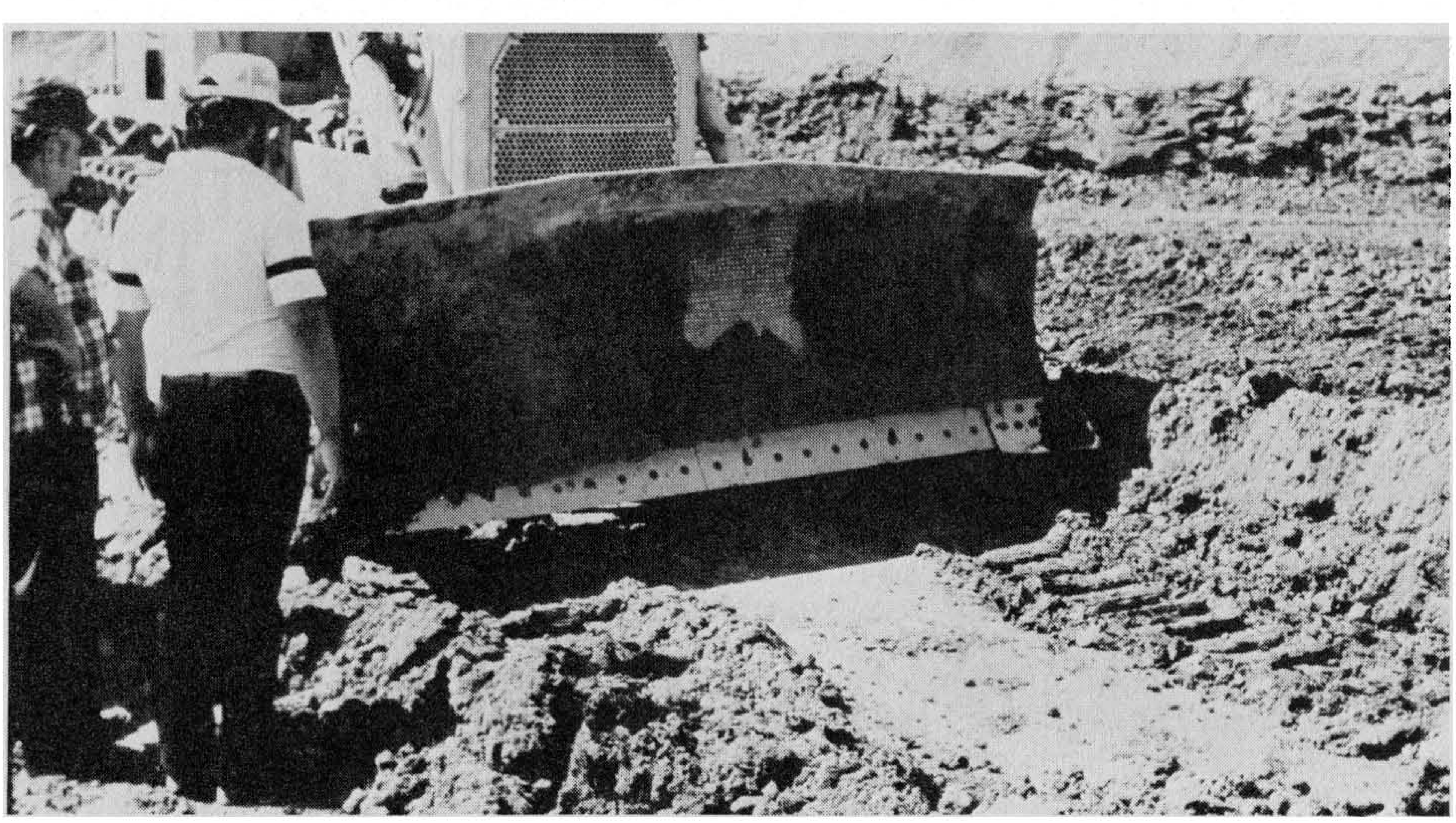


Figure 5-45 Excavating the fill down to dense compacted material for the location of a soil test. The supervising grading inspector (left) and the soil technician supervise the depth of penetration. Photograph by C. Michael Scullin.

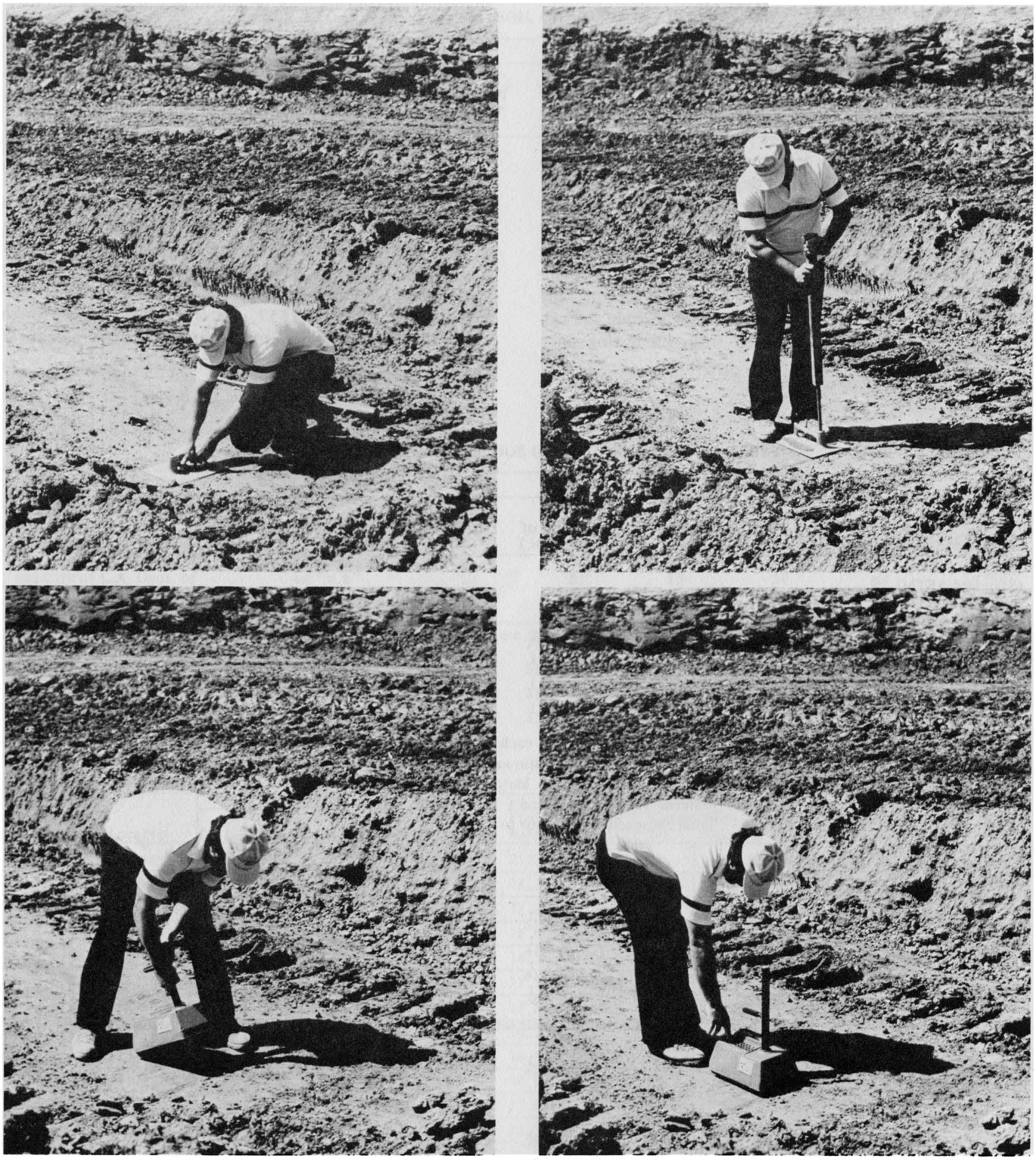


Figure 5-46 (a) A soil technician removes loose surface material and prepares a smooth level surface to seat a nuclear gage with the guide plate. (b) Using the pin and guide plate, the technician makes a hole at 90 degrees from the plane surface. (c) The nuclear gage is placed on the prepared surface with the bottom firmly seated in contact with the soil and the rod firmly against the side of the hole nearest the source or detector tube. (d) One-minute readings for density determination and moisture count are taken, the results recorded, and averaged. The percent relative compaction equals the average in-place wet density divided by the composite wet-test maximum density multiplied by 100. Photographs by C. Michael Scullin.

5-12 GRADING INSPECTION OF COMPACTION TESTING

Many of the older and more experienced grading inspectors were soil technicians prior to becoming grading inspectors and therefore had a working knowledge of the different types of compaction tests. More recently, however, grading inspectors seem primarily to come from the ranks of building inspectors or from the road department, or were public works inspectors without previous training or experience in grading-inspection methods and techniques. Since effective grading inspectors must be familiar with soil-testing methods and standards, we will discuss here some of the more commonly used soil compaction tests to help the reader become familiar with those standards. We will not include the calculations or mathematics involved with soil testing since analytical treatments may be found in soil mechanics textbooks such as *Soil Testing for Engineers* by T. William Lambe, John Wiley & Sons, Inc. A list of compaction testing equations has been prepared for this text by Delmar D. Yoakum, Chief Engineer of GeoSoils, Inc., of Van Nuys, California. The list is to be found in the appendix.

