BOLT-BEARING STRENGTH OF WOOD AND MODIFIED WOOD

BEARING STRENGTH OF COMMERCIAL CROSS-BANDED COMPREG UNDER AIRCRAFT BOLTS

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BOLT-BEARING STRENGTH OF WOOD AND MODIFIED WOOD

Bearing Strength of Commercial Cross-Banded

Compreg Under Aircraft Bolts[1, 2]

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Summary

This report presents the results of approximately 1,800 bearing tests on single-bolt specimens of commercial cross-banded compreg under steel aircraft bolts.

In this investigation, the bearing strength and the critical dimensions (minimum edge clearances and end margins required to develop the full bearing strength) were determined for compregs from three manufacturers (desig-

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[1] This is one of a series of progress reports prepared by the Forest Products Laboratory relating to the use of wood in aircraft. Results here reported are preliminary and may be revised as additional data become available. Report originally published February 1946.

[2] This is one of a series of reports dealing with bolt-bearing strength of wood and modified wood. Other reports are No. 1523, "Effects of Different Methods of Drilling Bolt Holes in Wood and Plywood;" and No. 1523-A, "Bolt-Bearing Strength of Laboratory-Made Cross-Banded Yellow Birch Compreg Under Aircraft Bolts." Other reports will be issued as data becomes available.

[3] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

nated in this report as A, B, and C), three grain orientations (0°, 45°, and 90°), three thicknesses of compreg (1/4-, 1/2-, and 1-inch), and three diameters of bolt (1/4-, 1/2-, and 1-inch), under one or more of three methods of loading: compressive, modified compressive, and tensile.

Edge clearance, as referred to in this report, is the dimension, perpendicular to the direction of loading, from the center of the bolt hole to the edge of the member. End margin is the dimension, parallel to the direction of loading, from the center of the bolt hole to the free end of the member.

The average bolt-bearing strength for the three commercial compregs investigated was only slightly less than that for laboratory-made compreg presented in Report No. 1523-A; the critical dimensions were about the same; the compressive strength parallel to the face grain was about 20 percent less than that for laboratory-made compreg as presented in Report No. 1523-A and about 25 percent less than that shown in table 2-14 of ANC Bulletin 18. The commercial compregs appeared to be more sensitive to notching than the laboratory-made compreg.

The bearing strength increased with increase in thickness of compreg, decreased with increase in diameter of bolt, but was practically the same for grain orientations of 0°, 45°, and 90°. In general, the critical dimensions were smaller for 45° grain orientations than for 0° and 90°; they were essentially the same for all thicknesses of compreg, and were approximately in proportion to the diameter of the bolt. Consistent relationships were developed between bearing stresses at proportional limit and ultimate and between ultimate stresses in bearing and in compression. Suggestions are made for determining design bearing stresses for any grain orientation by applying appropriate factors to the compressive strength of cross-banded compreg parallel to the face grain.

Repeated-loading tests employing 1/2-inch bolts in 1/2-inch compreg indicated that bearing stresses approximately one-third greater than proportional limit values can be applied repeatedly with no significant increase in the permanent deformation, or "set."

On the basis of these tests, cross-banded compreg can be expected to develop its proportional limit stress in bearing under steel aircraft bolts at deformations not exceeding 0.025 inch and its ultimate at deformations not exceeding 0.10 inch.

Introduction

The investigation of the bearing strength of commercial compreg, on which this report is based, was undertaken at the request of the ANC Technical Subcommittee on Wood Aircraft Structures to provide design data applicable to compregs available commercially to wood aircraft manufacturers. The information desired included bearing stresses at proportional limit and ultimate under both tensile and compressive loading and the minimum edge clearances and end margins necessary to develop the full bolt-bearing strength of the material. (Edge clearance is the dimension, perpendicular to the direction of loading, from the center of the bolt hole to the edge of the member. End margin is the dimension parallel to the direction of loading, from the center of the bolt hole to the free end of the member.) In addition, it was desired to compare the bolt-bearing characteristics of certain commercial compregs with those previously determined for compreg made at the Forest Products Laboratory.

Description of Material

The commercial compregs A, B, and C used in this investigation were made during the first quarter of 1943 by three reputable manufacturers. All material was cross-banded.

Compreg A was made from yellow birch veneers impregnated with 27 to 30 percent of water-soluble phenol-formaldehyde resin. The number of plies and the thickness of veneer varied with the finished thickness of the compreg, the 1/4-, 1/2-, and 1-inch material containing seven 1/16-, thirteen 1/16-, and thirteen 1/8-inch veneers, respectively. The assembled impregnated veneers were pressed at 1,300 to 1,500 pounds per square inch for 45 minutes. Additional resin was used to improve the bond between plies. The temperature during pressing varied from 275° to 290° F.

Compregs B and C were made from hard maple veneers impregnated with approximately 30 percent of alcohol-soluble resin. Information is not available as to whether additional adhesive was used between the plies. Compreg B was composed of 1/10-inch veneers, the 1/4-, 1/2-, and 1-inch panels containing 5, 9, and 17 plies, respectively. The 1/4-inch panels of compreg C were composed of seven 1/16-inch veneers; the 1/2- and 1-inch panels of seven and fifteen 1/8-inch veneers, respectively. Pressures between 2,000 and 3,000 pounds per square inch were used in making compregs B and C. The temperature during pressure was approximately 300° F.

Other detailed information concerning the individual panels of commercial compreg is presented in table 1.

The bolts used were steel aircraft bolts conforming to Army-Navy Specification AN-B-3a.

Preparation of Specimens

The scheme employed in preparing the bolt-bearing specimens was designed to isolate the effects of source of material, thickness and grain orientation of compreg, diameter of bolt, and method of loading on the bearing strength and on the critical dimensions. Specimens were usually prepared in an initial series of three to five in which either edge clearance or end margin was varied over a range intended to bracket the critical dimension. After the initial series was prepared, extra material was set aside so that all additional specimens relating to that particular series could be cut from the same panel, adjacent to the original specimens. If the critical dimension was not determined from tests of such an initial series, supplemental specimens were prepared to extend the range of dimensions until the critical dimension was bracketed. When the critical dimension was thus tentatively determined, one to six additional specimens were prepared to correspond to each of five specimens centered around the critical dimension. The additional specimens, together with those in the initial series, constituted a complete series of from two to seven specimens for each of five different edge clearances or end margins for each combination of diameter of bolt and thickness of compreg. Specimens for compression tests and specific gravity determinations were taken at random from each panel and were presumed to represent the entire panel.

Each bolt-bearing specimen was marked in the manner explained in Report No. 1523-A, with the addition of two qualifying letters. One letter was appended to the first numeral to indicate the source of material, while the other was appended to the final numeral to indicate the order of the specimen in a group for any one condition of test. Specimens were cut, holes were drilled, and completed specimens were conditioned in the manner described in Report No. 1523-A.

Test Procedure

General Discussion

The test procedure was the same as that described in Report No. 1523-A[2] with but few exceptions. In laboratory-made compreg, only one specimen was tested for each condition of test; in the commercial compregs, approximately three specimens were tested for each condition. In the following discussion, only the procedure which differs from that used for the laboratory-made compreg will be explained.

Bolt-Bearing Under Compressive Loading

In compreg A, a complete edge-clearance series was made for each of three grain orientations (0°, 45°, and 90°), and for each of seven combinations of compreg thickness and bolt diameters, consisting of 1/4-inch bolt in 1/4- and 1/2-inch compreg, 1/2-inch bolt in 1/4-, 1/2-, and 1-inch compreg and 1-inch bolt in 1/2- and 1-inch compreg. In compreg C, complete series were made for the same three grain orientations but for only five combinations of compreg thickness and bolt diameter. These consisted of 1/4- and 1/2-inch bolts in 1/4- and 1/2-inch compreg and 1-inch bolt in 1/2-inch compreg. Additional tests were made employing 1/2- and 1-inch bolts in 1-inch compreg C, with face grain parallel to the direction of loading, to determine bearing strength only. Specimens for these tests were purposely overdesigned with respect to critical dimensions in order to restrict failure to bearing. In compreg B, tests to determine bearing strength only were made for the seven combinations of compreg thickness and bolt diameter employed for compreg A, but only in material having face grain parallel to the direction of loading.

Bolt-Bearing Under Modified Compressive Loading

Only compreg A was tested under modified compressive loading. The combinations tested were those for which tensile loading was not practicable with available apparatus and included 1/2-inch bolt in 1-inch compreg and 1-inch bolt in 1/2- and 1-inch compreg. The three combinations were tested with grain orientations of 0°, 45°, and 90°.

Bolt-Bearing Under Tensile Loading

The specimen was suspended on an aircraft bolt between two fittings of an improved tension jig, and a self-aligning tension grip was attached to the lower end (fig. 1). The deformation of the specimen at the bolt hole was measured by means of a single 1/10,000-inch dial gage held directly above the top of the specimen by a cross-bar.

In compregs A and C, both critical edge clearances and critical end margins were determined by tensile loading for 1/4- and 1/2-inch bolts in 1/4- and 1/2-inch material and for three grain angles. No tests of compreg B were made under tensile loading.

Tests for Compressive Strength

Compressive tests were made with the grain of the face plies oriented to correspond with that of the related bolt-bearing specimens with the exception of those at 45°, which were made at both 0° and 90° and the averages of the values for the two orientations were assumed to apply at 45°.

Repeated-Loading Tests

Because of apparent differences between tensile and compressive loadings, and between laboratory-made and commercial compregs, with respect to the ratio of proportional limit to ultimate bearing stress, a few tests were made using 1/2-inch bolts in 1/2-inch compreg C under repeated tensile and compressive loadings.

The proportional limit stress was first determined in the usual manner by noting the point at which the load deformation curve departed from a straight line. Matched specimens were then loaded to this proportional limit stress, unloaded, and then reloaded successively to progressively higher loads until stresses exceeding two-thirds of the ultimate were attained. The tests were then carried to failure. A new proportional limit stress was obtained from the repeated-load curves. Additional matched specimens were then loaded to this new proportional limit stress 25 times to determine the extent of increase in the permanent deformation, or "set."

Explanation of Tables and Figures

Information pertaining to dimensions, specific gravity, and compressive strength of each compreg panel from which specimens were prepared is presented in table 1. Column 5 shows the wide variation in thickness of panels 10C and 11C as compared to other commercial panels.

A summary of the information obtained from both the bolt-bearing and compression tests is given in tables 2 through 14. Tables 2 through 7 relate to compreg A, table 8 to compreg B, and tables 9 through 14 to compreg C. The data for bolt-bearing tests under compressive and modified compressive loadings are presented in tables 2, 3, 4, 8, 9, 10, and 11 and the data for bolt-bearing tests under tensile loading in tables 5, 6, 7, 12, 13, and 14. Tables 2 through 14 are similar to tables 2 through 5 for laboratory-made compreg in Report No. 1523-A except that the compression test data relating to bolt-bearing tests at 45° in commercial compreg were determined by averaging the values for 0° and 90°.

In table 15 the critical dimensions for commercial compreg are summarized and compared with the critical dimensions for laboratory-made compreg. Tables 16, 17, 18, and 19 are similar summaries of bearing stresses, deformations, ratios of bolt-bearing stresses at proportional limit to ultimate, and ratios of bolt-bearing stresses to compressive stresses.

Figure 1 shows the improved tensile-loading apparatus employing a single 1/10,000-inch (0.0001-inch) dial gage, mounted directly above the specimen, for measuring deformation of the specimen at the bolt hole. Elongation in the compreg alongside the bolt hole and other minor deformations in the specimen and the apparatus are included in the deformation registered by the gage. These contributions are assumed to be comparatively insignificant, and the readings of the gage are accepted as measurements of the deformation at the contact between bolt and compreg.

Figure 2 illustrates the method of determining the critical edge clearance or end margin and the average proportional limit and ultimate bearing stresses.

Figures 3 through 6 show failures for four typical series of edge-clearance and end-margin tests under compressive, modified compressive, and tensile loadings, together with bearing strength data pertaining to each specimen.

Figure 7 is a graphical summary of bearing stresses at proportional limit and ultimate for all compreg studies (FPL, A, B, and C). This chart permits direct comparison of the bearing stresses for the various materials, grain orientations, types of loading, thicknesses of compreg, and diameters of bolts.

Figure 8 demonstrates the relationship of bearing stress to compressive stress for the three commercial compregs studied in this investigation.

Figure 9 consists of two logarithmic charts showing the effects of thickness of compreg and diameter of bolt on the ratio of bearing stress to compressive stress at ultimate. In figure 10A, the points and lines in figure 9B are plotted on rectangular coordinates. Figure 10B consists of derived curves relating the proportional limit stress in bearing to the ultimate in compression.

Figure 11 is a graphical presentation of the results of repeated-loading tests. Figure 11A consists of a series of consecutive load-deformation curves showing the increase in the apparent proportional limit under progressively increasing loads applied to the same specimen. Figure 11B shows the effect of repeated loadings to the maximum apparent proportional limit (determined in figure 11A) on the total deformation and on the permanent set.

Analysis of Results

Critical Dimensions

Critical values for edge clearance and end margin, determined only for compregs A and C in this investigation, are the minimum values that were found to develop the full bearing strength for each combination of diameter of bolt and thickness of compreg. These values are shown in the last two columns of tables 2 through 14 and are summarized in table 15.

Critical dimensions were based on ultimate stress, as illustrated in figure 2, rather than on ultimate loads as for laboratory-made compreg, because of considerable variations in the measured thickness of one of the commercial compregs (column 5, table 1). Specimens in which the dimension under study was inadequate failed in some manner other than bearing and at a computed bearing stress somewhat less than the true ultimate bearing stress. Specimens, tested under compressive loading, whose dimensions were equal to or greater than the critical dimension usually failed in bearing. Those tested under tensile loading, however, were more erratic in the manner of failure because of the notch sensitivity of the compreg. Many such specimens, particularly those tested at 0° or 90°, failed in bearing and in tension at the bolt hole simultaneously, even though the edge clearance was greater than the minimum that had been found necessary to develop the full bearing strength of the compreg. In all series of tests, however, regardless of the type of failure, a definite dimension was determined beyond which any further increase failed to produce a significant increase in ultimate stress. This value was considered to be the critical dimension.

The critical dimensions, as summarized in table 15, were essentially the same for the three compregs studied, and agreed favorably with those obtained from the laboratory-made material. They were not influenced consistently by the thickness of the compreg within the range studied (1/4 to

1 inch) but were approximately in proportion to the diameter of bolt. It is convenient, therefore, to express these dimensions in terms of diameter, D.

Wherever a difference was found among the critical dimensions for specimens of different grain orientations, those obtained under tensile loading for compreg at 45° were usually smaller and more consistent than those for 0° and 90°. Those obtained under compressive loading at 45° were similarly consistent but were equal to or slightly greater than those for 0° and 90°.

Edge clearances for compressive loading were determined for practically all combinations of diameter of bolt and thicknesses of compreg. While there was some variation among the individual values, there was no well-defined pattern, and the values, in terms of diameters, for all grain orientations were approximately the same. An edge clearance of two diameters was found to be adequate for all combinations.

Edge clearances for tensile loading were determined for only 1/4- and 1/2-inch bolts and 1/4- and 1/2-inch thicknesses. For each grain orientation, however, the values exhibited an approximate relationship to diameter, but no consistent relationship to thickness. Thus, the values determined, when expressed in terms of diameter, can be presumed to apply to all combinations of diameter and thickness. The values were found to vary considerably for different grain orientations. Edge clearances of 4, 2-1/2, and 5 diameters were found to be adequate for 0°, 45°, and 90°, respectively.

It should be kept in mind that these values of edge clearance for both tensile and compressive loading were determined by tests employing only single bolts. In fastenings employing two or more bolts in line, the tensile stresses at the critical section are increased proportionately. In wood structural members in which compreg is used for reinforcing plates, tensile and compressive stresses in the plates are reduced by transfer of stress to the wood. The required edge clearances may, therefore, be governed by the shear area necessary to transfer load from the reinforcing to the wood rather than by the tensile or compressive strength of the reinforcing plates.

End margins were determined by direct tensile loading for only 1/4- and 1/2-inch bolts in 1/4- and 1/2-inch compregs. Approximate values for the other combinations were determined by modified compressive loading. Previous tests had indicated reasonable agreement between results obtained by these two methods. Again, the thickness had little effect on the critical dimension. End margins of 5 diameters for 0°, and 90° and 3 diameters for 45° were found to be adequate.

Moisture Content of Compreg

The moisture content of the compreg, determined by oven drying to approximately constant weight, varied from 2.3 to 7.6 percent with an average of 4.3 percent. It is recognized that in drying compreg samples errors are introduced in the indicated moisture content by driving off volatile matter other than moisture. Because of the uncertainty thus created as to the actual moisture content, and since no relationships had been established between moisture content and strength properties of compreg, no attempt was made in this investigation to adjust bearing strength or other values for moisture content.

Bolt-Bearing Strength

Proportional limit loads were determined from load-deformation curves, which were obtained for all bolt-bearing tests. A typical curve is shown in figure 10 of Report No. 1523-A.[2] The general characteristics of the load-deformation curves and the method of determining ultimate loads were the same as those described in that report for laboratory-made compreg. Bearing stresses were computed by dividing loads by projected areas.

Typical failures of specimens for each of the four kinds of bolt-bearing tests made in this investigation are shown in figures 3 through 6. Average proportional limit and ultimate loads are listed for each edge clearance or end margin included in each series of specimens shown. The average proportional limit loads and hence average stresses for all five groups shown in figure 3 were approximately the same; all groups were used, therefore, in determining the average bearing stress at proportional limit. In each of figures 4, 5, and 6, however, the group of specimens labeled A developed average stresses at proportional limit lower than any of the other groups in their respective series, indicating that the dimension being varied was inadequate to develop even the proportional limit stress in bearing. Only the last four groups, therefore, were used in determining the average bearing stress at proportional limit for those particular series of tests. The ultimate stresses in each of figures 3 through 6 increased progressively with increase in dimension until the critical dimension was reached, after which they were practically uniform. Only those uniform values were averaged in determining the ultimate bearing stresses for each series. This is illustrated graphically in figure 2.

Bolt-bearing stresses at proportional limit for compregs A, B, and C and at ultimate for compreg A averaged about 20 percent less than those for laboratory-made compreg. The ultimates for both compregs B and C, however, averaged within 5 percent of the laboratory product. Since the composition of compreg A resembles more closely that of the laboratory-made compreg, it appears that the influence of composition on the bearing stress is less important than that of other factors not identified in this investigation.

In general, the proportional limit stresses and deformations obtained under tensile loading were from 10 to 35 percent lower for all commercial compregs studied than those obtained under compressive loading. The values of ultimate bearing stress, however, were about the same for both types of loading. It is probable that the lower values for proportional limit stress under tensile loading were due to a difference in end restraint imposed on the bolt by the different types of testing apparatus used. It follows that the proportional limit stresses obtained under compressive loading probably represent more accurately the true proportional limit bearing stresses for the material.

Both proportional limit and ultimate bearing stress decreased with an increase in diameter of bolt for all commercial compregs studied and increased with an increase in the thickness of the compreg. The trends, however, were not as well defined for proportional limit as for ultimate. The principal discrepancies occurred in the two combinations in which the ratio of bearing length or thickness to diameter (L/D ratio) was greatest, namely: 1/4-inch bolt in 1/2-inch compreg and 1/2-inch bolt in 1-inch compreg. The results of previous tests of bearing strength of aircraft bolts in wood parallel to grain indicated that the proportional limit of the wood in bearing is reduced by bending of the bolt if the L/D ratio is greater than one. It is probable that this effect is even more pronounced in compreg because of its greater density and strength and that this accounts for the reduction in proportional limit stress for the higher L/D ratios. There was no corresponding reduction in ultimate bearing stress, probably because none of the L/D ratios employed was sufficiently large to produce such a reduction.

