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GENERAL DESIGN (G 100)

LIST OF FIGURES

*Figures preceded by asterisks are in text. All others are at ends of chapters.

G 100 GENERAL DESIGN

This chapter presents the standards to which all City storm drain designs should conform. The policies, practices, types of drainage systems, and design criteria discussed herein are presently in use by the City.

G 110 POLICY

G 111 EXTENT OF RELIEF

Storm drain systems shall be independent of sanitary sewer systems.

*Storm drain facilities are considered necessary:

a. When the depth of flow during a storm of 10-year frequency exceeds curb height (usually 8 inches) in streets where the longitudinal slope is 2% or less. Where the longitudinal street slope exceeds 2%, the depth of flow shall be reduced so that the momentum (QV/g) does not exceed the value for flow at curb height on a slope of 2%. The method of computation and charts of computed values are in Appendix E, Office Standard No. 118.

b. When runoff floods improvements in sumps or hillside areas (see Section G 222).

c. To minimize inconvenience to vehicular and pedestrian traffic in major commercial areas.

G 112 DRAINAGE FACILITIES

Drainage facilities should be permanent. They shall be designed to conform to the standards approved by the City Engineer. Permanent drainage facilities consist of covered conduits, lined open channels, storage basins, pump stations, and appurtenant structures.

A storm drain must be designed to the frequency indicated in Section G 222, based on the ultimate development of the area; it must conform to the Master Plan of Drainage where practical; and it must conform to the materials and methods of construction indicated in the Standard Specifications for Public Works Construction. Should a new product or method of construction indicate a saving in cost or provide better performance, all substantiating data shall be submitted to the Chief Engineer of Design for approval prior to use.

G 120 DESIGN PRACTICES

G 121 WORK BY OTHERS

The designer shall make use of the many specialized services available to him from other City offices. Such services include:

Zoning data-Planning Department

Traffic requirements-Traffic Department

Geological and soil data-Street Opening and

Widening Division and Bureau of Standards

Right of way processing-Street Opening and Widening Division

Assessment data-Coordinating Division and Bureau of Assessment

Substructure data-Utility and Estimating Division

Field Surveys-Survey Division and all other design and related divisions within the Bureau of Engineering.

G 122 STANDARDS OF DRAINAGE EASEMENTS

Generally, easements for drainage purposes are acquired only if no alternate alignment in existing streets or public property is economically justifiable. Such acquisitions may be made by dedication (as in tracts), or through negotiation or condemnation by the Bureau of Right of Way and Land working with the Street Opening and Widening Division (see Section G 063).

A drainage easement may be either by itself or combined with a sewer easement. A drainage easement should never be combined with one under the jurisdiction of another City department, such as a utility easement.

*Municipal Code Section 17.05M

The standards shown in Figure G 122 illustrate the minimum widths and clearances recommended for drainage easements. The designer must use good judgment, however, in the application of these standards where existing improvements interfere. For example, the minimum width of an easement should be reduced to avoid an existing building or other permanent structure.

G 123 USE OF EXISTING STORM DRAINS

Existing drainage facilities may lie along the alignment or route of a proposed storm drain project. Whether these existing drainage facilities remain in service or not must be determined by investigating the type, size, and condition of each facility. Then the designer is able to consider the economic value of these facilities in conjunction with the proposed storm drain improvement.

Generally, if the existing facility meets present standards for a permanent installation (R. C. conduit, minimum slope, etc.) and is structurally sound, it should be kept in service. But if the existing drain interferes with the development of property or is incompatible with the proposed storm drain, then it should be removed. If an existing drain would only partially interfere with proposed construction, the interfering portion should be removed, the ends of the remaining portions sealed, and the drain abandoned in place, provided this would create no hazard or nuisance.

Many areas have entire storm drain systems which are structurally sound but of inadequate capacity. The designer should keep these existing facilities intact, if practicable, by intercepting surface overflow upstream, or by providing additional storm drain capacity by flow interchanges with relief drains.

G 124 DESIGN RECORDS

Records of the design of a project are very important for reference in designing similar or adjoining projects, and are a valuable supplement to office project files, maps, and miscellaneous records. Knowledge of a project's limitations and design details avoids duplication of work and allows better coordination of supplemental projects. The designer must conduct his work in an orderly manner to provide legible records, and he should remember that they are City property.

Design records are classified as permanent or temporary. Permanent records are those of reference value for the life of the drainage facility. The drainage map, hydrologic tabling, and hydraulic calculations are the most essential and must be complete and accurate to be of any reference value. The designer should place at least the above three records in good order in the office design record file for permanent reference.

Design worksheets are usually considered temporary records of preliminary design. They offer construction details shown in final form on the construction plan, and are of reference value in solving problems encountered during construction. Unless the worksheets have special importance, the designer may discard them upon completion of construction.

G 125 CARE OF PUBLIC RECORDS

All personnel shall take the necessary precautions to protect and preserve existing City plans, profiles, maps, field books, photographs, design records, and all other City records. Many of these public records are irreplaceable and must be maintained in legible condition indefinitely. The designer is cautioned to refrain from making any marks, notes, or corrections on tracings or field books without the specific permission of the Division or District Engineer.

No changes shall be made on approved plans of proposed storm drains except as specified in Sections G 755 and G 756 herein. Plans of proposed construction from other offices shall not be changed without the specific approval of the originating offices.

G 126 FLOW MEASUREMENT IN CONDUITS

The Storm Drain Design Division maintains gages in certain existing storm drain conduits to obtain flow data during a storm. A stripe gage is usually used in closed conduits and a staff gage is usually used in open channels. This gage gives the maximum depth of flow at a preselected location from which the quantity of flow can be determined.

A number of automatic stage recorders are maintained in watercourses and storm drains with relatively restricted drainage areas. These recorders plot the hydrograph of the conduit flow, which provides a check between the peak flow and the peak rainfall

G 127 LACFCD PERMIT ACQUISITION

A Los Angeles County Flood Control District (LACFCD) permit is required:

(a) For any work in an LACFCD easement.

(b) For storm drain connections or remodeling of existing LACFCD drainage facilities in City streets.

(c) For work in City streets which will physically affect existing LACFCD drainage structures.

A. To standardize the acquisition of LACFCD permits by the Bureau for all cash and assessment projects, this procedure shall be followed:

1. *Prior to design.* If the work requires the connection of a major lateral and/or a lateral which does not follow the original hydrologic boundaries of an LACFCD project, the design office shall arrange for a conference to determine LACFCD requirements. No pre-design conference is required for the connection of a small lateral (one block long), for remodeling or relocating LACFCD catch basins, or for exploratory work.

2. *Remodeling or Relocating LACFCD Facilities:* LACFCD design criteria and standards shall be used to remodel or relocate their facilities, e.g. for catch basin connector pipes, no horizontal curve or no horizontal angle point greater than 6~ shall be used.

3. *Permit Note:* The design office shall place the following permit note under Notice to Contractors on the title sheet of the final plans:

> "All provisions of the Los Angeles County Flood Control District permit shall be complied with. This permit is on file in the office of the City Engineer."

4. *Permit Acquisition:* The design office shall request the permit by letter after the Division/ District Engineer has signed the plans. Three copies of the plans of the proposed work showing that work requiring an LACFCD permit shall be transmitted with the request. If the connection is to a USED drain, two additional sets of prints are required. If right of way is involved or the project is only partially financed, the LACFCD shall be informed that it may be up to two years before the project goes to construction. The permit is normally for eighteen months, but with this information the permit may be given for a longer period. Upon receipt of the permit, the design office will retain one copy, send one copy to the Utility and Estimating Division, and send the original permit to Letter Files, Room 857, City Hall for filing.

5. *Permit Renewal:* If it is necessary to renew the permit, the Specifications Section of Utility and Estimating Division shall request a time extension or renewal just prior to completion of the bid proposal.

B. Property Owners wishing to fill or build over drains in an LACFCD easement must acquire a LACFCD permit. This permit will stipulate the LACFCD requirements and will contain a provision that approval by the City of Los Angeles must be secured before exercising the permit if the easement is in a natural watercourse. (See Section G070)

The LACFCD considers work over drains in its easement only on the basis of the work's effect on the structural integrity of its drainage structures and requirements for the operation and maintenance of its drains. The LACFCD will inspect only those operations which affect its facilities.

C. Work in City streets adjacent to existing LACFCD drains for which a LACFCD permit is required may consist of sewers or other structures which physically touch LACFCD structures. It may also consist of borings through the top or bottom slab of a LACFCD drain to determine the slab thickness and clearance required for a proposed sewer or other structure. Work in City streets adjacent to LACFCD drains not touching their structures does not require a permit, only a review of the project by the LACFCD. These projects are those that appear to add any unusual loads or stresses to existing LACFCD drains during construction.

D. For B-Permit projects requiring LACFCD permits, the City design office checking the plans shall be responsible for the following:

l. To see that the LACFCD permit note in A3 above is placed on the title sheet of the final plans.

2. To see that the private engineer responsible for project design acquires the LACFCD permit and submits three copies of the permit to the City design office after plan approval by the Division/ District Engineer. The Division/District Engineer will not transmit plans for further processing until the LACFCD permit has been received.

3. To retain one copy of the permit and send two copies to the Bureau of Contract Administration. The private engineer will provide permit copies to his own clientele and then submit the original permit to the design office for filing in Room 850, City Hall.

E. For Street Maintenance projects requiring a LACFCD permit, the design office shall obtain the permit and place the note described in paragraph A3 on the plans. The design office shall retain one copy of the permit, send two copies to the Bureau of Street Maintenance, and send the original permit to Letter Files, Room 857, City Halt for filing.

G 128 STATE ENCROACHMENT PERMIT ACQUISITION

A State Encroachment Permit is required for any work in State highways and freeways or in other State property. For City projects in State highways maintained by the City, the permit is written by the City, approved by the State, and signed by the City Engineer. For City projects in State highways maintained by the State, in freeways, or in other State property, the permit is issued by the State to the City. For "B" permit projects, the permit is issued to the permittee by the State or the City as stated above.

A State Encroachment Permit is required in a City street overlain or underlain by a freeway right of way when the freeway structural support is affected, freeway operations are interfered with, or the street is a State Highway. If in doubt as to whether a State permit is required, the design office should consult the Transportation Engineering Division.

The Transportation Engineering Division is responsible for coordinating all matters pertaining to the planning and design of projects involving joint participation between the City and the State Department of Transportation. The Transportation Engineering Division also serves as consultant to the District design offices and acquires all State Encroachment Permits for City projects.

To standardize the acquisition of State Encroachment Permits in this Bureau, this procedure shall be followed:

I CITY CASH AND ASSESSMENT PROJECTS

A. In State Highways Maintained by the City**--**

1. Design Office**-**The design office need not request State approval during design on construction maintained by the City. City requirements are generally acceptable to the State except that all trench backfill in State highways shall be densified by special compaction. For special or complicated projects or for construction affecting State structures maintained by the State, the design office shall arrange for a conference with the State during design and shall notify the Transportation Engineering Division of the time, place, and subject of the conference. The design office shall also place the following note under Notice to Contractors on the title sheet of the final plans prior to the Division/District Engineer approval:

> "The contractor shall comply with all the provisions of the State Encroachment Permit (Number) for the work in (Street Name). The permit is on file in the office of the City Engineer".

2. Transportation Engineering Division **-** The Transportation Engineering Division shall acquire all State Encroachment Permits when requested by the Utility and Estimating Division. The Transportation Engineering Division shall fill in the permit form, acquire the City Engineer's (or his designated representative's) signature, and submit the permit and four prints of the required plans to the State for approval. The original permit will be sent to Letter Files, Room 857, City Hall, for logging in and assignment to the Utility and Estimating Division.

3. Utility and Estimating Division-This Division will examine the status of the project during the preparation of bid documents and request the Transportation Engineering Division to acquire the State permit when the project is reasonably assured of going to bid within the next 60 days. For projects not so assured, the bid documents will be held in abeyance by the Utility and Estimating Division, which will monitor the project periodically until such assurance is obtained. Four copies (folded to 8 1/2" x 11") of the project title sheet and, other sheets delineating the construction on State property and the estimated date of start and completion of construction shall be transmitted with the request. Copies of the permit will be attached to bid documents, one copy will be sent to the design office, and the original permit will be sent to Letter Files, Room 857, City Hall.

B. In State Highways Maintained by the State, in Freeways, and in Other State Property-

1. Design Office-The design office shall contact the Transportation Engineering Division to determine if a conference with the State is needed during design. The following note shall be added to the State permit note under Notice to Contractors:

"The Contractor shall obtain a rider to the original permit from the State Department of Transportation before starting any work in (Name of Highway). The special terms and conditions required will be set forth on the permit rider. All inspection charges and soil tests made by the State Department of Transportation shall be charged to the contractor".

