REPORT TO
MOCKFORD & RUDD ARCHITECTS
723 Washington Street
Oregon City, Oregon

ON

SUBSURFACE INVESTIGATION
FOR SECOND ADDITION TO
COLLEGE CENTER BUILDING
PORTLAND STATE COLLEGE
PORTLAND, OREGON

July 16, 1963

SHANNON AND WILSON
Soil Mechanics and Foundation Engineers
1617 S.W. Morrison
Portland 5, Oregon
A. INTRODUCTION

Presented herein are the results of a subsurface investigation of the foundation conditions for the proposed second addition to the existing College Center Building located within the limits of a block bounded by S.W. Broadway, S.W. Park Avenue, S.W. Harrison Street, and S.W. Montgomery Street on the Portland State College campus in Portland, Oregon. In addition to the investigation for the second addition to the College Center, an analysis has been accomplished and presented herein to determine the ability of the existing footings for the College Center and Library to support additional floors and a central tower without inducing undesirable settlements.

The construction of the existing College Center and Library Building has been accomplished in several stages to form what is eventually to be a single integrated unit covering the entire block. At the present time the existing structure covers all of the block except for a small rectangular section approximately 70 feet by 90 feet in an area located in the southeast corner of the block. The existing structures are founded on spread footings which are designed for a maximum soil bearing pressure of approximately six kips per square foot upon
completion of all units and proposed additions in height. The footing elevations for the various existing units vary considerably, however, since the Library has one basement while the College Center has one basement and one partial sub-basement, and although each building has four floors at the present time, the roofs of the buildings do not terminate at the same elevation.

The proposed additions are to consist of a second addition to the College Center located on the southeast corner of S.W. Broadway and Harrison Street and of possible future additions to the entire integrated structure in height. The currently proposed unit at the southeast corner of S.W. Broadway and Harrison Street will consist of a four-story structure with basement and sub-basement, approximately 70 feet by 90 feet in plan. Planned as future additions in height are an additional three floors over the entire single integrated unit, except for the Library which will consist of four additional floors. In addition, a tower, approximately 32 feet wide and providing a portion of the completed building with a total of 14 floors, will be added along the approximate north-south centerline of the units.

The scope of this report includes a description of the field and laboratory testing programs, a description of the sub-
surface materials encountered, and an analysis of the bearing capacity, settlements, and subsurface construction problems for the second addition to the College Center, and an analysis of the bearing capacity and settlements under the load of the additional floors and tower for the future proposed additions to the College Center Library. Also included are recommendations and conclusions concerning the subsurface data and criteria necessary to design and construct the foundations for the proposed second addition to the College Center and to determine if the existing footings are adequate to support the future proposed additions in height to the existing structure.

B. SITE DESCRIPTION AND GEOLOGY

1. Site Description

The site comprises a full block bounded by S.W. Broadway, S.W. Park Avenue, S.W. Harrison Street, and S.W. Montgomery Street on the Portland State College campus. At the present time a single integrated structure consisting of the four-story College Center Building and Library Building exists on the site. On the southeast corner of the site, an area approximately 70 by 90 feet is covered with asphalt and used as a parking facility and access for a service loading dock. The parking area is the site for the proposed
second addition to the College Center to be integrated with the existing College Center Building and the Library Building. The area to the north and south of the site is occupied by multi-story structures comprising the Portland State College plant, while the area to the east and west is occupied by business and apartment structures. In general, the site is fairly level with a gentle slope of approximately one to two percent to the northeast.

2. Geology

The underlying bedrock of the area is a basaltic lava several hundred feet thick known as the Columbia River Basalt Formation. This basalt formation is believed to have been folded forming an anticline which is the root of the Portland Hills, south and to the west of the site, and a synclinal basin, later filled by sediments, which underlies a major portion of the Portland area. The oldest of the over-burden layers is a strata of cemented sands and gravels known as the Troutdale Formation. Above the Troutdale Formation is encountered a layer of silt, sands, and gravels known as the Portland Terrace Gravels, capped by a surficial mantle of silt which covers most of the Portland area.

The Columbia River Basalt Formation consists of a series of lava flows composed of dark gray to black, dense, fine-grained basalt
with well-developed columnar jointing. These basalts, lying layer upon layer, are considered middle to late Miocene in age.

The Troutdale Formation consists of indurated non-marine sedimentary rocks which are thick-bedded, pebble and cobble conglomerates, with lenses of sandstones and siltstones. This formation was deposited during the middle Pliocene epoch.