The average values for bearing stress at both proportional limit and ultimate appeared to be unaffected by the grain orientation (fig. 7). The 45° material, however, was more consistent in its manner of failure. Tensile failures in bolt-bearing specimens that developed the full bearing strength were less common in 45° than in 0° and 90° specimens.

Ratio of Proportional Limit to Ultimate Bearing Stress

The effects of unidentified variable factors on the proportional limit and ultimate bearing stresses can be minimized in this analysis by considering the ratios of proportional limit to ultimate. These ratios are shown in column 12 of tables 2 through 14 and are summarized in table 18. While there was some variation among the different compregs, there was a general tendency for this ratio to decrease with increase in diameter of bolt.

Except for the two combinations with L/D ratios of 2, there was no apparent effect of thickness of compreg. Excluding these two combinations (1/4-inch bolt in 1/2-inch compreg and 1/2-inch bolt in 1-inch compreg), the average ratios for compressive loading were 0.62, 0.54, and 0.48 for 1/4-, 1/2-, and 1-inch bolts, respectively.

Compressive Strength

Compressive stresses at proportional limit and ultimate are shown in columns 15 and 17, respectively, of tables 2 through 14, and are summarized according to panel numbers in table 1. There was some variation in these values among the different compregs. This variation, however, was only slightly greater than that among individual panels from any one manufacturer. There was no significant variation in compressive strength for different thicknesses of compreg.

The average ultimate compressive stress parallel to face grain for the three commercial compregs (18,000 pounds per square inch) was about 80 percent of that for laboratory-made cross-banded compreg presented in Report No. 1523-A and about 75 percent of that shown in table 2-14 of ANC-18.

Ratio of Bearing Strength to Compressive Strength

Ratios of bearing stress to compressive stress at proportional limit and ultimate are shown in columns 20 and 21 of tables 2 through 14, and are summarized in table 19. Average ratios are derived graphically and tabulated in figure 8. The ratios of ultimate stresses are more consistent than those of proportional limit stresses, probably because of the greater accuracy with which ultimate stresses can be determined both in bearing and in compression. Average ratios at ultimate are shown (on logarithmic coordinates) in relation to thickness of compreg in figure 9A and in relation to diameter of bolt in figure 9B. The extrapolations represented by the dotted portions of the graphs appear to be justified by the general, straight-line relationships. Since the compressive strengths were essentially the same for all thicknesses of compreg, these ratios followed the same trend as the ultimate bearing stresses, increasing with increase in thickness of compreg and decreasing with increase in diameter of bolt.

Values taken directly from the graphs of figure 9B are replotted on rectangular coordinates in figure 10A. Five of the seven average test values fall on these curves; the other two values are higher. Curves representing the relationship between proportional limit stress in bearing and ultimate in compression are shown in figure 10B. These curves were derived by multiplying values from figure 10A by appropriate average ratios of proportional limit to ultimate in bearing (compressive loading), shown in table 18.

Results of Repeated-Loading Tests

Only 1/2-inch bolts and 1/2-inch compreg were employed in the repeated-loading tests. Proportional limit bearing stresses determined as a preliminary step averaged 44 and 49 percent of ultimate for tensile and compressive loading, respectively. These percentages are in good agreement with average percentages obtained for the entire series of tests of commercial compreg (44 and 50 percent).

By subjecting matched specimens to loads equal to or slightly greater than the indicated proportional limit, unloading, and then subjecting to progressively higher loads, new load-deformation curves were obtained. In the first few reloadings, the straightline portion continued to a load approximately equal to the highest load applied in the test immediately preceding. The increase in apparent proportional limit persisted until finally a limiting stress was attained at which a break in the curve occurred with each subsequent loading. This is illustrated by the curves of figure 11A. The limiting stresses averaged 58 and 67 percent of ultimate for tensile and compressive loading, respectively, or an average increase of approximately one-third over the proportional limit stress determined by the first loading. For convenience this increased value is referred to as the maximum apparent proportional limit. It is conceivable that, had the tests been continued, the apparent proportional limits might have resumed their tendency to increase after seeming to become stabilized. This possibility will be explored in a separate study of repeated loading.

Other specimens matched to those tested as illustrated by figure 11A were then subjected to 25 loadings to the maximum apparent proportional limit. On the 25th loading, the test was continued to failure. The maximum deformation accompanying the 25th application of the maximum apparent proportional limit load was 0.0160 inch as compared with 0.010 inch at the initial proportional limit obtained in tests on matched specimens. The maximum permanent deformation or set was 0.0033 inch, and the maximum increase in permanent set due to 24 repetitions of loading was 0.0015 inch. These deformations are illustrated in figure 11B. It may be noted that the magnitude of the permanent set had become practically stabilized; hence no appreciable further increase might be expected with further repetitions of loading.

Probable Yield Stress

The bearing stresses at proportional limit indicated in figure 10B are probably unduly conservative for use as yield stresses. The repeated-loading tests, conducted for only 1/2-inch bolts in 1/2-inch compreg indicated that the apparent proportional limit is increased by over-stressing to approximately 1-1/3 times the value indicated in figure 10B, with no significant increase in the permanent set. The maximum apparent proportional limit thus determined might be assumed, tentatively, to represent a suitable yield stress for the material.

Since the lowest average ratio of proportional limit to ultimate bearing stress under compressive loading was 0.48, it can probably be expected that the lowest ratio of maximum apparent proportional limit to ultimate would be 1-1/3 times this ratio, or 0.64. It would seem, therefore, that tentative values for yield stresses in bearing for L/D ratios not greater than 1 might be assumed to be two-thirds of the ultimate bearing strength.

Determination of Design Stresses

The relationship shown in figure 10A permits determination of ultimate bearing stresses for various combinations of diameter of bolt and thickness of compreg on the basis of the ultimate compressive strength. Since the bearing strength is essentially the same for all grain orientations, compressive strength parallel to the face grain can be employed regardless of the grain direction with reference to the bearing load. In the absence of compressive strength data for the particular compreg to be employed, a value of 18,000 pounds per square inch, or approximately 75 percent of that for laboratory-made cross-banded compreg shown in table 2-14 of ANC-18 is reasonably conservative. If it is desired to base design stresses on the results of tests of a particular compreg, only ultimate compressive strength parallel to face grain need be determined. This simplifies the testing procedure, since no deformation measurements are required.

Deformations

The average, maximum, and minimum deformations for each combination of source of material, type of loading, diameter of bolt and thickness of compreg are shown in columns 9 and 11, tables 2 through 14. A summary of all average deformations is presented in table 17.

There was an increase in average deformation at both proportional limit and ultimate with an increase in thickness of the compreg and a decrease with an increase in diameter of the bolt. In general, the deformations at proportional limit were smaller for bolt-bearing under tensile loading than under compressive and modified compressive loading. The deformations at ultimate, however, did not show any consistent difference between types of loading.

On the basis of these tests, it could be expected that the proportional limit bearing stress will be attained at a deformation not exceeding 0.025 inch, and the ultimate at a deformation not exceeding 0.10 inch.

Conclusions

1. The average bolt-bearing strength for the three commercial compregs investigated was only slightly less than that of laboratory-made compreg presented in Report No. 1523-A.

2. The average bolt-bearing strength increased with increase in thickness of compreg and decreased with increase in diameter of bolt but was practically the same for grain orientations of 0°, 45°, and 90°.

3. Bearing stresses at proportional limit were reduced somewhat by bending of the bolts in tests in which the ratio of bearing length to diameter of bolt exceeded one; bearing stresses at ultimate were not reduced.

4. Bearing stresses at proportional limit determined under tensile loading were somewhat lower than those determined under compressive loading. This was probably due to a difference in the rigidity of the equipment used. The higher values are probably more truly representative of the actual bearing strength of the material. Bearing stresses at ultimate were essentially the same for both types of loading.

5. The ratios of bearing stress at proportional limit to bearing stress at ultimate decreased with increase in diameter of bolt, but were practically uninfluenced by thickness of compreg, except in those tests in which the ratio of bearing length to diameter exceeded one.

6. The average compressive strength parallel to the grain of the face plies for the three commercial compregs investigated was about 18,000 pounds per square inch. This was about 80 percent of that for laboratory-made compreg presented in Report No. 1523-A, and about 75 percent of that shown for laboratory-made, cross-banded compreg in table 2-14 of ANC Bulletin 18. Compressive strengths were essentially uninfluenced by thickness of compreg.

7. Bearing stresses at both proportional limit and ultimate were related to the corresponding compressive stresses; the relationship between ultimate stresses was the more consistent.

8. The apparent proportional limit for 1/2-inch bolts in 1/2-inch compreg was increased by over-stressing and subsequent reloading until it became stabilized at about 1-1/3 times its original value. For compressive loading, this was about two-thirds of the ultimate bearing stress. Twenty-five loadings to this stress failed to produce a significant increase in the permanent deformation, or "set," of the compreg. Tentatively, this maximum apparent proportional limit stress might be considered the yield stress for the material in bearing.

9. Ultimate bearing stresses for design for any grain orientation can be determined by applying ratios presented in figure 9A of this report to the ultimate compressive strength parallel to the grain of the face plies. In the absence of specific compressive strength data, a value of 18,000 pounds per square inch is satisfactory. If compression tests of a specific material are made for this purpose, load-deformation readings are unnecessary, since only the ultimate compressive strength is required.

10. Cross-banded compreg can be expected to develop its proportional limit stress in bearing at deformations not exceeding 0.025 inch and its ultimate at deformations not exceeding 0.10 inch.

11. The necessary edge clearances and end margins were essentially the same for the three commercial compregs and for the three thicknesses investigated; they varied about in proportion to the diameter of bolt. Except for edge clearances under compressive loading, which were the same for all grain orientations, the critical dimensions for 45° were smaller than for 0° and 90°. Tensile failures at the critical sections in specimens whose dimensions were adequate to develop the full bearing strength were more common in commercial than in laboratory-made compreg. This tendency was less pronounced for 45° grain orientation than for 0° and 90°.

Table 1.--Panel dimensions, specific gravity, and compressive strength of commercial cross-banded compreg used for bolt-bearing tests

Manufacturer	Panel number[1]	Panel dimensions					Specific gravity[2]	Compressive strength			
		Thickness			Width	Length		At proportional limit		At ultimate	
		Nominal	Actual								
			Average	Variation				0°	90°	0°	90°
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
		Inch	Inches	Inches	Inches	Inches		P.s.i.	P.s.i.	P.s.i.	P.s.i.
	1A	1/4	0.27	0.26-0.28	24	24	1.341	6,350	[3]5,840	15,390	[3]14,600
	2A	1/4	.27	.26- .28	24	24	1.330	6,830	[3]6,280	16,560	[3]15,710
	3A	1/4	.27	.27- .28	24	24	1.332	6,360	....	17,460	....
	4A	1/4	.27	.26- .28	24	24	1.360	6,560	[3]6,030	16,550	[3]15,700
	5A	1/4	.28	.27- .28	24	24	1.356	6,540	[3]6,010	16,570	[3]15,720
	6A	1/4	.27	.27- .28	24	24	1.358	5,930	....	15,760	....
	[4]7A	1/4	.26	None	24	24	1.318	6,680	6,330	16,750	15,230
	[4]8A	1/4	.26	.25- .26	24	24	1.350	6,750	5,700	17,790	16,180
	[4]9A	1/4	.26	.25- .26	24	24	1.330	[5]5,700	6,820	[5]17,860	18,860
	[4]10A	1/4	.26	.25- .26	24	24	1.339	[5]5,690	5,550	[5]16,940	16,100
	11A	1/4	.26	.25- .26	24	24	1.342	5,550	....	15,920	....
	12A	1/4	.26	.25- .26	24	24	1.340	6,080	....	16,290	....
	[4]13A	1/4	.26	None	24	24	1.331	[5]7,410	6,400	[5]17,790	16,100
	30A	1/2	.52	.52- .53	24	24	1.303	6,910	....	15,120	....
	31A	1/2	.51	.51- .52	24	24	1.267	6,490	....	14,650	....
	[4]32A	1/2	.52	.51- .53	24	24	1.316	7,080	6,340	15,840	15,150
	33A	1/2	.52	.52- .53	24	24	1.331	6,800	....	17,600	....
	[4]34A	1/2	.51	.50- .52	24	24	1.305	6,410	5,380	16,070	14,620
A	[4]35A	1/2	.51	.50- .52	24	24	1.309	6,440	5,360	16,720	14,940
	[4]36A	1/2	.51	.51- .52	24	24	1.333	[5]4,950	5,080	[5]16,380	15,900
	[4]37A	1/2	.51	.51- .52	24	24	1.328	[5]5,650	5,080	[5]16,600	16,180
	[4]38A	1/2	.51	.51- .52	24	24	1.332	5,950	5,780	16,570	16,540
	[4]39A	1/2	.52	.50- .53	24	24	1.337	[5]5,680	5,440	[5]16,220	15,360
	40A	1/2	.52	.51- .54	24	24	1.341	7,270	....	17,040	....
	[4]41A	1/2	.51	.50- .52	24	24	1.337	7,340	5,930	17,780	16,170
	42A	1/2	.51	.50- .51	24	24	1.333	5,920	....	15,700	....
	[4]43A	1/2	.51	.50- .51	24	24	1.344	[5]5,930	5,240	[5]15,580	16,140
	[4]44A	1/2	.51	.51- .52	24	24	1.349	[5]5,470	5,360	[5]14,400	15,620
	60A	1	1.00	.99-1.01	24	24	1.330	6,780	....	14,470	....
	61A	1	.99	.98- .99	24	24	1.327	5,620	....	14,140	....
	62A	1	.99	.98-1.00	24	24	1.317	5,790	....	14,250	....
	[4]63A	1	.99	.97-1.00	24	24	1.317	6,700	5,380	15,970	15,630
	[4]64A	1	1.00	.99-1.00	24	24	1.299	5,760	4,920	15,390	14,960
	[4]65A	1	.98	.98- .99	24	24	1.300	5,750	5,830	15,350	14,880
	[4]66A	1	.99	.98- .99	24	24	1.319	6,260	6,380	16,740	15,640
	[4]67A	1	.99	.99-1.00	24	24	1.316	[5]6,740	6,460	[5]17,470	16,540
	[4]69A	1	1.02	1.01-1.02	24	24	1.277	[5]6,790	6,130	[5]16,270	14,880
	[4]70A	1	1.02	1.02-1.03	24	24	1.293	5,970	5,800	14,760	13,610
	[4]71A	1	1.02	1.01-1.02	24	24	1.296	[5]5,970	5,950	[5]15,660	15,860
	[4]72A	1	1.01	1.00-1.01	24	24	1.314	[5]5,930	5,510	[5]15,900	13,550
	2B	1/4	.29	.29- .30	24	24	1.344	6,740	....	18,430	....
B	44B	1/2	.53	.52- .53	24	24	1.352	6,770	....	18,550	....
	81B	1	1.04	1.03-1.04	24	24	1.348	6,380	....	19,930	....
	1C	1/4	.27	.26- .28	23	81	1.343	7,230	6,000	18,740	19,060
	2C	1/4	.26	.25- .27	23	81-1/2	1.359	6,090	5,500	20,490	19,660
	3C	1/4	.26	.25- .27	23	81	1.355	7,770	5,630	20,770	18,880
	4C	1/4	.27	.26- .27	23	81	1.349	[5]6,560	5,470	[5]19,610	19,020
C	10C	1/2	.56	.49- .61	23	81	1.316	6,000	5,970	16,160	16,380
	11C	1/2	.57	.54- .61	23	81	1.347	6,850	5,510	16,890	16,480
	12C	1/2	.56	.54- .57	23	81-1/2	1.347	7,300	....	17,870	....
	13C	1/2	.55	.52- .58	23	81	1.327	7,310	5,580	16,570	15,420
	14C	1/2	.56	.54- .59	23	81-1/2	1.334	[5]6,310	5,390	[5]15,960	15,570
	22C	1	1.10	1.09-1.10	23	81-1/2	1.351	5,910	....	19,480	....

[1]Panels 68A, 1B, 30B through 43B, 60B through 80B, 20C and 21C were used for other purposes.

[2]Based on weight and volume at time of test. Average moisture content.

[3]No 90°-compression specimens were cut from panels 1A, 2A, 4A, and 5A. Values shown were computed from 0° values on the basis of the average relationship for compreg A.

[4]Panels containing values for both 0° and 90° material. These were the only panels considered in adjusting values for panels 1A, 2A, 4A, and 5A.

[5]Not correlated with bearing tests and therefore not used in tables 2 through 14.

Z M 65566 F

Table 2.--Bolt-bearing strength and critical dimensions for compreg A under compressive loading at 0°

Nominal bolt diameter	Nominal panel thickness	Panel number	Bolt bearing: Number of specimens: Total tested	Tested for proportional limit	Tested for ultimate load	Variation	Proportional limit: Stress	Proportional limit: Deformation	Ultimate: Stress	Ultimate: Deformation	Ratio of proportional limit to ultimate 1/	Compression: Number of specimens	Variation	Proportional limit: Stress	Proportional limit: Deformation	Ultimate stress	Ratio of proportional limit to ultimate 2/	Modulus of elasticity	Ratio of bolt-bearing stress to compressive stress: Proportional limit 3/	Ultimate 4/	Critical dimensions: Edge clearance	End margin 5/
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)
Inch	Inch						P.s.i.	Inch	P.s.i.	Inch				P.s.i.	Inch per inch	P.s.i.		1,000 p.s.i.			Bolt diameters	Bolt diameters
1/4	1/4	1A				Minimum	13,360	0.0076	20,390	0.0220			Minimum	5,500	0.0027	13,660		1,788				
			21	21	17	Average	14,870	.0096	21,930	.0294	0.678	22	Average	6,350	.0029	15,390	0.413	2,193	2.342	1.425	1-1/2	....
						Maximum	17,060	.0113	25,000	.0360			Maximum	7,150	.0034	20,200		2,421				
	1/2	30A				Minimum	17,030	.0098	27,850	.0420			Minimum	5,920	.0025	13,650		1,942				
			25	25	15	Average	18,370	.0127	29,890	.0527	.615	36	Average	6,910	.0032	15,120	.457	2,178	2.658	1.977	2	....
						Maximum	20,870	.0240	32,940	.0760			Maximum	8,270	.0040	16,450		2,392				
1/2	1/4	1A				Minimum	10,340	.0056	18,640	.0172			Minimum	5,500	.0027	13,660		1,788				
			25	17	17	Average	11,770	.0065	19,510	.0308	.603	22	Average	6,350	.0029	15,390	.413	2,193	1.854	1.268	1-1/4	....
						Maximum	13,210	.0076	20,700	.0380			Maximum	7,150	.0034	20,200		2,421				
	1/2	30A				Minimum	10,350	.0056	20,000	.0340			Minimum	5,920	.0025	13,650		1,942				
			23	23	19	Average	11,620	.0071	21,850	.0479	.532	36	Average	6,910	.0032	15,120	.457	2,178	1.682	1.445	1-1/4	....
						Maximum	12,790	.0085	25,120	.0580			Maximum	8,270	.0040	16,450		2,392				
	1	60A				Minimum	12,680	.0092	24,210	.0420			Minimum	6,550	.0026	13,480		1,994				
			34	33	20	Average	14,230	.0120	28,240	.0629	.504	12	Average	6,780	.0030	14,470	.469	2,306	2.099	1.952	1-3/4	....
						Maximum	17,000	.0172	30,990	.0900			Maximum	7,160	.0033	15,200		2,658				
		61A				Minimum	13,390	.0114	25,350	.0700			Minimum	5,260	.0022	13,620		1,736				
			20	17	13	Average	14,600	.0155	27,170	.0862	.537	15	Average	5,620	.0027	14,140	.397	2,121	2.598	1.921	....	3
						Maximum	16,810	.0204	29,700	.1080			Maximum	6,090	.0034	14,840		2,415				
1	1/2	30A				Minimum	9,490	.0055	19,200	.0219			Minimum	5,920	.0025	13,650		1,942				
			17	17	10	Average	10,400	.0067	20,870	.0430	.498	36	Average	6,910	.0032	15,120	.457	2,178	1.505	1.380	1-1/4	....
						Maximum	11,880	.0086	23,660	.0740			Maximum	8,270	.0040	16,450		2,392				
		33A				Minimum	10,720	.0095	22,490	.0580			Minimum	5,960	.0025	15,320		1,598				
			14	8	5	Average	11,950	.0113	22,850	.0700	.523	38	Average	6,800	.0031	17,600	.386	2,222	1.757	1.298	....	2-1/2
						Maximum	13,030	.0132	23,740	.0840			Maximum	7,660	.0042	19,460		2,552				
	1	60A				Minimum	9,580	.0053	18,210	.0256			Minimum	6,550	.0026	13,480		1,994				
			14	14	10	Average	10,180	.0078	20,150	.0457	.505	12	Average	6,780	.0030	14,470	.469	2,306	1.501	1.393	1-1/4	....
						Maximum	10,520	.0085	22,400	.0850			Maximum	7,160	.0033	15,200		2,658				
		62A				Minimum	8,920	.0069	22,510	.0940			Minimum	5,120	.0024	13,780		1,630				
			13	11	6	Average	9,920	.0104	23,040	.1013	.431	20	Average	5,790	.0029	14,250	.406	1,974	1.713	1.617	....	2-1/2
						Maximum	10,420	.0141	23,890	.1140			Maximum	6,440	.0038	15,040		2,202				

1/ Column 8 divided by column 10.

