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ABSTRACT

The United States Training and Employment Service General Aptitude Test Battery (GATB), first published in 1947, has been included in a continuing program of research to validate the tests against success in many different occupations. The GATB consists of 12 tests which measure nine aptitudes: General Learning Ability; Verbal Aptitude; Numerical Aptitude; Spatial Aptitude; Form Perception; Clerical Perception; Motor Coordination; Finger Dexterity; and Manual Dexterity. The aptitude scores are standard scores with 100 as the average for the general working population, and a standard deviation of 20. Occupational norms are established in terms of minimum qualifying scores for each of the significant aptitude measures which, when combined, predict job performance. Cutting scores are set only for those aptitudes which aid in predicting the performance of the job duties of the experimental sample. The GATB norms described are appropriate only for jobs with content similar to that shown in the job description presented in this report. A description of the validation sample is also included. (AG)

TECHNICAL REPORT

ON

STANDARDIZATION OF THE GENERAL APTITUDE TEST BATTERY

FOR

SURVEYOR (profess. & kin.) 0-64.10

~~B-619~~ S-339

U. S. Employment Service in
Cooperation with
California State Employment Service

April 1965

GATB# 2546

STANDARDIZATION OF THE GENERAL APTITUDE TEST BATTERY

FOR

SURVEYOR (profess. & kin.) 0-64.10

B- 619

Summary

The General Aptitude Test Battery, B-1002B, was administered to a final sample of 62 men employed as Surveyor (profess. & kin.) 0-64.10 at 30 firms in the San Francisco Bay Area in California. The criterion consisted of supervisory ratings. On the basis of job analysis data, mean scores, standard deviations, correlations with the criterion, and their combined selective efficiency, Aptitudes N-Numberical Aptitude, S-Spatial Aptitude, Q-Clerical Perception, and K-Motor Coordination were selected for inclusion in the test norms.

GATB Norms for Surveyor (profess. & kin.) 0-64.10, B-619

B-1001			B-1002		
Aptitude	Tests	Minimum Acceptable Aptitude Score	Aptitude	Tests	Minimum Acceptable Aptitude Score
N	CB-1- D CB-1- I	115	N	Part 2 Part 6	110
S	CB-1- F CB-1- H	105	S	Part 3 Part	100
Q	CB-1- B	95	Q	Part 1	95
T	CB-1- G CB-1- K	75	K	Part 8	80

Effectiveness of Norms

The data in Table IV indicate that only 60 percent of the non-test-selected workers used for this study were good workers; if the workers had been test-selected with the above norms, 88 percent would have been good workers. 40 percent of the non-test-selected workers used for this study were poor workers; if the workers had been test-selected with the above norms, only 12 percent would have been poor workers.

TECHNICAL REPORT

I. Purpose

This study was conducted to determine the best combination of aptitudes and minimum scores to be used as norms on the General Aptitude Test Battery for the occupation of Surveyor (profess. & kin.) 0-64.10.

II. Sample

The GATB, B-1002B, was administered between November 10, 1962 and March 11, 1964 to 74 male party chiefs. Of these, 12 were eliminated because their major job duties did not agree with those described for the sample or because valid test results and criterion ratings could not be obtained. Therefore, the final sample consisted of 62 men employed as Surveyor (profess. & kin.) 0-64.10.

The sample was obtained through the cooperation of the Joint Apprenticeship Council for Operating Engineers. Surveyors in the sample were employed by the following 30 engineering and surveying firms in the San Francisco Bay Area in California.

Name of Firm	Location
Bond & Dougherty	Vallejo
Bowman & Williams	Santa Cruz
Bryan & Murphy	Berkeley
Carlos E. Gonzales, Inc.	San Rafael
Charles W. Davidson	San Jose
Dan Coleman Associates	San Francisco
G. A. Fitch	Concord
Fremont Engineers	Fremont
George S. Nolte, Inc.	San Francisco
Green-Winston-Tecon	Valley Springs
Jones, Thenn & Associates	Palo Alto
K. Q. Volk & Associates	Dublin
Kister & Savio	Richmond
Lawrence G. Brian	Redwood City
Mackay & Somps	San Jose
Mark Thomas & Company, Inc.	San Jose
Mastin & Kingston	Santa Clara
Mission Engineers	Santa Clara
C.P. Muttersbach	Santa Cruz
Oglesby-Jacobs-Wickam	San Rafael
Philip B. Lygren	San Rafael
Richard K. Randles	San Pablo
Robert W. Schenck	Berkeley
Robert W. Tonkin	San Jose
Ruth & Going Associates	San Jose

