TEXAS TRANSPORTATION INSTITUTE

TEXAS HIGHWAY DEPARTMENT

COOPERATIVE RESEARCH

DRILLED SHAFTS
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1. "A Study of The Principal Factors Contributing To The Load Supporting Capacity of Straight Shaft Cast-in-Place Concrete Piles in Clay." Dissertation, Lawrence Addison DuBose, May 1956.

   The results of a research study of drilled and cast-in-place straight shaft concrete piles are presented in this dissertation. The principal factors investigated in this study included water migration from the fresh concrete into soil surrounding the pile, vibration of concrete, protuberances on piles, magnitude of strain necessary to mobilize skin friction, ratio of tension to compression pile load-capacity and distribution of pile load between bearing and skin friction forces. Tests were conducted on both full scale field test piles and small scale cast in a laboratory-compacted cube of soil.

   There was no evidence that an appreciable quantity of water migrated from fresh concrete into the soil surrounding the piles. Tests were conducted to evaluate the effect of time, pile diameter, hydrostatic head, initial water content of the soil and degree of rodding the fresh concrete. Load tests indicated that the pile load-supporting capacity was not increased by vibrating the fresh concrete. It was possible to increase the load-supporting capacity of a straight-shaft pile by cutting collars along the shaft. The test data indicated that the tension load-capacity of a straight-shaft pile was between ½ and 2/3 of the compression load-supporting capacity. Test data were consistent in showing that the major portion of the pile load capacity was resisted by skin-friction forces. It was possible to mobilize the skin friction forces with a small amount of pile deformation.

2. "A Comprehensive Study of Factors Influencing The Load Carrying Capacity of Drilled and Cast-in-Place Concrete Piles" Lawrence A. DuBose, Part I and II, Research Project Report between TTI and Texas A & M College System, 1956.

   The purpose of this report is to present the data from Research Project-4 to the Texas Highway Department. The data have been processed to a usable form which will permit members of the Highway Department to re-evaluate the results and conclusions, if desired. In most instances, the repetition of discussions presented in previously published papers have been avoided.

   The results of Research Project-4 have been prepared as two reports. The material presented in this report represents Part I of the final report for this study. The following sections are included in Part I:

Section I - Field Exploration and Soil Test Results

Section II - SR-4 Gages and Pressure Cells

Section III - Compression Load Test Results on 7- and 8- Inch Diameter Piles

Section IV - Compression Load Test Results on 10 foot Effective Length Straight Shaft Piles

Section V - Compression Load Test Results on 13- and 14- Inch Diameter Straight Shaft Piles

Section VI - Compression Load Tests Results on Underreamed Piles

Section VII - Compression Load Test Results on Specially Placed or Designed Piles

Section VIII - Tension Load Test Results on Straight Shaft Piles

Section IX - Summary

3. "Investigation of Bearing Capacity of Some Bored and driven Piles in London Clay" G. G. Meyerhof, L. J. Murdock, Geotechnique 3: n 7, Sept 1953, p 267-82.

   Soil investigation and loading tests made to study bearing capacity and settlement; description of sites and soil properties; driving of precast concrete piles; test results and their analysis.

4. Pile Foundations Theory--Design--Practice R. D. Ghellis, Mc-Graw-Hill Book Co., New York, Toronto, London, 1951, 681 p illus., diagrs., charts, tables, $12.50.

   Design, driving and maintenance of pile foundations; relations between borings and soil mechanics and pile foundations, determining pile capacities from driving resistances and friction values, selection of driving rigs, choice of pile type, evaluations of piles and sheet piling, structural design of piles, factors causing deterioration. Eng Soc Lib, NY.

5. "Drilling Holes For Timber Piles in Hard Sea Bed" C. M. Willington and D. M. Watson, Commonwealth Engr 38: n 11, June 1951, p 448-51.

   Improvement of shipping facilities at Port Victoria, Australia, necessitated extension of wharf by 90 ft. which required setting of 20 timber piles, 11 in. in diam; hard limestone of sea bed was drilled, piles were set by diver into 5 to 10 ft deep drilled holes and then driven.

6. "Bridge Foudation of 340-ft depth" Western Construction News 25: n 4, Apr. 1950, p 96-7.

Distance of 300 ft. between highwater level and bedrock at bridge site in northern Idaho required foundation made up of towers, 30 ft square; 24-inch steel cylinders at each corner of towers are braced by steel diagonals; 18-in. steel supporting column.