Tables 5-1 and 5-2 list some of the more commonly used soil compaction test methods. One of the most commonly used standards is the American Society for Testing and Materials (ASTM) designation D-1557, Method A, which uses 25 blows of a 10-pound sleeved hammer from an 18-inch drop on each of five layers in a 1/30 of a cubic foot mold. Many agencies have adopted the Uniform Building Code (UBC) Standards 70-1, which uses the same equipment as the ASTM D-1557, but is modified to use three rather than five layers required by the ASTM. The three-layer

TABLE 5-1 COMMONLY USED SOIL COMPACTION TEST METHODS

	Description						
Designation (Popular Name in Parentheses)	*Weight of Hammer (lbs.)*	*Height of Drop (in.)*	*No. of Blows*	*No. of Layers*	*Capacity of Cyl. (cu. ft.)*	*Screen Size Used*	*Compactive Effort (ft.-lb. per cu. ft.)*
ASTM-D 698-70 (Standard ASTM), or AASHO-T99-57 (Standard AASHO)							
Method A	$5\frac{1}{2} \pm 0.02$	$12 \pm \frac{1}{16}$	25	3	1/30	No. 4	12,400
Method B	$5\frac{1}{2} \pm 0.02$	$12 \pm \frac{1}{16}$	56	3	1/13.33	No. 4	12,400
Method C	$5\frac{1}{2} \pm 0.02$	$12 \pm \frac{1}{16}$	25	3	1/30	$\frac{3}{4}''$	12,400
Method D	$5\frac{1}{2} \pm 0.02$	$11 \pm \frac{1}{16}$	56	3	1/13.33	$\frac{3}{4}''$	12,400
	1. Use separate sample for each point where soil is fragile, or heavy clay. Clay soils to stand 12 hours after moisture added before compacting. 2. Uses material passing $\frac{3}{4}''$. Material between $\frac{3}{4}''$ and 2″ may be replaced with weight of material between No. 4 and $\frac{3}{4}''$-sieve, if percentage is critical. 3. Total compacted depth not to exceed 5 inches.						
ASTM-D1557-70, or AASHO-T180-57[1] (Modified AASHO)							
Method A	10 ± 0.02	$18 \pm \frac{1}{16}$	25	5	1/30	No. 4	56,200
Method B	10 ± 0.02	$18 \pm \frac{1}{16}$	56	5	1/13.3	No. 4	56,200
Method C	10 ± 0.02	$18 \pm \frac{1}{16}$	25	5	1/30	$\frac{3}{4}''$	56,200
Method D	10 ± 0.02	$18 \pm \frac{1}{16}$	56	5	1/13.3	$\frac{3}{4}''$	56,200
	All other requirements same as counterparts under AASHO T99-57 or ASTM-D698-58T.						
UBC Standard No. 70-1 (ASTM D1557-70 Method A, modified)	10 ± 0.02	$18 \pm \frac{1}{16}$	25	3	1/30	No. 4	33,800
Proctor Method (Standard Proctor)	$5\frac{1}{2}$	$12 \pm \frac{1}{16}$	25	3	1/30	No. 4	12,400
Test Method No. Calif. 216-F California Division of Highways Compaction Test, Impact or Field Method (Calif. Impact Method)[2]	10	18	20	5	[3]	No. 4	37,000 to 44,000

[1] These methods are specified in the grading ordinances of FHA, Los Angeles City, and Los Angeles County.

[2] *Calif. State Impact Method*—No. Calif. 216F. Materials manual for testing and control procedures, Volume I, Division of Highways, Department of Public Works, State of California.

[3] Split ring cylinder with an inside diameter of 2.86 inches is used. Weight of soil put in cylinder for each point remains constant at 5 pounds (±) to give sample 10 to 12 inches high. Volume is measured.

Source: Moore & Taber, Consulting Engineers and Geologists, "Fill Control Manual" (Anaheim, CA).

TABLE 5-2 COMMONLY USED SOIL COMPACTION TEST METHODS

	Description						
Designation	*Mold Size (ht. × dia.)*	*Weight of Hammer (lbs.)*	*Number of Layers*	*Height of Hammer Drop (in.)*	*Number of Blows per Layer*	*Material Passing Screen Size*	*Compactive Effort (ft.-lbs. per cu. ft.)*
Standard Proctor	4.6" × 4"	5.5	3	12	25	#4	12,375
ASTM D698-78T (Method A) AASHTO T99	4.6" × 4"	5.5	3	12	25	#4	12,375
ASTM D698-78T (Method B) AASHTO T99	4.6" × 6"	5.5	3	12	56	#4	12,320
ASTM D698-78T (Method C) AASHTO T99	4.6" × 6"	5.5	3	12	56	3/4"	12,320
ASTM D698-78T (Method D) AASHTO T99	4.6" × 6"	5.5	3	12	56	3/4"	12,320
Modified Proctor	4.6" × 4"	10	5	18	25	#4	56,250
ASTM D1557-78T (Method A) AASHTO T180	4.6" × 4"	10	5	18	25	#4	56,250
ASTM D1557-78T (Method B) AASHTO T180	4.6" × 6"	10	5	18	56	#4	56,000
ASTM D1557-78T (Method C) AASHTO T180	4.6" × 6"	10	5	18	56	3/4"	56,000
ASTM D1557-78T (Method D) AASHTO T180	4.6" × 6"	10	5	18	56	3/4"	56,000
ASTM D698-78T–Modified*	4.6" × 4"	10	3	18	25	#4	33,750
AASHO T99-57–Modified	4.6" × 4"	10	3	18	25	#4	33,750
Modified-Modified Proctor	4.6" × 4"	10	5	18	56	#4	126,000
Corps of Engineers	4.6" × 6"	10	5	18	55	#4	53,625
Test Method No. Calif. 216	Cal Impact Test	10	5	18	20	3/4"	37,500
City of L.A. Bldg. and Safety and City of L.A. Dept. of Public Works	Use ASTM D1557-78 4.6" × 6"	10	5	18	56	#4	56,000
County of L.A.	Use ASTM D1557-78						56,000

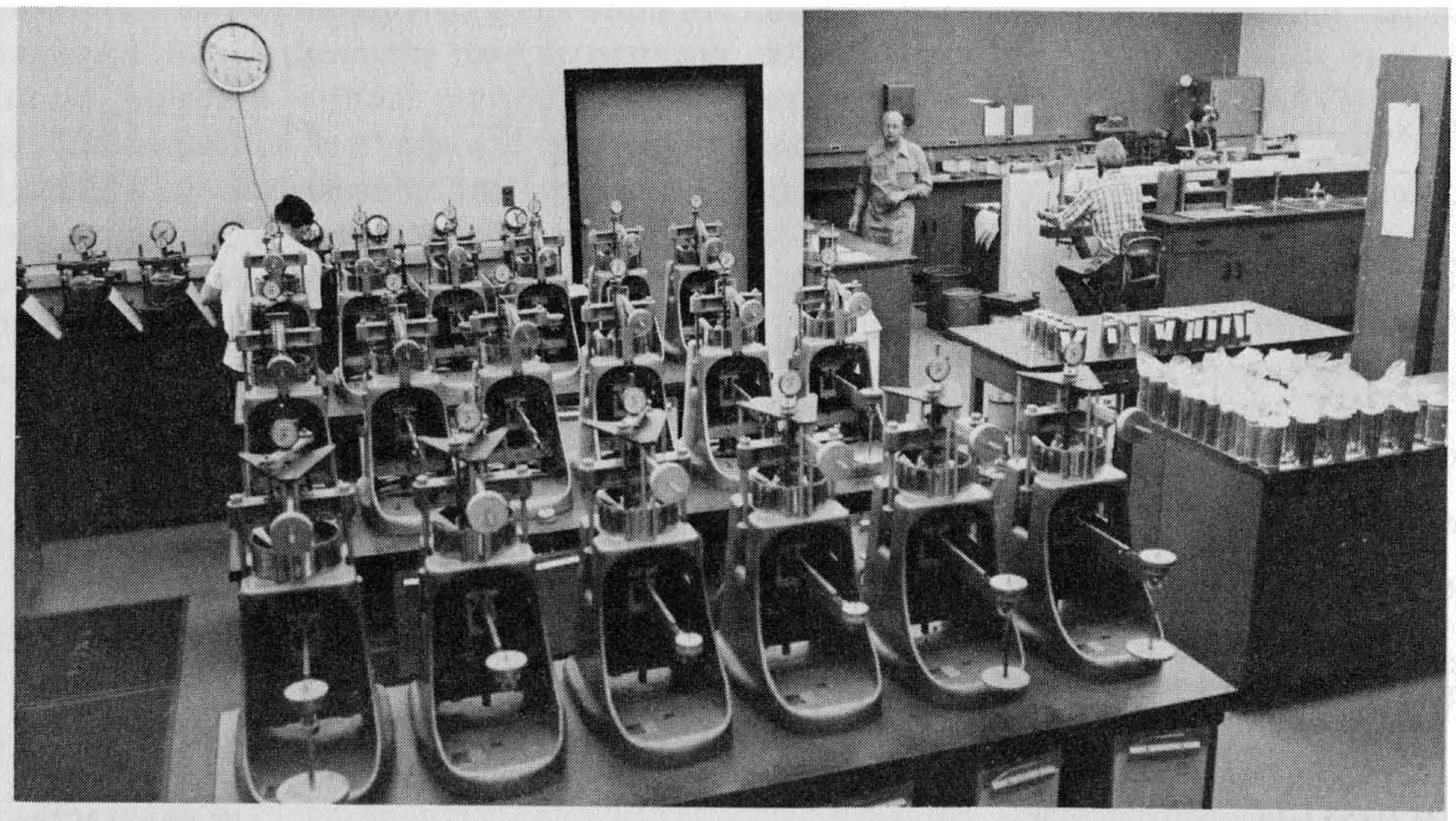
*Modified Tests are in-house (in-laboratory) modifications that vary from the standard test.

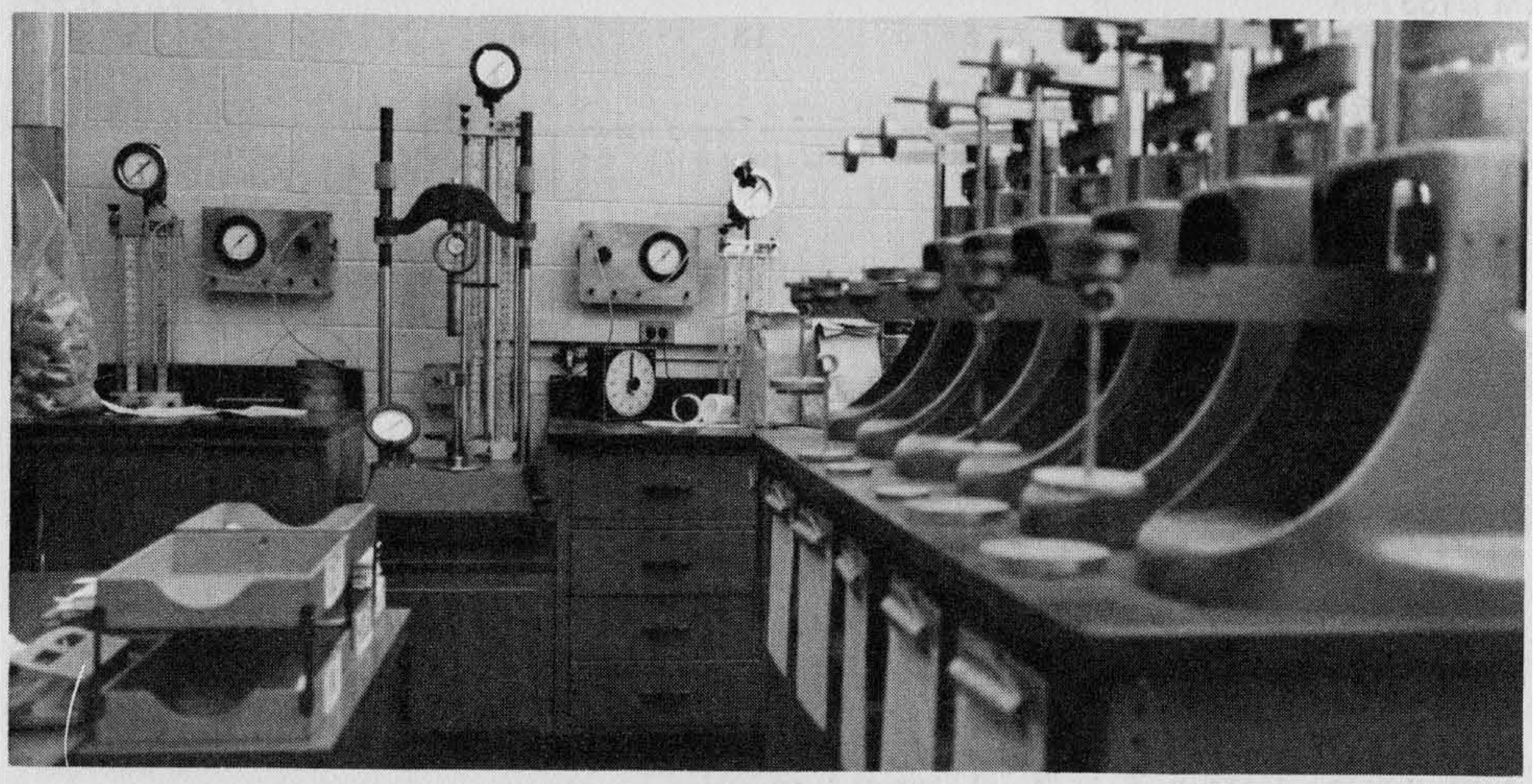
Source: C. Michael Scullin, personal files.