Name of Firm	Location
Sidney R. Mitchell	Sunnyvale
Theodore V. Tronoff	Daly City
Walsh Construction Company	San Mateo
Whitlow, Hoffman & Albratton	San Rafael
Wilsey, Han & Blair	Millbrae

There are no standard selection requirements among the various firms employing party chiefs, nor do they all use an application form. The engineer or licensed surveyor determines by interview and review of the applicant's work experience his suitability for the job opening. Entrance into the occupation has generally been from instrument man, chainman or rodman. However, an apprenticeship program has been instituted. The proposed training will be for 8000 hours, approximately 4 years. In 1964, 36 apprentices were indentured.

It is estimated that 1000 surveyors were employed in the Bay Area in the summer of 1964. It is not possible to obtain a figure on the actual number employed. Employing firms range from large to small companies. The number of party chiefs employed in the Bay Area seemed to be about equally divided among construction, professional services, government and public utilities.

It was determined that one year would be the minimum time necessary to learn the basic techniques of the job. Therefore, each individual included in the sample had at least one year of experience.

TABLE I

Means (M), Standard Deviations (σ), Ranges, and Pearson Product-Moment Correlations with the Criterion (r) for Age, Education and Experience

N = 62	M	σ	Range	r
Age (years)	37.1	7.8	25-58	-.118
Education (years)	13.0	1.5	10-16	.148
Experience (months)	9.1	5.3	1-25	.157

III. Job Description

Job Title: Surveyor (profess. & kin.) 0-64.10

Job Summary: Supervises, directs and is responsible for the accuracy of work of a survey party in laying off or determining the exact location and measurements of points, elevations, lines, areas and contours on the earth's surface to establish property or construction lines; secure data for construction, map-making, land valuation or other purposes. Establishes angles, points of reference, and measures distance using surveying instruments and equipment such as theodolite, transit, surveyor's chain and compass. Computes angles and linear measurements from information in basic documents and measurements made in the field. Keeps accurate notes, records and sketches of data secured and work performed in field notebook.

Work Performed: Supervises, directs and is responsible for the accuracy of work of a survey party in laying off or determining the exact location and measurements of points, elevations, lines, areas and contours on the earth's surface to establish property or construction lines and secure data for construction, map-making or other purposes.

Prepares for survey: Receives instructions from Field Crew Supervisor to survey and set monuments at each of four corners of a lot. Checks basic documents to verify location of lot; determines what previously-designated landmarks and permanent monuments will be used as reference points in performing survey and any unusual features of the area such as terrain, ground cover, type of soil, type of existing street improvements and automobile traffic which will influence conduct of survey. Estimates time required to complete survey, based on preparations and original estimates, and informs supervisor. Recommends smaller crew when survey can be accomplished without Rear Chainman. Selects surveying instrument and other equipment as determined by survey to be performed and degree of accuracy specified by supervisor. Instructs Head and Rear Chainmen to load survey vehicle. Insures that instrument, other equipment, materials and supplies such as theodolite, tripod, steel survey tape, plumb bob, portable calculator, traffic cones, iron pipe monuments, marking stakes and hand tools are included. Checks street map and directs Head Chainman to job site.

Begins survey: Upon arrival at job site, instructs Chainmen to unload equipment and supplies to be used and to assemble instrument, while organizing preliminary notes; checks basic documents for landmarks to get bearings for survey; views job conditions and verifies existence of permanent monuments in street as indicated in basic documents. Locates permanent monument nearest lot to be surveyed and instructs Rear Chainman to carry theodolite with tripod and steel survey tape to it. Designates this first reference point in notes as Permanent Monument #1 (PM 1). Directs Head Chainman to other street monument designated Permanent Monument #2 (PM 2). Instructs him to remove casting cover and expose monument pin, set a traffic cone nearby and other traffic cones around line between PM 1 and PM 2 to warn motorists.