7. "New Form of Bored Pile, R. Glossop and I. S. Greeves. Concrete & Constr Eng 41: n 12, Dec. 1946, p 344-51.

Review of bearing piles from point of view of load transmission, and construction; illustrated description of new type of bored piles; comparison of bored and driven piles; data on loading tests.

8. "Texas Bridge Footing Shafts Drilled and Underreamed" J. P. Exum Roads & Streets 89: n 3, Mar 1946, p 90-1.

Illustrated description of foundation of South Concho River Bridge in San Angelo, Texas; hole was drilled down to limestone and footings bearing then reamed to proper size; 30-in. steel casing was placed in hole and driven into underlaying soft shale, sealing off groundwater; prefabricated steel column was set and concrete placed.

9. "Reinforced Concrete Piles in Foundations" P. G. O'Rourke, Inst Civ Engrs Ireland-Trans 66: 1939-40, p 41-67 (discussion) 68-79.

Review, with special reference to cast-insitu driven pile, bored piles, and precast concrete piles; tests of site; selection of size of pile; determination of set; head stresses on piles; selection of hammer and calculation of set; Hiley's pile driving formula.

10. "Holes pre-bored for Underpass Falsework" Eng New-Rec 124: n 19, May 9, 1940, p 82-3.

Methods and equipment used in preboring of holes for pile foundation of underpass under three tracks of Baltimore Ohio and Chicago Terminal by at Argo near Chicago, where hard clay and shale formation precluded driving of piles in ordinary manner.

11. "Model of Test Borings" H. D. Hammond Eng News-Rec 121: n 15, Oct 13, 1938, p 476.

Construction of three-dimensional models showing graphically conditions disclosed by test borings for exhibit building being erected for General Motors at New York World's Fair, 1939.

12. "Drilled, reamed holes for bridge foundation piles" J. W. Beretta, Eng News-Rec 118: n 6, Feb 11, 1937, p 217-8.

Construction of pile supports for continuous solid slab bridge across San Pedro Creek in San Antonio, Tex; holes for 18-in.

circular piles were excavated by modified gasoline rotary weld drilling rig mounted on old truck chassis; steel pipe with 3/8 in walls and welded seams, driven several inches into clay, served as casing for reinforced concrete piles cast in place.

13. "Large Diameter Bored Piles" M. J. Tomlinson, Engineer 211: n 5484, Mar-Apr 1961, p 549-550.

Over the last ten years the use of large diameter (i.e. 30 in or over) bored piles in Britain has increased to a considerable extent, particularly over the last two or three years. This is due to two main reasons; first, to the present-day tendency to build high, with consequent increase in column loads of framed structures; and, second, to the development of efficient mechanical rigs for boring large diameter holes to depths of up to 200 ft. There is nothing new in large diameter deep foundations. They were used in Chicago and New York nearly seventy years ago to take the foundations of skyscrapers down through deep deposits of sands and clays to rock. The only difference is that these earlier deep foundations employed mainly hand methods of excavation within concrete or steel caissons or in timbered shafts. The well-known "Chicago Method" developed by William Sooy Smith (1830-1916) uses vertical timber sheeting supported by circular steel walings.

14. "Loading Test On Large Bored Piles in Clay" G. P. Manning, Concrete & Constructional Eng LIX: n 1, Jan 1964, p 28.

All the results of loading tests on bored piles, which I have seen, appear to me to be incomplete. With a driven test-pile, the resistance encountered throughout the entire depth is recorded and this is a great help in interpreting any subsequent redriving or static test loading. The test loading of a bored pile, as normally carried out, is a comparatively blind operation and not very convincing. The traditional outlook on the bearing capacity of a bored pile is that it oonsists partly of end-bearing and partly of skin friction. This is obviously not the whole story, and more exhaustive testing and a wider outlook are needed if we are to have a clearer view of the problem.

15. "Some Tests on Bored Piles in London Clay" H. Q. Golder and M. W. Leonard, Geotechnique (London) 4: n 1, pp 32-41, March 1954.

The paper discribes and gives the results of three loading tests carried out on bored piles constructed in the London clay at Kensal Green Gas Works. Two of the tests were carried up to the ultimate load of the piles. During the boring for the piles samples of clay were taken for tests, and in two of the borings, loading tests were carried out on plates placed at the bottom of the boring at three different depths.

Further strength tests on clay from the same site are quoted, and a correlation is made between the shear strength and the loading tests on piles do not agree with the value given by the Meyerhof-Murdock Formula.