2/ Column 15 divided by column 17.

3/ Column 8 divided by column 15.

4/ Column 10 divided by column 17.

5/ End margin for tensile loading determined by modified compressive loading.

Z M 65567 F

Table 3.--Bolt-bearing strength and critical dimensions for compreg A under compressive loading at 45°

Nominal bolt diameter	Nominal panel thickness	Panel number	Bolt bearing: Number of specimens: Total tested	Bolt bearing: Number of specimens: Tested for proportional limit	Bolt bearing: Number of specimens: Tested for ultimate load	Bolt bearing: Variation	Bolt bearing: Proportional limit: Stress	Bolt bearing: Proportional limit: Deformation	Bolt bearing: Ultimate: Stress	Bolt bearing: Ultimate: Deformation	Bolt bearing: Ratio of proportional limit to ultimate[1]	Compression: Number of specimens: Tested at 0°	Compression: Number of specimens: Tested at 90°	Compression: Number of specimens: Total	Compression: Variation	Compression: Proportional limit: Stress: 0°	Compression: Proportional limit: Stress: 90°	Compression: Proportional limit: Stress: Average	Compression: Proportional limit: Deformation: 0°	Compression: Proportional limit: Deformation: 90°	Compression: Proportional limit: Deformation: Average	Compression: Ultimate stress: 0°	Compression: Ultimate stress: 90°	Compression: Ultimate stress: Average	Compression: Ratio of proportional limit to ultimate[2]	Compression: Modulus of elasticity: 0°	Compression: Modulus of elasticity: 90°	Compression: Modulus of elasticity: Average	Ratio of bolt-bearing stress to compressive stress: Proportional limit[3]	Ratio of bolt-bearing stress to compressive stress: Ultimate[4]	Critical dimensions: Edge clearance	Critical dimensions: End margin[5]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)
Inch	Inch						P.s.i.	Inch	P.s.i.	Inch						P.s.i.	P.s.i.	P.s.i.	Inch per inch	Inch per inch	Inch per inch	P.s.i.	P.s.i.	P.s.i.		1,000 p.s.i.	1,000 p.s.i.	1,000 p.s.i.			Bolt diameters	Bolt diameters
1/4	1/4					Minimum	14,420	0.0066	23,790	0.0220					Minimum	5,980			0.0022			15,160				2,278						
		2A	28	28	22	Average	16,500	.0085	26,050	.0331	0.633	15	[6]16	31	Average	6,830	[6]6,280	6,560	.0027	[6]0.0029	0.0028	16,560	[6]15,710	16,140	0.406	2,501	[6]2,202	2,352	2.515	1.614	1-1/2	....
						Maximum	18,880	.0140	28,490	.0480					Maximum	7,720			.0034			17,940				2,712						
	1/2					Minimum	17,030	.0111	27,440	.0460					Minimum	6,280	5,460		.0029	.0026		14,960	14,020			1,820	1,844					
		32A	35	28	21	Average	18,980	.0138	29,990	.0552	.633	33	27	60	Average	7,080	6,340	6,710	.0034	.0031	.0032	15,840	15,150	15,500	.433	2,108	2,060	2,084	2.829	1.935	2	....
						Maximum	20,940	.0208	33,830	.0700					Maximum	8,760	7,290		.0040	.0039		16,900	16,410			2,420	2,200					
1/2	1/4					Minimum	11,160	.0066	20,120	.0420					Minimum	5,980			.0022			15,160				2,278						
		2A	26	26	19	Average	13,030	.0085	22,090	.0499	.590	15	[6]16	31	Average	6,830	[6]6,280	6,560	.0027	[6].0029	.0028	16,560	[6]15,710	16,140	.406	2,501	[6]2,202	2,352	1.986	1.369	1-1/2	....
						Maximum	15,920	.0112	24,740	.0600					Maximum	7,720			.0034			17,940				2,712						
	1/2					Minimum	12,430	.0070	22,880	.0440					Minimum	6,280	5,460		.0029	.0026		14,960	14,020			1,820	1,844					
		32A	35	30	23	Average	14,460	.0097	25,340	.0574	.571	33	27	60	Average	7,080	6,340	6,710	.0034	.0031	.0032	15,840	15,150	15,500	.433	2,108	2,060	2,084	2.155	1.635	1-1/2	....
						Maximum	17,120	.0139	27,860	.0720					Maximum	8,760	7,290		.0040	.0039		16,900	16,410			2,420	2,200					
	1					Minimum	14,160	.0103	26,100	.0500					Minimum	5,600	4,570		.0022	.0021		14,840	14,330			2,074	1,792					
		63A	30	30	18	Average	16,080	.0146	27,300	.0640	.589	15	12	27	Average	6,700	5,380	6,040	.0029	.0028	.0028	15,970	15,630	15,800	.382	2,295	1,968	2,132	2.662	1.728	2	....
						Maximum	18,070	.0192	28,640	.0740					Maximum	8,780	6,340		.0040	.0033		17,080	17,180			2,827	2,153					
						Minimum	13,860	.0134	27,890	.0600					Minimum	4,840	4,860		.0020	.0020		14,900	15,190			1,874	1,857					
		71A	16	16	13	Average	16,390	.0168	29,440	.0705	.557	10	10	20	Average	5,970	5,950	5,960	.0028	.0028	.0028	15,660	15,860	15,760	.378	2,117	2,132	2,124	2.750	1.868	....	2-1/2
						Maximum	18,970	.0250	32,430	.0860					Maximum	6,860	6,730		.0034	.0036		16,640	17,150			2,520	2,412					
1	1/2					Minimum	9,280	.0067	20,230	.0560					Minimum	3,310	3,180		.0013	.0014		11,980	12,140			2,150	1,896					
		34A	23	15	11	Average	10,850	.0083	21,540	.0651	.504	41	33	74	Average	6,410	5,380	5,900	.0027	.0026	.0027	16,070	14,620	15,340	.385	2,375	2,056	2,216	1.839	1.404	1-1/2	....
						Maximum	13,640	.0151	22,880	.0740					Maximum	7,730	7,230		.0035	.0036		17,490	16,280			3,091	2,286					
						Minimum	9,340	.0076	20,980	.0460					Minimum	3,760	2,730		.0014	.0014		13,060	12,600			2,166	1,770					
		35A	11	9	7	Average	11,370	.0116	21,650	.0577	.525	38	40	78	Average	6,440	5,360	5,900	.0027	.0027	.0027	16,720	14,940	15,830	.373	2,400	2,003	2,202	1.927	1.368	....	2
						Maximum	12,060	.0142	22,340	.0720					Maximum	7,680	6,870		.0034	.0035		20,040	16,200			2,768	2,336					
	1					Minimum	8,180	.0071	20,810	.0600					Minimum	5,280	4,040		.0025	.0022		14,540	14,420			1,995	1,844					
		64A	22	22	12	Average	9,640	.0091	21,990	.0790	.438	8	8	16	Average	5,760	4,920	5,340	.0027	.0025	.0026	15,390	14,960	15,180	.352	2,121	1,936	2,026	1.805	1.449	1-1/2	....
						Maximum	11,120	.0121	23,380	.1000					Maximum	6,110	5,480		.0030	.0028		16,180	15,430			2,273	2,035					
						Minimum	10,190	.0126	22,910	.0780					Minimum	2,490	4,880		.0007	.0025		14,720	14,320			1,852	1,722					
		65A	12	10	5	Average	11,850	.0151	23,360	.0804	.507	13	13	26	Average	5,750	5,830	5,790	.0028	.0031	.0029	15,350	14,880	15,120	.383	2,196	1,873	2,034	2.047	1.545	....	2-1/2
						Maximum	13,520	.0194	24,130	.0880					Maximum	6,730	6,440		.0035	.0035		16,440	15,650			3,766	2,052					
						Minimum	10,140	.0098	22,910	.0600					Minimum	4,350	5,150		.0015	.0021		16,090	14,800			2,097	1,990					
		66A	11	11	7	Average	11,610	.0134	24,150	.0669	.481	11	10	21	Average	6,260	6,380	6,320	.0025	.0029	.0027	16,740	15,640	16,190	.390	2,583	2,209	2,396	1.837	1.492	....	2-1/2
						Maximum	14,070	.0215	25,510	.0840					Maximum	7,120	7,090		.0033	.0034		17,450	16,280			3,419	2,463					

[1] Column 8 divided by column 10.

[2] Column 19 divided by column 25.

[3] Column 8 divided by column 19.

[4] Column 10 divided by column 25.

[5] End margin for tensile loading determined by modified compressive loading.

[6] No 90° compression specimens were cut from panel 2A. Values entered were computed from 0° values on the basis of the average relationship for compreg A.

Z M 65568 F

Table 4.--Bolt-bearing strength and critical dimensions for compreg A under compressive loading at 90°

Nominal bolt diameter	Nominal panel thickness	Panel number	Bolt bearing: Number of specimens: Total tested	Bolt bearing: Number of specimens: Tested for proportional limit	Bolt bearing: Number of specimens: Tested for ultimate load	Bolt bearing: Variation	Bolt bearing: Proportional limit: Stress	Bolt bearing: Proportional limit: Deformation	Bolt bearing: Ultimate: Stress	Bolt bearing: Ultimate: Deformation	Bolt bearing: Ratio of proportional limit to ultimate[1]	Compression: Number of specimens	Compression: Variation	Compression: Proportional limit: Stress	Compression: Proportional limit: Deformation	Compression: Ultimate stress	Compression: Ratio of proportional limit to ultimate[2]	Compression: Modulus of elasticity	Ratio of bolt-bearing stress to compressive stress: Proportional limit[3]	Ratio of bolt-bearing stress to compressive stress: Ultimate[4]	Critical dimensions: Edge clearance	Critical dimensions: End margin[5]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)
Inch	Inch						P.s.i.	Inch	P.s.i.	Inch				P.s.i.	Inch per inch	P.s.i.		1,000 p.s.i.			Bolt diameters	Bolt diameters
1/4	1/4	1A	19	19	13	Minimum Average Maximum	13,860 15,490 18,210	0.0069 .0087 .0104	23,390 24,300 26,050	0.0220 .0266 .0420	0.637	[6]23	Minimum Average Maximum	[6]5,840	[6]0.0030	[6]14,600	0.400	[6]1,931	2.652	1.664	1-1/2	....
	1/2	36A	15	15	9	Minimum Average Maximum	15,780 17,820 20,680	.0063 .0093 .0131	30,510 32,020 33,570	.0400 .0453 .0520	.557	51	Minimum Average Maximum	2,760 5,080 6,720	.0011 .0028 .0039	13,980 15,900 17,500	.319	1,482 1,871 2,559	3.508	2.014	2	....
1/2	1/4	1A	18	18	12	Minimum Average Maximum	10,520 11,590 13,000	.0058 .0065 .0078	18,670 19,630 20,630	.0180 .0278 .0500	.590	[6]23	Minimum Average Maximum	[6]5,840	[6].0030	[6]14,600	.400	[6]1,931	1.985	1.345	1-1/4	....
	1/2	36A	15	15	12	Minimum Average Maximum	11,810 13,550 15,020	.0064 .0078 .0090	21,820 26,200 31,140	.0163 .0439 .0620	.517	51	Minimum Average Maximum	2,760 5,080 6,720	.0011 .0028 .0039	13,980 15,900 17,500	.319	1,482 1,871 2,559	2.667	1.648	1-1/4	....
	1	67A	16	16	10	Minimum Average Maximum	14,960 16,760 21,440	.0104 .0138 .0217	27,400 29,450 31,860	.0480 .0576 .0680	.569	12	Minimum Average Maximum	5,760 6,460 7,360	.0026 .0030 .0037	15,560 16,540 17,690	.391	1,860 2,157 2,270	2.594	1.781	1-3/4	....
		72A	15	15	9	Minimum Average Maximum	12,340 15,040 17,560	.0120 .0163 .0213	23,650 25,880 27,440	.0620 .0744 .0900	.581	20	Minimum Average Maximum	2,470 5,510 6,500	.0014 .0029 .0034	12,430 13,550 14,700	.407	1,701 1,910 2,038	2.730	1.910	....	3
1	1/2	36A	16	12	9	Minimum Average Maximum	9,060 9,830 10,580	.0060 .0068 .0076	18,730 20,300 22,230	.0240 .0334 .0520	.484	51	Minimum Average Maximum	2,760 5,080 6,720	.0011 .0028 .0039	13,980 15,900 17,500	.319	1,482 1,871 2,559	1.935	1.277	1-1/4	....
		37A	12	12	6	Minimum Average Maximum	8,280 10,220 11,000	.0084 .0103 .0135	21,940 23,200 24,260	.0720 .0797 .0880	.441	30	Minimum Average Maximum	3,510 5,080 6,540	.0016 .0025 .0035	15,050 16,180 17,700	.314	1,831 2,012 2,202	2.012	1.434	....	2-1/2
	1	67A	16	16	6	Minimum Average Maximum	9,780 11,120 12,350	.0076 .0093 .0106	21,260 23,380 24,410	.0400 .0522 .0600	.476	12	Minimum Average Maximum	5,760 6,460 7,360	.0026 .0030 .0037	15,560 16,540 17,690	.391	1,866 2,157 2,270	1.721	1.414	1-1/2	....
		69A	12	7	5	Minimum Average Maximum	10,970 11,940 13,470	.0115 .0148 .0200	22,300 23,260 24,090	.0700 .0732 .0780	.513	20	Minimum Average Maximum	4,700 6,130 7,060	.0019 .0031 .0038	14,040 14,880 15,710	.412	1,835 2,013 2,428	1.948	1.563	....	2-1/2
		70A	11	11	6	Minimum Average Maximum	9,210 9,850 11,500	.0100 .0126 .0146	20,470 21,580 22,850	.0640 .0777 .0900	.456	20	Minimum Average Maximum	5,350 5,800 6,550	.0027 .0030 .0034	12,950 13,610 13,980	.426	1,772 1,932 2,039	1.698	1.586	....	2-1/2

[1]Column 8 divided by column 10.

[2]Column 15 divided by column 17.

[3]Column 8 divided by column 15.

[4]Column 10 divided by column 17.

[5]End margin for tensile loading determined by modified compressive loading.

[6]No 90° compression specimens cut from panel 1A. Values entered were computed from 0° values on the basis of the average relationship for compreg A.

Z M 65569 F

Table 5.--Bolt-bearing strength and critical dimensions for compreg A under tensile loading at 0°

Nominal bolt diameter	Nominal panel thickness	Panel number	Bolt bearing: Number of specimens: Total tested	Bolt bearing: Number of specimens: Tested for proportional limit	Bolt bearing: Number of specimens: Tested for ultimate load	Bolt bearing: Variation	Bolt bearing: Proportional limit: Stress	Bolt bearing: Proportional limit: Deformation	Bolt bearing: Ultimate: Stress	Bolt bearing: Ultimate: Deformation	Bolt bearing: Ratio of proportional limit to ultimate[1]	Compression: Number of specimens	Compression: Variation	Compression: Proportional limit: Stress	Compression: Proportional limit: Deformation	Compression: Ultimate stress	Compression: Ratio of proportional limit to ultimate[2]	Compression: Modulus of elasticity	Ratio of bolt-bearing stress to compressive stress: Proportional limit[3]	Ratio of bolt-bearing stress to compressive stress: Ultimate[4]	Critical dimensions: Edge clearance	Critical dimensions: End margin
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)
Inch	Inch						P.s.i.	Inch	P.s.i.	Inch				P.s.i.	Inch per inch	P.s.i.		1,000 p.s.i.			Bolt diameters	Bolt diameters
1/4	1/4	3A				Minimum	11,870	0.0056	27,120	0.0280			Minimum	5,650	0.0024	15,950		1,938				
			18	18	8	Average	13,490	.0072	30,840	.0698	0.437	10	Average	6,360	.0029	17,460	0.364	2,187	2.121	1.766	3	....
						Maximum	16,130	.0096	35,200	.1482			Maximum	6,940	.0033	19,440		2,422				
	1/4	11A				Minimum	10,320	.0038	25,080	.0256			Minimum	3,530	.0018	12,600		1,946				
			17	17	9	Average	13,290	.0057	28,230	.0308	.471	17	Average	5,550	.0025	15,920	.349	2,199	2.395	1.773	3	....
						Maximum	15,150	.0072	31,880	.0468			Maximum	6,320	.0029	18,950		2,384				
		11A				Minimum	11,080	.0033	23,920	.0194			Minimum	3,530	.0018	12,600		1,946				
			15	12	9	Average	12,670	.0046	25,130	.0314	.504	17	Average	5,550	.0025	15,920	.349	2,199	2.283	1.579	....	3
						Maximum	14,290	.0057	25,830	.0350			Maximum	6,320	.0029	18,950		2,384				
	1/2	31A				Minimum	10,220	.0085	25,220	.0505			Minimum	5,550	.0026	12,060		1,847				
			19	18	16	Average	12,490	.0099	29,190	.0648	.428	23	Average	6,490	.0031	14,650	.443	2,096	1.924	1.992	2-1/2	....
						Maximum	15,080	.0136	36,640	.0821			Maximum	7,770	.0039	16,540		2,376				
		40A				Minimum	11,420	.0064	30,190	.0311			Minimum	6,020	.0027	15,620		1,773				
			19	15	4	Average	13,170	.0089	32,200	.0468	.409	29	Average	7,270	.0033	17,040	.427	2,231	1.812	1.890	....	5
						Maximum	15,780	.0105	33,500	.0625			Maximum	9,100	.0040	20,000		2,420				
1/2	1/4	3A				Minimum	8,010	.0021	20,510	.0138			Minimum	5,650	.0024	15,950		1,938				
			8	8	3	Average	9,810	.0035	21,790	.0328	.450	10	Average	6,360	.0029	17,460	.364	2,187	1.542	1.248	4	....
						Maximum	10,620	.0047	23,020	.0518			Maximum	6,940	.0033	19,440		2,422				
		12A				Minimum	9,060	.0034	19,840	.0205			Minimum	3,340	.0018	15,290		1,881				
			16	15	9	Average	10,130	.0040	21,130	.0331	.479	11	Average	6,080	.0030	16,290	.373	2,035	1.666	1.297	4	....
						Maximum	12,600	.0055	22,690	.0431			Maximum	7,260	.0037	17,460		2.178				
		6A				Minimum	9,720	.0030	19,380	.0112			Minimum	5,360	.0023	14,520		2,044				
			12	12	11	Average	10,550	.0038	20,760	.0308	.508	10	Average	5,930	.0026	15,760	.376	2,332	1.779	1.317	....	2-1/2
						Maximum	12,030	.0064	21,600	.0362			Maximum	6,800	.0029	17,560		2,804				
	1/2	31A				Minimum	9,410	.0039	21,020	.0274			Minimum	5,550	.0026	12,060		1,847				
			12	12	8	Average	10,570	.0050	22,840	.0387	.463	23	Average	6,490	.0031	14,650	.443	2,096	1.629	1.559	2-1/2	....
						Maximum	12,160	.0070	24,580	.0525			Maximum	7,770	.0039	16,540		2,376				
		42A				Minimum	7,540	.0030	19,960	Dial removed			Minimum	4,580	.0021	14,390		1,820				
			12	12	4	Average	9,220	.0039	21,020		.439	14	Average	5,920	.0029	15,700	.377	2,069	1.557	1.339	....	3-1/2
						Maximum	11,180	.0052	22,560				Maximum	7,360	.0037	16,920		2,324				

[1]Column 8 divided by column 10.
[2]Column 15 divided by column 17.
[3]Column 8 divided by column 15.
[4]Column 10 divided by column 17.