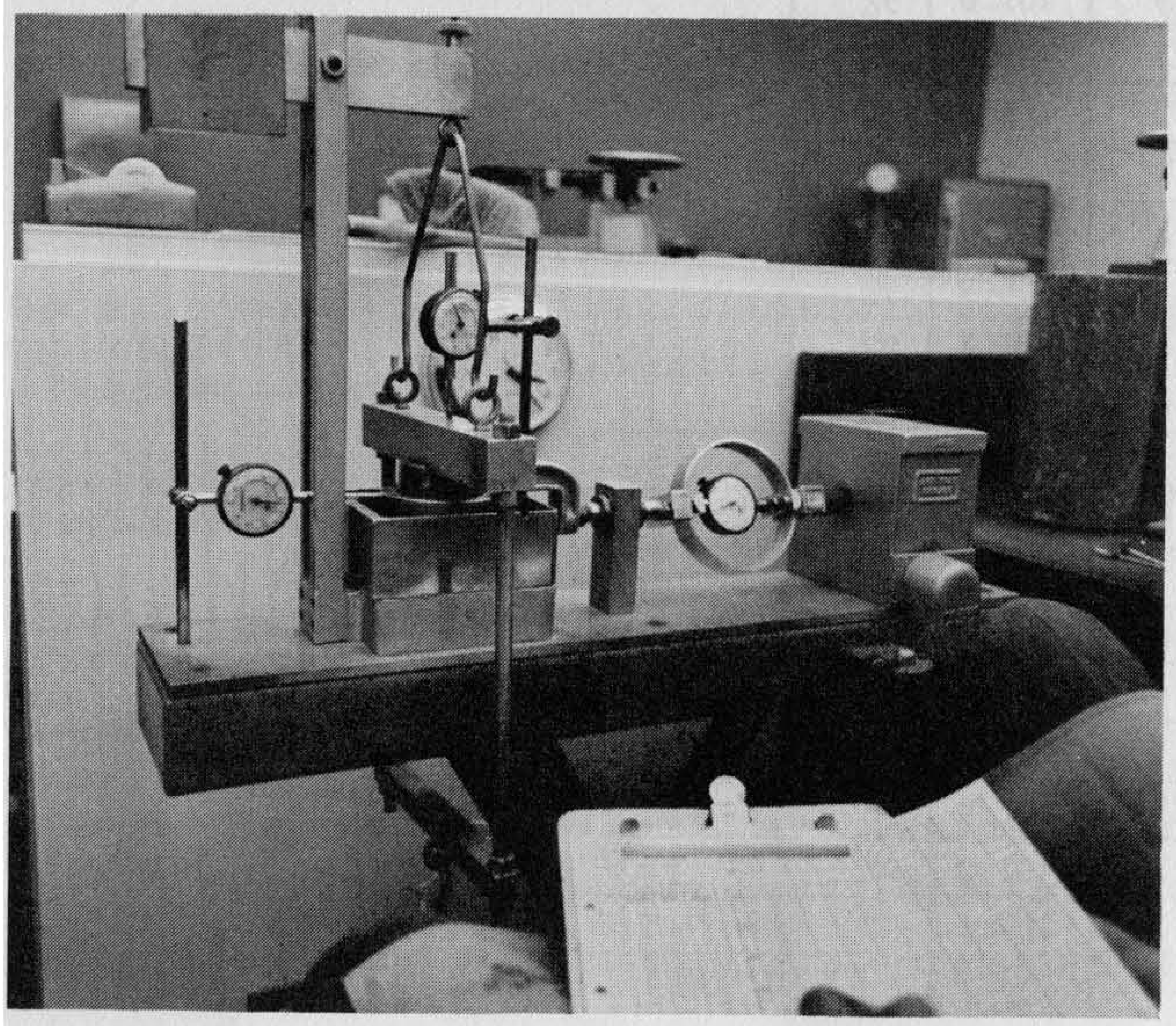
Figure 5-47 A typical table of test results. Source: G. Lee Upchurch, grading engineer, City Engineer's office, City of Orange, CA.

Test No.	1978 Test Date	Location	Elevations Test	Natural	Finish Grade	Opt. Moist.	Max. Dens.	Field Moist.	Field Dens.	%Compaction Max.	Rmks.
1	6/7	keyway	1010	1012		18.5	110.0	21.0	101.3	92	
2	6/7	keyway	1013	1014	1015	19.9	116.5	14.3	108.9	93	
3	6/9	fillslope	1018	1016	1025	14.9	116.5	12.4	107.4	92	
4	6/9	fillslope	1022	1023	1027	16.9	114.9	16.9	105.6	92	
5	6/9	fillslope	1018	1016	1021	16.2	115.0	14.3	105.8	92	
6	6/9	fillslope	1022	1017	1025	16.2	115.0	17.3	105.4	92	
7	6/9	fillslope	1028	1022	1033	16.2	115.0	17.3	105.5	92	
8	6/12	fillslope	1028	1017	1030	14.9	116.5	15.3	106.7	92	
9	6/12	fillslope	1026	1017	1030	14.9	116.5	14.9	106.9	92	
10	6/12	fillslope	1030	1020	1035	14.9	116.5	14.0	107.3	92	
11	6/12	fillslope	1028	1020	1035	14.9	116.5	13.6	107.2	92	
12	6/13	fillslope	1030	1023	1032	14.9	116.5	15.3	107.1	92	
13	6/13	fillslope	1026	1016	1028	14.9	116.5	14.9	107.3	92	
14	6/16	roadway	1034	1028	1035	16.9	114.9	17.3	105.5	92	
15	6/16	roadway	1033	1032	1035	16.9	114.9	17.6	105.2	92	
16	6/17	roadway	1045	1040	1055	16.9	114.9	20.5	109.5	92	
17	6/17	roadway	1040	1035	1050	16.9	114.9	20.1	107.9	94	
18	6/19	roadway	1045	1035	1050	16.9	114.9	20.1	107.9	93	
19	6/19	roadway	1051	1040	1057	16.9	114.9	19.7	107.0	93	
20	6/22	roadway	1057	1050	1060	14.9	116.5	16.3	109.1	93	

method provides a compactive effort of 33,750 foot pounds per cubic foot rather than 56,000 to 56,250 foot pounds per cubic foot exerted in the five-layer method. The grading inspector should be aware of the standards called for in the job specifications. If no standards are dictated in the specifications, the UBC Standard 70-1 would be advisable as a *minimum* standard. (See Table 5-2 for commonly used compaction tests. Laboratory soil testing apparatus are shown in Figure 5-48.)