Further loading tests on bored piles in London clay at other sites are quoted in which the test load satisfactorily carried (not the ultimate given load) is considerably higher than the ultimate given by Mererhof and Murdock.

16. "Some Loading Tests to Failure on Piles" H. Q, Golder, Proc 3rd Internat Conf Soil Mech 1953, 2, 41-6.

Four main types of pile (driven precast, driven in situ, bored precast and bored in situ) and four main catagories of soil (clay, sand, gravel and soft rock) are recognized. Tabulated data are presented and include information on soil properties, type of pile, driving record, loading test, and calculated bearing capacity. Dynamic and static methods of estimating ultimate bearing capacity are discussed.

From the test figures given it is tentatively concluded that: (1) The dynamic formulas considered tend to cause uneconomical design but may sometimes be unsafe. (2) The deep sounding method as used in Holland cannot be applied to gravels without modification owing to the marked variations in resistance which are obtained. The application of this method in clays deserves further investigation. (3) In gravel, the static formula can only be used to give safe lower limit of bearing capacity, but this is not so for sands. (4) The static formula may prove fairly reliable in clays when a better estimate of the skin friction in gravel overlying the clay becomes available. (5) There is some indication that for clays the ratio of point resistance per unit area to shear strength may be greater than the theoretical value. (6) The tests give some evidence that the allowable shear strength to be used in calculating skin friction on the shaft of a bored pile in clay is about half the unconfined-compression strength.

17. "Frictional Resistance of Bored Piles in Expansive Clays" Dinesh Mohan, Geotechnique 11: n 4, pp 294-301, December 1961.

A series of loading and pull-out tests were carried out on cast-in-situ bored concrete piles in highly expansive clays (black cotton soils) at four different sites in India. It was found that the frictional resistance has the same value in pushing and pulling and is about half the average shear strength of the soil along the pile shaft.

18. "Small-scale Load Tests on Drilled and Cast-in-Place Concrete Piles" L. A. DuBose, Nat'l. Research Council--Highway Board Proc 36: 1957, p 132-45.

In a laboratory investigation carried out at the University of Alabama, cubes of compacted medium plastic clay were used in studies of water migrations and small-scale load studies of piles. Auger holes, 2½ to 3½ in. in diameter and 16 to 18 in. long, were drilled in the cubes and filled with concrete. Several days after the piles had been placed the soil cube was sliced open and samples taken for moisture content determinations. For various experimental conditions it was found that there was little migration of water from the fresh concrete to the surrounding soil when the moisture content was not below the plastic limit, but when the soil was compacted with an initial moisture content of about 12 per cent (5 per cent below the plastic limit) significant migration occurred. In the load tests it was found that; (1) The compression load supporting capacity of small pile was approximately equal to the pile surface area multiplied by half the unconfined compression strength of the soil. (2) The deformation needed to mobilize skin friction was comparable to the shear displacement necessary to mobilize the shear strength of the soil in a direct shear test. (3) The tension load-carrying capacity of a pile was about two-thirds of its compression load carrying capacity. (4) During a test, the soil was deformed about 1 inc. from the pile surface and the failure surface was about ¼ in. from the pile surface. (5) Pressure cells at the base of a pile showed that the end-bearing portion of the load was not developed until after skin friction forces had been fully developed.

19. "Report on Loading Tests on a Large Diameter Underreamed Bored Pile" W. G. K. Fleming & T. H. Salter. Civil Engineering and Public Woks Rev. (Great Britain 57: n 675, Oct. 1962, p 1280-1281.

Prior to construction of piled foundations on a site in London, contractors were instructed to test a pile of 500 tons working capacity. Primary purpose of test was to obtain information about settlement behavior of pile in working load range.

20. "Deep Bored Cylinder Foundations" Road & Road Construction 42: n 493, Jan. 1964, p 24-25.

Many recent structures in London have been supported on deep piers or cylinders founded in London Clay. These foundations have been constructed by drilling holes, generally 3 ft to 5 ft. in diameter and up to 90 ft. deep, with mechanical augers, usually enlarging the base to between two and three times the shaft diameter by undercutting, and filling the hole with concrete.

Foundations of this type carried to rock. Compact gravel and similarly strong bearing soil have been used for many years but their use in clay represents a new feature.

There are many years of experience of the behaviuor of bored cast-in-place piles of the usual dimensions but there is no accepted method of design for a deep cylinder foundation with or without an enlarged base in London Clay, although it may be regarded as a special form of bored pile.