Z M 65570 F

Table 6.--Bolt-bearing strength and critical dimensions for compreg A under tensile loading at 45°

Nominal bolt diameter	Nominal panel thickness	Panel number	Bolt bearing: Number of specimens: Total tested	Tested for proportional limit	Tested for ultimate load	Variation	Proportional limit: Stress	Proportional limit: Deformation	Ultimate: Stress	Ultimate: Deformation	Ratio of proportional limit to ultimate[1]	Compression: Number of specimens: Tested at 0°	Tested at 90°	Total	Variation	Proportional limit: Stress: 0°	Stress: 90°	Stress: Average	Deformation: 0°	Deformation: 90°	Deformation: Average	Ultimate stress: 0°	Ultimate stress: 90°	Ultimate stress: Average	Ratio of proportional limit to ultimate[2]	Modulus of elasticity: 0°	Modulus of elasticity: 90°	Modulus of elasticity: Average	Ratio of bolt-bearing stress to compressive stress: Proportional limit[3]	Ultimate[4]	Critical dimensions: Edge clearance	End margin
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)
Inch	Inch						P.s.i.	Inch	P.s.i.	Inch						P.s.i.	P.s.i.	P.s.i.	Inch per inch	Inch per inch	Inch per inch	P.s.i.	P.s.i.	P.s.i.		1,000 p.s.i.	1,000 p.s.i.	1,000 p.s.i.			Bolt diameters	Bolt diameters
1/4	1/4					Minimum	13,100	0.0043	26,520	0.0234					Minimum	5,930			0.0027			14,450				1,648						
		4A	10	10	8	Average	15,210	.0067	28,280	.0416	0.538	18	[5]19	37	Average	6,560	[5]6,030	6,300	.0031	[5]0.0032	0.0032	16,550	[5]15,700	16,120	0.391	2,136	[5]1,881	2,008	2.414	1.754	2-1/2	....
						Maximum	16,870	.0086	29,280	.0680					Maximum	7,340			.0038			17,810				2,323						
						Minimum	10,940	.0038	24,490	.0237					Minimum	5,220	5,560		.0024	.0028		15,010	14,040			1,933	1,712					
		7A	20	16	16	Average	13,270	.0059	26,630	.0306	.498	12	13	25	Average	6,680	6,330	6,500	.0032	.0034	.0033	16,750	15,230	15,990	.407	2,103	1,883	1,993	2.042	1.665	....	2
						Maximum	15,700	.0074	26,980	.0366					Maximum	7,760	7,370		.0038	.0039		18,560	17,120			2,243	2,049					
	1/2					Minimum	12,200	.0081	30,280	.0424					Minimum	4,670	4,580		.0020	.0023		14,480	15,320			1,906	1,724					
		38A	17	14	9	Average	13,660	.0107	31,500	.0559	.434	43	38	81	Average	5,950	5,780	5,860	.0027	.0030	.0029	16,570	16,540	16,560	.354	2,181	1,952	2,066	2.331	1.902	2-1/2	....
						Maximum	16,610	.0160	34,380	.0680					Maximum	7,580	7,680		.0037	.0040		18,000	18,140			2,514	2,150					
						Minimum	10,200	.0062	31,460	.0500					Minimum	4,290	4,570		.0021	.0024		15,830	15,240			1,944	1,650					
		41A	10	7	6	Average	12,650	.0084	32,480	.0558	.389	44	39	83	Average	7,340	5,930	6,640	.0034	.0031	.0032	17,780	16,170	16,980	.391	2,192	1,902	2,047	1.905	1.913	....	3
						Maximum	14,960	.0098	33,250	.0627					Maximum	8,700	7,030		.0041	.0037		20,200	17,180			2,446	2,168					
1/2	1/4					Minimum	7,760	.0024	20,600	.0310					Minimum	5,930			.0027			14,450				1,648						
		4A	10	10	8	Average	9,000	.0035	21,310	.0401	.422	18	[5]19	37	Average	6,560	[5]6,030	6,300	.0031	[5].0032	.0032	16,550	[5]15,700	16,120	.391	2,136	[5]1,881	2,008	1.429	1.322	2-1/4	....
						Maximum	10,220	.0043	22,120	.0476					Maximum	7,340			.0038			17,810				2,323						
						Minimum	7,840	.0034	20,750	.0247					Minimum	5,470	3,910		.0024	.0022		16,360	14,720			2,054	1,744					
		8A	15	12	9	Average	10,070	.0047	22,420	.0423	.449	11	10	21	Average	6,750	5,700	6,220	.0031	.0030	.0030	17,790	16,180	16,980	.366	2,183	1,908	2,046	1.619	1.320	....	2
						Maximum	11,370	.0064	24,900	.0488					Maximum	7,620	7,040		.0036	.0037		19,080	18,600			2,344	2,015					
	1/2					Minimum	9,800	.0044	22,720	.0322					Minimum	4,670	4,580		.0020	.0023		14,480	15,320			1,906	1,724					
		38A	15	11	9	Average	10,790	.0058	24,490	.0482	.441	43	38	81	Average	5,950	5,780	5,860	.0027	.0030	.0029	16,570	16,540	16,560	.354	2,181	1,952	2,066	1.841	1.479	2	....
						Maximum	11,780	.0088	27,320	.0559					Maximum	7,580	7,680		.0037	.0040		18,000	18,140			2,514	2,150					
						Minimum	9,640	.0038	24,380	.0469					Minimum	4,290	4,570		.0021	.0024		15,830	15,240			1,944	1,650					
		41A	10	8	4	Average	11,640	.0060	26,260	.0522	.443	44	39	83	Average	7,340	5,930	6,640	.0034	.0031	.0032	17,780	16,170	16,980	.391	2,192	1,902	2,047	1.753	1.547	....	2-1/2
						Maximum	13,780	.0092	27,110	.0564					Maximum	8,700	7,030		.0041	.0037		20,200	17,180			2,446	2,168					

[1]Column 8 divided by column 10.

[2]Column 19 divided by column 25.

[3]Column 8 divided by column 19.

[4]Column 10 divided by column 25.

[5]No 90° compression specimens cut from panel 4A. Values entered were computed from 0° values on the basis of the average relationship for compreg A.

Z M 65571 F

Table 7.--Bolt-bearing strength and critical dimensions for compreg A under tensile loading at 90°

Nominal bolt diameter	Nominal panel thickness	Panel number	Bolt bearing: Number of specimens: Total tested	Tested for proportional limit	Tested for ultimate load	Variation	Proportional limit: Stress	Proportional limit: Deformation	Ultimate: Stress	Ultimate: Deformation	Ratio of proportional limit to ultimate[1]	Compression: Number of specimens	Variation	Proportional limit: Stress	Proportional limit: Deformation	Ultimate stress	Ratio of proportional limit to ultimate[2]	Modulus of elasticity	Ratio of bolt-bearing stress to compressive stress: Proportional limit[3]	Ultimate[4]	Critical dimensions: Edge clearance	End margin
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)
Inch	Inch						P.s.i.	Inch	P.s.i.	Inch				P.s.i.	Inch per inch	P.s.i.		1,000 p.s.i.			Bolt diameters	Bolt diameters
						Minimum	11,530	0.0034	23,390	0.0252			Minimum									
		5A	13	13	10	Average	13,010	.0063	27,080	.0396	0.480	[5]10	Average	[5]6,010	[5]0.0031	[5]15,720	0.382	[5]1,934	2.165	1.723	3-1/2	....
	1/4					Maximum	15,180	.0098	29,620	.0551			Maximum									
						Minimum	11,080	.0041	25,740	.0192			Minimum	3,350	.0020	14,840		1,494				
		9A	16	14	9	Average	14,010	.0058	27,150	.0283	.516	9	Average	5,610	.0032	16,830	.333	1,763	2.497	1.613	....	4
						Maximum	15,880	.0075	29,200	.0384			Maximum	6,820	.0036	18,860		1,931				
						Minimum	10,100	.0072	28,550	.0336			Minimum	4,420	.0019	12,760		1,884				
1/4		39A	13	12	6	Average	12,780	.0084	30,280	.0511	.422	21	Average	5,440	.0027	15,360	.354	2,038	2.349	1.971	4-1/2	....
						Maximum	14,070	.0098	32,420	.0590			Maximum	6,740	.0033	17,080		2,466				
						Minimum	12,720	.0062	23,520	.0440			Minimum	3,750	.0023	14,520		1,606				
	1/2	43A	11	10	6	Average	14,410	.0089	32,200	.0498	.448	15	Average	5,240	.0029	16,140	.325	1,824	2.750	1.995	4	....
						Maximum	17,760	.0109	33,520	.0551			Maximum	6,250	.0033	18,420		2,124				
						Minimum	13,550	.0065	31,200				Minimum	3,750	.0023	14,520		1,606				
		43A	11	11	7	Average	14,790	.0086	34,320	(6)	.431	15	Average	5,240	.0029	16,140	.325	1,824	2.823	2.126	....	5
						Maximum	16,770	.0103	37,960				Maximum	6,250	.0033	18,420		2,124				
						Minimum	7,650	.0022	20,360	.0398			Minimum									
		5A	10	10	2	Average	9,060	.0035	20,820	.0422	.435	[5]10	Average	[5]6,010	[5].0031	[5]15,720	.382	[5]1,934	1.507	1.324	5	....
						Maximum	10,570	.0050	21,280	.0446			Maximum									
						Minimum	10,900	.0038	19,450				Minimum	5,270	.0029	14,140		1,790				
	1/4	13A	11	11	9	Average	11,960	.0055	22,030	(6)	.543	9	Average	6,400	.0032	16,100	.398	2,005	1.869	1.368	5	....
						Maximum	15,260	.0078	24,440				Maximum	6,920	.0034	18,160		2,134				
						Minimum	8,240	.0012	18,970	.0131			Minimum	3,960	.0020	13,000		1,894				
		10A	9	9	3	Average	9,140	.0028	20,990	.0236	.435	9	Average	5,550	.0028	16,100	.345	1,993	1.647	1.304	....	4
1/2						Maximum	9,840	.0035	22,820	.0369			Maximum	7,120	.0034	18,400		2,092				
						Minimum	8,510	.0044	20,700	.0194			Minimum	4,420	.0019	12,760		1,884				
		39A	9	8	3	Average	10,100	.0048	21,520	.0207	.469	21	Average	5,440	.0027	15,360	.354	2,038	1.857	1.401	4-1/2	....
						Maximum	11,560	.0055	22,950	.0220			Maximum	6,740	.0033	17,080		2,466				
						Minimum	10,120	.0050	21,320				Minimum	4,200	.0021	13,390		1,626				
	1/2	44A	7	7	6	Average	10,510	.0058	23,070	(6)	.456	15	Average	5,360	.0030	15,620	.343	1,812	1.961	1.477	4-1/2	....
						Maximum	11,360	.0074	26,100				Maximum	6,220	.0034	18,160		2,029				
						Minimum	8,610	.0041	22,400				Minimum	4,200	.0021	13,390		1,626				
		44A	6	6	4	Average	10,230	.0055	23,580	(6)	.434	15	Average	5,360	.0030	15,620	.343	1,812	1.909	1.510	....	4-1/2
						Maximum	10,900	.0066	26,100				Maximum	6,220	.0034	18,160		2,029				

[1]Column 8 divided by column 10.
[2]Column 15 divided by column 17.
[3]Column 8 divided by column 15.
[4]Column 10 divided by column 17.
[5]No 90° compression specimens cut from panel 5A. Values entered were computed from 0° values on the basis of the average relationship for compreg A.
[6]Dial removed.

Z M 65572 F

Table 8.--Bolt-bearing strength for compreg B under compressive loading at 0°

Nominal bolt diameter	Nominal panel thickness	Panel number	Bolt bearing: Number of specimens: Total tested	Bolt bearing: Number of specimens: Tested for proportional limit	Bolt bearing: Number of specimens: Tested for ultimate load	Bolt bearing: Variation	Bolt bearing: Proportional limit: Stress	Bolt bearing: Proportional limit: Deformation	Bolt bearing: Ultimate: Stress	Bolt bearing: Ultimate: Deformation	Bolt bearing: Ratio of proportional limit to ultimate[1]	Compression: Number of specimens	Compression: Variation	Compression: Proportional limit: Stress	Compression: Proportional limit: Deformation	Compression: Ultimate stress	Compression: Ratio of proportional limit to ultimate[2]	Compression: Modulus of elasticity	Ratio of bolt-bearing stress to compressive stress: Proportional limit[3]	Ratio of bolt-bearing stress to compressive stress: Ultimate[4]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
Inch	Inch						P.s.i.	Inch	P.s.i.	Inch				P.s.i.	Inch per inch	P.s.i.		1,000 p.s.i.		
1/4	1/4	2B				Minimum	16,460	0.0084	27,420	0.0310			Minimum	5,840	0.0028	16,350		1,545		
			10	10	10	Average	18,040	.0097	28,690	.0496	0.629	10	Average	6,740	.0034	18,430	0.366	1,987	2.677	1.557
						Maximum	19,340	.0124	30,040	.0570			Maximum	7,970	.0040	19,780		2,162		
	1/2	44B				Minimum	17,640	.0086	34,200	.0440			Minimum	5,770	.0026	15,720		2,008		
			12	12	12	Average	22,600	.0112	38,100	.0572	.593	18	Average	6,770	.0032	18,550	.365	2,152	3.338	2.054
						Maximum	25,240	.0154	40,680	.0710			Maximum	7,920	.0036	19,950		2,280		
1/2	1/4	2B				Minimum	11,310	.0070	23,270	.0450			Minimum	5,840	.0028	16,350		1,545		
			7	7	7	Average	11,990	.0076	24,140	.0517	.497	10	Average	6,740	.0034	18,430	.366	1,987	1.779	1.310
						Maximum	12,550	.0083	24,860	.0540			Maximum	7,970	.0040	19,780		2,162		
	1/2	44B				Minimum	14,980	.0103	28,400	.0400			Minimum	5,770	.0026	15,720		2,008		
			7	7	7	Average	16,650	.0113	29,780	.0564	.559	18	Average	6,770	.0032	18,550	.365	2,152	2.459	1.605
						Maximum	18,140	.0123	31,260	.0640			Maximum	7,920	.0036	19,950		2,280		
	1	81B				Minimum	14,260	.0140	34,740	.0730			Minimum	5,500	.0022	18,870		2,186		
			6	6	6	Average	15,040	.0157	36,130	.0840	.416	10	Average	6,380	.0027	19,930	.320	2,414	2.357	1.813
						Maximum	16,340	.0178	39,580	.1060			Maximum	7,170	.0033	22,560		2,521		
1	1/2	44B				Minimum	12,450	.0085	22,880	.0279			Minimum	5,770	.0026	15,720		2,008		
			9	9	9	Average	13,070	.0093	24,440	.0402	.535	18	Average	6,770	.0032	18,550	.365	2,152	1.931	1.318
						Maximum	13,790	.0099	27,240	.0723			Maximum	7,920	.0036	19,950		2,280		
	1	81B				Minimum	11,670	.0108	27,140	.0540			Minimum	5,500	.0022	18,870		2,186		
			8	8	8	Average	13,400	.0122	28,520	.0702	.470	10	Average	6,380	.0027	19,930	.320	2,414	2.100	1.431
						Maximum	14,600	.0138	30,000	.0920			Maximum	7,170	.0033	22,560		2,521		

[1] Column 8 divided by column 10.
[2] Column 15 divided by column 17.
[3] Column 8 divided by column 15.
[4] Column 10 divided by column 17.

Z M 65573 F

Table 9.--Bolt-bearing strength and critical dimensions for compreg C under compressive loading at 0°

Nominal bolt diameter	Nominal panel thickness	Panel number	Bolt bearing: Number of specimens: Total tested	Bolt bearing: Number of specimens: Tested for proportional limit	Bolt bearing: Number of specimens: Tested for ultimate load	Bolt bearing: Variation	Bolt bearing: Proportional limit: Stress	Bolt bearing: Proportional limit: Deformation	Bolt bearing: Ultimate: Stress	Bolt bearing: Ultimate: Deformation	Bolt bearing: Ratio of proportional limit to ultimate[1]	Compression: Number of specimens	Compression: Variation	Compression: Proportional limit: Stress	Compression: Proportional limit: Deformation	Compression: Ultimate stress	Compression: Ratio of proportional limit to ultimate[2]	Compression: Modulus of elasticity	Ratio of bolt-bearing stress to compressive stress: Proportional limit[3]	Ratio of bolt-bearing stress to compressive stress: Ultimate[4]	Critical dimensions: Edge clearance	Critical dimensions: End margin[5]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)
Inch	Inch						P.s.i.	Inch	P.s.i.	Inch				P.s.i.	Inch per inch	P.s.i.		1,000 p.s.i.			Bolt diameters	Bolt diameters
1/4	1/4	10	20	20	12	Minimum	17,280	0.0062	30,100	0.0360	0.558	36	Minimum	5,000	0.0014	15,960	0.386	1,646	2.538	1.755	2	....
						Average	18,350	.0077	32,890	.0427			Average	7,230	.0033	18,740		2,104				
						Maximum	19,490	.0100	34,140	.0480			Maximum	9,220	.0052	22,370		2,330				
	1/2	100	15	14	12	Minimum	17,360	.0086	33,800	.0280	.545	60	Minimum	4,860	.0026	13,200	.371	1,476	3.290	2.243	1-1/2	....
						Average	19,740	.0102	36,240	.0439			Average	6,000	.0033	16,160		1,843				
						Maximum	21,160	.0130	38,020	.0620			Maximum	7,800	.0043	19,920		2,405				
1/2	1/4	10	20	20	12	Minimum	12,900	.0048	24,920	.0220	.523	36	Minimum	5,000	.0014	15,960	.386	1,646	1.971	1.454	1-1/2	....
						Average	14,250	.0061	27,240	.0369			Average	7,230	.0033	18,740		2,104				
						Maximum	16,760	.0078	28,940	.0470			Maximum	9,220	.0052	22,370		2,330				
	1/2	100	15	15	9	Minimum	12,180	.0068	26,920	.0290	.561	60	Minimum	4,860	.0026	13,200	.371	1,476	2.728	1.806	1-1/2	....
						Average	16,370	.0102	29,180	.0340			Average	6,000	.0033	16,160		1,843				
						Maximum	17,930	.0115	33,700	.0430			Maximum	7,800	.0043	19,920		2,405				
	1	220	6	6	6	Minimum	13,500	.0132	33,540	.0790	.398	12	Minimum	5,220	.0023	17,580	.303	2,005	2.443	1.860	Bearing only	
						Average	14,440	.0153	36,240	.0868			Average	5,910	.0028	19,480		2,136				
						Maximum	15,150	.0166	39,000	.0900			Maximum	6,810	.0032	20,620		2,458				
1	1/2	100	14	14	9	Minimum	9,100	.0051	22,810	.0247	.456	60	Minimum	4,860	.0026	13,200	.371	1,476	1.803	1.467	1-1/2	....
						Average	10,820	.0066	23,710	.0347			Average	6,000	.0033	16,160		1,843				
						Maximum	12,840	.0086	24,770	.0560			Maximum	7,800	.0043	19,920		2,405				
	1/2	110	15	12	9	Minimum	12,020	.0102	24,540	.0520	.490	94	Minimum	5,390	.0026	14,170	.406	1,700	1.959	1.622	....	2-1/2
						Average	13,420	.0124	27,400	.0734			Average	6,850	.0033	16,890		2,099				
						Maximum	14,660	.0147	29,900	.0900			Maximum	8,250	.0041	19,260		2,478				
	1	220	8	8	8	Minimum	12,340	.0113	26,730	.0580	.475	12	Minimum	5,220	.0023	17,580	.303	2,005	2.267	1.449	Bearing only	
						Average	13,400	.0121	28,230	.0685			Average	5,910	.0028	19,480		2,136				
						Maximum	15,070	.0132	29,960	.0820			Maximum	6,810	.0032	20,620		2,458				

[1]Column 8 divided by column 10.