2. Transportation Engineering Division This Division shall fill in the Application for Encroachment Permit form, which will be signed by the City Engineer (or his designated representative). The application together with four prints of the plans will be submitted to the State for approval. The State will issue the Encroachment Permit to the City and the original permit will be sent to Letter Files, Room 857, City Hall, for logging in and assignment to the Utility and Estimating Division. If a surety bond is required, the bond amount is sent to Utility and Estimating Division.

3. Utility and Estimating Division - The procedure is the same as in A (3) above except that if a surety bond is required, the amount (State Form P-4) will be included in the bid documents.

II "B" PERMIT PROJECTS

For "B" permit projects requiring State Encroachment Permits, the procedure shall be as follows:

A. In State Highways Maintained by the City: The City design office checking the "B" permit plans shall be responsible for the following:

1. To require the private engineer responsible for the design to submit four sets of prints (folded to 8 1/2" x 11") of the required plans to the City design office for permit acquisition and to require the permit note under Notice to Contractors on the plans. This is required prior to plan approval by the Division/District Engineer.

2. To fill in the permit form, obtain the City Engineer's (or his representative's) signature on the permit and acquire the permit.

3. To retain one copy of the permit and transmit two copies to the Bureau of Contract Administration.

B. In State Highways Maintained by the State, in Freeways, or in Other State property- In this case, the "B" permittee (in lieu of the City) applies for the State permit, which is issued by the State to the permittee. The form Application for Encroachment Permit and four prints of the plans are required to apply for the permit. The designer shall require that the proper permit notes (See Sections A-1 and B-1) are placed on the plans and six copies of the permit are submitted to the Division/District Engineer prior to his approval of the plans. The design office shall transmit two copies of the permit to the Bureau of Contract Administration and retain four copies. The permittee will provide permit copies to his own clientele.

G 130 TYPES OF DRAINAGE SYSTEMS

Of the various types of drainage systems, the gravity flow system is the most commonly used by far. Most watersheds have natural outlets. However, some have outlets of limited capacity. A few consist of terrain which makes flow by gravity impractical. In such cases, the water must either be stored in a basin prior to disposal, and/ or be pumped to an elevation adequate to provide gravity flow. A common use of storage basins is for temporary storage of runoff pending downstream improvement of drainage facilities. Any combination of the above systems that best suits existing conditions favorable to the economic disposal of runoff may be used. However, the designer must restrict his choice of drainage system to one which meets City standards.

G 131 GRAVITY FLOW

Drainage by gravity flow is usually most economical and should be used whenever possible. It may consist of either an underground conduit or a concrete lined open channel. The underground conduit, whether pipe, box, or arch, is usually designed for full flow. An open channel, either rectangular or trapezoidal, is usually designed for uniform flow. The selection of a conduit is made primarily on economic considerations.

G 132 STORAGE BASINS

A storage basin, as utilized by the City for storm drain purposes, consists of an open pit which has the capacity to receive and store surface runoff. A drainage system using a storage basin usually has a storm drain to collect the runoff for storage in the basin and a means of disposing of the water to restore the capacity of the basin.

Storage basins are classified as permanent or temporary. A permanent basin should serve a dual function: store runoff to retard peak flow, and provide a lake for recreation, recharging ground water supply, or other purposes. Where a gravity flow system can ultimately be provided but is presently not feasible, a retarding or detention basin is constructed on a temporary basis.

A retarding basin receives and stores surface runoff for a short period of time, thereby decreasing the peak flow. A common use of a temporary retarding basin is to accommodate an outlet of limited capacity. The outlet conduit, however, is designed to the ultimate capacity for the intent of the permanent drainage system.

G 133 PUMPING STATIONS

Whenever surface runoff cannot drain to its outlet by gravity flow, it is collected at a common location and pumped out. The pump station may be designed to pump peak flow (which is often the choice with small storm drains), or it may pump only a portion of the peak flow, storing the remaining portion in an adequate basin. Due to the high cost of pump stations, the allotted capacities of pumping and storing must be based on a thorough economic study. The use of storage in conjunction with pump stations is recommended because of the many advantages conducive to better operation and economy. (For design information see Chapter G 500.)

G 134 LIMITATIONS OF SYSTEMS

On occasions, it is impractical to construct a drainage system to ultimate requirements. A modified system must be devised, incorporating as much of the ultimate system as possible, and supplementing it with temporary drainage measures. A typical example is the situation of inadequate outlet capacity. Acceptable temporary measures may consist of (a) burping excess runoff in the streets, (b) delaying peak flow by a retarding basin, or (c) providing partial relief by limiting the capacity of catch basin inlets. All such measures must be very carefully analyzed economically and for undesirable effects. The use of temporary measures must be approved by the supervisor.

G 135 ECONOMIC FACTORS OF SYSTEMS

After evaluating existing conditions and drainage problems, the design engineer must choose the drainage system which gives the most benefit for the money while complying with design criteria. The system chosen may combine gravity-flow, storage, and even pumping. The extent of land development and the size and terrain of a watershed affect greatly the factors upon which the cost of a system is based, so that a careful economic evaluation of the proposed drainage system is essential.

The basic factors composing the total cost of a drainage system are the initial installation cost, the cost of acquisition of land or right of way, including tax loss, and the maintenance and operation cost. Whenever possible, the installation cost should be reduced by utilizing existing serviceable facilities. Land cost can sometimes be reduced by utilizing existing or combined easements, existing or future streets, watercourses, ravines, or other property less likely to become highly developed. Since the operation and maintenance of a pump station, including installation and replacement of equipment, is very expensive, a detailed cost estimate of these items should be obtained from the pump plant section of the Sewer Design Division for use in evaluation.

For comparative purposes, a tabling of the relative costs of different combinations of drainage systems is shown in Figure G 135. Each set of existing conditions influencing the design of a drainage system is unique; therefore, the designer must select a system on the basis of costs applicable to the given conditions. The figure emphasizes, however, that the overall cost during the life of the project must be considered, rather than only the initial installation cost.

G 140 EXCAVATION AND BACKFILL

Excavation for storm drain structures is generally open trench excavation, unless otherwise specified on the plans. Jacking, tunneling, or limited operations may be specified to meet existing field conditions. *(See Standard Specifications for Public Works Construction.)*

G 141 OPEN TRENCH

All storm drain conduits should be designed for open trench excavation to a depth of thirty feet, except where conditions warrant the use of jacking or tunneling. Such conditions may be created by:

a. traffic congestion
b. surface or subsurface obstructions
c. railroad requirements
d. .requirements for State highways
e. soil conditions unfavorable to trenching

Open cuts to depths greater than thirty feet are generally impractical, due to excavating equipment limitations.

The width of trench required for the case of pipe bedding used is specified in the standard plan Pipe Laying in Trenches.

G 142 JACKING

Jacking is usually an operation in which the earth ahead of the conduit is excavated and brought out through the conduit barrel while the conduit is pushed forward by heavy jacks placed at the rear of the conduit section. Complete subsurface investigations must be made to locate possible obstructions. Also, test borings must be taken to determine the type of soil through which the conduit will pass. For example, jacking should not be attempted in dry sand or where it is impractical to lower the water table below the excavation. Consideration should always be given to jacking across major streets in lieu of open trench because of heavy traffic requirements.

Pipes from 30" to 96" diameter have been installed by jacking; however, 36" to 60" sizes are most commonly jacked. Ordinarily, 36" pipe is the smallest size which should be used, as smaller sizes are hard to work in, and little, if anything, will be saved by their use unless boring, hydraulic backwash, and other such methods can be used. The casing to be jacked shall be of sufficient size to permit a vertical clearance of 2 feet from top of pipe barrel to soffit of casing to permit adequate space within the casing for workmen and inspectors.

The length of conduit jacked is subject to the conduit size, soil texture, and equipment available. However, it is not recommended to jack over 200 feet in length. The minimum cover for jacking varies with the size of pipe and the type of soil. Under railroads, the cover should not be less than 6 feet. (See Figure G613B). Under pavement, the cover should not be less than 3 feet.

An approach trench or work pit is required for jacking operations. It is usually located at the downstream end to prevent water from accumulating in the conduit. The designer should consider the area required for the work pit (estimated size shown in Figure G 143) before setting the limits of jacking. The work pit should not be located in street intersections.

The designer shall refer to Section 306-2.4 of the *Standard Specifications for Public Works Construction* for the design of conduits to be jacked in place. If applicable, the following general notes shall be placed on all plans for jacking operations:

1. The Contractor shall conform to the requirements of Section 306-2.4 of the Standard Specifications for Public Works Construction for all jacking operations unless otherwise specified.

2. The Contractor shall submit details of the following for approval:

a. jacking pit location and bracing,

b. conduit and jacking head,

c. pressure concrete mix design, placement, method, and equipment.

G 143 TUNNELING

The construction of storm drains in tunnel in lieu of open trenching or jacking is optional with the Contractor. For tunnels longer than 20 feet, the Contractor is required to submit supplemental drawings showing proposed details of tunnel construction, and shall obtain the Engineer's approval of his proposed scheme of tunnel operations prior to any tunnel construction. Test borings must be taken to determine the type of soil encountered in tunneling.

Where the depth of storm drains in tunnel does not exceed 30 feet, the concrete reinforcement and/or additional strength of R.C.P. required for the conduit in and contiguous to tunnel shafts, structure excavations, and tunnel portals is shown in Table B of the standard plan titled Pipe Laying in Trenches. It should be kept in mind that projection, and not trench,' conditions will almost invariably govern.

In all instances where the depth of storm drains to be constructed in tunnel exceeds 30 feet and in those instances where special substitute bedding is required in Table B of the standard plan titled Pipe Laying in Trenches, the reinforcement and/or R.C. Pipe shall be designed by the Bridge and Structural Design Division. In instances where the depth in tunnel is less than 30 feet, a review of the design by the Bridge and Structural Design Division is sufficient. In both instances the plans, accompanied by the logs of test borings showing soil classifications and ground water, shall be submitted to the Bridge and Structural Design Division.

Consideration should always be given to tunneling across major streets in lieu of open trench for depths less than 30 feet because of heavy traffic requirements. Tunnel shafts shall not be located in street intersections.

The designer shall refer to Section 306-2.5 of the *Standard Specifications for Public Works Construction* for the design of conduits in tunnel. Figure G 143 shows a typical Tunnel Cross Section and Details for R.C. Pipe. The details and notes shown thereon are for a tunnel bedding load factor of 4.5, which is equivalent to Case VI Bedding shown on the standard plan titled Pipe Laying in Trenches. If a load factor of less than 4.5 is found adequate for tunnel bedding by the Bridge and Structural Design Division, the plans shall show dimensions and type of bedding for the appropriate case.

The following general notes shall be placed on all plans for tunneling operations if applicable:

1. The Contractor shall conform to the requirements of Section 306-2.5 of Standard Specifications for Public Works Construction for all tunneling operations unless otherwise specified.

2. For tunnels longer than 20 feet, the Contractor shall submit details for approval of the following:

a. Tunnel shaft bracing and tunnel supports

b. Method of backpacking tunnel supports

c. Concrete support blocks

d. Bracing to prevent pipe shifting and flotation

e. Pressure concrete mix design, placement method, and equipment.

G 144 BEDDING AND BACKFILL

Backfill shall be considered as starting one foot above the pipe or conduit, or at the top of concrete bedding over the pipe or conduit. All material below this point shall be considered as bedding.

Backfill for cast-in-place structures (such as manholes, junctions, transitions, and reinforced concrete box) shall start at the subgrade for the structure. Bedding shall be according to Standard Plan Pipe Laying in Trenches.

The consolidation of backfill in trenches shall be in accordance with the following:

1. Loading over conduits shall be dead load (for width of trench specified in the Standard Plan Pipe Laying in Trenches) plus live load (H20-S16) except in steep slopes or in narrow easements not accessible to vehicles, where dead load only will be used.

2. Trench backfill in easements shall be considered the same as trench backfill in streets in loading, compaction methods, and backfill materials allowed.

3. Backfill in trenches shall be in accordance with Subsections 306-1.7 to 306-1.10 of the Standard Specifications (as amended by supplements) as modified by Sections 2-23, 3-21, 3-22, and 3-28 of Standard Plan Notice to Contractors-Comprehensive, and as modified herein.

4. Compaction by flooding shall not be allowed. Compaction by jetting shall be used as recommended by the Geology and Soils Engineering Section, Street Opening and Widening Division. The ninety percent relative compaction requirement shall not apply to jetted backfill. Where jetting is not allowed, mechanical compaction to ninety percent relative compaction or soil cement (see Item No. 5) backfill may be used.

Compaction by jetting shall not be used in:
a) Mechanically compacted fills
b) Unconsolidated fills
c) Steep slopes
d) Slide areas
e) Areas of pressure from structures

5. Backfill of trenches on steep slopes may be done by the use of soil cement in lieu of mechanical compaction. The use of soil cement shall be considered as a supplement to anchor blocks and baffle boards. The ninety percent relative compaction is not required with the use of soil cement.
Soil cement backfill shall consist of a mixture of 3/4 sack of cement to one (1) yard of soil or sand, and shall be thoroughly mixed, placed in 6" lifts, and sprinkled with water to saturation. The top. 12" of backfill shall be native soil, mechanically compacted.

