



GEOTECHNICAL AND CONSTRUCTION CONSIDERATIONS FOR A TYPICAL RESIDENTIAL STRUCTURE IN THE HOUSTON METRO AREA 07-06

Introduction

Performance of residential structures depends very much on proper design and construction of the foundations. Soil/structure interaction should always be considered in the design phase of foundations. Adequate quality control and inspection at the time of the construction is as important as proper design of foundations.

The purpose of this work plan is to identify the required design parameters and recommend quality control and inspection requirements for residential structures.

It is recommended that a designer/builder include this work plan in his/her bid to the owner to inform him/her of design/construction requirements, potential problems and liability that can arise from the improper design and construction of foundations. In general, the cost of foundation repair (underpinning) is significantly greater than conducting a proper geotechnical study and maintaining proper quality control at the time of project construction.

Typical Foundations

Foundations for support of residential structures in the Houston area consist of pier and beam type foundation, slab-on-fill supported on piers, conventionally reinforced slab, or a post-tensioned slab. In general, the performance of pier and beam foundations is better than a conventionally reinforced slab or a post-tensioned slab. However, the cost of a pier and beam type foundation is greater.

Geotechnical Design Parameter

The initial foundation design parameters can be developed by performing a geotechnical study of the project site.

The geotechnical studies will include drilling two or more undisturbed sample borings to depths ranging from 15- to 20-feet, laboratory testing and an engineering report. Deeper borings must be drilled in the areas that trees are present or have recently been moved and the subsoils are expansive. The engineering report will include recommendations on site preparation, earthwork, foundation type, depth, allowable loading and Homeowner Maintenance Program. The geotechnical study should also address potential problems with expansive soils, site drainage, the required fill type under the floor slabs, the use of void boxes, and the effect of trees on the foundations.

We recommend that a minimum of two borings be performed at each project site. Past experience indicates that subsoils within a lot can vary significantly. The design soil parameters should be developed on the basis of weaker soil boring conditions to minimize potential foundation settlement.

Construction Considerations

General. Construction monitoring and quality control tests should be planned to verify materials and placement in accordance with the project design documents and specifications. Earthwork observations on the house pad, pad thickness measurements, drilled footing installation monitoring, and concrete placement monitoring should be performed. Details of each of these items are described in the following paragraphs.

Proofrolling Observations. The house pad area should be cleared of all vegetation, roots and any other debris. Then the area should be proofrolled with a sheepsfoot roller or a loaded dump truck to locate any soft areas. These soft areas should be removed and replaced with on-site soils or select fill and recompact or stabilized and recompact.

Earthwork Observations. The subgrade and fill soils under the floor slabs should be compacted to about 95 percent of maximum dry density (ASTM D 698). Furthermore, the fill soils should be non-expansive. Atterberg limit tests should be performed on the fill soils, obtained from the borrow pit, to evaluate the suitability of these soils for use as structural fill and their shrink/swell potential.

Field density tests should be conducted on the subgrade soils and any borrow fill materials in the floor slab and pavement areas. In the areas where expansive soils are present, about 24 to 48-inches of structural fill is placed under the floor slab areas. Laboratory proctor tests will also be performed on the on-site soils as well as off-site borrow fill materials to evaluate the moisture-density relationship of these soils.

Fill Thickness Verification. Fill soils may have to be placed on the lots to raise the lot or to provide a buffer zone in between the on-site expansive soils and the floor slabs. We recommend that the required thickness of the fill be verified after the completion of the building pad. This task can be accomplished by drilling two borings to a depth of five-feet in the building pad area, examining and testing the soils to verify the fill thickness.

Drilled Footing Observations. In the event that the structure is supported by drilled footings, we recommend that the installation of the footings be observed by a geotechnical technician.

The four corner piers of the house should be drilled first to establish the proper footing depth. The technician will conduct hand penetrometer tests on the soil cuttings to estimate the bearing capacity of the soil at each footing location. He will make changes to the foundation depth and dimensions if obstacles, groundwater or soft soils are encountered; therefore, minimizing costly construction delays. In addition, the technician must verify the bell size by a bell measurement tool. Two sets of concrete cylinders (eight cylinders) will be made for each day of pour. Four cylinders will be broken at seven days, and four cylinders at 28 days.

Concrete Placement Monitoring. The concrete sampling and testing in the floor slab and placement areas will be conducted in accordance with ASTM standards. A technician will monitor batching and placing of the concrete. Twelve concrete cylinders will be made for each floor slab pour. Six concrete cylinders are tested at seven days and six cylinders at 28 days.