[2]Column 15 divided by column 17.

[3]Column 8 divided by column 15.

[4]Column 10 divided by column 17.

[5]End margin for tensile loading determined by modified compressive loading.

Z M 65574 F

Table 10.--Bolt-bearing strength and critical dimensions for compreg C under compressive loading at 45°

Nominal bolt diameter	Nominal panel thickness	Panel number	Bolt bearing: Number of specimens: Total tested	Bolt bearing: Number of specimens: Tested for proportional limit	Bolt bearing: Number of specimens: Tested for ultimate load	Bolt bearing: Variation	Bolt bearing: Proportional limit: Stress	Bolt bearing: Proportional limit: Deformation	Bolt bearing: Ultimate: Stress	Bolt bearing: Ultimate: Deformation	Bolt bearing: Ratio of proportional limit to ultimate[1]	Compression: Number of specimens: Tested at 0°	Compression: Number of specimens: Tested at 90°	Compression: Number of specimens: Total	Compression: Variation	Compression: Proportional limit: Stress: 0°	Compression: Proportional limit: Stress: 90°	Compression: Proportional limit: Stress: Average	Compression: Proportional limit: Deformation: 0°	Compression: Proportional limit: Deformation: 90°	Compression: Proportional limit: Deformation: Average	Compression: Ultimate stress: 0°	Compression: Ultimate stress: 90°	Compression: Ultimate stress: Average	Compression: Ratio of proportional limit to ultimate[2]	Compression: Modulus of elasticity: 0°	Compression: Modulus of elasticity: 90°	Compression: Modulus of elasticity: Average	Ratio of bolt-bearing stress to compressive stress: Proportional limit[3]	Ratio of bolt-bearing stress to compressive stress: Ultimate[4]	Critical dimensions: Edge clearance	Critical dimensions: End margin[5]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)
Inch	Inch						P.s.i.	Inch	P.s.i.	Inch						P.s.i.	P.s.i.	P.s.i.	Inch per inch	Inch per inch	Inch per inch	P.s.i.	P.s.i.	P.s.i.		1,000 p.s.i.	1,000 p.s.i.	1,000 p.s.i.			Bolt diameters	Bolt diameters
						Minimum	15,440	0.0069	29,120	0.0340					Minimum	5,000	5,240		0.0014	0.0028		15,960	15,880			1,646	1,766					
1/4	1/4	10	20	20	12	Average	17,240	.0083	30,050	.0453	0.574	36	20	56	Average	7,230	6,000	6,620	.0033	.0031	0.0032	18,740	19,060	18,900	0.350	2,104	1,945	2,024	2.604	1.590	2	....
						Maximum	19,940	.0105	31,110	.0640					Maximum	9,220	7,250		.0052	.0035		22,370	21,180			2,330	2,132					
						Minimum	14,690	.0078	31,760	.0480					Minimum	4,860	4,510		.0026	.0027		13,200	13,180			1,476	1,174					
	1/2	10C	15	15	9	Average	16,570	.0092	35,340	.0645	.469	60	44	104	Average	6,000	5,970	5,980	.0033	.0034	.0033	16,160	16,380	16,270	.368	1,843	1,777	1,810	2.771	2.172	2	....
						Maximum	18,700	.0103	37,400	.0800					Maximum	7,800	7,280		.0043	.0042		19,920	19,080			2,405	2,164					
						Minimum	11,380	.0045	25,420	.0400					Minimum	5,000	5,240		.0014	.0028		15,960	15,880			1,646	1,766					
1/2	1/4	10	17	17	6	Average	13,520	.0061	27,790	.0468	.487	36	20	56	Average	7,230	6,000	6,620	.0033	.0031	.0032	18,740	19,060	18,900	.350	2,104	1,945	2,024	2.042	1.470	2	....
						Maximum	15,580	.0080	29,120	.0540					Maximum	9,220	7,250		.0052	.0035		22,370	21,180			2,330	2,132					
						Minimum	10,740	.0076	24,240	.0380					Minimum	4,860	4,510		.0026	.0027		13,200	13,180			1,476	1,174					
	1/2	10C	25	25	15	Average	13,320	.0105	25,900	.0550	.514	60	44	104	Average	6,000	5,970	5,980	.0033	.0034	.0033	16,160	16,380	16,270	.368	1,843	1,777	1,810	2.227	1.592	1-1/2	....
						Maximum	17,110	.0147	29,500	.0710					Maximum	7,800	7,280		.0043	.0042		19,920	19,080			2,405	2,164					
						Minimum	9,700	.0066	25,700	.0620					Minimum	4,860	4,510		.0026	.0027		13,200	13,180			1,476	1,174					
1	1/2	10C	16	16	8	Average	11,350	.0080	26,890	.0815	.422	60	44	104	Average	6,000	5,970	5,980	.0033	.0034	.0033	16,160	16,380	16,270	.368	1,843	1,777	1,810	1.898	1.653	2	....
						Maximum	12,340	.0099	28,220	.1040					Maximum	7,800	7,280		.0043	.0042		19,920	19,080			2,405	2,164					
						Minimum	10,380	.0086	26,760	.0520					Minimum	5,390	4,500		.0026	.0026		14,170	14,340			1,700	1,442					
		11C	13	13	8	Average	12,140	.0110	27,430	.0674	.443	94	54	148	Average	6,850	5,510	6,180	.0033	.0032	.0033	16,890	16,480	16,660	.371	2,099	1,709	1,904	1,964	1.644	....	2-1/2
						Maximum	13,960	.0164	28,280	.0760					Maximum	8,250	6,690		.0041	.0041		19,260	20,480			2,478	2,022					

[1]Column 8 divided by column 10.
[2]Column 19 divided by column 25.
[3]Column 8 divided by column 19.
[4]Column 10 divided by column 25.
[5]End margin for tensile loading determined by modified compressive loading.

Z M 65575 F

Table 11.--Bolt-bearing strength and critical dimensions for compreg C under compressive loading at 90°

Nominal bolt diameter	Nominal panel thickness	Panel number	Bolt bearing: Number of specimens: Total tested	Bolt bearing: Number of specimens: Tested for proportional limit	Bolt bearing: Number of specimens: Tested for ultimate load	Bolt bearing: Variation	Bolt bearing: Proportional limit: Stress	Bolt bearing: Proportional limit: Deformation	Bolt bearing: Ultimate: Stress	Bolt bearing: Ultimate: Deformation	Bolt bearing: Ratio of proportional limit to ultimate[1]	Compression: Number of specimens	Compression: Variation	Compression: Proportional limit: Stress	Compression: Proportional limit: Deformation	Compression: Ultimate stress	Compression: Ratio of proportional limit to ultimate[2]	Compression: Modulus of elasticity	Ratio of bolt-bearing stress to compressive stress: Proportional limit[3]	Ratio of bolt-bearing stress to compressive stress: Ultimate[4]	Critical dimensions: Edge clearance	Critical dimensions: End margin[5]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)
Inch	Inch						P.s.i.	Inch	P.s.i.	Inch				P.s.i.	Inch per inch	P.s.i.		1,000 p.s.i.			Bolt diameters	Bolt diameters
1/4	1/4	1C				Minimum	15,980	0.0056	28,980	0.0320			Minimum	5,240	0.0028	15,880		1,766				
			20	20	12	Average	17,840	.0079	30,710	.0389	0.581	20	Average	6,000	.0031	19,060	0.315	1,945	2.973	1.611	2	....
						Maximum	19,240	.0103	32,400	.0460			Maximum	7,250	.0035	21,180		2,132				
	1/2	10C				Minimum	15,700	.0080	30,680	.0400			Minimum	4,510	.0027	13,180		1,174				
			15	15	9	Average	16,820	.0092	32,640	.0577	.515	44	Average	5,970	.0034	16,380	.364	1,777	2.817	1.993	2	....
						Maximum	18,200	.0105	35,330	.0800			Maximum	7,280	.0042	19,080		2,164				
1/2	1/4	1C				Minimum	12,860	.0062	25,350	.0195			Minimum	5,240	.0028	15,880		1,766				
			22	22	13	Average	14,930	.0071	27,980	.0340	.534	20	Average	6,000	.0031	19,060	.315	1,945	2.488	1.468	1-1/2	....
						Maximum	16,700	.0084	31,300	.0600			Maximum	7,250	.0035	21,180		2,132				
	1/2	10C				Minimum	11,430	.0091	23,060	.0400			Minimum	4,510	.0027	13,160		1,174				
			15	14	9	Average	13,050	.0103	24,870	.0472	.525	44	Average	5,970	.0034	16,380	.364	1,777	2.186	1.518	1-1/2	....
						Maximum	14,660	.0126	28,420	.0540			Maximum	7,280	.0042	19,080		2,164				
1	1/2	10C				Minimum	7,170	.0054	20,720	.0580			Minimum	4,510	.0027	13,180		1,174				
			14	14	8	Average	9,180	.0068	22,120	.0714	.415	44	Average	5,970	.0034	16,380	.364	1,777	1.538	1.350	1-3/4	....
						Maximum	11,180	.0092	24,420	.0860			Maximum	7,280	.0042	19,080		2,164				
		11C				Minimum	10,710	.0101	22,870	.0540			Minimum	4,500	.0026	14,340		1,442				
			15	15	9	Average	11,900	.0128	25,020	.0831	.476	54	Average	5,510	.0032	16,480	.334	1,709	2.160	1.518	....	2-1/2
						Maximum	14,220	.0161	27,420	.0960			Maximum	6,690	.0041	20,480		2,022				

[1]Column 8 divided by column 10.

[2]Column 15 divided by column 17.

[3]Column 8 divided by column 15.

[4]Column 10 divided by column 17.

[5]End margin for tensile loading determined by modified compressive loading.

Z M 65576 F

Table 12.--Bolt-bearing strength and critical dimensions for compreg C under tensile loading at 0°

Nominal bolt diameter	Nominal panel thickness	Panel number	Bolt bearing: Number of specimens: Total tested	Bolt bearing: Number of specimens: Tested for proportional limit	Bolt bearing: Number of specimens: Tested for ultimate load	Bolt bearing: Variation	Bolt bearing: Proportional limit: Stress	Bolt bearing: Proportional limit: Deformation	Bolt bearing: Ultimate: Stress	Bolt bearing: Ultimate: Deformation	Bolt bearing: Ratio of proportional limit to ultimate[1]	Compression: Number of specimens	Compression: Variation	Compression: Proportional limit: Stress	Compression: Proportional limit: Deformation	Compression: Ultimate stress	Compression: Ratio of proportional limit to ultimate[2]	Compression: Modulus of elasticity	Ratio of bolt-bearing stress to compressive stress: Proportional limit[3]	Ratio of bolt-bearing stress to compressive stress: Ultimate[4]	Critical dimensions: Edge clearance	Critical dimensions: End margin
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)
Inch	Inch						P.s.i.	Inch	P.s.i.	Inch				P.s.i.	Inch per inch	P.s.i.		1,000 p.s.i.			Bolt diameters	Bolt diameters
1/4	1/4					Minimum	13,490	0.0053	31,820	....			Minimum	3,560	0.0017	18,220		1,555				
		20	17	16	9	Average	17,060	.0077	33,350	0.0425	0.512	23	Average	6,090	.0027	20,490	0.297	2,295	2.801	1.628	3-1/2	....
						Maximum	19,140	.0096	35,480	....			Maximum	7,700	.0050	23,340		2,720				
						Minimum	15,440	.0061	30,420	.0360			Minimum	3,560	.0017	18,220		1,555				
		20	10	10	6	Average	17,560	.0075	31,310	.0380	.561	23	Average	6,090	.0027	20,490	.297	2,295	2.883	1.528	....	4
						Maximum	19,860	.0087	32,860	.0400			Maximum	7,700	.0050	23,340		2,720				
	1/2					Minimum	11,560	.0086	32,550	.0550			Minimum	6,150	.0027	15,730		1,753				
		120	25	25	15	Average	15,560	.0119	35,580	.0693	.437	54	Average	7,300	.0033	17,870	.409	2,192	2.132	1.991	2-1/2	....
						Maximum	19,900	.0184	39,610	.0840			Maximum	9,000	.0042	21,120		2,502				
						Minimum	12,000	.0072	33,700	.0600			Minimum	6,150	.0027	15,730		1,753				
		120	22	22	18	Average	15,290	.0105	36,910	.0656	.414	54	Average	7,300	.0033	17,870	.409	2,192	2.095	2.065	....	4
						Maximum	19,060	.0147	41,800	.0730			Maximum	9,000	.0042	21,120		2,502				
1/2	1/4					Minimum	8,060	.0030	20,820	....			Minimum	3,560	.0017	18,220		1,555				
		20	13	12	7	Average	9,930	.0036	22,420	.0186	.443	23	Average	6,090	.0027	20,490	.297	2,295	1.631	1.094	3-1/2	....
						Maximum	12,340	.0052	26,290	....			Maximum	7,700	.0050	23,340		2,720				
						Minimum	9,490	.0033	22,800				Minimum	3,560	.0017	18,220		1,555				
		20	10	9	5	Average	11,520	.0043	24,890	Dial removed	.463	23	Average	6,090	.0027	20,490	.297	2,295	1.892	1.215	....	4-1/2
						Maximum	13,460	.0052	27,520				Maximum	7,700	.0050	23,340		2,720				
	1/2					Minimum	8,400	.0024	23,660				Minimum	6,150	.0027	15,730		1,753				
		120	16	16	9	Average	10,380	.0049	27,100	Dial removed	.383	54	Average	7,300	.0033	17,870	.409	2,192	1.422	1.517	2-1/2	....
						Maximum	12,290	.0059	32,040				Maximum	9,000	.0042	21,120		2,502				
						Minimum	9,060	.0046	22,120	.0460			Minimum	6,150	.0027	15,730		1,753				
		120	20	20	11	Average	11,400	.0061	24,960	.0527	.457	54	Average	7,300	.0033	17,870	.409	2,192	1.562	1.397	....	4
						Maximum	12,840	.0081	28,180	.0600			Maximum	9,000	.0042	21,120		2,502				

[1] Column 8 divided by column 10.
[2] Column 15 divided by column 17.
[3] Column 8 divided by column 15.
[4] Column 10 divided by column 17.

Z M 65577 F

Table 13.--Bolt-bearing strength and critical dimensions for compreg C under tensile loading at 45°

Nominal bolt diameter	Nominal panel thickness	Panel number	Bolt bearing: Number of specimens: Total tested	Bolt bearing: Number of specimens: Tested for proportional limit	Bolt bearing: Number of specimens: Tested for ultimate load	Variation	Bolt bearing: Proportional limit: Stress	Bolt bearing: Proportional limit: Deformation	Bolt bearing: Ultimate: Stress	Bolt bearing: Ultimate: Deformation	Ratio of proportional limit to ultimate[1]	Compression: Number of specimens: Tested at 0°	Compression: Number of specimens: Tested at 90°	Compression: Number of specimens: Total	Variation	Compression: Proportional limit: Stress 0°	Compression: Proportional limit: Stress 90°	Compression: Proportional limit: Stress Average	Compression: Proportional limit: Deformation 0°	Compression: Proportional limit: Deformation 90°	Compression: Proportional limit: Deformation Average	Ultimate stress 0°	Ultimate stress 90°	Ultimate stress Average	Ratio of proportional limit to ultimate[2]	Modulus of elasticity 0°	Modulus of elasticity 90°	Modulus of elasticity Average	Ratio of bolt-bearing stress to compressive stress: Proportional limit[3]	Ratio of bolt-bearing stress to compressive stress: Ultimate[4]	Critical dimensions: Edge clearance	Critical dimensions: End margin
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)
Inch	Inch						P.s.i.	Inch	P.s.i.	Inch						P.s.i.	P.s.i.	P.s.i.	Inch per inch	Inch per inch	Inch per inch	P.s.i.	P.s.i.	P.s.i.		1,000 p.s.i.	1,000 p.s.i.	1,000 p.s.i.			Bolt diameters	Bolt diameters
1/4	1/4	3C	25	20	15	Minimum	16,180	0.0063	29,060	0.0150	0.667	19	19	38	Minimum	6,660	4,550	6,700	0.0027	0.0023	0.0033	17,560	15,360	19,820	0.338	1,754	1,504	2,020	2.997	1.670	2-1/2	....
						Average	20,080	.0079	33,100	.0286					Average	7,770	5,630		.0035	.0031		20,770	16,880			2,236	1,804					
						Maximum	22,580	.0096	35,280	.0330					Maximum	8,640	5,900		.0045	.0038		24,490	21,980			2,677	1,938					
		3C	15	11	9	Minimum	13,930	.0045	27,680	.0240	.527	19	19	38	Minimum	6,660	4,550	6,700	.0027	.0023	.0033	17,560	15,960	19,820	.338	1,754	1,504	2,020	2.476	1.589	....	3
						Average	16,530	.0068	31,490	.0286					Average	7,770	5,630		.0035	.0031		20,770	18,880			2,236	1,804					
						Maximum	21,260	.0090	41,420	.0320					Maximum	8,640	6,300		.0045	.0038		24,490	21,980			2,677	1,986					
	1/2	13C	15	15	9	Minimum	12,220	.0077	30,560	....	.397	58	54	112	Minimum	5,380	4,450	6,440	.0027	.0027	.0035	14,660	12,090	16,000	.402	1,749	1,398	1,824	2.220	2.252	2-1/2	....
						Average	14,300	.0094	36,040	.0590					Average	7,310	5,580		.0036	.0035		16,570	15,420			2,034	1,614					
						Maximum	16,660	.0107	43,540	....					Maximum	8,290	6,640		.0044	.0042		19,370	18,130			2,404	1,958					
		13C	16	13	10	Minimum	11,560	.0084	29,530	.0580	.396	58	54	112	Minimum	5,380	4,450	6,440	.0027	.0027	.0035	14,660	12,090	16,000	.402	1,749	1,398	1,824	2.165	2.201	....	3
						Average	13,940	.0101	35,210	.0638					Average	7,310	5,580		.0036	.0035		16,570	15,420			2,034	1,614					
						Maximum	15,600	.0123	40,490	.0740					Maximum	8,290	6,640		.0044	.0042		19,370	18,130			2,404	1,958					
1/2	1/4	3C	20	20	12	Minimum	8,370	.0029	24,700	.0300	.403	19	19	38	Minimum	6,660	4,550	6,700	.0027	.0023	.0033	17,560	15,960	19,820	.338	1,754	1,504	2,020	1.727	1.427	2-1/2	....
						Average	11,570	.0040	28,260	.0395					Average	7,770	5,630		.0035	.0031		20,770	18,280			2,236	1,804					
						Maximum	12,990	.0052	30,510	.0500					Maximum	8,540	6,300		.0045	.0038		24,490	21,980			2,677	1,986					
		3C	15	12	6	Minimum	8,960	.0026	23,790	.0320	.405	19	19	38	Minimum	6,160	4,550	6,700	.0027	.0023	.0033	17,560	15,360	19,820	.338	1,754	1,504	2,020	1.513	1.264	....	2-1/2
						Average	10,140	.0039	25,060	.0386					Average	7,770	5,630		.0035	.0031		20,770	18,880			2,236	1,804					
						Maximum	11,230	.0052	27,460	.0460					Maximum	8,540	6,300		.0045	.0038		24,490	21,980			2,677	1,986					
	1/2	13C	17	17	10	Minimum	9,720	.0034	26,300	.0448	.400	58	54	112	Minimum	5,980	4,450	6,440	.0027	.0027	.0035	14,660	12,090	16,000	.402	1,749	1,398	1,824	1.750	1.760	2-1/2	....
						Average	11,270	.0056	28,160	.0523					Average	7,310	5,580		.0036	.0035		16,570	15,420			2,034	1,614					
						Maximum	12,660	.0066	29,740	.0560					Maximum	8,290	6,640		.0044	.0042		19,370	18,130			2,404	1,958					
		13C	15	15	9	Minimum	9,210	.0046	24,400	.0530	.417	58	54	112	Minimum	5,980	4,450	6,440	.0027	.0027	.0035	14,660	12,090	16,000	.402	1,749	1,398	1,824	1.688	1.628	....	2-1/2
						Average	10,870	.0059	26,050	.0552					Average	7,310	5,580		.0036	.0035		16,570	15,420			2,034	1,614					
						Maximum	13,060	.0083	31,580	.0570					Maximum	8,290	6,640		.0044	.0042		19,370	18,130			2,404	1,958					

[1] Column 8 divided by column 10.
[2] Column 19 divided by column 25.
[3] Column 8 divided by column 19.
[4] Column 10 divided by column 25.