The Portland Terrace Gravels consist of light gray sand and fine gravel which consist primarily of andesite grit and pebbles derived from the Boring lava formation. This strata is believed to have been deposited during the Pleistocene epoch.

The surficial silt mantle consists of brown, tan, or sometimes reddish, fine-grained, clayey silt, silt, or fine sand with loessial characteristics, and is late Pleistocene to early recent in age.

C. FIELD EXPLORATIONS

A total of 301.8 lineal feet of drilling was accomplished on the site at the five test holes, B-1, B-2, B-3, B-4, and B-5, the locations of which are shown on Plate I. Boring B-1 penetrated to a depth of 120.8 feet, boring B-4 penetrated to a depth of 41.5 feet, and borings B-2, B-3, and B-5 penetrated to a depth of 46.5 feet below the existing ground surface.
The logs of the five borings are shown on Plate II. All borings were accomplished by Raymond Concrete Pile Division of Raymond Internation of Portland, Oregon, using a truck-mounted rotary drill. Four-inch steel casing with threaded couplings was used until an effective seal was formed to prevent the loss of the drilling fluid, and after an effective seal was accomplished, the remainder of the hole was drilled using bentonite "drilling mud" to prevent the sides of the holes from caving. Casing lengths varied from 9.5 feet in Boring B-3 and Boring B-4 to 34.5 feet in Boring B-1. Drilling commenced on May 20, 1963, and was completed May 28, 1963. All drilling was supervised by a trained inspector provided by Shannon and Wilson of Portland, Oregon.

Representatives samples were obtained in each boring at intervals of approximately five feet using either a two-inch O.D. split-spoon drive sample or a three-inch O.D. thin-walled seamless-steel tube.

The two-inch drive samples were obtained by driving the sampling spoon into the undisturbed material at the bottom of the boring with a 140-pound weight falling 30 inches. The number of blows required to produce a penetration of 12 inches, defined as the Standard Penetration Resistance, is shown on the Logs of Borings.
Plate II, and is also included on Table I. The samples obtained in this manner were classified in the field and then forwarded in airtight jars to our laboratory for further classification and testing.

The seamless-steel tube samples were obtained either by pushing the sampler into the undisturbed material at the bottom of the boring by means of a hydraulic ram mounted on the drilling rig, by driving the sampler using a 140-pound weight falling 30 inches, or by a combination of both. The samples obtained in this manner were classified in the field by examination of the material exposed at both ends of the sample, and then sealed with microcrystalline wax before being sent to our laboratory for additional classification and testing.

Observations of the ground-water level were accomplished by soundings in boring B-1, the deepest test hole which extended to a depth of 120.8 feet. Since the drilling was accomplished using bentonite "drilling mud," the boring was flushed out with water and the boring allowed to remain open until the remainder of the borings were completed before sounding. The level of the water in the boring on May 29, 1963, was approximately 68 feet below the ground surface and the level is shown on Plate II.
D. LABORATORY TESTING

1. General

All soil samples were visually classified in our laboratory with additional laboratory classification tests being accomplished as considered necessary. Laboratory testing was accomplished on selected three-inch relatively undisturbed samples obtained from the five borings for the purpose of determining the required strength and consolidation characteristics of the materials encountered.

2. Classification Tests

All samples were examined and classified in our laboratory. Natural water contents and in-place wet densities were determined for applicable, representative samples. Three wet mechanical-sieve analyses were accomplished to determine the grain-size distribution of the representative materials. One specific gravity determination was also accomplished. The results of all classification tests are summarized in Table I, and the results of the sieve analyses are shown on Figure 1.

3. Strength Tests

Four consolidated-undrained triaxial tests with pore-pressure measurements ( \overline{p} - test ) were performed on samples of a slightly silty fine sand at different confining pressures. The
results of these tests are shown plotted as stress vs. strain on Figures 2, 3, 4, and 5, and as a Mohr strength envelope on Figure 6. The test results indicate that the material under consolidated-undrained conditions has an effective angle of internal friction of 37° with no apparent cohesion.

Since the excavation for the basement and sub-basement for the second addition to the College Center will result in an increase in the shear stress through a reduction in the confining stress, strength data under these conditions were taken from a previous project near the site. To simulate the field conditions in the triaxial testing apparatus, the triaxial specimens were consolidated under an all-around pressure equal to the overburden load prior to the anticipated excavation. The confining pressure was then reduced, simulating the excavation, and the major principal stress is maintained unchanged until a condition of failure is produced. The test results indicate that the material under these conditions has an angle of internal friction of 36° with an apparent cohesion of 0.1 ton per square foot.