Cost Estimate

Geotechnical. In general, the cost of a geotechnical exploration for a typical residential structure in Houston ranges from \$720 for two, 15-ft borings and \$960 for two, 20-ft borings. The cost assumes that the site is accessible to a truck-mounted drilling rig. The cost estimate also includes laboratory testing, engineering analyses, recommendations and Homeowner Maintenance Program.

Construction Materials Engineering. The cost of performing quality control work will vary depending on project location and scope of work. We have estimated the required number of hours and testing requirements for the above-mentioned services. The details of our cost estimate are presented on Plate 1. In order to provide the most accurate estimate of the testing and inspection services, the actual construction schedules are necessary. The standard cost of testing and inspection services for this project ranges from 1 to 3% of the total new construction. Services will be billed monthly, with payment due on presentation.

A contractor/designer shall submit this document to the prospective home owner for approval. This will enable the builder to construct a better quality foundation system for the structure with much less liability exposure.

Conclusion

Proper geotechnical and quality control studies for residential projects in the Houston metro area will result in a quality foundation system for the residential structures. This will also significantly reduce potential liability problems to the builders/designers. In general, the cost of performing these studies are minimal compared to the total cost of the project and potential foundation repair costs.

ESTIMATED COST FOR QUALITY CONTROL SERVICES

Services	Unit Price	Unit Measure	Quantity	Cost
<u>Earthwork Testing</u>				
Compacted Subgrade				
Testing (Floor Slabs):				
Proctor Pick-Up/Proofrolling Observations	\$ 40.00	hour	4	\$ 160.00
Standard Proctor and PI Tests	170.00	each	1	170.00
Transportation	45.00	day	1	45.00
In-Place Densities for				
Subgrade Compaction:				
Technician	40.00	hour	4	160.00
Transportation	45.00	day	1	45.00
Nuclear Gauge	45.00	per trip	1	45.00
Compacted Select Fill				
Testing (Floor Slabs):				
Proctor Pick-Up	40.00	hour	4	160.00
Standard Proctor and PI Tests	170.00	each	1	170.00
Transportation	45.00	day	1	45.00
In-Place Densities				
(Three Lifts):				
Technician	40.00	hour	12	480.00
Transportation	45.00	day	3	135.00
Nuclear Gauge	45.00	per trip	3	<u>135.00</u>
Subtotal				\$ <u>1750.00</u>
<u>Drilled Footing Monitoring</u>				
Project Manager	\$ 120.00	hour	2	\$ 240.00
Transportation	45.00	day	2	90.00
Senior Technician	43.00	hour	22	946.00
Technical Typing, Reproduction	35.00	hour	2	70.00
Concrete Compression Tests	13.00	each	8	104.00
Cylinder pick up per trip (2-hrs min. chg.)	40.00	hour	2	80.00
Transportation	45.00	day	1	45.00
Project Manager				
Report Review	120.00	hour	2	<u>240.00</u>
Subtotal				\$ <u>1815.00</u>
<u>Concrete Floor Slab Monitoring</u>				
Technician	\$ 40.00	hour	10	\$ 400.00
Transportation	45.00	day	1	45.00
Concrete Compression Tests	13.00	each	12	156.00
Cylinder pick up per trip (2-hrs min. chg.)	40.00	hour	2	80.00
Transportation	45.00	day	1	<u>45.00</u>
Subtotal				\$ <u>726.00</u>
<u>Project Management</u>				
Project Manager	\$ 120.00	hour	3	\$ 360.00
Typing	35.00	hour	3	<u>105.00</u>
Subtotal				\$ <u>465.00</u>
Estimated Total				\$ <u>4764.00</u>

General Notes

1. Expenses necessarily incurred during the process of work will be charged at cost +15%. Such expenses are:
 - a. Travel, long distance calls
 - b. Preparation, printing, and report reproduction
 - c. Shipping charges for samples and equipment
 - d. Special fees, insurance, permits, etc.
 - e. Subsistence and out-of-pocket expenses.
2. Overtime rates of 1.5 times the regular hourly rate will be charged for hours worked over eight (8) hours on Monday thru Friday, hours worked before 8:00 a.m. and after 5:00 p.m., and all hours worked on weekends. Services performed on holidays will be billed at 2.0 times the regular hourly rate.