Z M 65578 F

Table 14.--Bolt-bearing strength and critical dimensions for compreg C under tensile loading at 90°

Nominal bolt diameter	Nominal panel thickness	Panel number	Bolt bearing: Number of specimens: Total tested	Bolt bearing: Number of specimens: Tested for proportional limit	Bolt bearing: Number of specimens: Tested for ultimate load	Bolt bearing: Variation	Bolt bearing: Proportional limit: Stress	Bolt bearing: Proportional limit: Deformation	Bolt bearing: Ultimate: Stress	Bolt bearing: Ultimate: Deformation	Bolt bearing: Ratio of proportional limit to ultimate[1]	Compression: Number of specimens	Compression: Variation	Compression: Proportional limit: Stress	Compression: Proportional limit: Deformation	Compression: Ultimate stress	Compression: Ratio of proportional limit to ultimate[2]	Compression: Modulus of elasticity	Ratio of bolt-bearing stress to compressive stress: Proportional limit[3]	Ratio of bolt-bearing stress to compressive stress: Ultimate[4]	Critical dimensions: Edge clearance	Critical dimensions: End margin
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)
Inch	Inch						P.s.i.	Inch	P.s.i.	Inch				P.s.i.	Inch per inch	P.s.i.		1,000 p.s.i.			Bolt diameters	Bolt diameters
1/4	1/4	1C				Minimum	12,950	0.0039	29,860	0.0290			Minimum	5,240	0.0028	15,880		1,766				
			26	26	20	Average	17,500	.0074	32,360	.0407	0.541	20	Average	6,000	.0031	19,060	0.315	1,945	2.917	1.698	3-1/2	....
						Maximum	20,610	.0096	36,520	.0550			Maximum	7,250	.0035	21,180		2,132				
		2C				Minimum	13,740	.0055	25,930	Dial removed			Minimum	4,820	.0026	18,340		1,698				
			16	13	8	Average	17,700	.0068	32,590		.543	11	Average	5,500	.0029	19,660	.280	1,884	3.218	1.658	....	4
						Maximum	20,700	.0085	37,280				Maximum	6,010	.0034	22,080		2,017				
	1/2	14C				Minimum	12,100	.0070	31,950	.0545			Minimum	4,480	.0027	13,820		1,322				
			16	16	12	Average	14,070	.0095	36,800	.0746	.382	43	Average	5,390	.0033	15,570	.346	1,640	2.610	2.364	4	....
						Maximum	16,860	.0110	41,900	.1100			Maximum	6,600	.0044	19,360		1,834				
		14C				Minimum	11,860	.0080	32,860	.0680			Minimum	4,480	.0027	13,820		1,322				
			12	12	10	Average	13,710	.0106	35,790	.0784	.383	43	Average	5,390	.0033	15,570	.346	1,640	2.544	2.299	....	4
						Maximum	17,890	.0158	43,720	.0820			Maximum	6,600	.0044	19,360		1,834				
1/2	1/4	1C				Minimum	7,870	.0028	20,120	.0134			Minimum	5,240	.0028	15,880		1,766				
			17	16	16	Average	10,960	.0045	24,280	.0252	.451	20	Average	6,000	.0031	19,060	.315	1,945	1.827	1.274	2-1/2	....
						Maximum	13,660	.0054	27,340	.0410			Maximum	7,250	.0035	21,180		2,132				
		4C				Minimum	9,160	.0025	17,840	....			Minimum	4,590	.0025	16,610		1,631				
			23	23	20	Average	11,130	.0043	21,890	.0380	.508	26	Average	5,470	.0029	19,020	.288	1,860	2.035	1.151	2-1/2	....
						Maximum	14,010	.0074	30,520	....			Maximum	6,580	.0034	21,130		2,061				
		4C				Minimum	9,040	.0032	19,590	Dial removed			Minimum	4,590	.0025	16,610		1,631				
			27	27	25	Average	11,090	.0043	22,640		.490	26	Average	5,470	.0029	19,020	.288	1,860	2.027	1.[illegible]90	....	3-1/2
						Maximum	13,460	.0060	26,810				Maximum	6,580	.0034	21,130		2,061				
	1/2	14C				Minimum	10,050	.0055	19,660	Dial removed			Minimum	4,480	.0027	13,820		1,322				
			17	15	10	Average	11,440	.0064	25,410		.450	43	Average	5,390	.0033	15,570	.346	1,640	2.122	1.632	4	....
						Maximum	13,650	.0085	30,300				Maximum	6,600	.0044	19,360		1,834				
		14C				Minimum	9,500	.0052	26,080	Dial removed			Minimum	4,480	.0027	13,820		1,322				
			14	14	8	Average	11,440	.0064	27,530		.416	43	Average	5,390	.0033	15,570	.346	1,640	2.122	1.768	....	4-1/2
						Maximum	13,500	.0086	31,100				Maximum	6,600	.0044	19,360		1,834				

[1]Column 8 divided by column 10.

[2]Column 15 divided by column 17.

[3]Column 8 divided by column 15.

[4]Column 10 divided by column 17.

Z M 65579 F

Table 15.--Summary of critical dimensions

Diameter of bolt	Thickness of compreg	Grain angle of face ply	FPL compreg[1]				Commercial compreg A				Commercial compreg B				Commercial compreg C			
			Edge clearance		End margin		Edge clearance		End margin		Edge clearance		End margin		Edge clearance		End margin	
			Under compressive loading	Under tensile loading	Under modified compressive loading	Under tensile loading	Under compressive loading	Under tensile loading	Under modified compressive loading	Under tensile loading	Under compressive loading	Under tensile loading	Under modified compressive loading	Under tensile loading	Under compressive loading	Under tensile loading	Under modified compressive loading	Under tensile loading
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Inch	Inch	Degrees	Bolt diameters	Bolt diameters	Bolt diameters	Bolt diameters	Bolt diameters	Bolt diameters	Bolt diameters	Bolt diameters	Bolt diameters	Bolt diameters	Bolt diameters	Bolt diameters	Bolt diameters	Bolt diameters	Bolt diameters	Bolt diameters
1/4	1/4	0	1-1/2	2-1/2	4	4	1-1/2	3	...	3	...	...	...	...	2	3-1/2	...	4
		45	2	2-1/2	3	3	1-1/2	2-1/2	...	2	...	...	...	...	2	2-1/2	...	3
		90	1-1/2	3-1/2	...	3	1-1/2	3-1/2	...	4	...	...	...	...	2	3-1/2	...	4
	1/2	0	2	3	4	5	2	2-1/2	...	5	...	...	...	...	1-1/2	2-1/2	...	4
		45	2	2-1/2	3	3	2	2-1/2	...	3	...	...	...	...	2	2-1/2	...	3
		90	1-1/2	4	...	4	2	4-1/2	...	5	...	...	...	...	2	4	...	4
1/2	1/4	0	1-1/2	2	3	3-1/2	1-1/4	4	...	2-1/2	...	...	...	...	1-1/2	3-1/2	...	4-1/2
		45	2	2-1/2	3	2-1/2	1-1/2	2-1/4	...	2	...	...	...	...	2	2-1/2	...	2-1/2
		90	1-1/2	3	3	4	1-1/4	5	...	4	...	...	...	...	1-1/2	2-1/2	...	3-1/2
	1/2	0	1-3/4	2-1/2	4	3-1/2	1-1/4	2-1/2	...	3-1/2	...	...	...	...	1-1/2	2-1/2	...	4
		45	2	2-1/2	3	2-1/2	1-1/2	2	...	2-1/2	...	...	...	...	1-1/2	2-1/2	...	2-1/2
		90	1-3/4	4	...	...	1-1/4	4-1/2	...	4-1/2	...	...	...	...	1-1/2	4	...	4-1/2
	1	0	2	...	3	...	1-3/4	...	3	...	...	...	...	...	...	...	...	...
		45	2	...	3	...	2	...	2-1/2	...	...	...	...	...	...	...	...	...
		90	2	...	3	...	1-3/4	...	3	...	...	...	...	...	...	...	...	...
1	1/2	0	1-1/2	...	2-1/2	...	1-1/4	...	2-1/2	...	...	...	...	...	1-1/2	...	2-1/2	...
		45	2	...	3	...	1-1/2	...	2	...	...	...	...	...	2	...	2-1/2	...
		90	1-1/2	...	3	...	1-1/4	...	2-1/2	...	...	...	...	...	1-3/4	...	2-1/2	...
	1	0	1-1/2	...	3	...	1-1/4	...	2-1/2	...	...	...	...	...	...	...	...	...
		45	2	...	2-1/2	...	1-1/2	...	2-1/2	...	...	...	...	...	...	...	...	...
		90	2	...	3	...	1-1/2	...	2-1/2	...	...	...	...	...	...	...	...	...

[1] Values taken from table 6 of Report No. 1523A.

Z M 65580 F

Table 16.--Summary of bearing stresses

Diameter of bolt	Thickness of compreg	Grain angle of face ply	FPL compreg[1]				Commercial compreg A				Commercial compreg B				Commercial compreg C			
			At proportional limit		At ultimate		At proportional limit		At ultimate		At proportional limit		At ultimate		At proportional limit		At ultimate	
			Under compressive loading[2]	Under tensile loading	Under compressive loading[2]	Under tensile loading	Under compressive loading[2]	Under tensile loading	Under compressive loading[2]	Under tensile loading	Under compressive loading[2]	Under tensile loading	Under compressive loading[2]	Under tensile loading	Under compressive loading[2]	Under tensile loading	Under compressive loading[2]	Under tensile loading
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Inch	Inch	Degrees	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.	P.s.i.
1/4	1/4	0	22,800	20,100	34,810	33,530	14,870	13,150	21,930	28,070	18,040	....	28,690	....	18,350	17,310	32,890	32,330
		45	21,390	20,430	30,730	32,840	16,500	14,240	26,050	27,460	....	....	....	....	17,240	18,340	30,050	32,300
		90	24,430	17,810	31,340	32,780	15,490	13,510	24,300	27,120	....	....	....	....	17,840	17,600	30,710	32,480
	1/2	0	20,690	15,670	34,240	35,350	18,370	12,830	29,890	30,700	22,600	....	38,100	....	19,740	15,420	36,240	36,240
		45	22,250	16,330	34,060	36,300	18,980	13,160	29,990	31,990	....	....	....	....	16,570	14,120	35,340	35,620
		90	24,330	15,630	34,710	39,420	17,820	13,990	32,020	32,270	....	....	....	....	16,820	13,890	32,640	36,300
1/2	1/4	0	16,130	14,630	26,910	28,360	11,770	10,160	19,510	21,230	11,990	....	24,140	....	14,250	10,720	27,240	23,660
		45	18,500	14,780	28,360	28,120	13,030	9,540	22,090	21,860	....	....	....	....	13,520	10,860	27,790	26,670
		90	17,630	12,960	31,470	27,610	11,590	10,050	19,630	21,280	....	....	....	....	14,930	11,060	27,980	22,940
	1/2	0	16,980	15,780	27,670	30,450	11,620	9,900	21,850	21,930	16,650	....	29,780	....	16,370	10,890	29,180	26,030
		45	19,940	13,880	30,660	29,700	14,460	11,220	25,340	25,380	....	....	....	....	13,320	11,070	25,900	27,100
		90	19,580	14,190	30,660	30,000	13,550	10,280	26,200	22,720	....	....	....	....	13,050	11,440	24,870	26,470
	1	0	15,740	....	29,120	....	14,420	....	27,700	....	15,040	....	36,130	....	14,440	....	36,240	....
		45	17,850	....	34,080	....	16,240	....	28,370	....	....	....	....	....	....	....	....	....
		90	18,010	....	32,560	....	15,900	....	27,660	....	....	....	....	....	....	....	....	....
1	1/2	0	14,890	....	27,730	....	11,180	....	21,860	....	13,070	....	24,440	....	12,120	....	25,560	....
		45	15,910	....	29,380	....	11,110	....	21,600	....	....	....	....	....	11,740	....	27,160	....
		90	15,040	....	27,610	....	10,020	....	21,750	....	....	....	....	....	10,540	....	23,570	....
	1	0	14,700	....	27,160	....	10,050	....	21,600	....	13,400	....	28,520	....	13,400	....	28,230	....
		45	16,160	....	29,120	....	11,030	....	23,170	....	....	....	....	....	....	....	....	....
		90	13,960	....	31,520	....	10,970	....	22,740	....	....	....	....	....	....	....	....	....

[1] Values taken from table 7 of Report No. 1523A.

[2] Includes modified compressive loading.

Z M 65581 F

Table 17.--Summary of deformations

Diameter of bolt	Thickness of compreg	Grain angle of face ply	FPL compreg[1] At proportional limit Under compressive loading[2]	FPL compreg[1] At proportional limit Under tensile loading	FPL compreg[1] At ultimate Under compressive loading[2]	FPL compreg[1] At ultimate Under tensile loading	Commercial compreg A At proportional limit Under compressive loading[2]	Commercial compreg A At proportional limit Under tensile loading	Commercial compreg A At ultimate Under compressive loading[2]	Commercial compreg A At ultimate Under tensile loading	Commercial compreg B At proportional limit Under compressive loading[2]	Commercial compreg B At proportional limit Under tensile loading	Commercial compreg B At ultimate Under compressive loading[2]	Commercial compreg B At ultimate Under tensile loading	Commercial compreg C At proportional limit Under compressive loading[2]	Commercial compreg C At proportional limit Under tensile loading	Commercial compreg C At ultimate Under compressive loading[2]	Commercial compreg C At ultimate Under tensile loading
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Inch	Inch	Degrees	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch
1/4	1/4	0	0.0070	0.0059	0.0257	0.0224	0.0096	0.0058	0.0294	0.0440	0.0097		0.0496		0.0077	0.0076	0.0427	0.0402
		45	.0085	.0067	.0276	.0260	.0085	.0063	.0331	.0361					.0083	.0073	.0453	.0286
		90	.0102	.0057	.0244	.0269	.0087	.0060	.0266	.0340					.0079	.0071	.0389	.0407
	1/2	0	.0079	.0082	.0350	.0420	.0127	.0094	.0527	.0558	.0112		.0572		.0102	.0112	.0439	.0674
		45	.0102	.0089	.0390	.0450	.0138	.0096	.0552	.0558					.0092	.0097	.0645	.0614
		90	.0106	.0081	.0280	.0427	.0093	.0086	.0453	.0505					.0092	.0100	.0577	.0765
1/2	1/4	0	.0056	.0037	.0250	.0191	.0065	.0038	.0308	.0322	.0076		.0517		.0061	.0040	.0369	
		45	.0076	.0047	.0259	.0247	.0085	.0041	.0499	.0412					.0061	.0040	.0468	.0391
		90	.0070	.0034	.0300	.0221	.0065	.0039	.0278	.0329					.0071	.0044	.0340	.0316
	1/2	0	.0061	.0055	.0328	.0287	.0071	.0044	.0479	.0387	.0113		.0564		.0102	.0055	.0340	.0527
		45	.0102	.0053	.0352	.0277	.0097	.0059	.0574	.0502					.0105	.0058	.0550	.0537
		90	.0087	.0049	.0300	.0233	.0078	.0054	.0439						.0103	.0064	.0472	
	1	0	.0102		.0471		.0137		.0746		.0157		.0840		.0153		.0868	
		45	.0121		.0411		.0157		.0672									
		90	.0128		.0532		.0150		.0660									
1	1/2	0	.0086		.0418		.0090		.0565		.0093		.0402		.0095		.0541	
		45	.0087		.0424		.0100		.0614						.0095		.0745	
		90	.0098		.0326		.0086		.0565						.0098		.0773	
	1	0	.0088		.0450		.0091		.0735		.0122		.0702		.0121		.0685	
		45	.0117		.0388		.0125		.0754									
		90	.0063		.0487		.0122		.0677									

[1] Values taken from table 8 of Report No. 1523A.

[2] Includes modified compressive loading.