6. Native trench soil unsuitable for backfill may be made acceptable under the following conditions:

a) It may be mixed with a more suitable soil in proportions determined by the Geology and Soils Engineering Section.

b) It may be compacted by jetting to within 3 feet of pavement subgrade, provided the remainder of backfill is Crushed Aggregate Base. In easements not under pavement, the top 12" of backfill shall be native top soil.

Unsuitable backfill soil shall be removed and may be replaced with imported soil in accordance with the Standard Specifications, Subsection 306-1.10. Sand or cohesionless material shall not be used as backfill except where the native soil in the trench area is sand.

7. The procedure to determine the adequacy of native soil for backfill and method of compaction is as follows:

a) The designer, in his memo to the Geology and Soils Engineering Section requesting borings, shall also request that samples of fine soils be taken.

b) The Geology and Soils Engineering Section shall determine the extent of soil analysis needed, request tests from the Bureau of Standards, and, based on the results, recommend the trench backfill requirements to the designer.

G 145 SUBSIDENCE

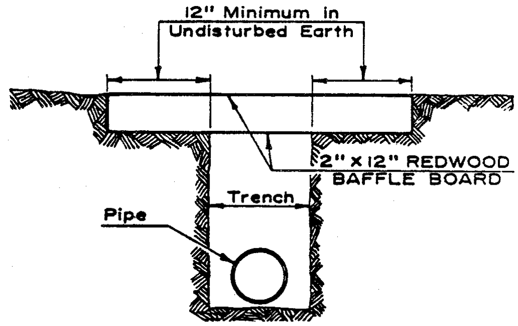
When subsidence is predicted in fill or soft ground, or because of surcharge loading, the designer must provide for satisfactory structural and flow conditions. In fill or soft ground, a rock or gravel blanket or suitable support from stable ground should be specified on the plans. In high fills or other surcharge loading, the conduit may be cambered (similar to a vertical curve) to a height equal to the predicted subsidence above the desired final grade; or special bedding may be provided.

In areas of general subsidence, such as the Wilmington area in San Pedro, the design of the conduit grade must be steep enough to maintain flow during the years of continuous subsidence which can be predicted from survey records.

G 146 TRENCHES ON STEEP SLOPES

If the slope of the trench over a conduit exceeds 5:1, the backfill material shall be consolidated by special compaction or soil cement. The necessity of mounding the backfill over the excavation to avoid forming a surface drainage channel is emphasized.

Redwood baffle boards 2" by 12" held in position with redwood stakes at 20-foot centers shall be installed where ground slope is greater than 35% and at S-foot centers where ground slope is greater than 100 %.



BAFFLE BOARDS ACROSS TRENCH

Figure G 146

G 150 GRADING AND EROSION CONTROL

All grading and erosion control work within or adjoining public property or public rights of way shall be performed in accordance with the provisions stated in sections 61.02 and 91.3002 to 91.3008 of the Municipal Code and as approved by the City Engineer. The designer shall refer to these Municipal Code sections and the notes in sections G151 and G153 to check Grading Plans and Erosion Control Plans.

Cut an fill slopes shall not be steeper than 2 horizontal to 1 vertical (See exceptions in the Municipal Code). Cut or fill slopes shall not exceed 100 feet vertically unless horizontal benches of 30 feet minimum width are installed at each 100 foot height. Also intervening paved benches of 8 foot minimum width shall be installed at each 25 foot height. Where a combined cut and fill slope exceeds 25 feet in height, the required drainage bench shall be placed at the top of the cut slope.

Runoff shall be based upon the proper 50-year isohyetal and shall be computed by a method as outlined in Chapter G200. Cut and fill slopes shall be landscaped and irrigated as required by section 91.3007 of the Municipal Code. Perforated subdrains, or equivalent, shall be installed and backfilled with approved filler material (to dimensions and details shown on the plans) under all fills placed in natural watercourses and their tributaries along the watercourse flow line after excavation to firm material (See section G635).

The annual rainy season is between December 1 and April 15. No grading in excess of 200 cubic yards will be authorized on any single grading site under permit during this period where the Department determines such work will endanger public health and safety. Previously authorized grading work extending into the rainy season shall be protected by incorporating temporary erosion control devices as determined by the Engineer (see Section G 153). Plans of erosion control devices shall be submitted to the Department of Public Works and design approval obtained not later than September 15 of the coming rainy season. Desilting basins (Figure G 154) shall be installed not later than October 15. Temporary erosion control devices shall be installed not later than December 1, and may not be removed during the rainy season without prior approval of the District Engineer.

G 151 GRADING PLAN

The following notes shall be on all grading plans requiring approval by the District or Division Engineers.

1. All work detailed on these plans under the jurisdiction of the Board of Public Works shall be constructed in accordance with Standard Specifications for Public Works Construction and in the presence of an inspector appointed by the Board of Public Works.

2. Approved hereon is the work in dedicated or proposed public streets, easements, and watercourses under jurisdiction of the Board of Public Works and slopes adjacent to such streets, subject to the provisions of Permit "B", No................ No erosion control or drainage devices shall be installed in the area covered by Permit "B", No......, except as shown hereon, or as approved by the Board of Public Works.

3. This grading plan when approved by the District Engineer, as well as permits for work within State or County rights of way, shall be on the site of work at all times.

4. If at any time during grading operations, any unfavorable geological conditions are encountered, grading in that area will stop until approved corrective measures are obtained.

5. Department of Public Works, Bureau of Engineering, Geology and Soils Engineering Section, Street Opening and Widening Division, shall be notified prior to commencing grading operations. All fills shall be compacted to 90% relative compaction unless otherwise recommended by the Geology and Soils Engineering Section, Street Opening and Widening Division, and specified by the Engineer.

6. Drainage from all lots shall be carried to the improved street gutter by means of an approved driveway or drainage structure.

7. All slopes in private property adjoining streets, drainage channels, or other public facilities shall be graded not steeper than 2 to 1 for cut and fill.

The following additional note is required if:

(1) Area is hillside in nature;

(2) Plans are submitted between April 16 and September 15; and

(3) Plans do not show temporary erosion control measures and devices.

8. If any grading operations covered by said Permit "B", No …………… shall extend into or through or shall be commenced during the period of December 1 to April 15, the Permittee will be required to submit plans of the temporary erosion control methods and devices he proposes to use in connection with the grading operations to be performed during that period. Said plans shall be submitted to the City Engineer on or before September 15, or at least 30 days before commencing grading operations, and shall be approved by the District or Division Engineer before any grading is performed during said period.

G 152 DRAINAGE STRUCTURES ON SLOPES

Their use is briefly summarized herein. Thecriter.

The drainage structures required on cut and fill slopes are shown in Figures G 152 andG152A. Their use is briefly summarized herein. The criteria given are for construction under the jurisdiction of the Department of Public Works and do not necessarily apply to construction under the jurisdiction of the Department of Building and Safety, although the same structures may be used. These structures may be modified to fit unusual conditions.

An earth berm (Detail "A") is used at top of slope to prevent surface overflow of runoff. A diverter terrace (Detail "B") is used to intercept surface runoff at the top of all cut and fill slopes where the tributary drainage area above has a slope greater than 10 horizontal to 1 vertical with a horizontal projection greater than 50 feet.

An interceptor terrace (Detail "E") is used to intercept surface runoff on cut or fill slopes at 25 feet vertical intervals. These terraces shall have longitudinal slope of 4% minimum and 12% maximum with no decreasing grade changes.

The terraces shall be provided with inlet structures of concrete or corrugated metal hot-dipped in asphalt (Detail "D") at spaced intervals of 150 feet maximum. The inlets shall be grated or grilled to prevent entry of objects greater than 4 inches. Each inlet shall have a downdrain from terrace to terrace outletting into a storm drain or, where none exist, into the street or other approved location. Downdrains may be closed conduits or open channels. A closed conduit downdrain shall consist of corrugated metal pipe hot-dipped in asphalt and paved invert. It shall have a minimum cover of 1.5 feet, and shall be installed with concrete anchors or corrugated metal bulkheads (De

tail "C") spaced as shown on Figure G152A. The pipe shall be sized by runoff calculations but shall not be less than 12 inches in diameter (18 gage). Open channel downdrains shall be concrete and shall have a minimum capacity of four times the required pipe size. Where concrete terrace drains or open channel downdrains are visible from the street (existing or future), an earth-color (or any other suitable color) concrete or an epoxy paint shall be used.

Downdrains outletting into a street shall use a concrete outlet chamber as delineated in section G638. Downdrains outletting into a natural watercourse or other approved location shall be provided with an energy dissipator as shown in Figure G633 or other adequate velocity reducer.

Where it is necessary to convert concentrated or channel flow to sheet flow at the toe of a cut or fill slope, a dispersal wall (Detail "F") is used. The wall shall be located along the full length of the contour line affected by the grading to establish uniform overflow over the wall or seepage through the head joints of the first course.

G 153 EROSION CONTROL PLAN

Temporary erosion control measures shall be effective during the rainy season from December 1 to April 15. Sections 91.30 and 61.02 of the Municipal Code provide for the following:

1. The submittal to the Board of Public Works of design plans for temporary erosion control devices by September 15 in connection with a division of land development in hillside areas.

2. The installation of all temporary erosion control desilting basins by October 15 and all other temporary control devices not later than December 1 when required by the Board of Public Works or the Department of Building and Safety.

3. Legal authority to allow the Board of Public Works or the Department of Building and Safety to determine that an actual or potential erosion of flood hazard exists and to require that temporary erosion control devices be installed in hillside areas by the owner of a division of land development.

4. Establishment of a fund to be drawn upon by the Board of Public Works for the sole purpose of financing contractual services of construction contractors for the performance of emergency temporary erosion control work when such work is beyond the capability of City forces.

5. Legal authority to allow the following actions to be taken if the work is not accomplished and temporary erosion control desilting basins and devices are not installed as required:

a. City forces or the City's contractual agents be directed by the Board of Public Works to enter onto private property to perform emergency erosion control work under the City's police powers.

b. The Department of Building and Safety and the Board of Public Works to request the City Attorney to proceed against the Principal and the Surety or Sureties named in the grading and/or improvement bond to recover monies expended.

The procedure for the administration of temporary erosion control is as follows:

1. The Bureau of Contract Administration prepares a list of all Department of Public Works and Department of Building and Safety projects under permit which require temporary desilting basins or other erosion control devices. The Bureau of Contract Administration also notifies the owner, permittee, private engineer and surety of each project to submit erosion control plans to the Bureau of Engineering prior to September 15, to have all required temporary desilting basin constructed not later than October 15 and to have all other control devices constructed not later than December 1st.

2. The Bureau of Engineering shall submit erosion control plans to the Department of Building and Safety for their recommendation on projects under their permit. Upon return of the plans, The Bureau of Engineering shall review, approve, and forward the plans to either the owner, permittee, private engineer or surety as applicable. Also two sets of prints of the approved plans shall be sent to both the Department of Building and Safety and the Bureau of Contract Administration.

3. If the required plans are not submitted by September 15, the Bureau of Engineering shall notify the Bureau of Contract Administration and the Department of Building and Safety of those projects for which plans will be prepared. A work order shall be initiated for those projects not covered by a valid "B" permit. Plans prepared by the Bureau of Engineering shall follow the review procedure given in 2 above.

4. Should the permittee, owner, or surety of a project have not complied with the required erosion control construction in accordance with the approved plans by October 20 for desilting basins and December 6 for other erosion control devices, the Department of Building and Safety notifies the Bureau of Contract Administration who instructs the temporary erosion control contractor for the Department of Public Works to construct the erosion control measures required by either Department. In the event that the temporary erosion control contractor is already working to maximum obligation on other projects, the Bureau of Contract Administration requests the Bureau of Street Maintenance to do the work and charge it to the appropriate erosion control work order. All charges are accumulated by the Bureau of Accounting.

The Bureau of Engineering shall determine the interim field measures adequate for each project which may be required separately from the devices and/or basins otherwise provided for herein.

Control of erosion shall be in accordance with the notes given below. These notes shall be placed on all erosion control plans requiring approval by the District or Division Engineer.

1. Temporary erosion control devices shown on the grading plan which interfere with the work shall be relocated or modified as and when the Inspector so directs as the work progresses.

2. All loose soil and debris shall be removed from the street areas upon starting operations and periodically thereafter as directed by the Inspector.

3. When the Inspector so directs, a 12-irlch berm shall be maintained along the top of the slope of those fills on which grading is not in progress.

4. a) Velocity check dams shall be provided across the outlets of all lots draining into the street.

b) All fills shall be graded to promote drainage away from the edge of the fill.