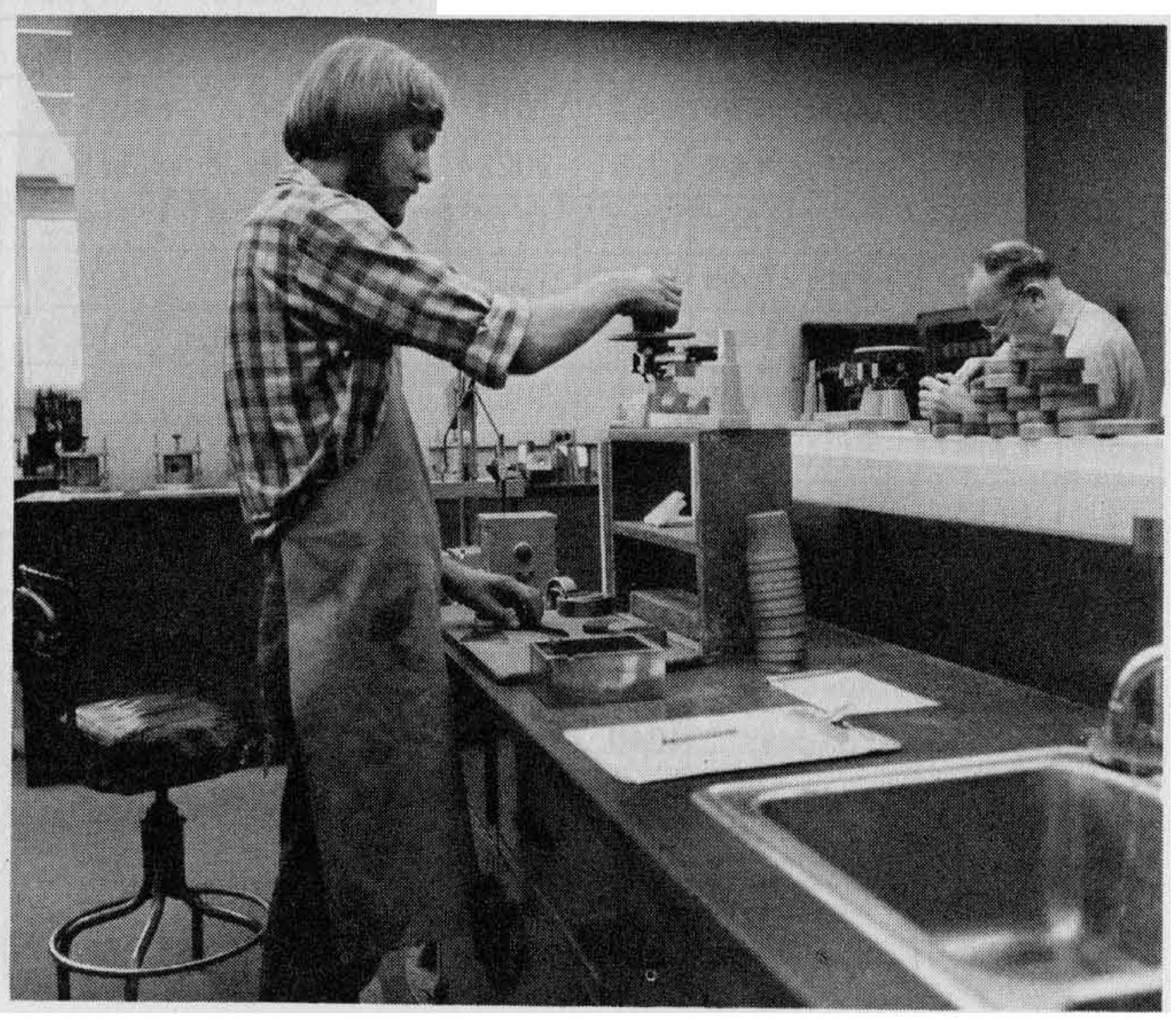


Figure 5-48 (a) A quality soil testing laboratory, with ranks of consolidometers in foreground, soil samples on tables at right, a shear machine operated by a lab technician in right background. (b) The tri-axial testing apparatus is shown in center background, with consolidometers at right. (c) A shear box apparatus with shear test in progress. (d) A lab technician weighs the soil sample after completion of shear test to determine moisture and density. The shear box is on the bench; expansion tests are in progress along rear wall. Photographs by Leopold Hirschfeldt, courtesy of LeRoy Crandall & Associates.

Tests for Determining Field Density

The field inspector should be familiar with methods of obtaining in-place unit weight. The most commonly used is the sand volume method. (See Figures 5-42 through 5-44.) The ASTM, D-1556 test uses a one-gallon jar, a threaded cone with a flow control valve and a base plate. The UBC Standard 70-1 uses the same equipment. The overflow cone, used in some areas, gives a constant flow of sand but does not have a shut-off valve. It overflows into the container used with the cone.

The sand volume method is considered by the ASCE, Geotechnical Engineering Group members in Southern California as the most reliable means of determining the in-place density of soils. It is the standard by which other methods are measured. Many governmental agencies and developers will accept only sand volume tests. One large developer in the County of Orange, California, will not allow any density test methods other than the sand cone method.

Some of the larger building departments rely upon the expertise of professional organizations, such as ASCE, Geotechnical Engineering Group, Soil and Foundation Engineers Association (SAFEA) and AEG Building Codes Committee to provide them with standards of practice or to review and approve equivalent methods of construction.

The drive cylinder test and the nuclear gage density and moisture test methods (see Figures 5-45 through 5-46), have not been accepted by these professional societies as methods equal to the sand cone method. Consequently, these other methods are not always acceptable nor approved in the grading permit specifications or by local grading codes. Even where other methods are used, such as the drive cylinder test or the nuclear gage, the site soil engineer normally requires that these methods be checked by the sand volume test for accuracy. Acquiring a soil density by the sand volume method is more costly and time-consuming than most other methods, and this is the primary reason it is not used exclusively.

Selecting the Proper Test Method

The sand volume test should be used in all cases where pebbles and rocks are present in the soil. It should also be used where accuracy of tests is subject to question, such as possible court cases, testing fills that were originally tested by another soils laboratory, or testing an area that might acquire large amounts of removal or rework by a contractor.

The drive cylinder test method is intended to be used for testing fine-grained cohesive soils and is not for use in soils with gravel or broken rock. It is one of the fastest methods of obtaining relative density, but is neither always acceptable nor as accurate as the sand cone method. The drive cylinder test sample must be undisturbed; therefore, much care must be exercised during sampling. The test hole must be six to eight inches below where the dozer has excavated for the test location since the dozer blade will have sheared or loosened the existing surface. The driver is held in a vertical position, and no horizontal movement is allowed as the sliding bar is raised and dropped. The top of the tube must be driven at least one to six inches below the ground surface. Much care must be exercised in removing the sample. If the sample is broken off inside the tube, the area must be resampled since it is unacceptable to fill in or remold a broken sample.

Soil Technician's Recording and Testing Equipment

The grading inspector should make sure that the soil technician has the testing equipment on the job site. In addition to testing equipment, the soil technician should have a stove, oven, or other suitable equipment for drying moisture content sample. In addition to determining the density and the moisture content for each field density test, the soil technician should record the following data at the time of taking the test:

1. test number and date;
2. location of test, depth below the proposed surface of the fill and the depth of fill below the test (usually the elevations are noted);
3. description of the soil type;
4. optimum moisture, maximum density, field moisture, field density, maximum percent compaction, and any remarks such as retest.

The table of typical test results is shown on Figure 5-47.

When the soil types, or mixtures of soil types, encountered during the density testing differ from the soil type in which a laboratory maximum density has been previously determined, a new maximum density must be determined in the laboratory. Bulk samples would need to be taken to the laboratory. This situation should be avoided as much as possible by pre-determining all maximum densities in the laboratory in advance of the field grading. Occasionally, however, it is necessary for the soil technician to make an immediate determination of the compaction percentage for a new soil type. This can be done on a wet density basis by compacting a sample of the new soil type at approximately its estimated optimum moisture content, using the standard hammer and mold in the field. The maximum density and optimum moisture must then be determined as soon as possible by a laboratory determination. (See Figure 5-48).

Compaction Research and Standards

Robert F. Baker [2] discussed current research relative to soil compaction. The statistical approach to the control of materials and construction processes was discussed. These data indicated that there have been many cases in highway or dam construction where there may be tests below the 90% to 95% of standard density. The percentage of tests failing the desired standard had been 2% to 40% less than the minimum acceptable standard, and yet the highways had performed satisfactorily. However, since pavements normally were placed at least six months after fill placement, the major settlement had already occurred prior to pavement construction. Many of the specifications allowed for an average of tests results above a desired minimum standard rather than no acceptable tests below the desired minimum standard. Research indicated that *average* densities of 5% to 10% (percent of maximum density) above the lowest value *desired* will need to be specified in the future. Mr. Baker [2] further stated that housing developments offer a more critical problem than highways so far as density requirements are concerned. Since buildings are more critically (and personally) evaluated, the added costs for greater compaction will frequently be a proper judgment. Consequently, the higher compaction standard should be used in housing developments.

Many public works and building officials have looked to the state and federal highway departments for their standard specifications relative to grading control. However, these highway departments have maintenance money allocated for embankment and pavement repairs and can readily divert traffic until repairs are completed. The private home owner has neither the large maintenance budget nor the large property for diverting or relocating and consequently cannot afford even small settlements or embankment failures.

The *minimum* standards of grading control discussed in this chapter are *minimum* acceptable standards. That means that anything less than these standards is unacceptable in grading control. Where density tests have failed to meet the required 90% or 95% maximum compaction, the test area is reworked until the retests show that the compaction has achieved these minimum standard requirements. Averaging of compaction tests is neither suitable nor satisfactory in our urban development grading control. The removal of compressible soils, the benching and keying into competent bedrock or soils, subdrain construction, and the minimum compaction requirements are techniques of grading control that increase the properties required for shearing resistance and decrease settlement or the expansive potential.

MacFadyen [1] has indicated that testing the fill at times may interfere to some extent with the grading operations. It is essential that the owner and the grading contractor understand that field density tests are an essential part of grading control and under no circumstances may that owner dictate the method, frequency, or location of field density tests to the soil firm providing the grading control, unless that firm is not meeting the minimum standards of grading control. Should a firm actually submit to such dictates, it is not providing grading control, but merely making density tests. These facts should be clearly understood by all concerned.

The final compaction report submitted to the building official should include information that identifies the test standards and methods used, the locations, the elevations, and the results of the tests. The locations of the tests should be shown on the as-graded plan attached to the report. Figure 5-57 illustrates a typical table of test results that should be shown in the compaction report. The report should verify that the work covered by the report is adequate for the proposed construction, is in compliance with the job specifications and recommendations, and is signed by the licensed civil (soil) engineer under whose supervision the work was performed.

5-13 CUT-SLOPE INSPECTION

There are several grading-inspection considerations during cut-slope inspection.

Location of Top of Cut Relative to Property Line

Grading plans should identify the location of the top of the cut relative to the property line in order to assure proper lateral support for adjacent property. The top of the cut slope should be surveyed and staked by the site civil engineer prior to the beginning of excavation. The area between the property line and the top of cut is normally designated for the placement of a brow-ditch (top of slope) drain, which is used to intercept surface water and direct it away from the cut-slope face. These brow-ditch drains must maintain positive flow and must be excavated prior to the actual top of the cut since access to that location is normally removed during the excavation of the cut slope. Top soils located at the tops of slopes should be trimmed at a flatter angle than the design cut-slope gradient as these top soils generally become saturated and turn into mud flows during periods of heavy rain. (See Figures 9-9 and 9-10.)

Line and Grade Requirements

The grading inspector must check the design slope angle and constructed gradient of the slope to make sure they are being excavated to line and grade requirements. Normally the grading contractor has a grade checker who checks the gradient every 3 to 5 feet of vertical cut; the contractor normally uses slope bars attached to the blades on the excavating equipment to provide a smooth cut for line and grade. (See Figure 5-22.) The site civil engineer should survey to make sure that these line and grade conditions are being properly addressed during construction.

The Site Geologist

The site geologist should inspect and map the geologic conditions of the cut slope during construction to evaluate the geologic conditions, to determine if there are any adverse structural conditions present that could result in instability, and to map the geologic conditions for the as-graded or as-built geologic map required at rough-grade stage. Sometimes during the preliminary site investigation, a geologic condition may exist that indicates the need for a buttress support design on a proposed cut slope. Frequently in these cases if the actual geologic parameters are not established adequately for such a design, it may require a *false cut*, which is made prior to the final cut to determine whether or not a buttress is necessary. Since it is sometimes a problem for the grading contractor to get his equipment back up onto the slope in order to make the re-cut for the final excavated slope, these conditions should be discussed and analyzed prior to the actual false cut being made so the grading contractor has his method established for the re-cut. If the false cut indicates that a buttress design is required, the soil engineer will have to make the calculations and submit the design to the grading division prior to the excavation being continued. At this point, the grading contractor would want to negotiate with his client about payment of the extra costs involved.