Z M 65582 F

Table 18.--Summary of ratios of bolt-bearing stress at proportional limit to bolt-bearing stress at ultimate

Diameter of bolt	Thickness of compreg	Grain angle of face ply	FPL compreg[1]: Under compressive loading	FPL compreg[1]: Under tensile loading	Commercial compreg "A": Under compressive loading	Commercial compreg "A": Under tensile loading	Commercial compreg "B": Under compressive loading	Commercial compreg "B": Under tensile loading	Commercial compreg "C": Under compressive loading	Commercial compreg "C": Under tensile loading	Average ratios for all commercial compreg: Under compressive loading	Average ratios for all commercial compreg: Under tensile loading	Average ratios for all thicknesses[2]: Under compressive loading	Average ratios for all thicknesses[2]: Under tensile loading
Inch	Inch	Degrees												
1/4	1/4	0	0.65	0.60	0.68	0.47	0.63	......	0.56	0.54	......	......	......	......
		45	.70	.62	.63	.52	......	......	.57	.57	......	......	......	......
		90	.78	.54	.64	.50	......	......	.58	.54	......	......	......	......
	1/2	0	.60	.44	.61	.42	.59	......	.54	.43	......	......	......	......
		45	.65	.45	.63	.41	......	......	.47	.40	......	......	......	......
		90	.70	.40	.56	.43	......	......	.52	.38	......	......	......	......
1/2	1/4	0	.60	.52	.60	.48	.50	......	.52	.45	......	......	......	......
		45	.65	.53	.59	.44	......	......	.49	.41	......	......	......	......
		90	.56	.47	.59	.47	......	......	.53	.48	......	......	......	......
	1/2	0	.61	.52	.53	.45	.56	......	.56	.42	......	......	......	......
		45	.65	.47	.57	.44	......	......	.51	.41	......	......	......	......
		90	.64	.47	.52	.45	......	......	.52	.43	......	......	......	......
	1	0	.54	......	.52	......	.42	......	.40	......	......	......	......	......
		45	.52	......	.57	......	......	......	......	......	......	......	......	......
		90	.55	......	.57	......	......	......	......	......	......	......	......	......
1	1/2	0	.54	......	.51	......	.53	......	.47	......	......	......	......	......
		45	.54	......	.51	......	......	......	.43	......	......	......	......	......
		90	.54	......	.46	......	......	......	.45	......	......	......	......	......
	1	0	.54	......	.47	......	.47	......	.47	......	......	......	......	......
		45	.55	......	.48	......	......	......	......	......	......	......	......	......
		90	.44	......	.48	......	......	......	......	......	......	......	......	......
			Average ratios for all grain orientations											
1/4	1/4	0, 45, & 90	.71	.59	.65	.50	.63	......	.57	.55	0.62	0.52	0.62	0.52
	1/2	0, 45, & 90	.65	.43	.60	.42	.59	......	.51	.40	[3].57	[3].41		
1/2	1/4	0, 45, & 90	.60	.51	.59	.46	.50	......	.51	.45	.53	.46	.54	.45
	1/2	0, 45, & 90	.63	.49	.54	.45	.56	......	.53	.42	.54	.44		
	1	0, 45, & 90	.54	......	.55	......	.42	......	.40	......	[3].46	......	......	
1	1/2	0, 45, & 90	.54	......	.49	......	.53	......	.45	......	.49	......	.48	
	1	0, 45, & 90	.51	......	.48	......	.47	......	.47	......	.47	......		

[1] Values taken from tables 2 through 5 of Report No. 1523-A.

[2] For commercial compregs only.

[3] Bearing length equals twice the diameter of the bolt. Ratio shown is not included in average for each diameter of bolt.

Z M 65583 F

Table 19.--Summary of ratios of bolt-bearing stress to compressive stress[1]

Diameter of bolt	Thickness of compreg	Grain angle of face ply of bolt-bearing specimens	FPL compreg[2]				Commercial compreg A				Commercial compreg B				Commercial compreg C			
			At proportional limit		At ultimate		At proportional limit		At ultimate		At proportional limit		At ultimate		At proportional limit		At ultimate	
			Under compressive loading	Under tensile loading	Under compressive loading	Under tensile loading	Under compressive loading	Under tensile loading	Under compressive loading	Under tensile loading	Under compressive loading	Under tensile loading	Under compressive loading	Under tensile loading	Under compressive loading	Under tensile loading	Under compressive loading	Under tensile loading
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Inch	Inch	Degrees																
1/4	1/4	0	2.31	1.71	1.44	1.35	2.34	2.26	1.42	1.71	2.68	...	1.56	...	2.54	2.84	1.76	1.58
		45	...	1.73	...	1.43	2.52	2.22	1.61	1.71	...	...	...	...	2.60	2.74	1.59	1.63
		90	2.24	1.64	1.22	1.27	2.65	2.33	1.66	1.67	...	...	...	...	2.97	3.06	1.61	1.68
	1/2	0	2.06	1.50	1.67	1.63	2.66	1.86	1.98	1.94	3.34	...	2.05	...	3.29	2.11	2.24	2.03
		45	2.19	1.61	1.45	1.66	2.83	2.11	1.93	1.91	...	...	...	...	2.77	2.19	2.17	2.23
		90	2.24	1.49	1.52	1.84	3.51	2.63	2.01	2.03	...	...	...	...	2.82	2.58	1.99	2.33
1/2	1/4	0	1.64	1.24	1.11	1.14	1.85	1.66	1.27	1.29	1.78	...	1.31	...	1.97	1.76	1.45	1.15
		45	...	1.25	...	1.23	1.99	1.52	1.37	1.32	...	...	...	...	2.04	1.62	1.47	1.35
		90	1.62	1.19	1.22	1.07	1.98	1.68	1.34	1.33	...	...	...	...	2.49	1.96	1.47	1.20
	1/2	0	1.69	1.46	1.35	1.33	1.68	1.60	1.44	1.44	2.46	...	1.61	...	2.73	1.49	1.81	1.46
		45	1.96	1.37	1.31	1.36	2.15	1.80	1.63	1.51	...	...	...	...	2.23	1.72	1.59	1.69
		90	1.87	1.35	1.43	1.40	2.67	1.91	1.65	1.46	...	...	...	...	2.19	2.12	1.52	1.70
	1	0	1.96	...	1.42	...	2.33	...	1.94	...	2.36	...	1.81	...	2.44	...	1.86	...
		45	1.75	...	1.48	...	2.71	...	1.80	...	...	...	...	...	...	...	...	...
		90	1.97	...	1.49	...	2.66	...	1.84	...	...	...	...	...	...	...	...	...
1	1/2	0	1.42	...	1.28	...	1.63	...	1.34	...	1.93	...	1.32	...	1.89	...	1.55	...
		45	1.43	...	1.22	...	1.88	...	1.39	...	...	...	...	...	1.93	...	1.65	...
		90	1.42	...	1.20	...	1.97	...	1.36	...	...	...	...	...	1.84	...	1.43	...
	1	0	1.83	...	1.33	...	1.60	...	1.50	...	2.10	...	1.43	...	2.27	...	1.45	...
		45	1.58	...	1.27	...	1.90	...	1.49	...	...	...	...	...	...	...	...	...
		90	1.37	...	1.37	...	1.79	...	1.51	...	...	...	...	...	...	...	...	...

[1]All FPL compression specimens were tested with the direction of loading parallel to the grain of the face plies. All bolt-bearing values, therefore, were related to 0° compression values. For commercial compregs A, B, and C, the relationships were as follows: The 0° bolt-bearing values were related to 0° compression values; the 45° bolt-bearing values were related to the average of 0° and 90° compression values; and the 90° bolt-bearing values were related to 90° compression values.

[2]Values taken from tables 2 through 5 of Report No. 1523A.

Z M 65584 F

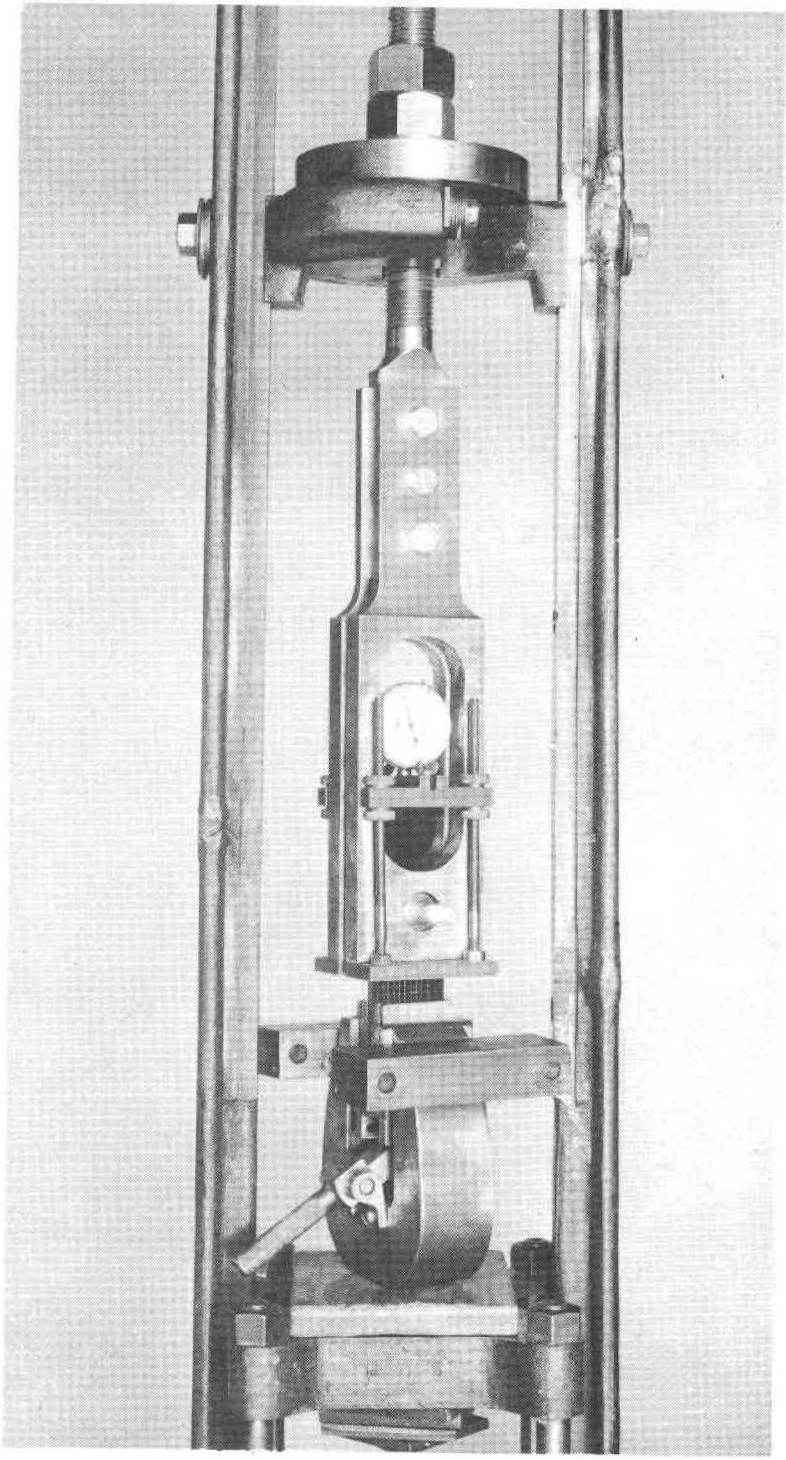


Figure 1.--Improved apparatus for bolt-bearing tests under tensile loading.

Z M 66507 F

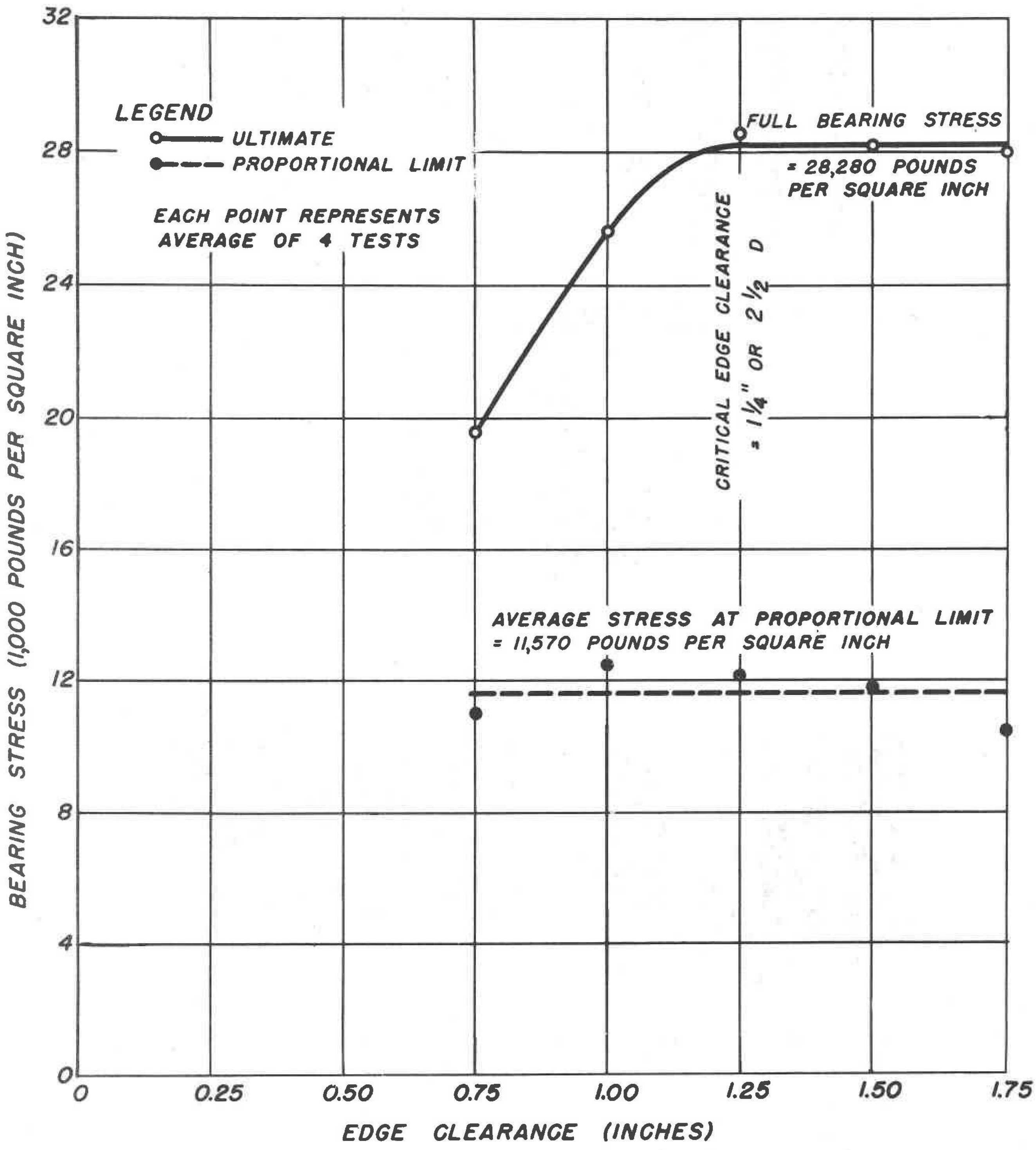


Figure 2.--The determination of critical edge clearance and average proportional limit and ultimate bearing stresses for a 1/2-inch bolt in 1/4-inch compreg C under tensile loading at 45° to the grain of the face plies.

Z M 65585 F

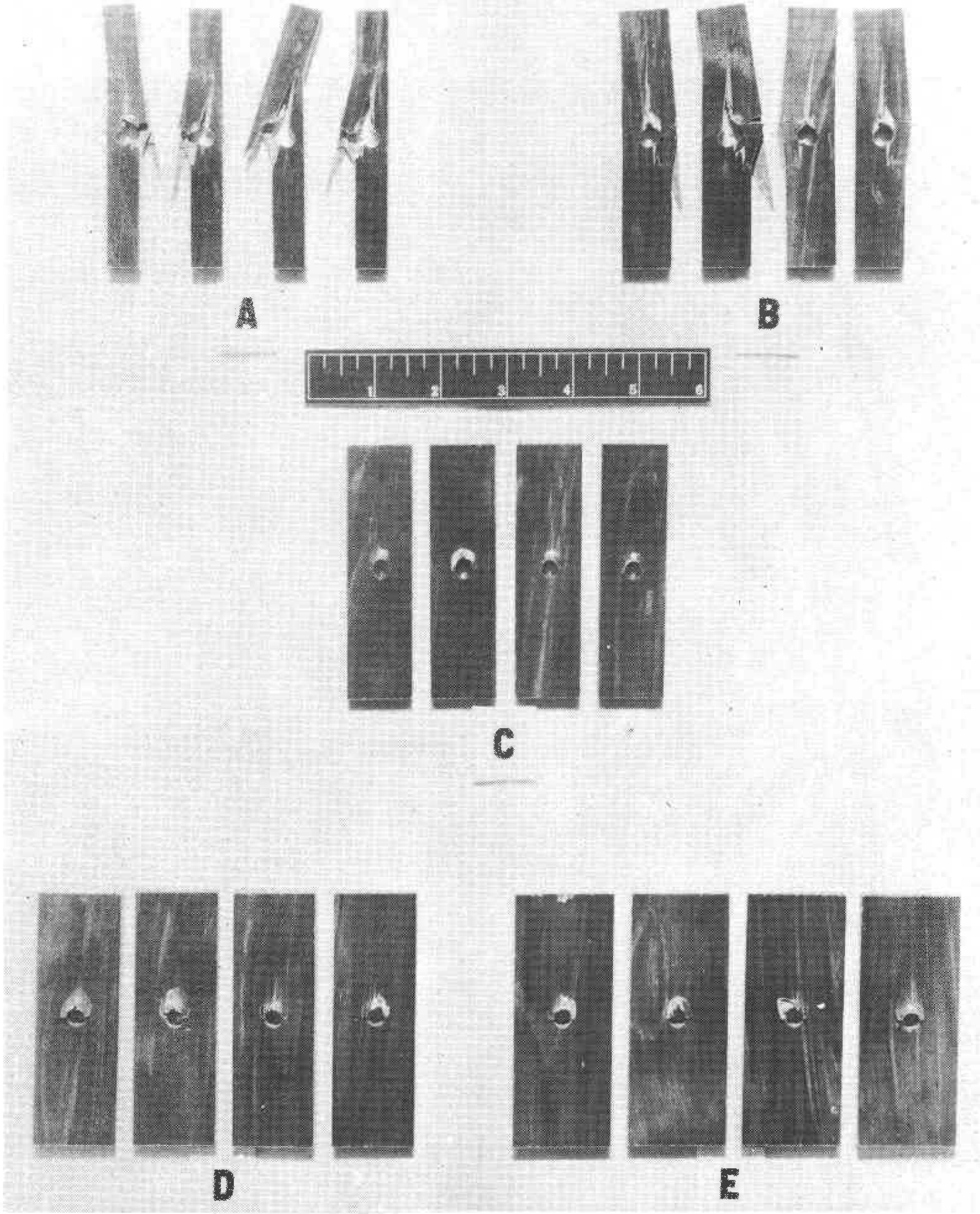


Figure 3.--Edge-clearance series tested under compressive loading 0° to face grain. One-quarter inch bolt in 1/4-inch commercial, cross-banded, hard maple compreg C.

A. Edge clearance = 1/4 inch; average proportional limit load = 1,225 pounds; average ultimate load = 1,786 pounds.
B. Edge clearance = 3/8 inch; average proportional limit load = 1,225 pounds; average ultimate load = 1,945 pounds.
C. Edge clearance = 1/2 inch; average proportional limit load = 1,188 pounds; average ultimate load = 2,206 pounds.
D. Edge clearance = 5/8 inch; average proportional limit load = 1,225 pounds; average ultimate load = 2,234 pounds.
E. Edge clearance = 3/4 inch; average proportional limit load = 1,262 pounds; average ultimate load = 2,158 pounds.