5. Stand-by crews shall be alerted by the permittee or contractor for emergency work during rainstorms.

6. All utility trenches shall be blocked at the prescribed intervals from bottom to top with a double row of sandbags prior to backfill. Sewer trenches shall be blocked at the prescribed inter-

vals with a double row of sandbags extending downward, two sandbags from the graded surface of the street. Sandbags are to be placed with alternate header and stretcher courses. The intervals prescribed between sandbag blocking shall depend on the slope of the ground surface, but shall not exceed the following:

Grade of the Street	Interval
Less than 2%	As required
2% to 4%	100 feet
4% to 10%	50 feet
Over 10%	25 feet

7. Velocity check dams shall be provided in all unpaved street areas at the intervals indicated above. Velocity check dams may be constructed of sandbags, timber, or other erosion-resistant materials approved by the Inspector, and shall extend completely across the street or channel at right angles to the centerline. Earth dikes may not be used as velocity check dams.

8. Velocity check dams shall be provided in all unpaved graded channels at the intervals indicated below.

Grade of Channel	Intervals between Check Dams
Less than 3%	100 feet
3% to 6%	50 feet
Over 6 %	25 feet

9. After sewer and utility trenches are backfilled and compacted, the surfaces over such trenches shall be mounded slightly to prevent channeling of water in the trench area. Care should be exercised to provide for cross flow at frequent intervals where trenches are not on the centerline of a crowned street.

10. Except when the Inspector directs otherwise, all devices shown shall be in place at the end of each working day when rain is forecast, and shall be maintained during the rainy season (December 1 to April 15).

11. All basins and check dams shall have the debris and silt removed after each storm to restore their capacity.

12. Sandbags shall be stockpiled in parkway at intervals shown on erosion plans, ready to be placed in position when rain is forecast, or when the Inspector so directs.

13. Brush and ground cover may not be removed more than 10 feet above fills between December 1 and April 15.

All applicable notes on desilting basins and spillways given in Section G 154 shall also be on all erosion control plans.

G 154 DESILTING BASINS AND SPILLWAYS

The desilting basin (or basins) shall be of sufficient capacity to serve the watershed area as estimated from Figure G 154B. A typical desilting basin with inlet, standpipe, and overflow spillway is illustrated in Figure G 154. The capacity of the basin shall be limited to that capacity existing below the top of the standpipe as located in section A-A of Figure G 154. The standpipe shall be 18-inch CMP or equivalent unless otherwise approved by the engineer. The spillway dimensions shall be determined as shown on Figure G 154A.

Desilting basins shall be constructed in accordance with the notes given below. The following notes shall be on all erosion control plans requiring desilting basins.

1. Basin Outlet: The placement of spillway and outlet pipe shall be as far as practicable from the inlet. Spillways shall be paved to the existing paved street, storm drain, catch basin, or approved watercourse. All weirs shall be flat across the invert; semi-circular or "V" weirs are not permitted. If a gravity pipe outlet drain is impractical, a standby pump shall be provided for each basin.

2. Basin Inlet: Wingwalls shall be paved. Sandbag berms may be used where approved by the engineer. The slope of the inlet shall be equal to or more than the slope of the carrying surface immediately above the inlet to avoid silting at the inlet.

3. Dikes: Dikes must be compacted to 95% compaction and shall be constructed under the direct supervision of the Public Works Erosion Control Inspector. Walls shall not exceed 2:1 slope.

4. Location and Maintenance:

a. Basins constructed on lots adjacent to dwellings must be completely lined with AC or gunite.

b. Sewer or storm drain trenches that are cut through basin dikes or basin inlet dikes shall be plugged with sandbags from top of pipe to top of dike. Sewer lines shall first be encased in concrete before sandbags are placed.

c. Basins will not be permitted in the dedicated street areas unless specifically authorized by the Engineer.

d. All basins shall have been pumped dry and all debris and silt removed within 24 hours after each storm.

e. Basins may not be removed or made inoperative between October 15 and April 15 without prior approval of the Engineer, until all surface improvements have been completed.

f. A guard is to be on continuous duty while basin contains water.

G 160 SOIL MECHANICS NOMENCLATURE

Soil mechanics is the application of the laws and principles of mechanics and hydraulics to engineering problems dealing with soil as an engineering material. The Unified Soil Classification System as shown on Figure G 160 shall be used to classify soils, and the letter and/or picture symbols shown thereon shall be used on Test Borings delineated on construction plans (Figure G 713.4A). Definitions of soil mechanics terms are presented herein as a reference to the designer to help him comprehend soil reports.

The following list of terms is an abbreviated version selected from a draft of ASTM Designation D 653-57, Standard Definitions of Terms and Symbols Relating to Soil Mechanics, prepared by Subcommittee G-3, Nomenclature and Definitions, of ASTM Committee D-18, Soil for Engineering Purposes, in cooperation with the Committee on Glossary of Terms and Definitions in Soil Mechanics, Soil Mechanics and Foundations Division, American Society of Civil Engineers.

ADHESION:

Shearing resistance between soil and another material under zero externally applied pressure.

ALLOWABLE BEARING VALUE (ALLOWABLE SOIL PRESSURE):

The maximum pressure that can be permitted on foundation soil, giving consideration to all pertinent factors, with adequate safety against rupture of the soil mass or movement of the foundation- of such magnitude that the structure is impaired.

ALLOWABLE PILE BEARING LOAD:

The maximum load that can be permitted on a pile with adequate safety against movement of such magnitude that the structure is endangered.

ALLUVIUM:
Soil the constituents of which have been transported in suspension by flowing water and subsequently deposited by sedimentation.

ANGLE OF EXTERNAL FRICTION (ANGLE OF WALL FRICTION):
Angle between the abscissa and the tangent of the curve representing the relationship of shearing resistance to normal stress acting between soil and surface of another material.

ANGLE OF INTERNAL FRICTION:
Angle between the abscissa and the tangent of the curve representing the relationship of shearing resistance to normal stress acting within a soil.

ANGLE OF REPOSE:
Angle between the horizontal and the maximum slope that a soil assumes through natural processes. For dry granular soils the effect of the height of slope is negligible; for cohesive soils the effect of height of slope is so great that the angle of repose is meaningless.

ANISOTROPIC MASS:
A mass having different properties in different directions at any given point.

AQUIFER:
A water-bearing formation that provides a ground-water reservoir.

ARCHING:
The transfer of stress from a yielding part of a soil mass to adjoining less-yielding or restrained parts of the mass.

AREA OF INFLUENCE OF A WELL:
Area surrounding a well within which the piezometric surface has been lowered when pumping has produced the maximum steady rate of flow.

ATTERBERG LIMITS:
Water contents that correspond to the boundaries between the states of consistency, such as the Liquid Limit, Plastic Limit, and Shrinkage Limit.

BASE COURSE (BASE):
A layer of specified or selected material of planned thickness constructed on the subgrade or subbase for the purpose of serving one or more functions such as distributing load, providing drainage, minimizing frost action, etc.

BEARING CAPACITY (OF A PILE):
The load per pile required to produce a condition of failure.

BEDROCK:
All relatively indurated material (shales, sandstones, granite, conglomerates, etc.) underlying relatively unindurated material such as sands, gravels, clays, silts, etc.

BENTONITIC CLAY:
A clay with a high content of the mineral montmorillonite, usually characterized by high swelling on wetting.

BERM:
A shelf that breaks the continuity of a slope.

BINDER (SOIL BINDER):
Portion of soil passing No. 40 United States standard sieve.

BOULDER:
A rock fragment, usually rounded by weathering or abrasion, with an average dimension of 12 inches or more.

BULKING:
The increase in volume of a material due to manipulation. Rock bulks upon being excavated; damp sand bulks if loosely deposited, as by dumping, because the "apparent cohesion" prevents movement of the soil particles to form a reduced volume.

CALIFORNIA BEARING RATIO:
The ratio of (1) the force per unit area required to penetrate a soil mass with a 3-square-inch circular piston (approximately 2-inch-diameter) at the rate of 0.05 inch per minute to (2) that required for corresponding penetration of a standard material. The ratio is usually determined at 0.1 inch penetration, although other penetrations are sometimes used. Original California procedures required determination of the ratio at 0.1-inch intervals to 0.5 inch. Corps of Engineers' procedures require determination of the ratio at 0.1 inch and 0.2 inch. Where the ratio at 0.2 inch is consistently higher than at 0.1 inch, the ratio at 0.2 inch is used.

CAPILLARY ACTION (CAPILLARITY):
The rise or movement of water in the interstices of a soil due to capillary forces.

CAPILLARY FRINGE ZONE:
The zone above the free water elevation in which water is held by capillary action.

CAPILLARY RISE (HEIGHT OF CAPILLARY RISE):
The height above a free water elevation to which water will rise by capillary action.

CAPILLARY WATER:
Water subject to the influence of capillary action.

CLAY (CLAY SOIL):
Fine-grained soil or the fine-grained portion of soil that can be made to exhibit plasticity (puttylike properties) within a range of water contents, and which exhibits considerable strength when air-dry. The term has been used to designate the percentage finer than 0.002 mm. (0.005 in some cases), but it is strongly recommended that this usage be discontinued, since there is ample evidence that from an engineering standpoint the properties described in the above definition are many times more important.

CLAY SIZE:
That portion of the soil finer than 0.002 mm. (0.005 mm. in some cases). (See discussion under Clay.)

COBBLE (COBBLESTONE):
A rock fragment usually rounded or semi-rounded with an average dimension between 3 and 12 inches.

COEFFICIENT OF EARTH PRESSURE:
The principal stress ratio at a point in a soil mass.

ACTIVE:
The minimum ratio of (1) the minor principal stress to (2) the major principal stress. This is applicable where the soil has yielded sufficiently to develop a lower limiting value of the minor principal stress.

AT REST:
The ratio of (1) the minor principal stress to (2) the major principal stress. This is applicable where the soil mass is in its natural state without having been permitted to yield or without having been compressed.

PASSIVE:
The maximum ratio of (1) the major principal stress to (2) the minor principal stress. This is applicable where the soil has been compressed sufficiently to develop an upper limiting value of the major principal stress.

COEFFICIENT OF INTERNAL FRICTION:
The tangent of the angle of internal friction. (See Internal Friction.)

COEFFICIENT OF PERMEABILITY (PERMEABILITY):
The rate of discharge of water under laminar flow conditions through a unit cross-sectional area of a porous medium under a unit hydraulic gradient and standard temperature conditions (usually 20^o C.).

COEFFICIENT OF UNIFORMITY:
The ratio D_{60}/D_{10} where D_{60} is the particle diameter corresponding to 60 percent finer on the grain-size curve, and D_{10} is the particle diameter corresponding to 10 percent finer on the grain-size curve.

COHESION:
The capacity of a soil to resist shearing stresses without any normal stresses, or that portion of shearing strength of a soil that is independent of normal stresses on the soil.

APPARENT COHESION:
Cohesion in granular soils due to capillary forces.

COHESIONLESS SOIL:
A soil that when unconfined has little or no strength when air-dried, and that has little or no cohesion when submerged.

COHESIVE SOIL:
A soil that when unconfined has considerable strength when air-dried, and that has significant cohesion when submersed.

COMPACTION:
The densification of a soil by means of mechanical manipulation.

COMPACTION CURVE (MOISTURE-DENSITY CURVE):
The curve showing the relationship between the dry unit weight (density) and the water content of a soil for a given compactive effort.

COMPACTION TEST (MOISTURE - DENSITY TEST):

A laboratory compacting procedure whereby a soil at a known water content is placed in a specified manner into a mold of given dimensions, subjected to a compactive effort of controlled magnitude, and the resulting unit weight determined. The procedure is repeated for various water contents sufficient to establish a relation between water content and unit weight.

COMPRESSIBILITY:

Property of a soil pertaining to its susceptibility to decrease in volume when subjected to load.

COMPRESSIVE STRENGTH (UNCONFINED COMPRESSIVE STRENGTH):

The load per unit area at which an unconfined prismatic or cylindrical specimen of soil will fail in a simple compression test.

CONSISTENCY:

The relative ease with which a soil can be deformed.

CONSOLIDATED DRAINED TEST (SLOW TEST):

A soil test in which essentially complete consolidation under the confining pressure is followed by additional axial (or shearing) stress applied in such a manner that even a fully saturated soil of low permeability can adapt itself completely (fully consolidate) to the changes in stress due to the additional axial (or shearing) stress.

CONSOLIDATED UNDRAINED TEST (CONSOLIDATED QUICK TEST):

A test in which complete consolidation under the vertical load (in a direct shear test) or under the confining pressure (in a triaxial test) is followed by a shear at constant water content.

CONSOLIDATION:

The gradual reduction in volume of a soil mass resulting from an increase in compressive stress.

INITIAL CONSOLIDATION (INITIAL COMPRESSION):

A comparatively sudden reduction in volume of a soil mass under an applied load due principally to expulsion and compression of gas in the soil voids preceding primary consolidation.