The Building Research Station commenced a model study of this type of foundation at the time when the design and construction of the foundations for the Shell Building on South Bank were attracting attention. One of the principal objects of them was to determine the proportions of the load carried by the shaft as skin-friction and by the base, and for this purpose a load cell was incorporated in each model to measure the base reaction.

21. "Foundations sur Pieux" H. Lossier, Genie Civil 136: n 20, Oct. 15, 1959, p 405-14.

Foundations on piles; review of present knowledge on subject; several European applications; role of soil conditions, ground-water, nearby structures, and structural requirements; use of drilling for large diameter piles; Hammer-grab, Benoto, and Soletanche drilling methods and machines.

22. "New Piling Method Cuts Noise and Costs at Same Time" Roads & Eng Construction 98: n 4 Apr 1960, p 90-1.

Construction firm working on joint venture job on Toronto subway devised unusual method of placing piles by boring holes in ground and dropping steel piles into holes thus avoiding noise and vibration; giant auger, used for pre-boring piles holes, is mounted on Lorain L58A crane; turntable which drives auger is driven by 65-hp Continental Red Seal engine through marine oil transmission with 3 to 1 reducer.

23. "Essais Statiques de Pieux" L. Carpentier, Construction 15: n 6, June 1960, p 252-62.

Static testing of piles; testing of drilled piles of 357 ft long railroad viaduct near Bordeaux; required safety load was one and half times working load (70 tons); observed subsidence was 5 mm under 105 tons; two special piles were subjected to same load tests and also to extraction tests; stresses were transferred to special penetrometer setup for this purpose; formulas for friction calculations; comparison with driven piles.

24. "Pile Loading Tests on Underreamed Bored Pile" W. G. K. Fleming, W. W. Frishmann, Civ Eng (Lond) 55: n 650, Sept. 1960, p 1151-2

Pile Test was conducted to determine strength/depth relationship for London clay; results concerning shaft friction and load settlement relationship are given.

25. "Pile Drilling Replaces Driving" Construction Methods & Equipment 41: n 4, Apr 1959, p 127-8.

Construction of foundation of Royal Orleans Hotel in New Orleans, La., by pile drilling method to 60 ft. below street level, in order to prevent damages in surrounding buildings; clay soil was stiff enough to hold walls of holes until piles could be inserted; caving-in of sand layer was prevented by mud lining of hole; piles were driven last 10 ft in sand; passing trucks on street gave higher siesmograph readings than piling operation.

26. "Unique Bridge Construction Across Connecticut River " G. Linberg, Explosives Engr 34: n 3, May-June 1956, p 88-90.

Placing concrete foundations in rock under 20 ft of water for construction of bridge piers at Hartford, Conn; frame of angle trusses oovering entire pier area; two T-500 Joy drills with extended masts mounted on rails; when excavation was completed drill frame was floated into position on pontoons; four 14-in H-beam spud piles placed in spud wells fastened to frame and driven to solid rock.

27. "Paper Forms Solve Tough Foundation Problem" E. L. Scruggs, Eng News-Rec 153: n 24, Dec 9, 1954, p 58.

Construction of 2-story warehouse for Springs Cotton Mills, Lancaster, SC; site was filled material, water table was within 4 ft of grade, but 10 to 15 ft below grade was good rock stratum; concrete piles were founded on rock by using hole boring machine with 20 in. diam auger to excavate to rock then quickly dropping 16 in. diam heavy paper form into hole which was then filled with concrete.

28. "Dual-purpose Pile Cut Building Costs" H. T. Perex, Construction Mehtods & Equipment 36: n 5, May 1954, p 54-7.

Sides of building excavations of 21-story South Texas National Bank Building, and Club Building, Houston, are supported by cast-in-place concrete piling; piles, 20 in. in diam, are poured in uncased drilled holes on 3-ft. centers; later they become part of permanent basement wall by guniting between and over piles.

29. "Laterial Friction of Drilled Piles and of Piles rammed Into Blue Clay" S. Rodin, J. Tomlinson, La mechanique des sois et las force portante des pieux. Annales de l'Institut Technique du Batiment et des Travaux Publics 6: n 63-64, Mar-Apr 1953, p 283, 289.

Symposium on Soils Mechanic and Bearing Capacity of Piles.

30. "Large-diameter Piles" L. E. Hunter, Concrete & Constr Eng 49: n 5, May 1954, p 165-8.