Frequently, the back cut of a buttress is excavated at a very steep angle of $\frac{1}{2}$-to-1 or 1-to-1 gradient in order to provide the widest mass of compacted fill for the support. The back slope will have a potential for failure during construction that will have to be considered by the grading contractor for safety purposes.

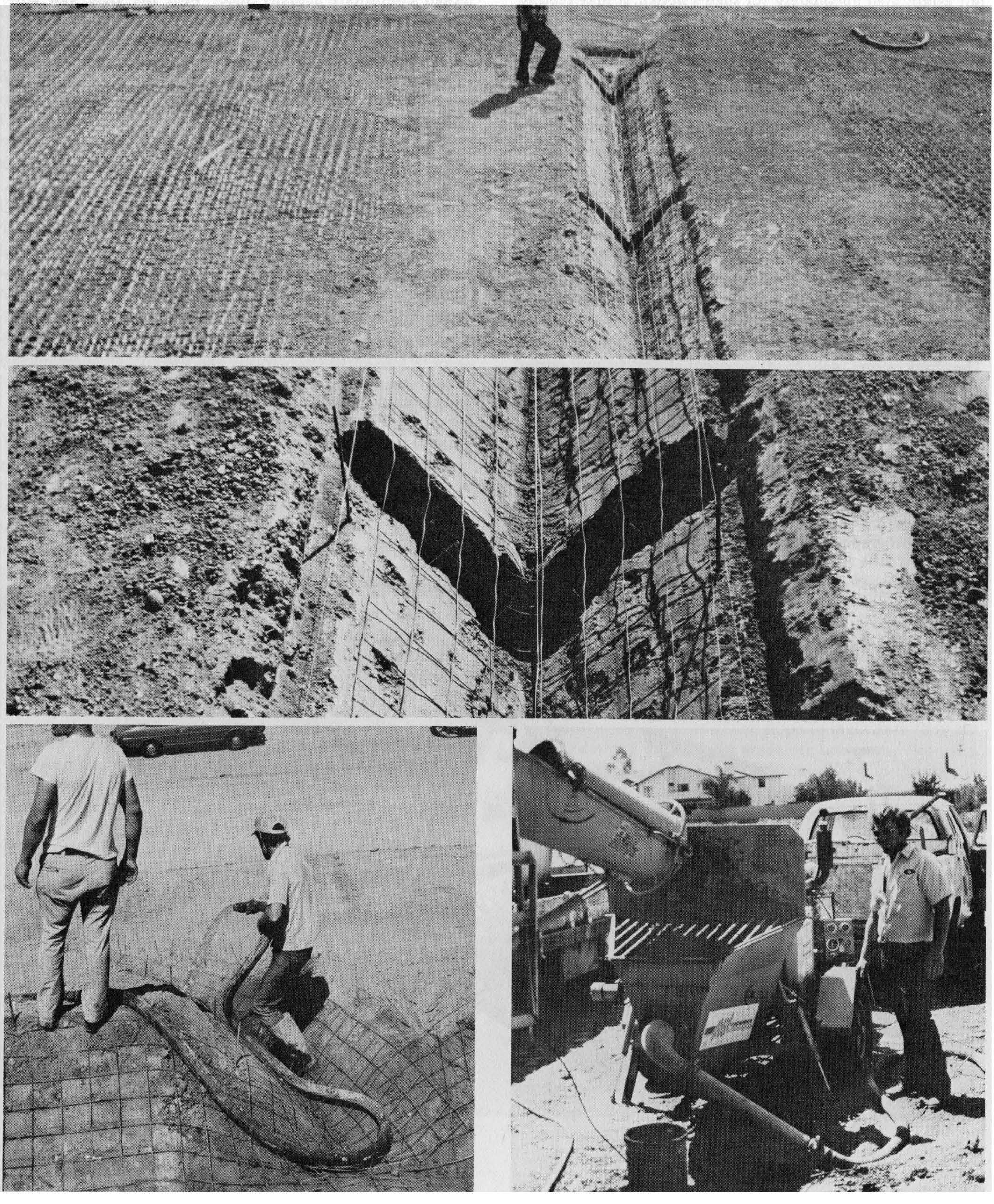
The Site Civil Engineer

The site civil engineer must survey the cut slope throughout to make sure that it is properly excavated and that the design conditions actually meet with the field and construction conditions. The civil engineer must stake the cut slope for terrace drain and down drains relative to line, grade, and width. The grading inspector must make sure that the excavated width and gradient of the drains meet the requirements of the design plan. (See Figures 5-49 through 5-57.)

A problem prevalent in hillside grading is where a cut slope frequently is adjacent to a proposed dedicated right-of-way. When the rough grading is completed and the right-of-way improvement sections are surveyed for construction, it is often found that insufficient area for proper placement of the sidewalks and street improvements has been left. To correct this deficiency, vertical cuts are made at the toe of the cut slopes. These vertical cuts are generally 2 feet to 4 feet high, unsupported, and require a design surcharged retaining wall to provide support for the cut slope. Close survey control by the site civil engineer during rough construction can help keep this problem from arising. (See Figure 5-58.)

Figure 5-49 Excavating terrace drains with a backhoe and a "formed" bucket. Excavated material is dumped over the slope to be removed by a "tractor-walking" dozer followed by a sheepsfoot roller and a "grid roller," which finishes the slope. Photograph by C. Michael Scullin.

Figure 5-50 (a) The terrace and down drains are excavated, and wire mesh reinforcement is placed and ready for construction. (b) A V-shaped down-drain anchor excavation is shown in center. Down-drain anchors are excavated at 10-ft. vertical intervals down the slope to lock the drain into the slope. The drain acts as a cut-off wall and is reinforced with rebars or wire mesh. (c) Here the terrace and down drain are presaturated with water prior to paving. Presaturation helps keep moisture in concrete or gunite. (d) The concrete mixer drops gunite or concrete into a hopper from which it is pumped through hoses for placement on terraces. Photographs by C. Michael Scullin.



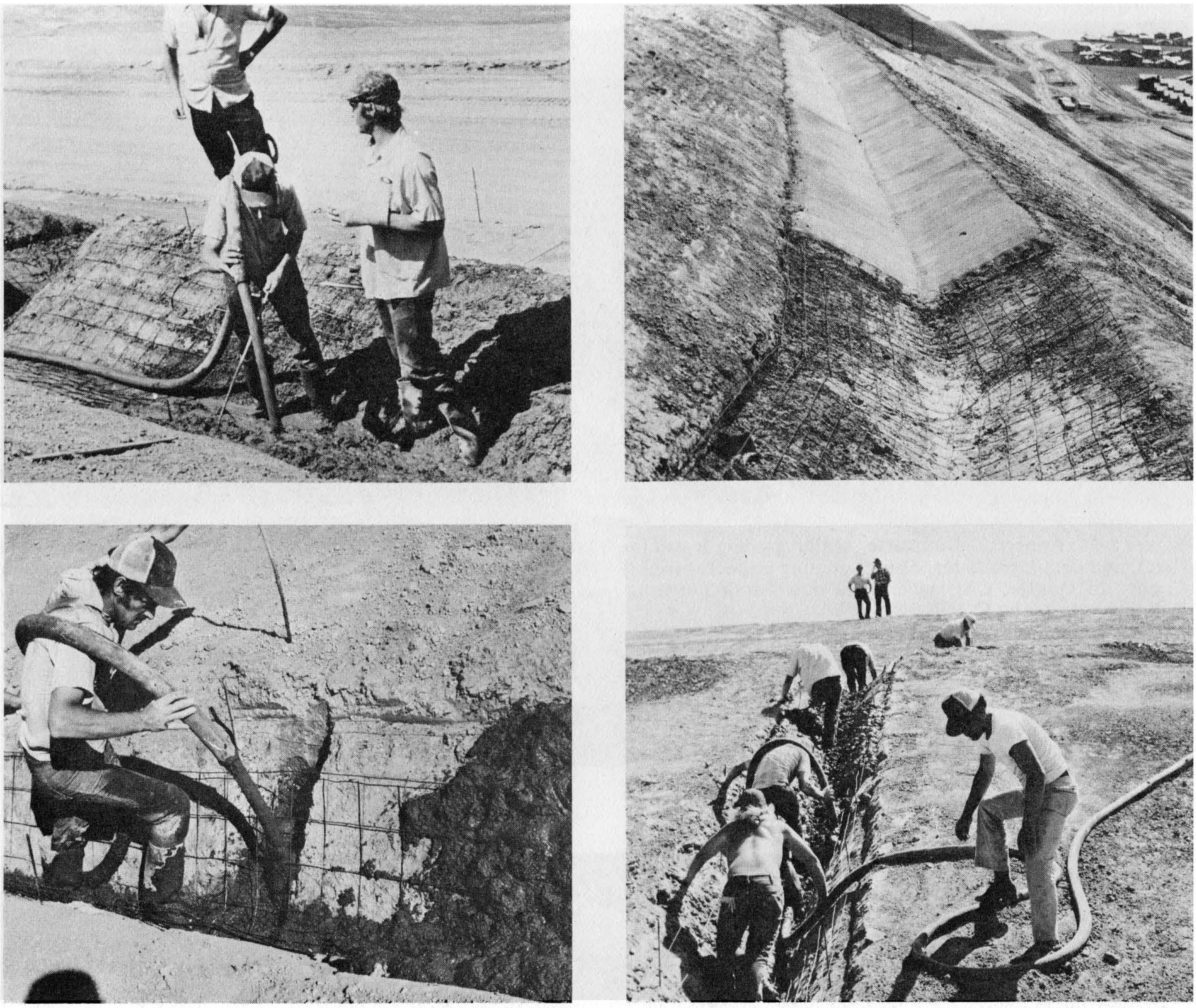


Figure 5-51 (a) Gunite is shot or hosed onto the terrace. The wire mesh should be lifted with a hook rod as gunite is placed to assure that the mesh reinforcement is within the gunite and is not pushed to the bottom by the weight of the gunite. (b) Guniting of this terrace drain is near completion. The surface is finished with a flat trowel and broom. The 4- to 6-inch vertical cut along the backslope (at left) of the terrace acts as a cut-off wall for drainage flowing down slope. (c) Guniting the down drain and anchors. Notice that the wire mesh reinforcement is pulled up off the ground surface and is well within the paved section. (d) Guniting the down drain. Photographs by C. Michael Scullin.