4. **Consolidation Tests**

One triaxial consolidation test was performed to determine the consolidation characteristics of the silty to slightly silty fine sand. In this test the sample was allowed to fully consolidate under a series of confining pressures selected so that
the lateral displacement of the sample under increments of effective vertical load was limited. By measuring the change in height and change in volume of the sample under each increment of effective vertical stress, the plot of effective vertical stress vs. void ratio, shown on Figure 7, was computed.

E. SUBSURFACE SOIL CONDITIONS

In general, the exploratory borings disclose that the site in the area of the proposed second addition to the College Center is underlain by approximately five feet of soft to medium clayey silt which is believed to be fill. At boring B-1, a fill of approximately 33.3 feet in depth was encountered, however, it is believed that the boring was located in an old cistern or well. At other locations on the site, the borings disclosed granular fill associated with the construction of the existing structures. Beneath the fill, a deposit of light brown to gray-brown, medium dense to very dense, slightly silty, fine sand with thin seams of fine sandy silt or silty fine sand was encountered to a depth of approximately 114 feet. Beneath this sand deposit a strata of black, rounded to sub-rounded basalt gravel and sand was encountered to the bottom of boring B-1 at a depth of 120.8 feet.
E. FOUNDATION STUDIES

1. New Foundations

The probable performance of foundation materials must be judged with respect to the inter-related properties of strength and consolidation. First, the material must be able to support the structure without shear failure, and second, the settlement of the structure due to consolidation of the material must not be so great or uneven as to cause damage to the structure.

The bearing capacity of sands increases as the footing size and the depth of embedment increases; however, the settlement of the footing increases as the footing size increases. Figure 8 shows the relationship of footing size vs. settlement for both square and strip footings with various footing unit loads. These relationships were computed assuming that the results of the triaxial consolidation tests were applicable and that the footings were embedded approximately four feet below the finished sub-basement floor. Figure 8 may be used to design the footings for the additional unit by selecting the amount of settlement which is tolerable. Anticipated differential settlements will be approximately one-half the total settlement.

Since the structure is to have a basement and sub-basement, the walls must be structurally designed to resist la-

Revised 9-23-63
tural earth pressures. If a clean washed medium sand is used for the backfill against basement walls using nominal compaction and adequate footing drains and adequate inspection is provided to insure that materials from the site are excluded from the backfill, the design lateral pressure may be computed using an "equivalent fluid" unit weight of 45 pounds per cubic foot. If select material from the silty fine sand in the excavation is used, an equivalent fluid unit weight of 60 pounds per cubic foot is recommended. In designing the wall it would be closer to reality to assume the distribution of the lateral earth pressure force acts on the basement wall as shown on Figure 9.

2. Existing Foundations

Since a subsurface investigation was not accomplished prior to the construction of the existing College Center and Library Building, a settlement analysis was made to determine the magnitude of the settlements of the footings under the load of the proposed additional floors and central tower. The assumption was made that the results of the triaxial consolidation tests are valid for the materials upon which the existing footings are supported. Since the footing sizes, loads, and elevations varied, only those footings which are considered critical were analysed. The following tabulation indicates the results of the analysis:

Revised 9-23-73
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Strip Ftg.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A-1 to A-7</td>
<td>5.5' wide</td>
<td>135' 8&quot;</td>
<td>0.90</td>
<td>2.38</td>
<td>0.5</td>
</tr>
<tr>
<td>A-8</td>
<td>13.0' x 13.0'</td>
<td>131' 2&quot;</td>
<td>0.88</td>
<td>1.95</td>
<td>0.4</td>
</tr>
<tr>
<td>A-9</td>
<td>13.0' x 13.0'</td>
<td>133' 2&quot;</td>
<td>0.88</td>
<td>1.95</td>
<td>0.4</td>
</tr>
<tr>
<td>D-2</td>
<td>8.7' x 8.7'</td>
<td>134' 2&quot;</td>
<td>2.89</td>
<td>2.89</td>
<td>0</td>
</tr>
<tr>
<td>D-3</td>
<td>8.0' x 8.0'</td>
<td>131' 6&quot;</td>
<td>2.70</td>
<td>2.70</td>
<td>0</td>
</tr>
<tr>
<td>D4, D5, D6</td>
<td>8.0' x 8.0'</td>
<td>128' 6&quot;</td>
<td>2.70</td>
<td>2.70</td>
<td>0</td>
</tr>
<tr>
<td>D-7</td>
<td>8.0' x 8.0'</td>
<td>127' 8&quot;</td>
<td>2.70</td>
<td>2.70</td>
<td>0</td>
</tr>
<tr>
<td>D-8</td>
<td>8.7' x 8.7'</td>
<td>128' 8&quot;</td>
<td>2.21</td>
<td>2.21</td>
<td>0</td>
</tr>
<tr>
<td>D-9</td>
<td>9.7' x 9.7'</td>
<td>128' 8&quot;</td>
<td>2.26</td>
<td>2.26</td>
<td>0</td>
</tr>
<tr>
<td>G-3</td>
<td>13.4' x 13.4'</td>
<td>125' 8&quot;</td>
<td>1.11</td>
<td>2.58</td>
<td>0.4</td>
</tr>
<tr>
<td>(G4, G5, G6,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(G7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spread Ftg.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(K1, K2, K11,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(J1, J2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spread Ftg.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(J9, J10, H9,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(H10, G9,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G10</td>
<td>42.0' x 38.0'</td>
<td>128' 8&quot;</td>
<td>0.49</td>
<td>1.72</td>
<td>1.1</td>
</tr>
<tr>
<td>G11, M11</td>
<td>13.0' x 13.0'</td>
<td>123' 5&quot;</td>
<td>0.69</td>
<td>1.86</td>
<td>0.8</td>
</tr>
<tr>
<td>M12, M13,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M14, M15,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(N11, N12,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(N13, N14,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(N15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strip Ftg.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(E16, M16,</td>
<td>7.5' wide</td>
<td>136' 8&quot;</td>
<td>0.86</td>
<td>2.9</td>
<td>0.6</td>
</tr>
<tr>
<td>(N16)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3. Basement Excavation for Second College Center Addition

Due to the relatively small area of the addition with respect to the required depth of excavation and the limited area of access, excavation for the basement and sub-basement cannot be sloped for the full depth of the excavation. A means of supporting the deep excavation (approximately 30 feet) must be provided on the two sides adjacent to S.W. Broadway and S.W. Harrison Street. The use of soldier beams and horizontal sheeting appears to be the most applicable type of support. This method consists of a series of H-piles (soldiers) spaced at intervals of approximately four to eight feet so that their flanges are parallel to the sides of the excavation. As the soil adjacent to the piles is removed, horizontal boards (lagging) are wedged against the soil outside the cut. As the general depth of the excavation advances in depth, wales and struts are inserted to support the soldier beams.

At this site the H-piles should be set in prebored holes to a predetermined depth below the lowest point of the excavation, and then concreted up to the bottom of the excavation. The remainder of the hole can be filled with sand. Figure 19 indicates the relationship of depth of penetration (L) vs. spacing for various
prebored hole diameters. The values shown in the figure were calculated for a F. S. = 1, and the values should be multiplied by an appropriate factor of safety in order to determine the required penetration. In designing the required H-pile, wale, and strut sections, the soil pressure distribution should be assumed to be as shown on Figure 9 using an equivalent fluid pressure of approximately 40 pounds per cubic foot. The load on each strut may be calculated assuming that the pressure distribution acts on simple beams with hinges at the strut locations. Some means of supporting the soldier beam wales, however, is required, and this support is generally provided by struts for which a reaction must be provided. The method used to provide the necessary reaction for the struts may be the use of the ground and basement floor beams of the existing buildings, the construction of reaction "heels" at the bottom of the excavation, the use of the interior footings and columns of the new structure, or a combination of any two or all of the methods.

Because of the limited working space available, it is our opinion that careful consideration be given to a construction sequence that would permit the use of the interior footings, columns, and floor beams of the new structure as reaction for the struts supporting the soldier beam wales. This approach is considered desirable. The interior footings and columns would have to be constructed prior to
complete excavation. In order to accomplish this, the excavation after placement of the soldier beams can be sloped from the exterior limit of the surface of the excavation to the edge of the proposed outer column footings. A shaft or pit would then be sunk at each footing location to the desired grade, and the footings and columns constructed before completing the entire excavation. Figure 11 indicates a diagram of the proposed scheme, and various slopes with their respective factors of safety. The factors of safety were computed assuming that the soil has an internal angle of friction of 36 degrees and an apparent cohesion of 0.1 tons per square foot. Although these values were not taken from tests performed for this project, they were taken from similar materials using triaxial tests which simulated the condition of an increase in the shear stress through a reduction in the confining stress resulting from the excavation. It was further assumed that the outside limit of the excavation would be outside the building line approximately five feet. Although the results of the slope computations shown on Fig. 11 indicate a rather steep slope, may be possible, it is our opinion that the steepness of the slope should be limited to a slope which is between 1 horizontal on 1 vertical to 3 horizontal on 4 vertical,
and the depth of the sloped excavation be limited to approximately 15 feet prior to placing of the upper set of wales and struts.