Pile foundation developed in France by removing soil from large diameter (3 to 5 ft.) tubes, later filled with reinforced concrete and then generally withdrawn; method known as Benoto system, comprised patented hammer grabs operating inside tube; method is particularly suitable when loads are very heavy; at Corbusier apartment building, Marseilles, each pile is loaded with 666 tons.

31. "Investigation of Foundations By Seismic Method", D. I. Gough, S African Instn Civ Engrs--Trans 3: n 2, Feb. 1953, p 61-70.

New method of seismic investigation; comparison between results obtained by drilling, resistivity method and those obtained by seismic method.

32. "House Foundations; short-bored Pile" W. H. Ward, H. Green, Civ Eng (Lond) 47: n 557, Nov. 1952, p 928-30.

Method of foundation construction suitable for two-story houses and other light buildings, such as one and two-story schools, which consists of number of concrete piles cast in holes bored by mechanical or hand augers to depth of 10 ft. and more and distributed under walls; piles support reinforced concrete beam which may form part of ground floor slab; it serves to tie tips of piles together and to distribute building loads to piles.

33. "Foundation Repair Saves Texas Sawmill" R. J. Brentzel, Civ Eng NY 22: n 2, Feb. 1952, p 38-9.

Settlements of sawmill at Voth, Tex., necessitated construction of new foundation; drilled holes and cast-in-place concrete footings about 30 in. in diam were chosen in order to avoid vibrations inherent in driven piles; illustrated description of work.

34. "Reprise en Sous-oeuvre de deux monuments Historiques," a Lille, R. Gordon, Technique des Travaux 24: n 11-12, Nov-Dec 1948, p 378-84.

Underpinning of two historical buildings in Lille:Rihour palace and St Maurice church; procedure using piles and lifting jacks; 87 Mega piles 25 cm in diam used for palace foundation, carrying from 35 to 40 tons each; church underpinning performed with Forum piles, 40 mm in diam, drilled down to chalk formation and Mega piles; safety required obtained by charging piles by hydraulic jacks.

35. "Un Nuevo Procedimiento Para La Construccion de Pilotes de Hormigon Armado "In-Situ", S. Montagut Cuadrat, Revista de Obras Publica 97: n 2812, Aug 1949, p 378-83.

New process for construction of concrete piles in place; features of method devised by author and protected by Spanish "Capblanch" patent; holes are bored with any type of perforating machine and water is expelled by injecting compressed air; concrete is placed in lock compartment, valve is closed, and concrete is rammed into place as lock compartment is refilled successively.

36. "Deep Caissons Support River-Side Power Plant" C. B. Spencer, Civ Eng (NY) 14: n 2, Feb. 1944, p 67-8.

Building of Williamsburg station of Pennsylvania Edison Co. is carried on concrete footings bearing on firm clay about 10 ft. below grade; borings made for extension to plant showed that shale underlaying firm clay fell away rapidly on new site; foundations were extended by drilling through boulders and shale into rock; 16 drilled-in caissons were installed for support of 6 columns and 100 lin ft. of wall.

37. "Modern Piling Methods" R. Hammond, Civ Eng (Lond) 36: n 421, July 1941, p 508-14.

Relative merits of precast and cast-in-place piles; review of various types of work and methods employed to carry them out.

38. "Foundations of Mississippi River Bridge at New Orleans" W. P. Kimball, Civ Eng (Lond) 34: n 400 Oct. 1939, p 369-70.

Discussion of results of deep boring tests of pier foundations of steel truss bridge 4½ mi long; sand movement; settlement predictions; yield and compaction; skin friction. Before Brit Am Eng Congress.

39. "Probing for Bridge Foundations" N. R. Sack, Eng News-Rec 123: n 15, Oct 12, 1939, p 69-72.

Practical methods and tools developed by Missouri highway department for subsurface exploration for bridge foundations; tools and operating procedure; hand augers; sounding rods; churn drilling outfit; core drill practice; servicing equipment.

40. "Effect of excavation on settlement of buildings" K. Terzaghi Civ Eng (Lond) 34: n 400, Oct. 1939, p 370-1.

Brunner method of bored concrete piles; method uses usual water filled boring tubes, but has special technique for concreting; concrete is carried by cylindrical holder, freely movable within tube, provided with alligator head; jaws open automatically for discharge at contact and secure continuous concrete filling; up and down agitated and successively withdrawn boring tube secures good compacted.