5-14 SLOPE DRAIN INSPECTION

The grading inspector must require the site civil engineer to certify that the line and grade of the slope drains meet the design requirements prior to the actual construction of the slope drains. The grading inspector must make sure that the slope drains have proper keys and anchors excavated for reinforcement and paving, and that the reinforcement wire mesh or rebars are properly chaired (lifted off the ground) prior to the placement of concrete, pumpcrete, gunite, or whatever paving material is used. Normally, guide wires are placed in the flow line to provide guidance for the thickness of paving as it is being placed. The grading inspector must require that, during the placement of paving, the slopes are properly kept clean of rebound (excess) material that frequently will be spilled over the slope. The pavement must be properly treated with a Hunt's Process or equivalent to prevent cracking due to moisture loss. Light watering of the graded terrace or bench prior to paving assists in moisture retention during curing of the paving. (See Figures 5-49 through 5-57.) Inspection should be made during paving to assure that the reinforcement mesh is raised into the paving and not pushed down into the dirt.

Figure 5-52 Robert J. Guilmette, senior grading inspector (left), and Sam Lawmaster, district grading inspector (right) County of Orange, CA, inspect this down drain construction. Photograph by C. Michael Scullin.

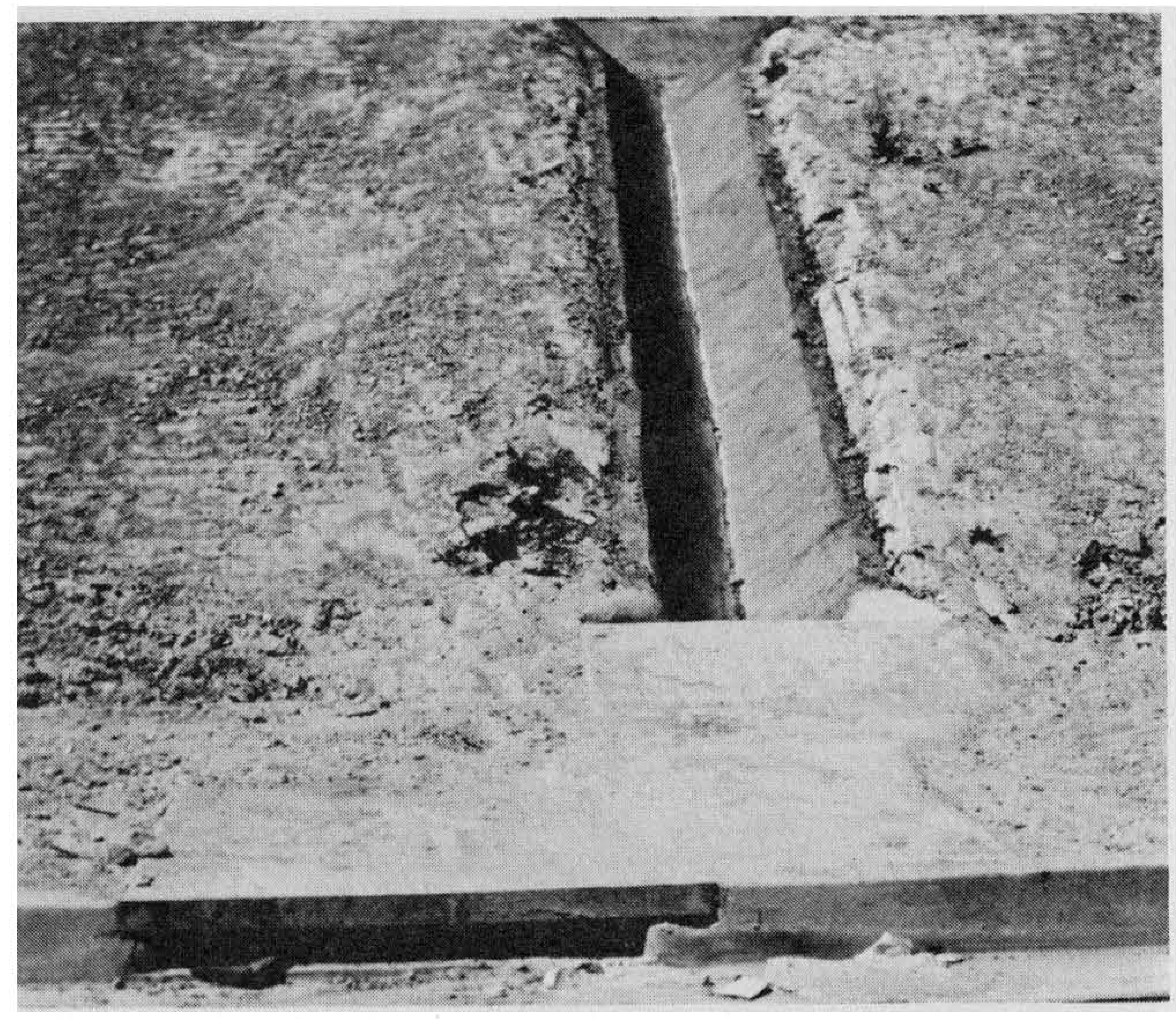


Figure 5-53 Completed down drain and outlet structure beneath sidewalk and through the curb face. Photograph by and courtesy of Alex Bruce, senior building inspector, City of Los Angeles, CA.

Figure 5-54 Kenyon H. Carr, senior grading inspector, West Los Angeles office, inspects and measures width and depth of terrace and down drains as part of final inspection of slope drainage at the rough grade stage. Photograph by and courtesy of Alex Bruce, senior building inspector, City of Los Angeles, CA.

Figure 5-55 Kenyon H. Carr, senior grading inspector, West Los Angeles office, inspects and measures the width and depth of a slope down drain at rough grade stage. Photograph by Alex Bruce, senior building inspector, City of Los Angeles, CA.

Figure 5-56 A completed lateral canyon fill slope is shown with paved terrace drains and a down drain constructed down the "daylight" line of the fill. Note seepage from subdrains into the drainage channel. Photograph by and courtesy of James E. Slosson.

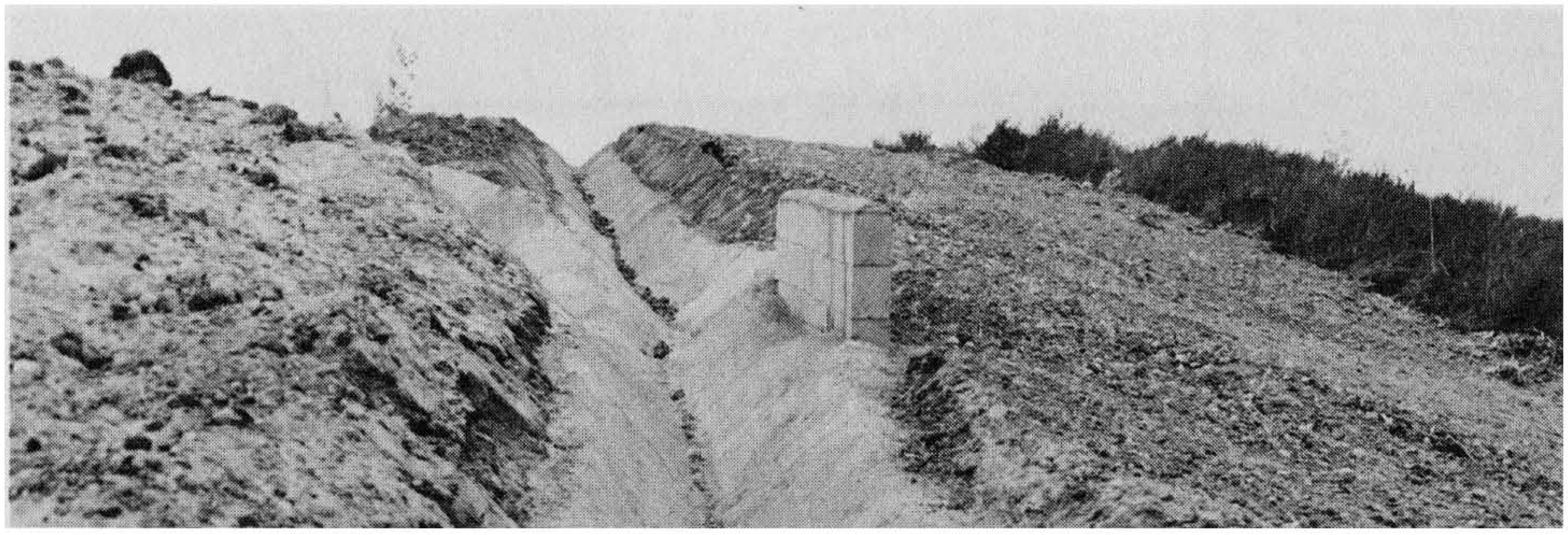


Figure 5-57 (a) A "diverter" wall constructed on the side of a down drain to turn water coming from a terrace drain at center left. Raising the freeboard with a diverter wall reduces the amount of water that may overflow the drain and cause erosion of the slope beside the drain.