Sets up instrument at Permanent Monument #1: Removes casting cover and exposes monument pin at PM 1; postions and roughly levels theodolite on tripod directly over monument pin by visually checking built-in circular spirit level in instrument and adjusting tripod legs; places wooden pads under tripod leg tips to stabilize tripod on pavement. Suspends plumb bob on plumb line from tripod by attaching to tripod head by means of thumb screw at end of plumb line; adjusts tripod legs until point of plumb bob is directly over monument pin. Removes plumb bob from tripod by unscrewing thumb screw. Makes fine leveling and positioning of vertical axis of instrument over monument pin by sighting through theodolite optical plummet scope: Pulls out sight; focuses prismatic scope by sliding in and out; loosens and tightens setting screws in instrument until monument pin is centered in bulls-eye sight of optical plummet. During this set-up, directs Chainmen to measure distance from PM 1 to PM 2, cautioning them to make sure that steel survey tape is under proper tension level and not touching any obstructions.

Begins Field Notes: Receives distance measurement from Head Chainman and records in field notebook. Uses protractor to begin sketch drawing of survey, which will be further developed as work progresses. Adjusts tape measurment for temperature: Suspends thermometer in shaded area for several minutes; reads temperature; corrects measurement for temperature by allowing 1/100 foot expansion or contraction of tape for each 15° above or below 68°; records corrected distance in field notes. Compares distance measurement with that shown on record map. If not identical, decides whether or not adjustment of measured distance is necessary to comply with record measurement between the two permanent monuments, which has legal stat. and must be accepted even though it may actually be in error. Computes difference using portable calculator and instructs Chainmen to prorate difference in their measurements of all lines, which run in the same direction as the centerline of street and between the two permanent monuments, throughout survey.

Backsights Permanent Monument #2 to establish basis of bearings for survey: Instructs Head Chainman to hold plumb bob over monument pin at PM 2. Looks into optical microscope in upper motion of instrument and turns lower motion until upper and lower zero indicators on micrometer are aligned. Locks upper and lower motions together by tightening upper motion clamp and makes find alignment of both motions by adjusting upper motion tangent screw. Looks into telescope and rough sights plumb line held by Head Chainman; turns instrument until plumb line appears to be coincident with vertical crosshair of telescope within fraction of an inch. Fixes assembly (interlocked upper and lower motions) on line of sight by locking lower motion clamp. Makes precise adjustment of instrument sight on plumb line by turning lower motion tangent screw until vertical crosshair of telescope is exactly coincident with plumb line. Instructs Head Chainman to set a target on this same line of sight, at a point clear of traffic and other obstructions; directs him in positioning target by sighting through telescope and using vocal and hand signals.

Establishes next instrument position at property line: Checks record map to determine first course of a traverse from PM 1 to and around lot to be surveyed and back to PM 1. Unlocks upper from lower motion; sets micrometer to zero; rotates upper motion and sets horizontal circle on micrometer at 270° azimuth, which is a clockwise angle from PM 2 (Head Chainman's position) to curb and equals a 90° angle to the left of the instrument position. Directs Head Chainman, by vocal and hand signals, to set a hub on this new line of sight at property line, which is half the record width of the street measured from centerline.

Makes Foresight by doubling the angle: Directs Head Chainman to set pencil or plumb bob mark on hub, exactly on new line of sight. Double-checks accuracy of 90° angle: Releases theodolite lower motion; inverts telescope and sights target previously set near PM 2; fixes theodolite lower motion and precisely adjusts lower motion tangent screw to make vertical crosshair of telescope exactly coincident with target. Releases theodolite upper motion; sets micrometer to zero again; rotates upper motion and sets horizontal circle at 180° azimuth. Directs Head Chainman to set pencil or plumb bob mark on hub exactly on new line of sight. Receives lateral distance between these two marks, if one exists, from Head Chainman and decides whether or not error is within allowable limit to maintain required survey accuracy. When error is allowable, instructs Head Chainman to set tack in hub midway between the two marks or on mark if no error found. When error is not allowable, repeats foresight to determine if personal mistake exists. Adjusts instrument by following procedures in instruction manual if no personal mistakes are found.