46. "Bohrpfaehle and Pfahlwaende System "Benoto", H. Bucher, Schweiz Bauzeitung 79: n 5, Feb. 2, 1961, p 66-70.

Drilled piles and pile walls by Benoto system; new French method can drill holes to 50 m depth into soil by up and down movement of hydraulic hammer-driven bore tube; concrete is placed within tube and is compacted by slight up and down movement of tube; at least 10 m long sections are filled with concrete before with-drawing corresponding length of tube; aspect of load bearing capacity of piles.

47. "Pressbeton-Bohrpfaehle System "Hochstrasser-Weise", R. Ledergerber, Schweiz-Bauzeitung 79: n 7, Feb. 16, 1961, p 108-11.

"Hochstrasser-Weise" system of bored and pressure grouted piles; method used boring tube with top mounted driving head, compressor and grouting equipment, and service crane; concreting under pressure of compressed air is made by pulling back tube successively; if reinforcement is needed it is inserted before application of grout; applications of method in Germany and Switzerland; bearing capacity calculations.

48. "Pieux Fores et Ecrans en Piles Secants Suivant Le Procede Benoto," H. Buchar Bul Technique de la Suisse Romande 87: n 5, Mar 11, 1961 p 53-9.

Bored piles and "secant" pile curtains of Benoto method; French Benoto method uses "Hammergraph" borer based on bucket excavating principle and weighting up to 3000 kg conforming to size of bore; it operates wither in dry or waterfilled holes; in "secant" piling, one pile cuts into bore of other pile, and is driven by "tubeuse" machine; various applications are described including 30 m deep 1.5 m diam piles in Le Havre harbor.

49. "The Influence of Soil Mechanics Techniques on The Choice of Equipment for Sampling and Testing" R. Glossop and A. C. Meight, Publ Wks Munic Services Congr., 1962, Final Report, 453-64; Discussion 465-74.

The paper reviews site exploration methods including accounts of boring and sampling equipment, in-situ testing methods, and laboratory testing. It indicates how the equipment used affects the reliability of the information obtained.

50. "Soil Drilling by Vibration" B. M. Gumenskii and N. S. Komarov, Authorized translation from the Russian: Published by the Ministry of Municipal Services of the RSFSR in Moscow in 1959. Consultants Bureau , 1961 80 p.

A very promising new type of geological exploration tool, vibrodrilling in soils, has been introduced in recent years into the field of engineering-geological investigations. As tests on the vibrodrilling have shown, the technique is suitable for engineering geological investigations on construction areas and on railroad and highway beds, and in prospecting and exploring for construction material and other mineral deposits. Vibrodrilling may be especially effective when drilling holes for heat treatment of the soil, for the setting of sand piling, for horizontal and vertical drainage, and for treatment offills in earthern railroad beds; that is, for those circumstances when a precise geologic section is not required...

51. "Crane attachment Drills 100-ft Caissons in 4 hr." Construction Equipment and Materials 27: n 3, March 1963, p 73-74.

Washington State Highway Dept. to save half-a-million dollars on interchange between Evergreen Point and bridge across Lake Washington by this method of predrilling caissons for foundation piles.

52. "Preboring Helps drive large Thin-shell Prestressed Piles" H. K. Glidden, Roads & Streets 106: n 2, Feb. 1963, p 64-67.

Roanoke Expressway across a peat bog skirting University of Washington Arboretum in Seattle.

53. "Drilling Experts Develop Tools to Speed Caisson Work" Ralph E. Juergens, Construction Methods & Equipment 45: n 1, Jan 1963, p 80-83.

54. "Piles are Driven In Pre-Drilled Holes to Cut Nois" Construction & Method & Equipment 44: n 5, May 1962, p 177.

55. "Some Pile Loading Tests in Stiff Clay, K.Y. Lo and A. G. Stermac Canadian Geotechnical Journal (Civ Engineering Dept., Univ. of Toronto, Toronto 5, Ont.), v 1, n 2, pp 63-80, March 1964

Loading tests on two timber piles and a Frinki pile, embedded principally in a stiff clay, were carried out. Analysis of the results appear to indicate that the adhesion of the piles is the fully mobilized undrained shear strength of the clay. Reasons for this apparent anomaly with data reported in the literature are suggested.

Pore water pressures set up in the soil adjacent to the piles during load testing were very small and calculations in terms of effective stresses indicated that the ratio of horizontal to vertical effective stress at failure is approximately 1.2.