PRIMARY CONSOLIDATION (PRIMARY COMPRESSION) (PRIMARY TIME EFFECT):

The reduction in volume of a soil mass caused by the application of a sustained load to the mass and due principally to a squeezing out of water from the void spaces of the mass and accompanied by a transfer of the load from the soil water to the soil solids.

SECONDARY CONSOLIDATION (SECONDARY COMPRESSION) (SECONDARY TIME EFFECT):

The reduction in volume of a soil mass caused by the application of a sustained load-to the mass and due principally to the adjustment of the internal structure of the soil mass after most of the load has been transferred from the soil water to the soil solids.

CONSOLIDATION TEST:

A test in which the specimen is laterally confined in a ring and is compressed between porous plates.

CONSOLIDATION-TIME CURVE (TIME CURVE) (CONSOLIDATION CURVE)
(THEORETICAL TIME CURVE):

A curve that shows the relation between (1) the degree of consolidation and (2) the elapsed time after the application of a given increment of load.

CREEP:

Slow movement of rock debris or soil usually imperceptible except to observations of long duration.

CRITICAL CIRCLE (CRITICAL SURFACE):

The sliding surface assumed in a theoretical analysis of a soil mass for which the factor of safety is a minimum.

CRITICAL HEIGHT:

The maximum height at which a vertical or sloped bank of soil will stand unsupported under a given set of conditions.

CRITICAL SLOPE:

The maximum angle with the horizontal at which a sloped bank of soil of given height will stand unsupported.

DEFORMATION:
Change in shape.

DEGREE OF CONSOLIDATION (PERCENT CONSOLIDATION):

The ratio, expressed as a percentage, of (1) the amount of consolidation at a given time within a soil mass, to (2) the total amount of consolidation obtainable under a given stress condition.

DENSITY:

See Unit Weight.

Note--Although it is recognized that density is defined as mass per unit volume in the field of soil mechanics the term is frequently used in place of unit weight.

DEVIATOR STRESS:

The difference between the major and minor principal stresses in a triaxial test.

DILATANCY:

The expansion of cohesionless soils when subject to shearing deformation.

DIRECT SHEAR TEST:

A shear test in which soil under an applied normal load is stressed to failure by moving one section of the soil container (shear box) relative to the other section.

DRAWDOWN:

Vertical distance the free water elevation is lowered or the reduction of the pressure head due to the removal of free water.

EARTH PRESSURE:

The pressure or force exerted by soil on any boundary.

ACTIVE EARTH PRESSURE:

The minimum value of earth pressure. This condition exists when a soil mass is permitted to yield sufficiently to cause its internal shearing resistance along a potential failure surface to be completely mobilized.

AT REST:

The value of the earth pressure when the

soil mass is in its natural state without having been permitted to yield or without having been compressed.

PASSIVE EARTH PRESSURE:

The maximum value of earth pressure. This condition exists when a soil mass is compressed sufficiently to cause its internal shearing resistance along a potential failure surface to be completely mobilized.

EFFECTIVE DIAMETER (EFFECTIVE SIZE):

Particle diameter corresponding to 10 percent finer on the grain-size curve.

EFFECTIVE FORCE:

The force transmitted through a soil mass by intergranular pressures.

ELASTIC STATE OF EQUILIBRIUM:

State of stress within a soil mass when the internal resistance of the mass is not fully mobilized.

EQUIPOTENTIAL LINE:

Line along which water will rise to the same elevation in piezometric tubes.

EQUIVALENT FLUID:

A hypothetical fluid having a unit weight such that it will produce a pressure against a lateral support presumed to be equivalent to that produced by the actual soil This simplified approach is valid only when deformation conditions are such that the pressure increases linearly with depth and the wall friction is neglected.

FILL:

Manmade deposits of natural soils and waste materials.

FILTER (PROTECTIVE FILTER):

A layer or combination of layers of pervious materials designed and installed in such a manner as to provide drainage, yet prevent the movement of soil particles due to flowing water.

FINES:

Portion of a soil finer than a No. 200 United States standard sieve.

FLOW CHANNEL:

The portion of a flow net bounded by two adjacent flow lines.

FLOW LINE:

The path that a particle of water follows in its course of seepage under laminar flow conditions.

FLOW NET:

A graphical representation of flow lines and equipotential lines used in the study of seepage phenomena.

FLOW SLIDE:

The failure of a sloped bank of soil in which the movement of the soil mass does not take place along a well-defined surface of sliding.

FLOW VALUE:

A quantity equal to $\tan^2 (45^o + \phi/2)$.

ϕ = Angle of internal friction.

FOOTING:

Portion of the foundation of a structure that transmits loads directly to the soil.

FOUNDATION:

Lower part of a structure that transmits the load to the earth.

FOUNDATION SOIL:

Upper part of the earth mass carrying the load of the structure.

FREE WATER (GRAVITATIONAL WATER) (GROUND WATER) (PHREATIC WATER):

Water that is free to move through a soil mass under the influence of gravity.

FREE WATER ELEVATION (WATER TABLE) (GROUND-WATER SURFACE) (FREE WATER-SURFACE) (GROUND-WATER ELEVATION):

Elevations at which the pressure in the water is zero with respect to the atmospheric pressure.

FROST ACTION:

Freezing and thawing of moisture in materials and the resultant effects on these materials and on structures of which they are a part or with which they are in contact.

GRADATION (GRAIN SIZE DISTRIBUTION) (SOIL TEXTURE):

Proportion of material of each grain size present in a given soil.

GRAIN SIZE ANALYSIS (MECHANICAL ANALYSIS):

The process of determining gradation.

GRAVEL:

Rounded or semirounded particles of rock that will pass a 3-inch and be retained on a No. 4 United States standard sieve.

HARDPAN:

Layer of extremely dense soil.

HEAVE:

Upward movement of soil caused by expansion or displacement resulting from phenomena such as moisture absorption, removal of overburden, driving of piles, and frost action.

HOMOGENEOUS MASS:

A mass that exhibits essentially the same physical properties at every point throughout the mass.

HUMUS:

A brown or black material formed by the partial decomposition of vegetable or animal matter; the organic portion of soil.

HYDRAULIC GRADIENT:

The instantaneous loss of hydraulic head per unit distance of flow.

CRITICAL HYDRAULIC GRADIENT:

Hydraulic gradient at which the intergranular pressure in a mass of cohesionless soil is reduced to zero by the upward flow of water.

HYDROSTATIC PRESSURE:

The pressure in a liquid under static condition; the product of the unit weight of the liquid and the difference in elevation between the given point and the free water elevation.

EXCESS HYDROSTATIC PRESSURE (HYDROSTATIC EXCESS PRESSURE):

The pressure that exists in pore water in excess of the hydrostatic pressure.

HYGROSCOPIC WATER CONTENT:

The water content of an air dried soil.

INTERNAL FRICTION:

The portion of shearing strength of a soil that is directly proportional to the normal stresses on the soil.

ISOTROPIC MASS:

A mass having the same property (or properties) in all directions.

KAOLIN:

A variety of clay containing a high percentage of kaolinite.

LANDSLIDE (SLIDE):

The failure of a sloped bank of soil in which the movement of the soil mass takes place along a surface of sliding.

LEACHING:

The removal of soluble soil material and colloids by percolating water.

LINE OF CREEP (PATH OF PERCOLATION): The path that water follows along the surface of contact between the foundation soil and the base of a dam or other structure.

LINE OF SEEPAGE (SEEPAGE LINE) (PHREATIC LINE):

The upper free water surface of the zone of seepage.

LINEAR EXPANSION:

The increase in one dimension of a soil mass, expressed as a percentage of that dimension at the shrinkage limit, when the water content is increased from the shrinkage limit to any given water content.

LINEAR SHRINKAGE:

Decrease in one dimension of a soil mass, expressed as a percentage of the original dimension, when the water content is reduced from a given value to the shrinkage limit.

LIQUID LIMIT:

(1) The water content corresponding to the arbitrary limit between the liquid and plastic states of consistency of a soil.

(2) The water content at which a pat of soil, cut by a groove of standard dimensions, will flow together for a distance of one-half inch under the impact of 25 blows in a standard liquid limit apparatus.

LIQUEFACTION (SPONTANEOUS LIQUEFACTION):

The sudden large decrease of the shearing resistance of a cohesionless soil. It is caused by a collapse of the structure by shock or other type of strain and is associated with a sudden but temporary increase of the pore-fluid pressure. It involves a temporary transformation of the material into a fluid mass.

LIQUIDITY INDEX (WATER PLASTICITY RATIO) (RELATIVE WATER CONTENT):

The ratio, expressed as a percentage, of (1) the natural water content of a soil minus its plastic limit to (2) its plasticity index

LOAM:

A mixture of sand, silt, or clay, or a combination of any of these, with organic matter (humus). It is sometimes called topsoil in contrast to the subsoils that contain little or no organic matter.

LOESS:

A uniform aeolian deposit of silty material having an open structure and relatively high cohesion due to cementation of clay or calcareous material at grain contacts. A characteristic of loess deposits is that they can stand with nearly vertical slopes.

MODULUS OF ELASTICITY (MODULUS OF DEFORMATION):

The ratio of stress to strain for a material under given loading conditions; numerically equal to the slope of the tangent or the secant of a stress-strain curve. The use of the term Modulus of Elasticity is recommended for materials that deform in accordance with Hooke's law; the term Modulus of Deformation for materials that deform otherwise.

MOHR CIRCLE:

A graphical representation of the stresses acting on the various planes at a given point.

MOHR ENVELOPE (RUPTURE ENVELOPE) (RUPTURE LINE):

The envelope of a series of Mohr Circles representing stress conditions at failure for a given material. According to Mohr's rupture hypothesis, a rupture envelope is the locus of points the coordinates of which represent the combinations of normal and shearing stresses that will cause a given material to fail.

MOISTURE CONTENT (WATER CONTENT):

The ratio, expressed as a percentage, of (1) the weight of water in a given soil mass to (2) the weight of solid particles.

MUCK:

An organic soil of very soft consistency.

MUD:

A mixture of soil and water in a fluid or weakly solid state.

NORMALLY CONSOLIDATED SOIL DEPOSIT:

A soil deposit that has never been subjected to a pressure greater than the existing overburden pressure.

OPTIMUM MOISTURE CONTENT (OPTIMUM WATER CONTENT):
The water content at which a soil can be compacted to the maximum dry unit weight by a given compactive effort.

ORGANIC CLAY:
A clay with a high organic content.

ORGANIC SILT:
A silt with a high organic content.

ORGANIC SOIL:
Soil with a high organic content. In general, organic soils are very compressible and have poor load-sustaining properties.

OVER CONSOLIDATED SOIL DEPOSIT (PRE COMPRESSED DEPOSIT):
A soil deposit that has been subjected to pressure greater than the present overburden pressure.

PARENT MATERIAL:
Material from which a soil has been derived.

PEAT:
A fibrous mass of organic matter in various stages of decomposition, generally dark brown to black in color and of spongy consistency.

PENETRATION RESISTANCE (STANDARD PENETRATION RESISTANCE) (PROCTOR PENETRATION RESISTANCE):
Number of blows of a hammer of specified weight falling a given distance required to produce a given penetration into soil of a pile, casing, or sampling tube.

PERCENT SATURATION (DEGREE OF SATURATION):
The ratio, expressed as a percentage, of (1) the volume of water in a given soil mass to (2) the total volume of intergranular space (voids).

PERCHED WATER TABLE:
A water table usually of limited area maintained above the normal free water elevation by the presence of an intervening relatively impervious confining stratum.

PERCOLATION:
The movement of gravitational water through soil. (See Seepage.)

PIEZOMETER:
An instrument for measuring pressure head.

PIEZOMETRIC SURFACE:
The surface at which water will stand in a series of piezometers.

PILE:
Relatively slender structural element which is driven, or otherwise introduced, into the soil, usually for the purpose of providing vertical or lateral support.

PIPING:
The movement of soil particles by percolating water leading to the development of channels.

PLASTIC EQUILIBRIUM:
State of stress within a soil mass or a portion thereof, which has been deformed to such an extent that its ultimate shearing resistance is mobilized.

ACTIVE STATE OF PLASTIC EQUILIBRIUM:
Plastic equilibrium obtained by an expansion of a mass.

PASSIVE STATE OF PLASTIC EQUILIBRIUM:
Plastic equilibrium obtained by a compression of a mass.

PLASTICITY:
The property of a soil which allows it to be deformed beyond the point of recovery without cracking or appreciable volume change.

PLASTIC LIMIT:
(1) The water content corresponding to an arbitrary limit between the plastic and the semisolid states of consistency of a soil.

(2) Water content at which a soil will just begin to crumble when rolled into a thread approximately one-eighth inch in diameter.

PLASTIC SOIL:
A soil that exhibits plasticity.