Sets up at Traverse Station #1 (TS 1): Adjusts lower motion tangent screw to make vertical crosshair of telescope exactly coincident with center of tack. Instructs Head Chainman to set a target on new line of sight at visible and convenient distance behind PM 1, most often on opposite side of street from hub just set. Designates the hub as Traverse Station #1 in field notes. Picks up theodolite and tripod and sets up over TS 1. Computes exact distance from PM 1 to TS 1 and from TS 1 to first lot corner by adding and subtracting distances found on record map. Backsights last target and instructs Head Chainman to make a rough mark at the approximate location of the first lot corner as determined by computations made from record map.

Sets up at Traverse Station #2. Instructs Rear Chainman to clean the ground in this area and carefully dig for hubs which may have been previously set by another surveyor. If none are found, instructs Head Chainman to set an iron pipe monument at first lot corner, determined by foresighting, doubling the angle and measuring with steel survey tape. Designates monument TS 2. Sets up at TS 2 and computes angle for next foresight from bearings on record map. Backsights TS 1; sets horizontal micrometer to zero; releases upper motion; views micrometer and turns instrument until computed angle appears on micrometer; locks telescope on new line of sight; directs Head Chainman to set rough mark at approximate location of TS 3.

Determines horizontal distance to Traverse Station #3: Assists Chainman making slope distance measurement if ground slopes steeply between TS 2 and TS 3. Directs Head Chainman to set temporary hub on line between TS 2 and TS 3, and to suspend plumb bob from zero end of tape over this hub. Instructs Rear Chainman to hold other end of tape at an even foot mark at horizontal axis mark of theodolite. Records slope distance between these points in field notes. Sights vertical angle of intersection of tape and plumb line with telescope; fixes telescope motion and adjusts telescope tangent screw to make center horizontal crosshair exactly coincident with intersection; reads vertical circle micrometer and records angle in field notes. Makes two measurements: One vertical angle with telescope direct, and one with telescope inverted. Determines horizontal distance to temporary hub by combining slope distance with cosine of both vertical angles and averaging results. Uses Book of Tables of Trigonometric Functions to find cosines. Computes additional or subtractive distance needed to reach position of TS 3. Instructs Head Chainman to set monument at TS 3.

Sets up at Traverse Station #3: Directs Head Chainman to set rough mark at approximate location of TS 4 as in setting TS 3. If an existing hub or similar monument is found at a location other than that indicated by record map; measures difference between the two locations with pocket tape measure and records discrepancy in field notes.

Sets up at Traverse Station #4: Directs Head Chainman to set monument at last lot corner using established procedures. After last lot corner has been set, instructs Head Chainman to set a nail and shiner at point where prolongation of line from TS 4 through last lot corner will intersect centerline of street at record distance if survey measurements and computations have been done correctly. Designates this point as TS 5.

Sets up at Traverse Station #5: Backsights TS 4; measures azimuth from TS 4 to PM 1 by making one observation with telescope direct and one with telescope inverted; records readings in field notes. Averages these two readings and compares with angle computed from record map. Directs Chainman to measure distance between TS 5 and PM 1; compares this measurement with distance computed from record map. If difference exists between record and measured distances, determines whether error is allowable within accuracy standards of survey. If allowable, directs Head Chainman to reposition monuments at lot corners to equalize error and to set marking stakes at each, since monuments are not visible above ground. If error is not allowable, rechecks all computations. If no miscalculation is found, retraces survey from the beginning.

Completes survey: Directs Rear Chainman to reload vehicle; completes field notes. Returns to office and reviews survey with supervisor. Double checks field calculations on office calculator; posts survey to office index of completed surveys.

IV. Experimental Battery

All the tests of the GATB, B-1002B, were administered to the sample group.

V. Criterion

The criterion measure for this study consisted of supervisory ratings based on a modification of USES Form SP-21 "Descriptive Rating Scale." The modified scale consists of ten items relating to job performance, with five alternatives for each item. Weights of one through five indicating the degree of work proficiency attained were assigned to each alternative.

Work performance ratings were obtained between March 1, 1964 and June 1, 1964 from the many immediate supervisors of the party chiefs. Two ratings by the same supervisor were taken at least 14 days apart for each party chief in the sample.