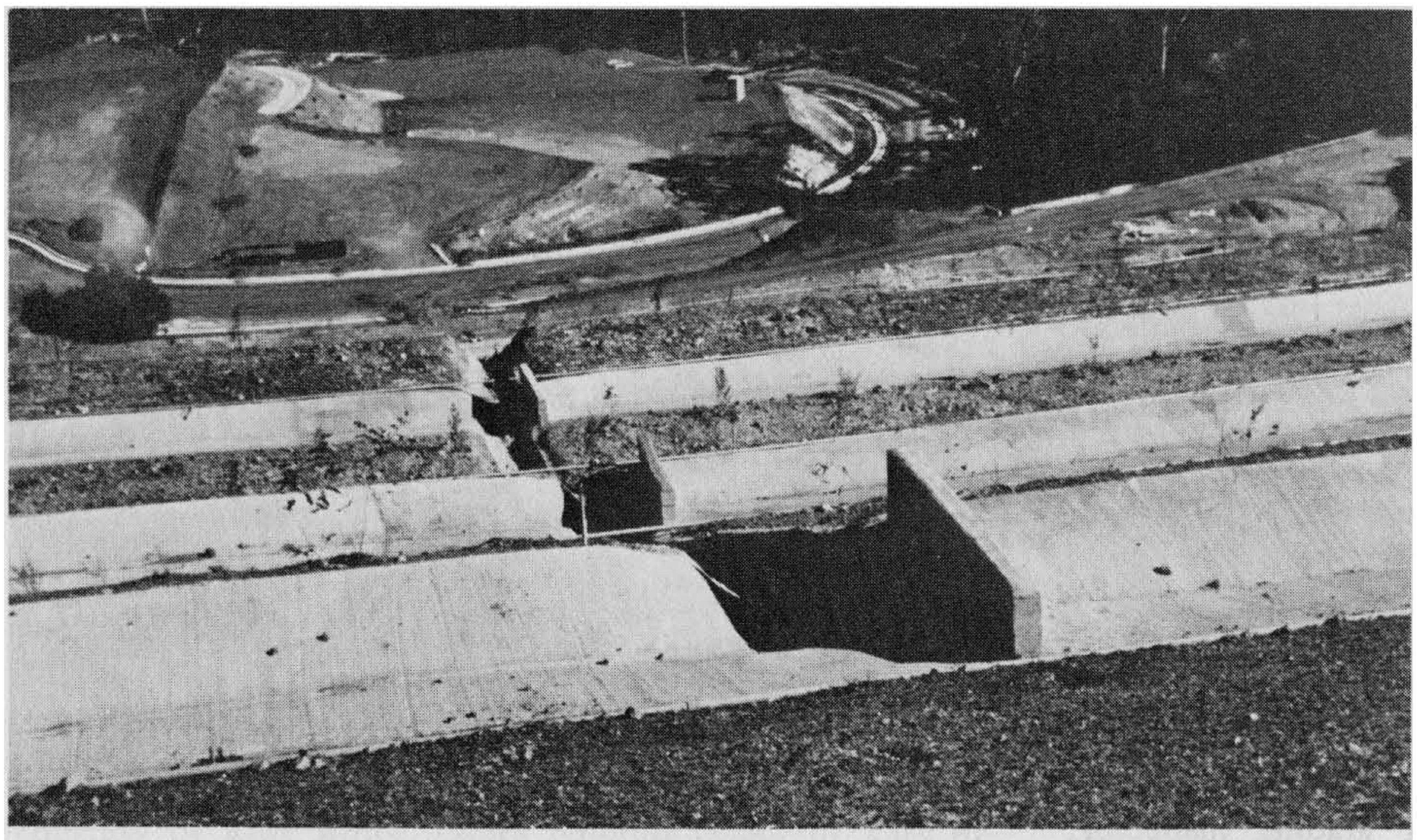


Figure 5-57 (b) Diverter walls constructed across terrace drains help turn water into the down drain. These diverters are sometimes used to divide water among several down drains. A lineal distance of 150-ft. is established normally between down drains. Photographs by C. Michael Scullin.

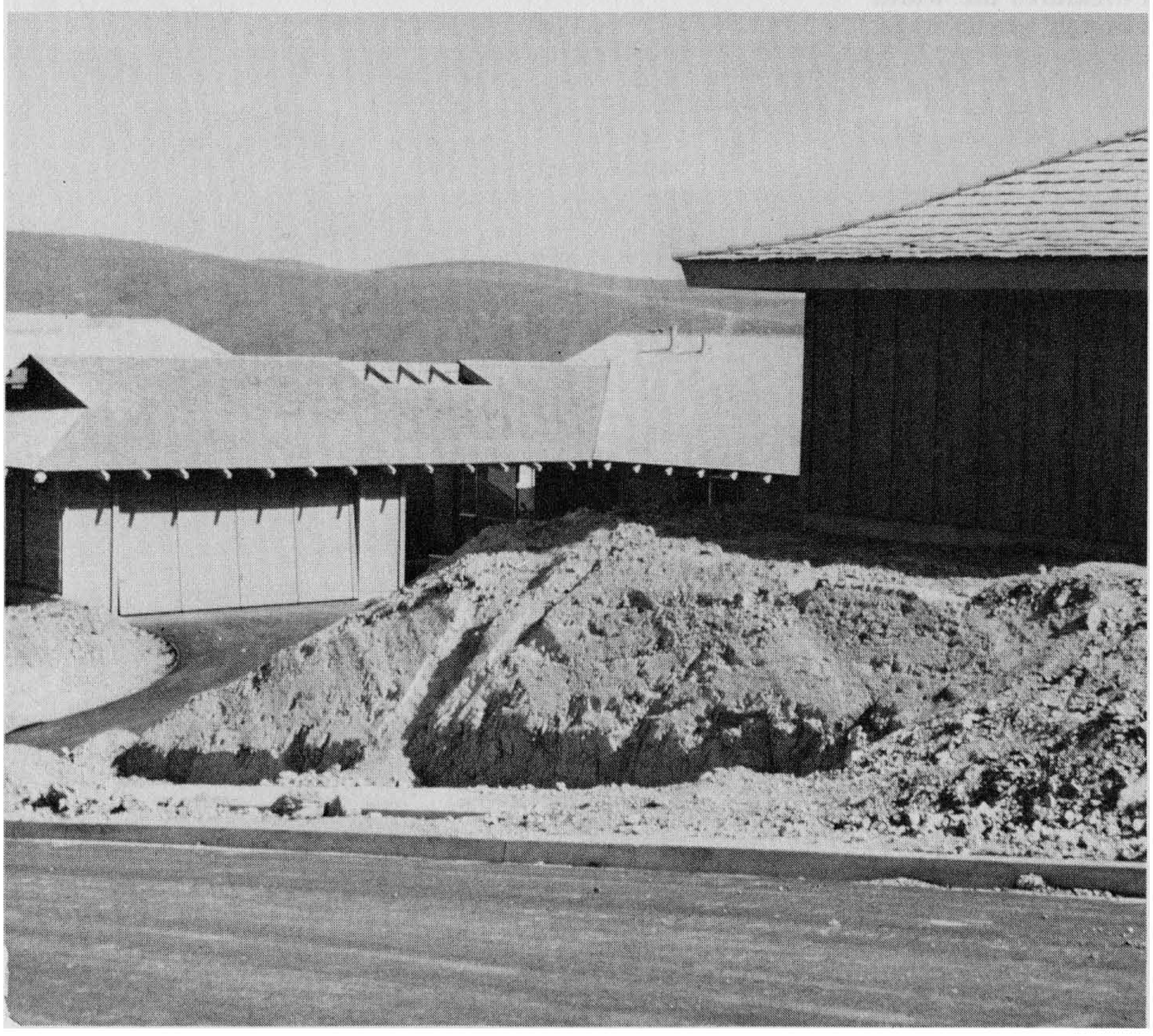


Figure 5-58 Here street improvement excavation has created a 2-foot vertical cut along the sidewalk, which needs a surcharged retaining wall for support. Rains during construction have caused a loose utility trench to erode down the slope. Roof gutters are needed to control water runoff, and this sideyard appears to be too narrow. Loose dirt has been pushed into parkway area in front. Photograph by and courtesy of Robert W. Ross.

5-15 ROUGH- AND FINAL-GRADE INSPECTIONS AND APPROVAL

The Rough-Grade Stage

This stage of completion is the time in the grading construction sequence when all rough grading is completed; all drainage structures are completed and functioning as intended; all protective devices are completed, such as buttresses, retaining or bin-type walls; the as-graded plan is completed and submitted; and all the required final geotechnical reports and approvals have been submitted. No building permits for residences or buildings should be issued until this work is completed and approved by the grading inspector and grading staff. The reason for holding up building permits until rough-grade approval is that the *site is not considered safe or stable* until these grading functions are completed and professionally approved. The site civil engineer must assure on the as-graded plan the actual constructed line and grade elevations, locations of constructed drainage structures and flow lines, and all protective devices in place. Subdrain locations and buttress keys should be shown on the as-graded plan as well as rough-graded pad elevations and drainage. The soil engineer and geologist must base their final reports and maps upon the as-graded plan. The site is not considered a safe building site until the grading staff has received, reviewed, and approved these assurances from the site professional consultants. A written memo of grading approval should be issued prior to issuance of building permits on each lot.

The Grading Contractor's Certification of Compliance

This certification is required by Section 7014(C), Engineered Grading Requirements, of Chapter 70, UBC. This section states, "The grading contractor shall submit in a form prescribed by the building official a statement of compliance to said as-built plan." Such a form would include the job address, lot and tract number, the owner, permit number, the grading contractor and license number, and a statement similar to the following:

"I certify that the grading was done in accordance with the plans and specifications, the grading ordinance, and the recommendations of the Civil Engineer, Soil Engineer, and Engineering Geologist. It is understood that this certification includes only those aspects of the work under my responsibility that can be controlled and determined by me, as a competent grading contractor, without special equipment or professional skills."

The certification should be signed by the contractor or the owner, if the grading was not done by a licensed grading contractor.

Rough-Grade Inspection

The grading inspector should make the rough-grade inspection in the field with the as-graded plan and final geotechnical reports. The inspector should have noted and recorded all conditions during grading, so they may be checked against the professional reports, to assure that all necessary considerations have been properly addressed and provided for within the final analysis of the site. The soil engineer's report should supply a lot-by-lot breakdown of the expansive soil characteristics and the recommended footing and slab details and designs. The building pad should be rough-graded to a minimum of 1% from rear to front with the drainage swales roughed in and berms excavated at the top of slopes for proper drainage control during building construction. All detached retaining walls should be completed at rough grade allowing sufficient clearances for proposed building structures.

Field elevations are established by providing a *blue-top stake* (blue ribbon on the top of the stake with the top of the footing wall elevation written on the stake) on each building pad. This survey provides the relationship between the elevation of the foundation, the elevation of the drainage swale flowline, and floor elevation at a time when the finished street does not yet exist. The floor elevations can be more accurately referenced and, consequently, the final grading after building construction is easier to complete without undercutting foundations, and so forth. Also, the building pad and terrace or slope drains should drain satisfactorily if the site undergoes rainstorms during building construction. (See Figures 5-59 and 5-63.)

Figure 5-59 Left to right; Gordon S. Erwin, district grading inspector, Charles E. Deveau, principal grading inspector, and John R. Westphal, senior grading inspector, City of Los Angeles, CA. review rough-grade stage on-site prior to ussuance of building permits. Close communication between supervisors and field personnel help raise standards of performance. Photograph by C. Michael Scullin.

Figure 5-60 Rough-grade stage nears completion. Slope terrace and down drains are complete except for outlet structures. The model houses are under construction; the access road is paved; smaller desilting basins are complete and slope planting is in progress. Photograph courtesy of the Dept. of Building & Safety, City of Los Angeles, staff photographer John Shadle.

Figure 5-61 This large desilting basin at low end of tract will collect silt runoff and protect adjacent property down slope during rough grading and before street and storm drain construction. Photograph courtesy of the Dept. of Building & Safety, City of Los Angeles, staff photographer John Shadle.

Figure 5-62 Canyon bottom drop structure composed of concreted rip rap. Sideslope and right-of-way landscaping are in progress. Photograph by C. Michael Scullin.

The grading inspector may write a memo to the structural inspector to recommend pertinent procedures to follow during building construction based on analyzing the site conditions. This list may include:

1. foundation, footing excavation, pre-saturation or underslab treatment recommended by the soil engineer in the rough-grade report;
2. retention of berms at the top of slopes;
3. no excessive stockpiling of materials that would tend to destroy or make ineffective drainage or grading devices;
4. no truck travel within certain distances of grading devices, so the truck weight won't break the devices;
5. any additional specific instructions or considerations warranted.