PLASTIC STATE (PLASTIC RANGE):
The range of consistency within which a soil exhibits plastic properties.

PLASTICITY INDEX:
Numerical difference between the liquid limit and the plastic limit.

PORE PRESSURE (PORE WATER PRESSURE)
See Neutral Stress under Stress.

POROSITY:
The ratio, usually expressed as a percentage, of (1) the volume of voids of a given soil mass to (2) the total volume of the soil mass.

POTENTIAL DROP:
The difference in pressure head between two equipotential lines.

PRECONSOLIDATION PRESSURE (PRE STRESS):
The greatest pressure to which a soil has been subjected.

DROP:
PRESSURE:
The load divided by the area over which it acts.

PRESSURE BULB:
The zone in a loaded soil mass bounded by an arbitrarily selected isobar of stress.

PRESSURE-VOID RATIO CURVE (PRESSURE-PERCENT COMPRESSION CURVE) (PRESSURE-PERCENT CONSOLIDATION CURVE):
A curve representing the relationship between pressure and void ratio of a soil as obtained from a consolidation test. The curve has a characteristic shape when plotted on semi-log paper with pressure on the log scale. The various parts of the curve and extensions to the parts have been designated as recompression, compression, virgin compression, expansion, rebound, and other descriptive names by various authorities.

Note: Although it is recognized that the term Percent Consolidation is defined as a function of Time, it is very often used in place of Void Ratio as a function of Pressure.

PROGRESSIVE FAILURE:
Failure in which the ultimate shearing resistance is progressively mobilized along the failure surface.

QUICK CONDITION (QUICKSAND):
Condition in which water is flowing upward with sufficient velocity to reduce significantly the bearing capacity of the soil through a decrease in intergranular pressure.

QUICK TEST:
See Unconsolidated Undrained Test.

RADIUS OF INFLUENCE OF A WELL:
Distance from the center of the well to the closest point at which the piezometric surface is not lowered when pumping has produced the maximum steady rate of flow.

RELATIVE COMPACTION:
The ratio, expressed as a percentage, of (1) dry unit weight of a soil to (2) maximum unit weight obtained in a laboratory compaction test.

RELATIVE DENSITY:
The ratio of (1) the difference between the void ratio of a cohesionless soil in the loosest state and any given void ratio to (2) the difference between its void ratios in the loosest and in the densest states.

REMOLDED SOIL:
Soil that has had its natural structure modified by manipulation.

RESIDUAL SOIL:
Soil derived in place by weathering of the underlying material.

ROCK:
Natural solid mineral matter occurring in large masses or fragments.

SAND:
Particles of rock that will pass the No. 4 United States standard sieve and be retained on the No. 200 sieve.

SAND BOIL:
The ejection of sand and water resulting from piping.

SEEPAGE (PERCOLATION):
The slow movement of gravitational water through the soil.

SEEPAGE FORCE:
The force transmitted to the soil grains by seepage.

SEEPAGE VELOCITY:
The rate of discharge of seepage water through a porous medium per unit area of void space perpendicular to the direction of flow.

SENSITIVITY:
The effect of remolding on the consistency of a cohesive soil.

SHAKING TEST:
A test used to indicate the presence of significant amounts of rock flour, silt, or very fine sand in a fine-grained soil. It consists of shaking a pat of wet soil, having a consistency of thick paste, in the palm of the hand; observing the surface for a

glossy or livery appearance; then squeezing the pat; and observing if a rapid apparent drying and subsequent cracking of the soil occurs.

SHEAR FAILURE (FAILURE BY RUPTURE):
Failure in which movement caused by shearing stresses in a soil mass is of sufficient magnitude to destroy or seriously endanger a structure.

GENERAL SHEAR FAILURE:
Failure in which the ultimate strength of the soil is mobilized along the entire potential surface of sliding before the structure supported by the soil is impaired by excessive movement.

LOCAL SHEAR FAILURE:
Failure in which the ultimate shearing strength of the soil is mobilized only locally along the potential surface of sliding at the time the structure supported by the soil is impaired by excessive movement.

SHEAR STRENGTH:
The maximum resistance of a soil to shearing stresses.

SHEAR STRESS (SHEARING STRESS) (TANGENTIAL STRESS):
See Stress.

SHRINKAGE INDEX:
The numerical difference between the plastic and shrinkage limits.

SHRINKAGE LIMIT:
The maximum water content at which a reduction in water content will not cause a decrease in volume of the soil mass.

SILT (INORGANIC SILT) (ROCK FLOUR):
Material passing the No. 200 United States standard sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air-dried.

SILT SIZE:
That portion of the soil finer than 0.02 mm. and coarser than 0.002 mm. (0.05 mm. and 0.005 mm. in some cases).

SKIN FRICTION:
The frictional resistance developed between soil and a structure.

SLAKING:
The process of breaking up or sloughing when an indurated soil is immersed in water.

SLOW TEST:
See Consolidated-Drained Test.

SOIL (EARTH):
Sediments or other unconsolidated accumulations of solid particles produced by the physical and chemical disintegration of rocks, and which may or may not contain organic matter.

SOIL PROFILE (PROFILE):
Vertical section of a soil, showing the nature and sequence of the various layers, as developed by deposition or weathering, or both.

SOIL STABILIZATION:
Chemical or mechanical treatment designed to increase or maintain the stability of a mass of soil or otherwise to improve its engineering properties.

SOIL STRUCTURE:
The arrangement and state of aggregation of soil particles in a soil mass.

FLOCCULENT STRUCTURE:
An arrangement composed of flocs of soil particles instead of individual soil particles.

HONEYCOMB STRUCTURE

All arrangement of soil particles having a comparatively loose, stable structure resembling a honeycomb.

SINGLE-GRAINED STRUCTURE:
An arrangement composed of individual soil particles; characteristic structure of coarse grained soils.

SOIL SUSPENSION:
Highly diffused mixture of soil and water.

SOIL TEXTURE:
See Gradation.

SPECIFIC GRAVITY OF SOLIDS:
Ratio of (1) the weight in air of a given volume of soil solids at a stated temperature to (2) the weight in air of an equal volume of distilled water at a stated temperature.

STONE:
Crushed or naturally angular particles of rock that will pass a 3-inch sieve and be retained on a No. 4 United States standard sieve.

STRAIN:
The change in length per unit of length in a given direction.

STRESS:
The force per unit area acting within the soil mass.

EFFECTIVE STRESS (EFFECTIVE PRESSURE) (INTERGRANULAR PRESSURE):
The average normal force per unit area transmitted from grain to grain of a soil mass. It is the stress that is effective in mobilizing internal friction.

NEUTRAL STRESS (PORE PRESSURE) (PORE WATER PRESSURE):
Stress transmitted through the pore water (water filling the voids of the soil).

NORMAL STRESS:
The stress component normal to a given plane.

PRINCIPAL STRESS:
Stress acting normal to three mutually perpendicular planes intersecting at a point in a body, on which the shearing stress is zero.

MAJOR PRINCIPAL STRESS:
The largest (with regard to sign) principal stress.

MINOR PRINCIPAL STRESS:
The smallest (with regard to sign) principal stress.

INTERMEDIATE PRINCIPAL STRESS:
The principal stress whose value is neither the largest nor the smallest (with regard to sign) of the three.

SHEAR STRESS (SHEARING STRESS) (TANGENTIAL STRESS):
The stress component tangential to a given plane.

TOTAL STRESS:
The total force per unit area acting within a mass of soil. It is the sum of the neutral and effective stresses.

SUBBASE:
A layer used in a pavement system between the subgrade and base course, or between the subgrade and portland-concrete pavement.

SUBGRADE:
The soil prepared and compacted to support a structure or a pavement system.

SUBGRADE SURFACE:
The surface of the earth or rock prepared to support a structure or a pavement system.

SUBSOIL:
Soil below a subgrade or fill.

TALUS:
Rock fragments mixed with soil at the foot of a natural slope from which they have been separated.

THIXOTROPY:
The property of a material that enables it to stiffen in a relatively short time on standing, but upon agitation or manipulation to change to a very soft consistency or to a fluid of high viscosity, the process being completely reversible.

TOPSOIL:
Surface soil usually containing organic matter.

TRANSPORTED SOIL:
Soil transported from the place of its origin by wind. water, or ice.

TRIAXIAL SHEAR TEST (TRIAXIAL COMPRESSION TEST):
A test in which a cylindrical specimen of soil encased in an impervious membrane is subjected to a confining pressure and then loaded axially to failure.

ULTIMATE BEARING CAPACITY:
The average load per unit of area required to produce failure by rupture of a supporting soil mass.

UNCONFINED COMPRESSIVE STRENGTH:
See Compressive Strength.

UNCONSOLIDATED-UNDRAINED TEST (QUICK TEST):
A soil test in which the water content of the test specimen remains practically unchanged during the application of the confining pressure and the additional axial (or shearing) force.

UNDERCONSOLIDATED SOIL DEPOSIT:
A deposit that is not fully consolidated under the existing overburden pressure.

UNDISTURBED SAMPLE:
A soil sample that has been obtained by methods in which every precaution has been taken to minimize disturbance to the sample.

UNIT WEIGHT: Weight per unit volume.

DRY UNIT WEIGHT (UNIT DRY WEIGHT):
The weight of soil solids per unit of total volume of soil mass.

EFFECTIVE UNIT WEIGHT:
That unit weight of a soil which, when multiplied by the height of the overlying column of soil, yields the effective pressure due to the weight of the overburden.

MAXIMUM UNIT WEIGHT:
The dry unit weight defined by the peak of a compaction curve.

SATURATED UNIT WEIGHT:
The wet unit weight of a soil mass when saturated.

SUBMERGED UNIT WEIGHT (BUOYANT UNIT WEIGHT):
The weight of the solids in air minus the weight of water displaced by the solids per unit of volume of soil mass; the saturated unit weight minus the unit weight of water.

UNIT WEIGHT OF WATER:
The weight per unit volume of water; nominally equal to 62.4 pounds per cubic foot or 1 gram per cubic centimeter.

WET UNIT WEIGHT (MASS UNIT WEIGHT): The weight (solids plus water) per unit of total volume of soil mass, irrespective of the degree of saturation.

ZERO AIR VOIDS UNIT WEIGHT:
The weight of solids per unit volume of a saturated soil mass.

UPLIFT:
The upward water pressure on a structure.

VOID:
Space in a soil mass not occupied by solid mineral matter. This space may be occupied by air, water, or other gaseous or liquid material.

VOID RATIO:
The ratio of (1) the volume of void space to t2) the volume of solid particles in a given soil mass.

VOLUMETRIC SHRINKAGE (VOLUMETRIC CHANGE):
The decrease in volume, expressed as a percentage of the soil mass when dried, of a soil mass when the water content is reduced from a given percentage to the shrinkage limit.

WALL FRICTION:
Frictional resistance mobilized between a wall and the soil in contact with the wall.

WATER CONTENT:
See Moisture Content.

WATER-HOLDING CAPACITY:
The smallest value to which the water content of a soil can be reduced by gravity drainage.

ZERO AIR VOIDS CURVE (SATURATION CURVE):
The curve showing the zero air voids unit weight as a function of water content.

ZERO AIR VOIDS DENSITY (ZERO AIR VOIDS UNIT WEIGHT):
See Unit Weight.

G 170 GEOLOGICAL NOMENCLATURE

The following definitions of geological terms are presented herein as a reference to the designer to help him comprehend geological reports.

Abrasion-The mechanical wearing of solid materials by impact and friction.

Agglomerate-A fragmental volcanic rock consisting of large, somewhat rounded stones in a finer matrix, much like conglomerate in appearance but wholly volcanic in constitution.

Aggraduation-The process of building up a surface by deposition.

Alignment; Alignment-The placing or existence of points along a straight line. Also, the location of points with reference to a straight line or system of straight lines.

Alluvium—Unconsolidated gravel, sand, and finer rock debris deposited principally by running water; adjective alluvial.

Angular (adj.)-A roundness grade showing very little or no evidence or wear, with edges or corners sharp.

Anomaly-A deviation from uniformity, a local feature distinguishable in a geophysical geochemical or geobotanical measurement over a larger area.

Anticline-A fold in stratified rock convex upward. Beds on the flanks are inclined outward.

Apparent dip-The dip of a rock layer as exposed in any section not at a right angle to the strike.

Aquiclude-A formation which, although porous and capable of absorbing water slowly, will not transmit it fast enough to furnish an appreciable supply for a well or spring.

Acquifer-A formation, group of forrnations, or part of a formation that is water bearing.

Aquifuge-A rock which contains no interconnected opening or interstices and therefore neither absors nor trasmits water.

Arenaceous-An adjective applied to rocks that have been derived from sand or that contain sand.

Argillaceous-Applied to all rocks or substances composed of clay, or having a notable proportion of clay in their composition.

Arroyo-The wide, flat-floored channel of an intermittent stream in dry country.