All professional rates and transportation charges are on a portal-to-portal basis. Charges for the professional staff will be in setting up and closing out projects, evaluation or analysis of field and laboratory data, report preparation, conferences, telephone conversations and consultation as pertaining to the practice of geotechnical, materials, forensic and environmental services. Special non-listed charges may apply for hazardous waste sites. Court appearances, depositions, etc. will be charged at 1.5 the standard rate.
3. All services billed on an hourly rate are charged at the applicable rate. Report reviews and preparation by technicians and engineers are charged at the applicable personnel rates. Minimum Project Manager report review and technical typing charge is 0.2 hours per report. Minimum technician time per trip is four hours. Minimum charge per job is \$450.
4. All reports are reviewed by a Project Manager. Drilled footing reports are to be reviewed by the Principal Engineer.
5. Trip charges should be added to all services that require transportation. Vehicle charge per trip is \$45 per day. Trip charges are computed at a rate of \$0.75 per mile both ways.
6. Fees include two (2) copies of the report mailed, per the specified distribution list. Reproduction, secretarial time, and mailing cost for additional copies will be billed at a rate of \$1.00 per sheet. Fax service will be at a rate of \$2.00 per sheet.
7. All cylinders must be made and delivered to our laboratory by our technician. In the event that the cylinders are made by the contractor, the cost of breaking the concrete cylinder and reporting will be \$30 each, with a \$200 minimum charge per report, and \$650 minimum per project.
8. Services required in addition to the above (such as failed field density tests that should be repeated) are billed in accordance with the standard fee schedules. A minimum of four density tests will be charged for each density trip.
9. All samples of materials will be discarded 10 days after submission of our report unless the client advises us otherwise. Upon request, we will deliver the samples in accordance with client's instructions, charges collect, or will store them for an agreed charge.
10. All pertinent records relating to services performed hereunder shall be destroyed after completion of the work.
11. Unless otherwise agreed, client will furnish right-of-entry on the land for us to make the planned borings, testing, surveys, explorations and observations. We will take reasonable precautions to minimize damage to the land caused by our equipment, but we have not included in our fee the cost of restoration or damage which may result from our operations. If client desires us to restore the land to its former condition, we will accomplish this and add the cost to our fee.
12. The only warranty or guarantee made by Geotech Engineering and Testing in connection with its services performed hereunder is that we will use that degree of care and skill ordinarily exercised under similar conditions by reputable members of our profession practicing in the same or similar locality. No other warranty, express or implied, is made or intended by our proposal for consulting services or by our furnishing oral or written reports of the findings made.

13. The entire payment is due upon receipt of our invoice. If payment is not received within ten (10) days from the invoice date, Client agrees to pay a finance charge on the principal amount of the past due account of one and one-half percent per month (18% per annum). If one and one-half percent per month exceeds the maximum allowed by law, the charge shall automatically be reduced to the maximum legally allowable. Reasonable attorney fees, David Eastwood hourly charges spent on collections, or any other cost incurred in collecting delinquent accounts will be charged to the client. All sums are due and payable in Harris County, Texas. In the event of any dispute concerning this contract, venue for such dispute shall be in the County and State of GET's principal office location, Harris County, Texas, and shall be determined by binding arbitration conducted by the American Arbitration Association, if and only if, the amount in controversy exceeds the jurisdictional limits of the Small Claims Courts of Harris County, Texas. All disputes not exceeding the Small Claims Court's jurisdictional limit shall be litigated in the Small Claims Courts Precinct 2, located at 107 E. Shaw, Pasadena, Harris County, Texas 77506. By signing this document, the client agrees this will be the venue for the litigation and it will override any other venues.

In the event Client requests termination of the services prior to completion, a termination charge in an amount equal to all charges incurred through the date services are stopped plus any shutdown costs may, at the discretion of GEOTECH ENGINEERING AND TESTING ("GET"), be made. If during the execution of the services, GET is required to stop operations as a result of changes in the scope of services, such as requests by the Client or requirements of third parties, additional charges will be applicable.

14. GET maintains Worker's Compensation and Employer's Liability Insurance in conformance with applicable state law. In addition, we maintain Comprehensive General Liability Insurance and Automobile Liability Insurance with bodily injury and property damage. A certificate of insurance can be supplied evidencing such coverage upon written request. The certificate contains a clause providing fifteen days written notice is given prior to cancellation by the Insurer. Cost of providing such certificate is included in our quoted fees.
15. Client agrees that GET's liability for any damage on account of any error, omission or other professional negligence will be limited to a sum not to exceed GET's fee. If Client prefers to have higher limits on professional liability, GET agrees to increase the limits up to a maximum of \$250,000 (Annual claims made) upon Client's written request at the time of accepting our proposal provided that Client agrees to pay an additional consideration of five percent of our total fee, or \$100.00, whichever is greater. The additional charge for the higher liability limits is because of the greater risk assumed and is not strictly a charge for additional professional liability insurance.
16. The fees included in this proposal do not include costs associated with surveying of the site or the accurate horizontal and vertical locations of tests. Field tests or boring locations described in GET's report, or shown on sketches, are based on specific information furnished by others or estimates made in the field by our technicians. Such dimensions, depths, or elevations should be considered as approximations unless otherwise specified in our report.