Final-Grade Stage

At this stage all site construction has been completed, but there has been no release of utilities nor issuance of the certificate of occupancy or certificate of grading completion.

The final grading inspection includes fine-grade and drainage certification by the civil engineer, utility trench backfill compaction test report by the soil engineer, restoration of any berms, grading, or drainage devices damaged during building construction, and landscape planting of slopes.

If the lot is not built upon, but graded for lot sale, the building pad must be graded with the standard berms at tops of slopes and the pad drained at a minimum of 2% from the rear to a designed and constructed drainage device or the improved street.

Grading for apartments, condominiums, commercial or industrial tracts, and private streets and alleys should be certified as to the compaction of utility trenches and fills by the soil engineer and the fine-grade drainage certified by the civil engineer. It is strongly suggested that the gradients of all swales and berms be inspected prior to any landscape work so that costly plant removal is not necessary to obtain proper drainage. Minimum drainage requirements for interior grades should be 1% or greater except where paved concrete gutters or sidewalks are used as drainage devices, one half of 1% could be acceptable. It is desirable for the site civil engineer to provide grade stakes to properly set sidewalks and driveways for drainage control. Sometimes the contractor fills across a drainage swale or builds to a flat pad that requires extensive excavation to create drainage swales at fine grade. This results in a large amount of earth removal at the fine-grade stage that must be exported or placed in an approved disposal site established under grading permit control. (See Figure 5-85.)

Construction of sidewalks, garden borders, and planters may pond water or destroy the designed drainage patterns. Sidewalks should be depressed below grade to allow for drainage control. Raised planters should be provided with weep holes to allow drainage to percolate.

Other types of final inspection considerations are involved with special investigations or special inspections. Some of these are utility trench considerations, engineered foundations, and seawalls. These will be discussed in Chapter 6.

Figure 5-63 Poor drainage control during house construction is shown here. Water is ponding in the rear, front, and side yards and next to the footings. Utility trenches are eroding in the front yards. This is a good example of poor drainage control during house construction. Photograph by and courtesy of Robert W. Ross.

Figure 5-64 A finished subdivision that makes optimum use of existing topography and forest vegetation. Each lot drains readily to the street, and lawns are landscaped to control runoff in an acceptable manner. Photograph by Gordon S. Smith, courtesy of the Soil Conservation Service, United States Dept. of Agriculture.

5-16 CLOSING OUT GRADING PERMITS AND FUTURE FILE UTILIZATION

Closing out a grading permit file involves correlation of data with other sections within the building department. The number one copy of the Grading Permit Application should be forwarded to the release clerk where it is held without release to utility companies and without issuance of the Certificate of Occupancy until the following final approvals are completed:

1. building permit;
2. electrical permit;
3. plumbing permit;
4. heating and ventilating permit;
5. land use, if required;
6. Certificate of Grading Completion.

Withholding the release to utilities and the Certificate of Occupancy until all finals are completed is the strongest enforcement technique available to the building official outside of the courtroom. The holding up of building permits until the rough-grade stage assurances of safety are approved by the grading section is also an effective method of code compliance. As discussed in Section 3-1, these final approvals and releases are directly related to building-code regulations in functional activity and operational processes.

The number one copy of the Certificate of Occupancy and the Certificate of Grading Completion are maintained by the release clerk, and the owner's copy of the Certificate of Occupancy is forwarded to the owner or to the prime contractor for delivery to the owner. The grading file should be brought up to date for proper storage. All field notes, pre-inspection sheet, plan-check sheet, any photographs, stop-work orders, correction notes, bond forms, and one copy of all of the soil and geologic reports and the as-graded plan should be placed into the office file for future reference. This file should be located within the Grading Division or within easy access by the grading personnel in a central file storage as there will be need to refer to or review the files in the future. This is particularly true of tract grading files. The grading permit index cards should show the date that the files were submitted to central files.

Future utilization of files should include file review by soil engineers, geologists, design engineers, attorneys, grading personnel, realtors, and prospective home buyers. Sometimes the files will be subpoenaed by the courts in cases involving land failure. The contents of the files are reviewed for the geotechnical facts, standards of approval and performance at the time the work was performed, the conditions of approval by the governing agencies at the time that the permits were issued, and the assurances that all work specified was completed in accordance with those specifications. Many times, these grading files are the only accurate account in sequential order available to the courts and to the public. Responsible recording and maintenance of such public documents increases the capability of the courts to render decisions based upon accurate facts. If the records are partially lacking or have been destroyed, it becomes an embarrassment to the building official as well as a negative reflection upon the building official's capability to maintain the public trust in a responsible manner.

If filing or storage space becomes the main objection to keeping the records, either the files should be microfilmed, or the records should be kept in a public library, county recorder, or some other location for public reference. They must be stored in a public place in order to be available for public inspection. Their importance seems to increase with time. The Van Nuys, California, branch office of the City of Los Angeles, Department of Building and Safety, Grading Division, is a good example of the value of maintaining public records and of the extensive use to which these records have been put.

5-17 SUMMARY AND CONCLUSIONS

In this chapter we have discussed the numerous grading-inspection field functions and methods, the techniques of field inspecting mass grading construction, the detailed field involvement of professional experts, the skills and techniques of grading contractors, the salient aspects of grading control, and the fundamentals of compaction testing and cut-slope inspection. We have attempted to illustrate each step in the process of stage approvals by private experts as well as government inspectors.

Grading-code plan-check and field inspection is a process of checks and balances with stage approvals as the primary technique. The review process method of stage approvals improves public safety and welfare. It reduces the effectiveness of fraudulent activity and increases the level of performance within the industry.

Within this chapter we discussed called inspections; the pre-grading meeting; in-progress grading inspections other than the called inspections; changing professional consultants during grading; professional inspection, testing, reports, and approvals; the details of different types and aspects of grading control; fill control testing and inspection; rough-grade and fine-grade inspection and conditions; and the closing of the grading permit file and subsequent file utilization. The effectiveness of this type of grading control has improved the quality of construction performance, and, consequently, has improved the quality of site performance. These techniques will continue to evolve, and the improvement of skills and methods will continue to lend assurance of safe and improved building sites.

In Chapter 6, we will first describe special grading inspections and investigations that are not normally a part of the mass grading construction, and, therefore, such inspections may possibly be provided by structural building inspectors, zoning, or other types of inspectors. However, due to their relationship to earth sciences and geotechnical activity, these special inspections may be performed more readily by the grading inspector. It is also an area where the building official might consider the most efficient utilization of grading inspector skills.

In addition to the special investigations, we will discuss complaint and violation investigations and reporting, and the court and legal preparations that are common to building- and grading-code enforcement. These functions may be common knowledge to most building officials, but the emphasis will be placed in the area of grading-code enforcement procedures.

We will complete Chapter 6 with a discussion of private road grading and the grading control of mass grading that may ultimately become public right-of-way. This may be a special consideration that can provide a safer grading-control effort in the field.

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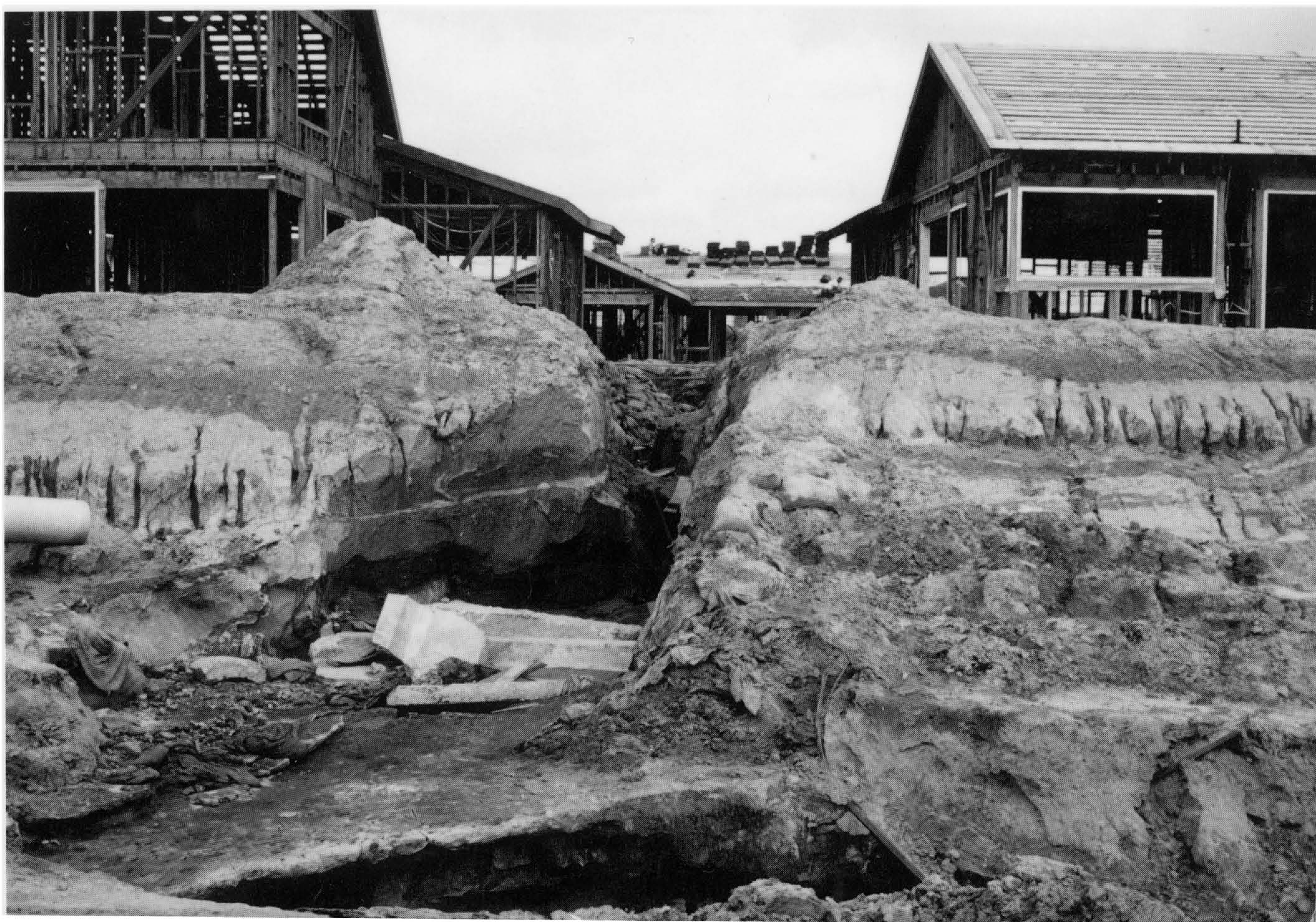

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