56. "Lateral Resistance of Piles in Cohesive Soils" Bengt B. Broms, Journal of the Soil Mechanics and Foundations Division American Society of Civ Engineers v 90, n SM2, Proc Paper 3825, pp 27-63, March 1964

Methods are presented for the calculation of the deflections at working loads, the ultimate lateral resistance, and moment distribution for laterally loaded single piles and pile groups. Both unrestrained and restrained piles have been considered. The laterial deflections have been calculated using the concept of a coefficient of subgrade reaction. The ultimate lateral resistance has been evaluated. The results from the proposed methods of analysis have been compared with available test data. Statisfactory agreement was found at working loads between measured and maximum bending moments.

57. "Effect of Shape and Volume on The Capacity of Model Piles in Sand" E. I. Robinsky, W. L. Sagar and C. F. Morrison, Canadian Geotechnical Journal v 1, no. 4, pp 189-204, Nov. 1964.

Load tests were performed on instrumented model piles, both straight sided and tapered, driven into standard Ottawa sand in both loose and medium dense states. The distribution of load between pile points and wells and the overall pile capacity at various depths of embedment were studied. Tests revealed continuous changes in the intensity of unit load transfer through the walls as the piles were advanced. These changes, as well as the limited ability of the straight-sided piles to transfer large loads through their walls, are presumed to be the result of the development of a system of arching in the sand surrounding the piles. The most interesting, and as yet unexplained, results obtained in these tests revealed that for all piles, straight-line relationships exist between embedded pile volumes and their capacities.

58. "Prediction of Pile Capacity by the Wave Equation" P. W. Forehand, J. L. Reese, Jr., Journal of the Soil Mechanics and Foundations Div. - Proc of the Amer Soc of Civ Engrs. v 90 n SM2 March 1964 p 1.

The use of the wave equation method of pile driving analysis of predicting the ultimate bearing capacity of a pile is investigated. Development of the method is traced, and the validity of the mathematical model proposed by E. A. L. Smith is examined. The method of representing ground resistance is shown to be reasonably consistent with experimental findings of others for the resistance developed in a soil due to high rates of loading. Values of ground damping to be used for various soils are derived from published reports; these values result in correlation of pile driving records and load tests using the wave equation method and values of ground quake reported in the literature. The results of correlation efforts for 24 piles driving records and load tests are summarized. It is concluded that additional research is necessary, but that the wave equation method of analysis promised to become an accurate and general method to be used in conjunction with other factors for predicting the ultimate bearing capacity of a pile from its dynamic behavior under the last hammer blow for all combinations of driving equipment, pile, and types of soil.

59. "Lateral Resistance of Piles in Cohesive Soils" Bengt B. Broms, Journal Soil Mech and Foundations Div - Proc of the Amer Soc of Civ Engrs. v 90 n SM2 p 27, March 1964.

Methods are presented for the calculation of the ultimate lateral resistance and lateral deflections at working loads of single piles and pile groups driven into saturated cohesive soils. Both free and fixed headed piles have been considered. The ultimate lateral resistance has been calculated assuming that failure takes place either when one or two plastic hinges form along each individual pile or when the lateral resistance of the supporting soil is exceeded along the total length of the laterally loaded pile. Lateral deflections at working loads have been calculated using the concept of subgrade reaction taking into account edge effects both at the ground surface and at the bottom of each individual pile.

The results from the proposed design methods have been compared with available test data. Satisfactory agreement has been found between measured and calculated ultimate lateral resistance and between calculated and measured deflections at working loads. For design purposes, the proposed analyses should be used with caution due to the limited amounts of test data.

60. "Analysis of Pile Groups with Flexural Resistance" Arthur J. Francis Jour Soil Mech and Foundations Div - Proc of the Am Soc Civ Engrs. v 90 n SM3 May 1964 p 1.

A procedure is presented for the analysis of groups of piles subjected to loading in one plane, both when the piles are assumed to be pinned at both head and tip, and also when the flexure of the piles and the lateral resistance of the ground is taken into account.

The resistance offered to the flexure of piles by soil of uniform stiffness and by soil whose stiffness is proportional to depth below the surface is calculated, and the effective depth to fixity is determined for piles with various depths of embedment and umembedded lengths. Information is given on methods of estimating the lateral resistance of given soils, and on the stability of partially embedded piles. An illustrative example is included.