Authigenic-Generated on the spot; applied to those constituents that came into existence with or after the formation of the rock of which they constitute a part.

Axis-The central line of an elongated geological structure such as an anticline or syncline.

Barranca-A vertical walled gully cut by an intermittent stream in relatively unconsolidated material.

Basalt-A fine-grained black lava relatively rich in calcium, iron, and magnesium. The extrusive equivalent (in composition) of gabbro.

Basement-Old crystalline rocks upon which younger rocks have been deposited.

Bed-The smallest division of a stratified series, and marked by a more or less well-defined divisional plane from its neighbors above and below.

Bedding-Collective term signifying existence of beds or laminae. Planes dividing sedimentary rocks of the same or different lithology.

Bedding Plane-In sedimentary or stratified rocks, the division planes which separate the individual layers, beds or strata.

Bedrock-Consolidated rock material of any sort.

Bench-A level or gently sloping area interrupting an otherwise steep slope.

Bentonite-Bentonite is a clay usually formed from the decomposition of volcanic ash and is largely composed of the clay mineral montmorillonite and beidellite. Usually characterized by a large amount of expansion on wetting and shrinkage upon drying; highly plastic when wet.

Breccia-A fragmental rock whose components are angular.

Carbonate Rocks-Those composed of the minerals calcite (calcium carbonate) and dolomite (calcium-magnesium carbonate).

Calcareous-Rich in calcite.

Calcite-A common mineral composed of calcium, carbon and oxygen ($CaCO_3$).

Caliche-A calcareous deposit formed within dryregion soils by evaporation of the ground water.

Colluvium-A general term applied to loose and incoherent debris deposits, usually at the foot of a slope or cliff brought there chiefly by gravity.

Creep- See landslide.

Competent Beds-Those beds or strata which, because of massiveness or inherent strength, are able to lift not only their own weight, but also that of overlying rock without internal flowage, during folding.

Concretion-A nodular or irregular concentration of certain authigenic constituents of sedimentary rocks and tuffs; developed by localized deposition of material from solution, generally about a central nucleus.

Confluence-The point where two streams meet.

Conglomerate-A sedimentary rock consisting of larger rounded rock and mineral fragments embedded in a finer, usually sandy matrix and all cemented together.

Consolidation-In geology any or all of the processes whereby loose, soft or liquid earth materials become firm and coherent.

Contact-The place or surface where two different kinds of rocks come together.

Contorted-Bent or twisted together. Used where strata are folded or crumpled on a considerable scale. If on a small scale they are said to be corrugated.

Correlation-The determination of the equivalence in geologic age and stratigraphic position of two formations or other stratigraphic units in separated areas.

Corrugated-see contorted.

Crystalline-Substances having fixed internal atomic arrangements.

Crystalline Rocks-A term commonly applied to mixed igneous and metamorphic rocks, or to either separately.

Debris-Broken up and usually partly decomposed rock materials.

Debris Flow-A flow of usually wet, muddy rock debris of mixed sizes, much like a slurry of freshly mixed concrete pouring down a chute.

Decomposition-The chemical breakdown of rocks and minerals.

Diatomite-A sedimentary rock consisting almost entirely of the siliceous skeletons of single-celled algae.

Dike-A sheet-like body of igneous rock formed by intrusion usually along a fracture, and cutting across the structure of the rocks or cutting massive rock.

Diorite-A coarse grained, igneous rock, composed of plagioclase hornblende, biotite. Assigned to "granitic rocks." May contain quartz, then it is a quartz diorite.

Dip-The direction and degree of inclination (from horizontal) of a sedimentary bed or any other geological planar feature.

Disintegration-The physical breakup of rocks and minerals.

Epicenter-The spot on the earth's surface directly above the subsurface point at which an earthquake shock originates.

Erosion-The removal of rock material by any natural process.

Extrusive Rock-Rock extruded onto the earth's surface, usually in molten condition (lava).

Fanglomerate-The consolidated deposits of an alluvial fan; a variety of conglomerate which is coarse, ill-sorted, and contains angular stones.

Fault-A fracture or fracture zone along which there has been displacement of the two sides relative to one another parallel to the fracture. The displacement may be a few inches or many miles.

Fault Zone-A zone in the earth's crust consisting of many roughly parallel, overlapping, closely spaced faults and fractures; may be up to several miles wide.

Fissility-A property of splitting easily along closely spaced parallel planes.

Fluvial-Features of erosion or deposition created by running water.

Fold-A bend in strata or any planar structure.

Foliation-The laminated structure resulting from segregation of different minerals into layers parallel to the schistosity.

Formation-The ordinary unit for geologic mapping-it consists of a large stratum or strata with persistent characteristics.

Fracture-Breaks in rocks due to intense folding or faulting.

Gabbro-A dark, coarse-grained intrusive igneous rock richer in iron, magnesium.

Gneiss-A coarse-grained metamorphic rock with irregular banding (foliation).

Gouge-Finely abraded, (clay like) material occurring between the walls of a fault. It is the result of the grinding movement along the fault.

Grain size-A term relating to the size of mineral particles that make up a rock or sediment.

Graben-A sizeable block of the earth's crust dropped down between two steeply inclined faults, giving a keystone shape to the block, longer than it is wide.

Granite-A common, coarse-grained, igneous intrusive rock relatively rich in silica, potassium, and sodium.

Granitic-A term commonly used for many coarsegrained igneous intrusive rocks not strictly of granite composition.

High-angle Fault-A fault with a dip of greater than 45^{o}.

Igneous Rocks-A class of rocks formed by crystallization from a molten state.

Imbricate-The shingling or overlapping effect of stream flow upon flat pebbles in the stream bed. The pebbles are inclined so the upper edge of each pebble is inclined in the direction of current.

Inclination-In geology, the dip of a bed, fault or other tabular body measured from the horizontal.

Inclusion-A fragment of older rock.

Incompetent-A rock which is relatively weak and responds readily to pressure by crumpling or by flow.

Indurated-In modern usage the term is applied to rocks hardened not only by heat but also by pressure and cementation.

Intrusive contact-A contact between an igneous rock and some other rock indicating that the igneous rock is younger.

Joint-A fracture or parting which abruptly interrupts the physical continuity of the rock mass. This term is used for a discontinuity along which no movement has taken place.

Lamination-(1) The layering or bedding less than lcm (one) in thickness in a sedimentary rock. (2) The more or less distinct alteration of material, which differ one from the other in grain size or composition.

Landslide-Rapid displacement of a mass of rock, residual soil or sediments adjoining a slope, in which the center of gravity of the moving mass advances in a downward and outward direction. A similar movement proceeding to an imperceptible rate is called creep. These are broken in various categories with regard to type of failure.

Left Lateral Fault-One on which the opposing block appears to have moved to the left as you face the fault, no matter which side of the fault you stand on.

Limstone of the two sides of anticline or syncline.

Limestone-A sedimentary rock composed wholly or almost wholly of the mineral calcite.

Lineation-The parallel orientation of structural features that are lines rather than planes.

Lithology-The physical character (composition, texture, etc.) of a rock, generally as determined megascopically or with the aid of a low-power magnifier

Low-angle fault-A fault dipping less than 45 degrees Magma-Molten rock within the earth's crust.

Marine-The ocean environment; marine sediments are those deposited in the ocean.

Mass Movement-Unit movement of a portion of the land surface as in creep, landslide or slip.

Massive-Of homogeneous structure, without stratification, foliation, schistocity and the like; occurring in thick beds, free from minor joints and lamination.

Mass-Wasting-A general term for a variety of processes by which large masses of earth material are moved by gravity either slowly or quickly from one place to another.

Matrix-The fine-grained constituents of a rock in which coarser particles are embedded.

Metamorphism-The mineralogical and structural adjustment of solid rocks to physical or chemical conditions differing from those under which the rock in question originated.

M.Y.-An abbreviation for million years.

Mineral- chemical compound formed under natural conditions, having essentially uniform properties and composition.

Mudflow-A form of mass movement involving the flow of mud, usually containing coarser rock debris, in which instance the term debris flow is equally applicable.

Mudstone-A fine-grained sedimentary rock which is hard to characterize as shale or siltstone due to lack of structure (bedding, fissility, etc.).

Mylonite-A fine-grained rock, usually laminated, formed by extreme microbrecciation and milling of rocks during movement on fault surfaces.

Oblique Air Photo-One taken with the axis of the camera tilted from vertical. If the horizon shows, it is a high-oblique photo.

Outcrop-An exposure of bedrock at the surface of the ground.

Overturned-Having been tilted past vertical from the original position and hence inverted in the outcrop.

Plunge-The inclination from horizontal of the long axis of a fold or warp.

Pyroclastic-Hot or firey (pyro) fragmental (clastic) debris thrown out of an explosive volcanic vent.

Quartz-One of our most common minerals, hard and chemically resistant, composed of silicon and oxygen (SiO_2).

Quartzite-A rock formed by metamorphism of sandstone, which is hard, coherent, and consists of quartz.

Recharge Well-A well designed for injection of fluids into the ground.

Regolith-The layer or mantle of loose, incoherent rock material, of whatever origin, that nearly every where forms the surface of the land and lies on the hard or "bed" rock.

Relief-Topographic relief is the difference in elevation of contiguous parts of a landscape, valley to peak.

Right Lateral Fault-One on which the opposing block appears to have moved to the right, no matter which side you stand on.

Riprap-Broken rock used for revetment, the protection for bluffs or structures exposed to wave action, foundations, etc.

Rock-An aggregate of minerals.

Rock Cleavage-The facility to break along parallel smooth planes within a mass of rock.

Rockfall-The relatively free fall of rock masses from steep bedrock faces.

Rock Glacier-An accumulation of large angular blocks of rock, usually lobate in form with steep margins, that moves slowly by creep.

Sandstone-A sedimentary rock formed by cementation of sand-size particles.

Scar-A straight steep bank or face which can be a few feet to thousands of feet in height and length.

Schist-A medium or coarse-grained metamorphic rock with subparallel orientation of the micaceous minerals which dominate its composition.

Schistosity-That variety of foliation that occurs in the coarser-grained metamorphic rocks. Generally the result of the parallel arrangement of platy and ellipsodial mineral grains.

Sedimentary Rocks-A class of rocks of secondary origin, made up of transported and deposited rock and mineral particles and of chemical substances derived from weathering.

Shale-A laminated sediment, in which the constituent particles are predominatly of the clay grade and which shows well developed fissility or parts readily parallel to the bedding.

Shear Zone-A zone in which shearing has occurred on a large scale, so that the rock is crushed and brecciated.

Sill-An intrusive body of igneous rock intruded parallel to the bedding or schistosity of the intruded rock.

Siliceous-Rich in silica, SiO.

Siltstone-A fine-grained, sedimentary rock composed of silt, finer than sand and coarser than clay.

Slate-A weakly metamorphosed rock derived from shale by compaction with the development of closely spaced, smooth, parallel breaking surfaces (slaty cleavage).

Sorting-The arrangement of particles by size.

strata-Layers of a sedimentary rock. Bedded rocks are stratified.

Strike-The course or bearing of the outcrop of an inclined bed or structure on a level surface; the direction or bearing of a horizontal line in the plane of an inclined stratum, joint or fault.

Structure-Phenomena that determine the geometrical relationships of rock units, such as folds, faults, and fractures, etc.

Subjacent-Lying under or below.

Superjacent-Lying over or above.

Surficial-Formed at or on earth's surface, consisting of unconsolidated residual materials.

Syncline-A fold in rocks in which the strata dip inward from both sides toward the axis.

Talus-A heap of coarse rock waste at the foot of a cliff or a sheet of such waste covering a slope below a cliff.

Terrace-A geometrical form consisting of a flat tread and a steep riser or cliff. Stream terraces, lake terraces, marine terraces, and structural terraces are distinguished in geology.

Terrestrial-Deposits laid down on land as contrasted to the sea, terrestrial conditions as compared to marine conditions.

Tertiary-A period of the Cenozoic Era embracing the time from 70 to 2 m. y. ago.

Thrust Fault-A gently inclined fault along which one block is thrust over another.

Thrust Plate-The upper block of a thrust fault.

Volcanic-Made of material derived from volcanoes (volcanic rocks, debris, ash, etc.).

Weathering-The group of processes, such as the chemical action of air and rain water and of plants and bacteria and the mechanical action of change of temperature, whereby rocks on exposure to the weather change in character, decay and finally crumble into soil.

G 180 PRELIMINARY STUDY

The purpose of the preliminary study is to determine the feasibility, extent, and estimated cost of a drainage project. Such studies are made to investigate special drainage problems, to submit proposals for capital improvement financing, to survey drainage deficiencies, etc. The study consists of a short cut method of investigating and evaluating the factors which affect the design and cost of a storm drain. Accuracy is sacrificed, therefore, to save time.

A preliminary study method is outlined to show what factors should be considered and to what extent the study should be carried out. The sequence of this method is in the order of the subsections given herein.