A reliability coefficient of .94 was obtained for the criterion. Therefore the two sets of ratings were combined resulting in a distribution of final criterion scores of 45 through 100 with a mean of 78.9 and a standard deviation of 11.8.

No known "true" point of demarcation between satisfactory and unsatisfactory workers could be determined as a criterion dichotomy point. Therefore, after discussion with supervisors, a criterion critical score of 78 was decided upon. This arbitrary dichotomy point placed approximately 60 percent or 37 workers in the high criterion group, and approximately 40 percent or 25 workers in the low criterion group.

VI. Qualitative and Quantitative Analysis

A. Qualitative Analysis

On the basis of job analysis data, the following aptitudes were rated "important" for success in this occupation:

G - Intelligence - Important to understand survey principles and techniques and apply these when making survey; to use independent judgment in planning, conducting and completing the survey; to adapt procedures to fit job conditions.

N - Numerical Aptitude - Important to compute and calculate angles and linear measurements quickly and accurately in the field.

S - Spatial Aptitude - Important to read and interpret basic documents such as record maps, diagrams and sketches; to visualize angles; and to draw maps and sketches.

B. Quantitative Analysis:

TABLE II

Means (M), Standard Deviations (σ), and Pearson Product-Moment Correlations with the Criterion (r) for the Aptitudes of the GATB; N = 62

Aptitudes	M	σ	r
G-Intelligence	118.7	15.9	.524**
V-Verbal Aptitude	108.3	18.5	.493**
N-Numerical Aptitude	117.6	16.6	.558**
S-Spatial Aptitude	117.5	16.4	.167
P-Form Perception	104.3	15.8	.208
Q-Clerical Perception	107.5	14.9	.605**
K-Motor Coordination	101.2	14.3	.265*
F-Finger Dexterity	93.3	18.3	.091
M-Manual Dexterity	94.9	18.2	.184

*Significant at the .05 level
**Significant at the .01 level

C. Selection of Test Norms:

TABLE III

Summary of Qualitative and Quantitative Data

Type of Evidence	Aptitudes								
	G	V	N	S	P	Q	K	F	M
Job Analysis Data									
Important	X		X	X					
Irrelevant									
Relatively High Mean	X		X	X					
Relatively Low Sigma						X	X		
Significant Correlation with Criterion	X	X	X			X	X		
Aptitudes to be Considered for Trial Norms	G	V	N	S		Q	K		

Trial norms consisting of various combinations of Aptitudes G,V,N,S,Q and K with appropriate cutting scores were evaluated against the criterion by means of the Phi Coefficient technique. A comparison of the results showed that B-1002 norms consisting of N-110, S-100, Q-95 and K-80 had the best selective efficiency.

VII. Concurrent Validity of Norms

The validity of the norms was determined by computing a phi correlation coefficient between the test norms and the dichotomized criterion and applying the Chi Square test.

Table IV shows the relationship between test norms consisting of Aptitudes N, S, Q and K with critical scores of 110, 100, 95 and 80 respectively, and the dichotomized criterion for Surveyor (profess. & kin.) 0-64.10. Workers in the high criterion group have been designated as "good workers" and those in the low criterion group as "poor workers."

TABLE IV

Validity of Test Norms for Surveyor 0-64.10

N = 62	Non-Qualifying Test Scores	Qualifying Test Scores	Total
Good Workers	9	28	37
Poor Workers	21	4	25
Total	30	32	62

Phi Coefficient = .59

$\chi^2 = 21.291$

$P/2 < .0005$

The data in the above table indicate a significant relationship between the test norms and the criterion for the sample.

VIII. Conclusions

On the basis of the results of this study, Aptitudes N, S, Q and K with minimum scores of 110, 100, 95 and 80, respectively, have been established as B-1002 norms for Surveyor (profess. & kin.) 0-64.10. The equivalent B-1001 norms consist of 115, 105, 95 and 75.

IX. Determination of Occupational Aptitude Pattern

The data for this study did not meet the requirements for incorporating the occupation studied into any of the 36 OAP's included in Section II of the Guide to the Use of the General Aptitude Test Battery, January 1962. The data for this sample will be considered for future groupings of occupations in the development of new occupational aptitude patterns.