Probably the most critical part of the excavation will be for the sub-basement wall footing along column line 17. The reason for the difficulty is the close proximity of the existing strip footing along column line 16 of the Library Building. The distance between column line 16 and column line 17 is approximately 10 feet center to center, and in addition the existing footing is at an elevation of approximately 136.7 feet which is approximately 10 feet above the sub-basement wall footing along column line 17.

Figure 12 indicates the relationship of the slope angle of the subsurface material from the bottom of the existing footing (Column line 16) vs. the bearing capacity for various factors of safety against bearing failure. As indicated by Figure 12, a slope angle of 37 degrees is the steepest allowable slope angle under any practical condition at this site for the strip footing at Column line 16. This slope angle of 37 degrees, however, does not provide any margin of safety against failure, and it is necessary to flatten the slope to approximately 32 degrees to provide a factor of safety of 2 against failure. To preclude the possibility of progressive failure at the toe of the existing footing a berm approximately five feet in width is advisable.

Revised 9-23-63
Because of the close proximity of column line 17 to the existing column line 16, the footings for column line 17 will be well below the surface of the sloping berm required to support the existing column line 16. To accomplish the design and construction of a wall at column line 17 will involve the same problems as the design and construction of a wall at column line 16, although the lateral forces will be somewhat smaller at column line 17 than at column line 16. Inasmuch as the difficulties are approximately the same, the feasibility of designing and constructing the wall at column line 16 without any loss of lateral earth support should be investigated. If the wall is constructed at column line 16, however, the problems of eccentric footing loads and high lateral forces against the wall can be greatly reduced or eliminated, with no increase in construction problems, if the wall is constructed directly under the centerline of column line 16. Accordingly the problems associated with the underpinning approach and the adjacent wall approach of supporting column line 16 are presented herein.

Access to the existing strip footing supporting column line 16, should be gained by a series of narrow trenches which are perpendicular to the strip footing supporting the Library wall. Excavation and construction should be accomplished in sections not exceeding five feet in length with the sections spaced at intervals of app...
approximately 20 feet center to center. Each series of sections should be completed, including curing, before adjacent sections are started. This method is dependent upon the ability of the existing footing to bridge across the five foot excavations.

Consideration should be given to the possibility of gaining access to the back face of the wall by the use of a series of vertical shafts adjacent to the existing strip footing at column line 16. The use of shafts will provide more lateral stability of the sloped berm below the footing, although some timbering would probably be required to provide protection to workmen in the shafts.

If the new wall is not located directly beneath the center of the existing footing, lateral pressures due to the existing footing load will be exerted against the wall in addition to the normal lateral earth pressure. Figure 13 shows the pressure distribution acting on the wall for the present load and the ultimate load on the existing footing, and the wall should be designed for both conditions with consideration given to the conditions which may exist during construction. Some of the problems associated with the lack of lateral support of column line 16 during the construction of the new wall, could possibly be avoided by the use of temporary interior tension tie back rods to column line 15 at the Library basement level. After construction, the wall will have lateral support at the basement level, however, the wall should be designed to support the

Revised 9-23-63
the lateral loads induced by the ultimate load on the existing footing if it is not located under the existing wall centerline. In order to prevent hydrostatic pressures from building up against the wall, a drainage system should be installed either on the outside of the wall using drain tile, or by providing weep holes in the wall with an interior drainage system.

In order to reduce settlements of column line 16 to a minimum during and after construction of the new sub-basement, it will be necessary to take certain precautions during the construction of the new wall at column line 16. The precautions should include the following:

a. The design of the new wall should be one in which the load distribution on the existing strip footing along column line 16 is not eccentric. If an eccentric load distribution does occur, the possible result may be the rotation of the existing footing.

b. The proper construction of the excavation slope below the existing footing in accordance with the information provided on Figure 12 and using a reasonable factor of safety.

c. The slotting of the sloped berm to construct the new wall to support the existing footing should be

Revised 9-23-63
made as small as practical and the walls must be well sheeted and braced with struts to support lateral pressures as indicated on Fig. 13. The face of the slots under the existing footing must be excavated with caution, and if at all possible without support.