61. "Lateral Resistance of Piles in Cohesionless soils" Begt B. Broms, J of the Soil Mech and Foundations Div - Proc of the Am Soc of Civ Engrs., v 90, n SM3, May 1964, p 123.

Herein methods are presented for the determination of lateral deflections at working loads and the ultimate resistance of laterally loaded piles driven into cohensionless soils. The lateral deflections have been computed assuming that the coefficient of subgrade reaction increases linearly with depth. The evaluation of the coefficient of subgrade reactions is discussed and the calculations lateral deflections are compared with available test data.

The ultimate lateral resistance of laterally loaded piles has been assummed to be governed by the lateral resistance of the surrounding cohesionless soil or by the yield or ultimate moment resistance of the pile sections. It has been assumed further that the ultimate lateral resistance of a cohesionless soil is equal to three times the Rankins passive pressure. The calculated ultimate lateral resistances are compared with available test data. Satisfactory agreement is found between measured and calculated values.

62. "Thrust Loading On Piles" James F. McNulty, Journal Soil Mechanics and Foundations Division, Proc Am Soc of Civ Engrs. v 82, n SM2 Paper 940, page 940-1, April 1956.

Lateral load tests were performed on two separate projects for the National Advisory Committee for Aeronautics, Langley Field, Virginia. The first project utilized concrete cast-in-place piles, heads not fixed, embedded in a medium dense silty-sand. The second project employed fixed-end timber piles embedded in a medium sandy clay. The field data and an approximate method of analysis are presented and discussed. Graphs of a preliminary nature indicating the relationship between deflection and load for various soil conditions are included.

63. "Analytical Approach to Bearing Capacity and Settlement of Large Diameter Bored Pile" N. B. Hobbs, Instn Civ Engrs-Proc 25: 177-82 June 1963.

Results of study on immediate settlement load relationships of single pile on assumption of elastic-plastic relationship between safety factors on base and shaft resistance; base resistance depends on Young's modulus; safety factor depends on shear strength of ground and varies in direct proportion with base diameter; increase of shaft diameter will not necessarily result in increase of shaft resistance; enlarge base of large diameter piles will not be more effective than using extra concrete in longer shaft if settlements are to be restricted.

64. "Problems, Limitations, and Applications of Cast-in-Situ Bored Piling" B. C. Hadfield, New Zealand Eng 17: 315-26, Sept. 15, 1962.

Methods of piling developed in New Zealand and comparative advantages are dependent on subsoil conditions; use of bored piles in construction of bridges, car parking building and foundations for bridges, portland cement silos and packhouse; drilling and casing methods, sealing of casings and pressure granted below completed piles are discussed among other construction techniques.

65. "Reports on Loading Tests on Large Diameter Underreamed Bored Pile" W. G. K. Fleming, Civ Eng (Lond) 57: 1280-1, Oct. 1962

Pile of 500 tons working capacity was tested prior to construction of piled foundation on construction site of new West London Air Terminal; since primary purpose of test was to obtain information about settlement behavior of pile in working load range, it was decided to restrict test load to approximately one and half times working load; results, regarded as very satisfactory, indicate that "immediate" settlement of pile as tested, would be of 0.45 in.

66. "Bored'n Poured Piles, Texas Style" Roads and Streets 107: 60 - 1 + March 1964.

Bored pile construction method used for building open type reinforced concrete piers for 4000 ft. long twin freeway bridge in Dallas; . . . which carries 8 lane segment of 1-20 over rail yards and local streets; work was to sink 380 drilled shafts of 36 in. diameter to 55 or 60 ft. depth to support 66 pier bends and abutments; no stream sites or wet surface conditions were involved.

67. "Deep Bored Cylinder Foundations in London Clay" Surveyor 123: 26, Jan. 11, 1964.

Investigation of deep cylinder foundations in London clay; experiment comprised construction and load testing of 13 foundations covering range of sizes 2, 2.5, and 3 ft. diam, 30, 40, 50 ft. deepth, with and without enlarged bases; load cell developed for investigation consists of steel pillars welded between pair of steel plates; compression of pillars under load is measured by strain gages; testing of foundations is described.

68. "Hand-dug Holes Finish Caissons for Office Buildings Over Tracks" Eng News-Rec 172: 44-5 Apr. 16, 1964.

With 60,000 passengers/day traveling under train sheds, hand digging methods sank 64 caisson holes to hardpan for first building in Chicago's Gateway Center; machine digging was used for 56 caisson holes of smaller diameter.