The preliminary study data should consist of the following:

1. A first sheet showing the project title, type of project and financing (if known), project justification, the origin and date of request, and the design and construction cost. (Form CAO-39, Figure G 180.)

2. A plan sketch of the proposed drainage facilities. (Suggested scale 1" = 400', taken from a drainage map, Figure G 180A.)

3. Preliminary Estimate Sheet and Work Order (Figure G 187).

4. Condensed Tabling Sheet (Figure G 184).

5. Engineer's Cost Estimate (Figure G 185).

6. Typical Intersection Costs (Figure G 185A, if applicable).

The first three items above should be submitted to the Coordinating Division on 8 ½" x 11" size sheets.

After completion of the study, all the design data should be placed in a manila folder, appropriately- titled by project name, and filed for future reference.

G 181 INVESTIGATIONS

The designer should first determine the purpose of the project and its limitations. For example, street projects financed by gas tax funds will not include drains which do not benefit highway user, etc. Office files shall be searched for past communications, drainage complaints, inundation reports, or previous studies on the project. Hydrologic records of existing drains in the vicinity shall be compared to the project location on the drainage map to establish watershed boundaries. Should the study project be within the watershed of an existing storm drain, the hydraulic records of the existing drain shall be investigated to determine the outlet location, capacity, and hydraulic gradient to which the study will be computed. Plans of the existing drain will give the depth, size, and details at the outlet location.

If no record data are available, the designer should determine the watershed limits and its outlet. All assumptions made during the study should be verified by field investigations. Should problems of right of way, slide areas, etc., arise which might increase the cost of the project, the designer should call a preliminary field meeting with the appropriate bureaus to get their views on the matter.

G 182 WATERSHED AND OUTLET

The watershed boundary of the project can be quickly outlined on a print of the drainage map by joining the ridges of the contour lines all around the project location. Should the watershed be in a developed area, the points of opposite flow as shown by the street flow arrows indicate the ridges. The designer is cautioned to include all the areas contributing flow to the project, even partial sumps contributing overflow. The points of flow concentration from two or more areas and the low point of sump areas are located and marked on the map. Also, the natural courses of surface flow are traced to their natural outlet. Each area contributing to a point of concentration and each sump area within the watershed are outlined in the same manner as the watershed boundary. (See the drainage area map, Figure G 241.1.) All these points will be utilized in determining the conduit alignment (see Section G 183).

The proper outlet for the project storm drain must be an existing storm drain, watercourse, or ocean. The natural outlet for surface flow should be chosen and established as the downstream end for the hydrologic calculations of the project.

Having properly evaluated the existing conditions within the watershed, the designer selects the most economical drainage system. (See Sections G 130 to G 135 and Figure G 135 for the types of drainage systems used and their comparative costs.) The chosen drainage system must be approved by the supervisor before the cost estimate is prepared.

G 183 ALIGNMENT AND GRADE

Select the alignment (main line and laterals) to collect all points of runoff concentration and sumps along the general path of surface flow. For a watercourse alignment, the distance between points of concentration shall be a straight line. In a developed area, the storm drain should be located in the street where possible. All distances shall be scaled from the drainage map. The grade of the drain shall be the average ground slope between points of concentration. Sumps shall be taken from contours or street corner elevations of the drainage map.

A street alignment may not always be practical, due to substructure interference, heavy traffic, or restricted working area All major substructures, including sewer, water, and others, should be investigated to verify that the storm drain can be placed under the pavement area of all streets along the alignment without excessive substructure relocation. In congested areas, sound judgment is required to choose an economical alignment. State highways and major streets are usually avoided in the alignment because of heavy traffic restrictions. Large drains in narrow streets may so restrict the construction work area as to be uneconomical. Even considering all these possible restrictions, the designer must not lose sight of the merits of the shortest and most direct alignment.

Where the best alignment is not obvious or alternate alignments seem equally beneficial, a profile should be plotted along each alignment. A comparison should be made of the quantity of excavation as well as of the size and length of conduit required for each alignment. The vertical scale should be large enough to avoid a break in the profile. Elevations or contours from the drainage map or existing plans may be used.

G 184 CONDENSED HYDROLOGY

The condensed method for tabling runoff uses the Peak Rate Equation ($Q = F_{RO}$ X BPRR x Area) for the design storm frequency selected. (See Sections G 201, G 222, and G 240 to G 243 inclusive.) It is intended to be a quick method of computing runoff with some measure of accuracy. Liberal use is made of representative values of F_{RO}, t_c, and flow velocities. This method of calculation is only for the purpose of determining pipe sizes for getting a preliminary cost estimate and is not intended for determining runoff values.

With the drainage area outlined (Section G 182) and the alignment and grade determined (Section G 183), the pipe sizes are then computed on Condensed Tabling (Figure G 184) as follows:

1. Outline each sub-area contributing to each intersection (see Figure G 241.1), determine the acreage of each sub-area, and list actual acreage (no conversion) on the condensed tabling sheet opposite the area number.

2. Using the average isohyetal for the entire watershed, determine the F_{RO} (Ave. Iso x storm

frequency factor). For sumps, increase area to equivalent 50-year frequency by dividing by the frequency factor (0.762).

3. The time of concentration (t_C) consists of the inlet time plus the travel time. For the initial area (say 1000+ feet of alignment), the inlet time is assumed as 8 minutes for flatland areas and 5 minutes for hillside areas. The travel time is the distance between intersections divided by the velocity (feet per minute). List inlet time on tabling sheet.

4. Enter Figure G 242.2L with the t_C determine the BPRR, and list.

5. Calculate Q and list (Q = F_{RO} x BPRR x Area).

6. List the average street or ground slope(s). For street or watercourse flow, use the average ground slope. For pipe flow use 80% of the average street slope. Enter Figure G 184A or B or C with Q and S to determine flow velocity and list. Check if street flow is equivalent to a 36" pipe by entering Figure G 184B with Q and S. If so, use pipe flow to next point of concentration. If not, continue with street flow.

7. Scale distance to next point of concentration along the alignment on the drainage map and list. Determine time of flow to next point of concentration by No. 3 above. List in "t_C" column and add to previous time.

8. Repeat procedure to completion of tabling.

9. The "t_{CX}" at junctions (t_C of combined flows) is determined as shown in Subsection G 242.2, No. 7.

G 185 ENGINEER'S COST ESTIMATE

The engineer's cost estimate shown in Figure G 185 is a class "B" estimate (see Section G 033) sufficient for financing purposes. The Los Angeles County Flood Control District Cost and Quantity Estimating Manual may be used for unit costs. These unit costs should be increased by 30% for pipes and 20% for structures on projects with a construction cost of less than $200,000. For the Central Business District the unit prices should be 50% to 100% higher, with a lesser increase for other congested areas within the City. It is generally preferable to consult the Estimating Section of Utility and Estimating Division for verification of prices in this area. The designer is reminded that the cost estimate should be conservative to assure adequate funds for construction. To simplify the estimate, the following assumptions shall be made:

1. Use R.C. pipe and 6 feet of cover on the conduit.

2. To estimate the catch basin requirements, apply the typical intersections shown on Figure G 185A. Add additional costs for unusual flow conditions.

3. For an alignment in the street, add only the structures required beyond those included in Figure G 185A. For an alignment in a watercourse, add all the junctions, manholes, and inlet and outlet structures.

4. List the quantities and sizes on Figure G 185 and complete cost estimate, using Figure G 185B to determine inspection and engineering costs. Judgment based on knowledge of the specific area must be used whenever possible to determine the street, sewer, traffic, and street light costs. In the absence of this knowledge, a percent value may be used if a cost is anticipated. The percent value for incidentals and contingencies may vary from 10% to 25%, based on the cost of the project and the engineer's evaluation of difficulties encountered. For long range estimates, consult the Utility and Estimating Division for costs which may be modified by price indices.

G 186 SPECIAL PROBLEMS

The economical solution of many of the existing drainage problems in the City is a challenge to the engineer's ingenuity. Obvious solutions to many special problems, such as unfavorable topography, would result in prohibitive costs. Good judgment is necessary both in determining the extent to which these problems should be studied and in devising economical solutions for them. Should a proposed solution provide limited benefits, the designer should state (and sketch) the limitations and show the basis of the cost estimate. If alternate solutions are proposed, they should be based on comparable service; a cost estimate should be made for each alternate and most economical solution submitted.

G 187 PRELIMINARY ESTIMATE SHEET AND WORK ORDER

The Preliminary Estimate Sheet and Work Order form (Figure G 187) provides all the data necessary relative to financing of project and request for a work order. It is used for Capital Improvement projects, Assessment projects, or a combination of both. It also provides a record of processing from the project's inception to the issuance of the work order number. The design office of jurisdiction initiates the project, prepares the estimate, and submits it to Coordinating Division with the CAO-39 form. (See Section G 180)

In preparing this estimate, the following particular features should be noted:

1. In the top line, only the "Date of Cost Estimate," "Type," "Engineering District," and "Councilmanic District" items are filled in by the design office. All other lines applicable to the project are filled in except the last three lines in the bottom and "Date of Revised W.O."

The project title and description are the same as given in the CAO-39 form.

2. In the column headed "Item," a brief description of the improvement is shown. For Street Lighting, Traffic Signals, and Right of Way, only the date is given. Other items pertaining to "Cost" or "Charges" need no entry except the percent rate.

3. The column headed "Estimated Cost" should be filled in for every item; if zero, so indicate. Each item should include the estimated cost of incidentals and contingencies (10% to 25%, #4, Section G 185) plus any appropriate bond discount on A'11 projects based on each item's construction cost. All estimates of cost on this form should be rounded upward to the nearest $100.

4. The four columns headed "Suggested Financing" are to show fund eligibility. This should be determined by the initiating design offlce. (See Sections G 031 and G 042). The sum of these values should equal the "Estimated Cost" value for each line.

5. The last column titled "Direct Charges" is the estimated City labor costs charged to the project work order. These charges include design, survey, processing and inspection costs which may be taken from the Engineering Cost Schedule (Figures G 185B and C). For small projects where design time can be determined, the Bureau of Accounting provides the rates, including compensated time off, as a guide. The survey cost taken from the Engineering Cost Schedule is for the project to completion of construction, therefore, half could be applied to precontract costs and half to postcontract costs based on total construction cost. The precontract miscellaneous cost are, the processing cost shown on the Engineering Cost Schedule. Both the processing and inspection costs on the Engineering Cost Schedule are based on the total construction cost. The estimated construction and design-costs from other offices such as Streets, Sewers, Street Trees, Street Lighting, Traffic, and Right of Way should be either obtained from or confirmed by that office. All "Direct Charges" above the line "Total Precontract Costs" are added. Then the "Postcontract Costs" are added to the above sum to arrive at "Total Direct Charges."

6. On the line "Total Direct Charges Plus. 70,' a percentage of the value "Total Direct Charges" is added to the original value for City indirect costs and the sum is placed on that line in the "Estimated Cost" column. That percentage is given annually by the Bureau of Accounting. That sum is then distributed on that line in the four columns under "Suggested Financing" by a ratio of total construction cost in each column divided by the total construction cost in the "Estimated Cost" column times the "Total Direct Charges Plus ….. …%" value in the estimated Cost column. The value thus determined for the Assessment column must not exceed 20% of the assessment total construction cost. If so, the balance must be financed by other means and placed in the other column as a Budgetary item.

7. The values of Total Construction Cost plus "Right of Way" cost plus "Total Direct Charges Plus …%" cost are added in each column to get the "Total Estimated Project Cost." Again the sum of the four columns under "Suggested Financing" must equal the value under the "Estimated Cost" column on the "Total Estimated Project Cost" line.

G 190 HYDRAULIC LABORATORY

The Experimental Hydraulic Research Laboratory Section of the Drainage Systems Engineering Division constructs and tests hydraulic models to determine prototype conditions for specific design problems and to develop design standards.

The facilities of this laboratory are available to all Bureaus and Departments of the City of Los Angeles, and to other governmental agencies, for the solution of hydraulic problems. The laboratory is located at 2400 Altman Street, Los Angeles.

The Bureau of Engineering is concerned, from an economic viewpoint, with the hydraulic losses which occur in storm drain structures. It is customary in designing storm drains to allow for these hydraulic losses, which are involved when water flows through catch basins, manholes, junction structures, transition structures, and drainage conduits. An examination of engineering literature reveals much conflicting, and some unreliable, information on the subject. These hydraulic losses have occasionally been computed on the basis of theoretical hydro-dynamic analysis. There has been very little experimental evidence to verify the correctness of theoretical analysis, and practically none to verify the loss coefficients customarily used in computing and reviewing computations of the elevations of the hydraulic and energy gradient lines for both open channel and covered conduit drains.

The District Design Office shall consult the Drainage Systems Engineering Division for tests on special structures where normal hydraulic analysis would not provide an adequate solution.