d. The face of the excavation below the existing footing should be protected with "gunite" and the new supporting wall section, in widths not exceeding five feet, should be single-formed and the concrete placed directly against the "gunite" protected face. Careful inspection of each section should be made to insure that no sloughing will take place before or during placement of the concrete.

e. To prevent eccentric footing loads on column line 16 it may not be advisable to make a physical tie between the existing footing and the new wall. However, if a physical tie is made, each wall segment should be preloaded by Jacking after it is completed and cured. After jacking dry pack or grout should be wedged or pumped between the existing footing and the finished wall section. Extreme caution should be exercised during the jacking oper-
ation to avoid eccentric loads on the existing footing, and if necessary grouting under the footing should be considered.

An alternate method to install the sub-basement wall is similar to the method previously described with the exception that the wall location would not be altered from the original location at column line 17. Excavation would be accomplished in sections as described in the previously proposed manner after sloping the ground from the bottom of the footing at an angle indicated by Figure 12. The wall in this case should be designed for a lateral earth pressure as shown on Figure 9 plus some passive pressure due to the existing footings which is approximately one-half of that indicated on Figure 13.

Another alternate method would be to devise some means of sheeting to provide lateral support similar to the support for the rest of the excavation, however, the pressures would be much higher and the wall must be much stiffer. The sheeting may be supported laterally by the interior footings constructed previously.

G. CONCLUSIONS AND RECOMMENDATIONS

The site of the proposed additions to the College Center

Revised 9-23-63
and library building is underlain generally by a deposit of light brown to gray-brown, medium dense to very dense, slightly silty, fine sand with seams of fine sandy silt or silty fine sand to a depth of approximately 114 feet. Beneath the deposit of sand a strata of black, rounded to sub-rounded basalt gravel was encountered to the bottom of the deepest boring at 120.9 feet. At the surface, a fill generally associated with construction was encountered to approximately 3 feet, although the depth was somewhat variable.

Foundations for the additional unit should consist of spread footings designed on the basis of the amount of settlement beneath each footing which can be tolerated. The design should be done with the aid of the graphs on Figure 8. The adequacy of the existing foundations is again dependent as to the amount of settlement which can be tolerated beneath the existing footings under additional loads. These settlements for some of the more critical footings are tabulated in Section F, part 2, Foundation Studies, Existing Foundation, of this report.

Basement walls should be structurally designed to resist lateral earth pressures on the wall equivalent to a fluid

Revised 9-23-63
pressure of approximately 45 to 60 pounds per cubic foot, depending upon the type of backfill used and the drainage system provided. The pressure distribution should be assumed to act on the wall as shown on Figure 9, where the value of the resultant lateral earth pressure "P" is computed as in the case of true hydrostatic pressure. In addition, the sub-basement wall, column 17, should be designed to resist passive pressures exerted by the existing basement wall footing along column line 16.

Excavation for the additional unit should be accomplished in stages following installation of steel H-piles to be used as soldier beams. These soldier beams should be set in prebored holes which should be filled with concrete to the bottom of the excavation. The depth of embedment beneath the bottom of the excavation should be based upon Figure 10. Design of the soldier beams should be based on the pressure distribution given on Figure 9 with an equivalent fluid pressure of 40 pounds per cubic foot. The first stage in excavation should consist of excavating the site with side slppes adjacent to the streets based on Figure II. In no case, however, should the excavation extend below the bottom of the highest existing footing adjacent to the excavation. Several methods are available to support the soldier beams so

Revised 9-23-63
that the sloping berm can be removed. Of the methods available and discussed elsewhere in this report, it is recommended that a construction sequence be devised that will permit the use of the new interior footings, columns, and floor beams as a reaction for the struts, providing lateral support for the soldier beams and wales.

The excavation of the sub-basement adjacent to the existing library is very critical. Considering the problems involved, it is recommended that the wall be located at column line 16 and the existing footing be underpinned. Excavation for and construction of the new wall should be accomplished in sections which are about five feet in length. During construction of this wall careful attention should be given to the lateral support of the existing footing and to the excavations required to gain access to the new wall below the existing footing. If the new wall for the sub-basement is located adjacent to, but not on, the centerline of the existing column line 16, the wall should be designed for additional pressures exerted by the existing footing of column line 16 as indicated by Figure 13, and eccentric loads on the existing footing should be avoided.

Revised 9-23-63

Walter L. Wright
Student Associate