Z M 66510 F

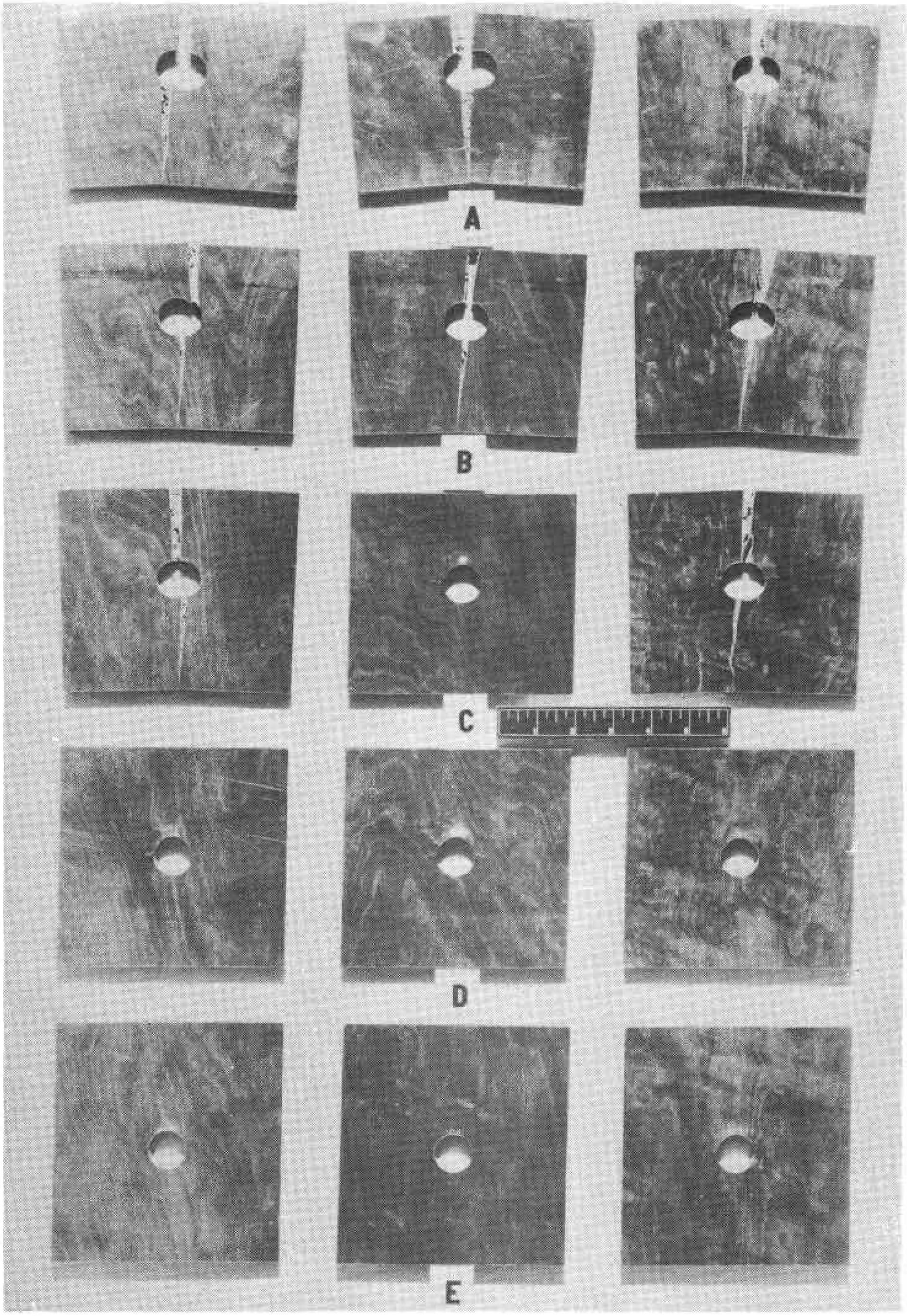


Figure 4.--End-margin series tested under modified compressive loading 0° to face grain. One-inch bolt in 1/2-inch commercial cross-banded hard maple compreg C.

A. End margin = 1-1/2 inches; average proportional limit load = 6,400 pounds; average ultimate load = 8,200 pounds.

B. End margin = 2 inches; average proportional limit load = 7,200 pounds; average ultimate load = 11,940 pounds.

C. End margin = 2-1/2 inches; average proportional limit load = 7,667 pounds; average ultimate load = 15;333 pounds.

D. End margin = 3 inches; average proportional limit load = 7,300 pounds; average ultimate load = 15,360 pounds.

E. End margin = 3-1/2 inches; average proportional limit load = 7,900 pounds; average ultimate load = 15,540 pounds.

Z M 66511 F

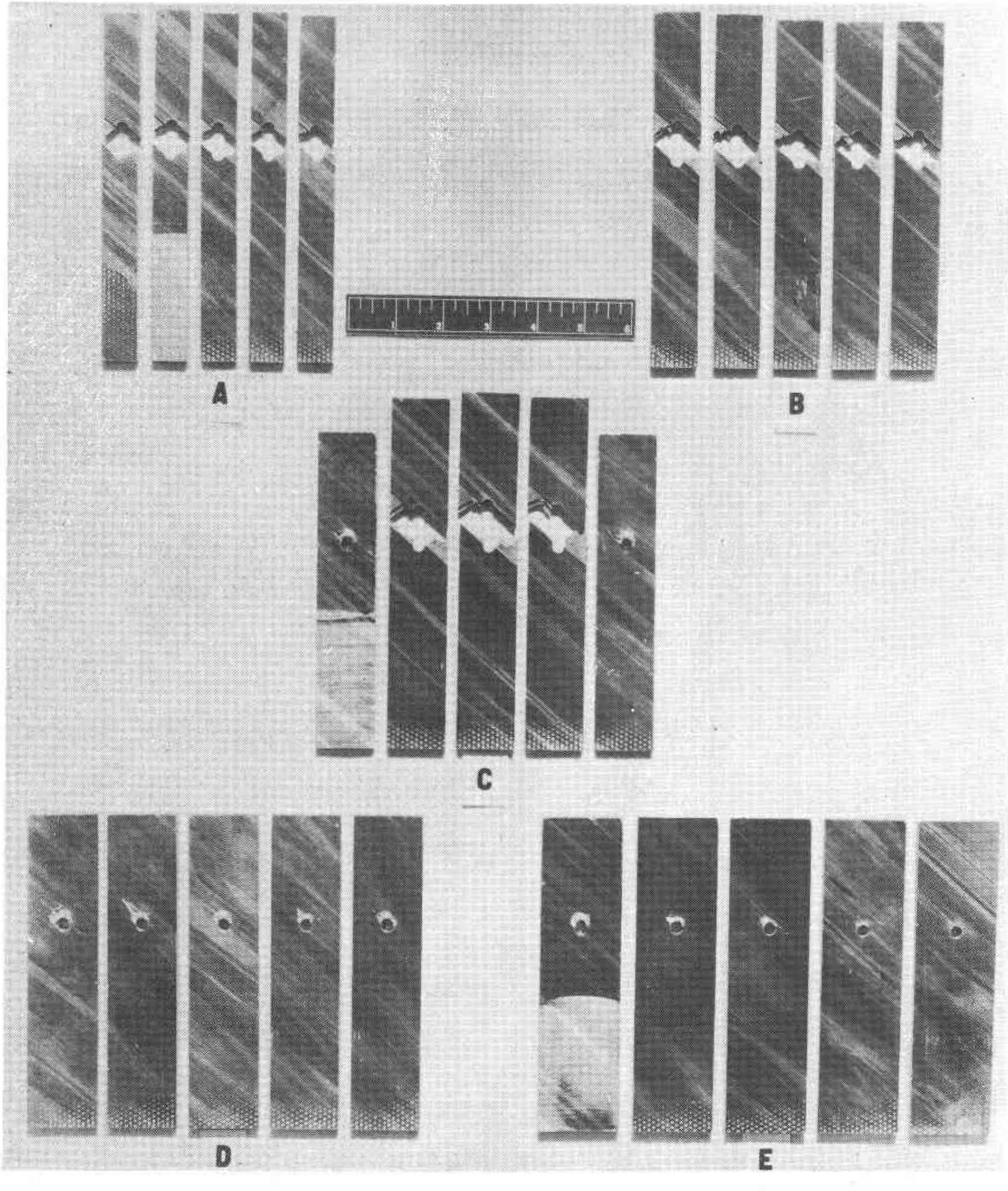


Figure 5.--Edge-clearance series tested under tensile loading 45° to face grain. One-quarter-inch bolt in 1/4-inch commercial cross-banded hard maple compreg C.

A. Edge clearance = 3/8 inch; average proportional limit load = 1,100 pounds; average ultimate load = 1,328 pounds.
B. Edge clearance = 1/2 inch; average proportional limit load = 1,365 pounds; average ultimate load = 1,817 pounds.
C. Edge clearance = 5/8 inch; average proportional limit load = 1,290 pounds; average ultimate load = 2,103 pounds.
D. Edge clearance = 3/4 inch; average proportional limit load = 1,235 pounds; average ultimate load = 2,088 pounds.
E. Edge clearance = 7/8 inch; average proportional limit load = 1,245 pounds; average ultimate load = 2,169 pounds.

Z M 66509 F

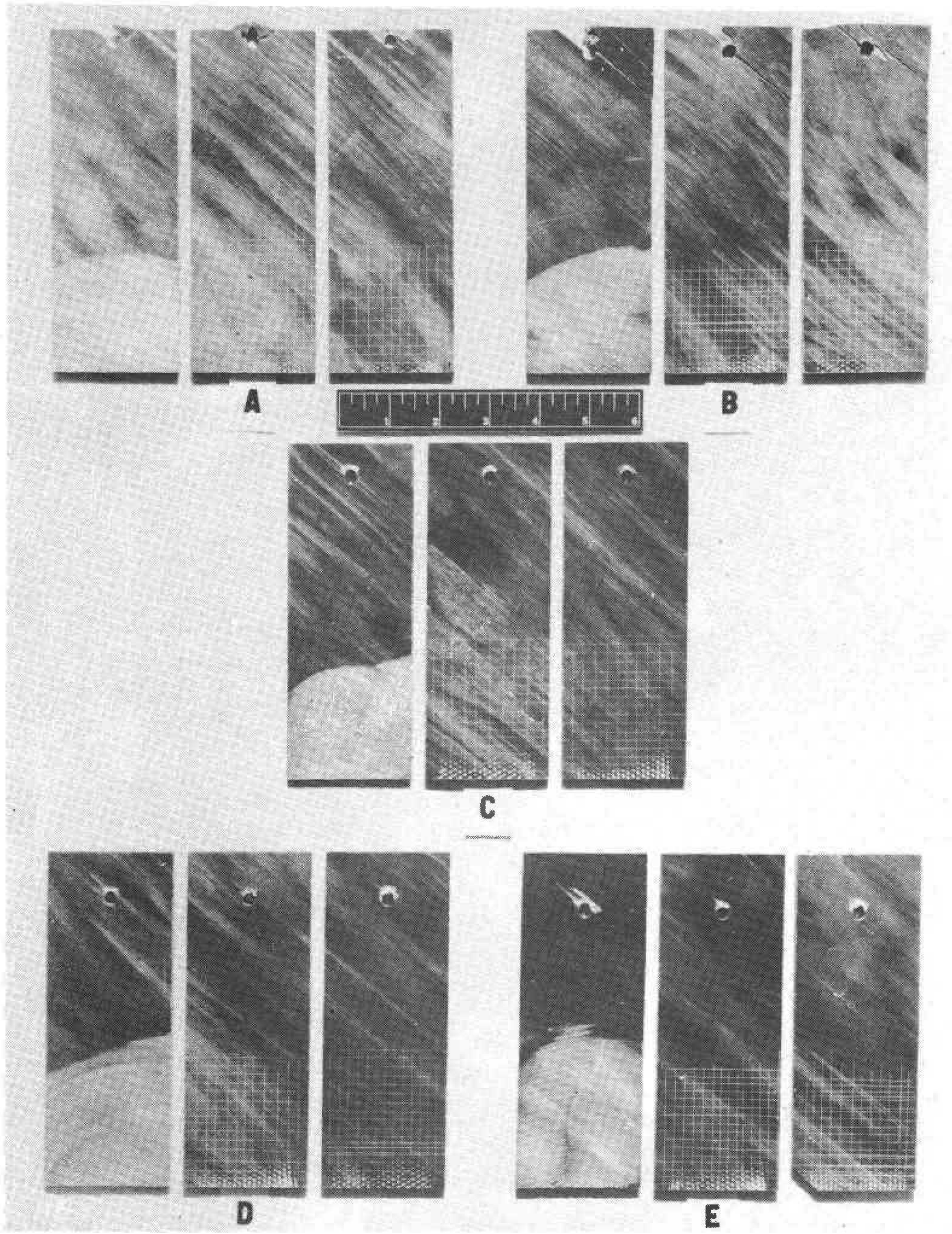
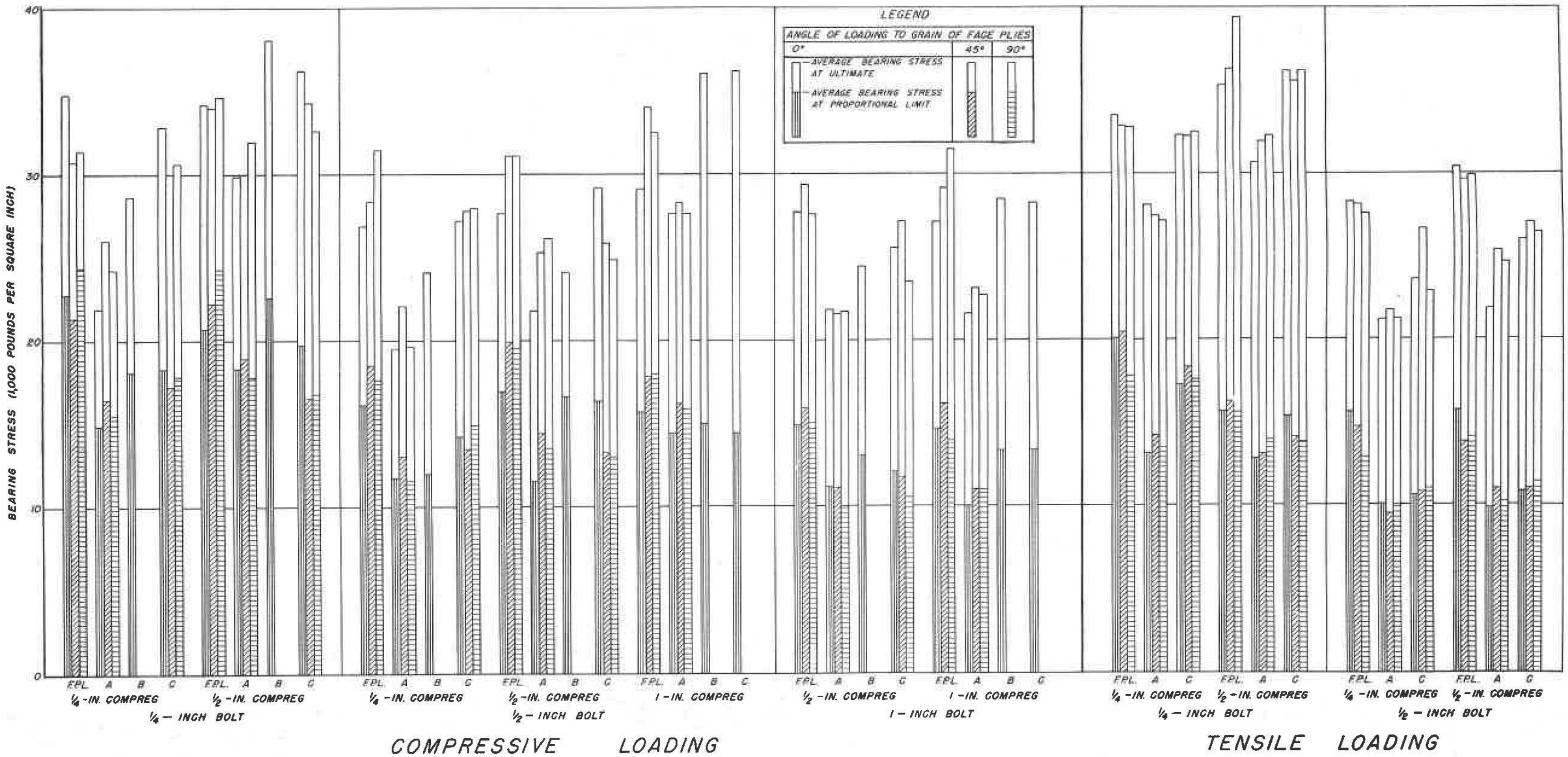


Figure 6.--End-margin series tested under tensile loading 45° to face grain. One-quarter-inch bolt in 1/4-inch commercial cross-banded hard maple compreg C.

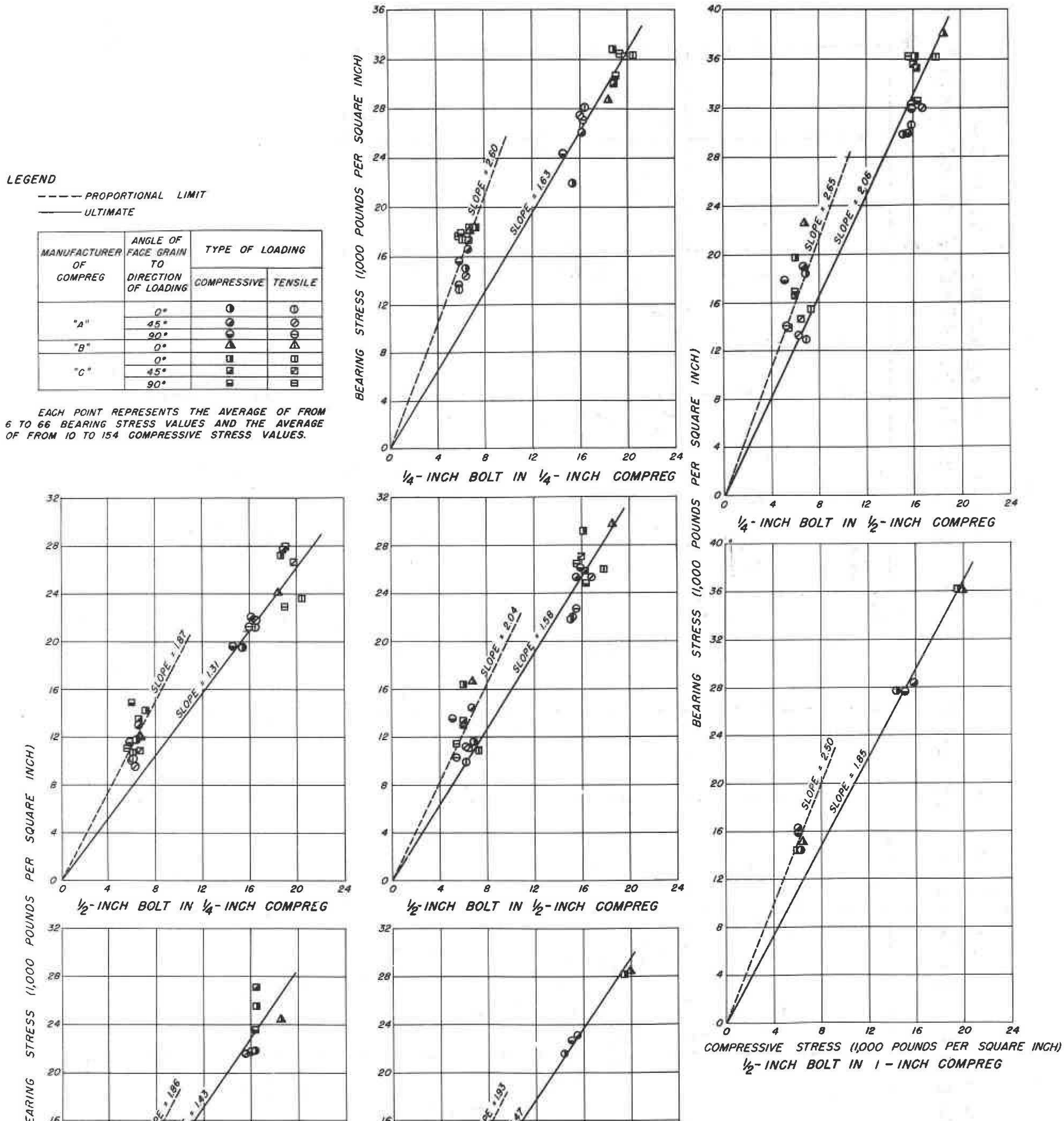
A. End margin = 1/4 inch. Maximum load attained, 738 pounds, was less than average proportional limit load.
B. End margin = 1/2 inch; average proportional limit load = 1,117 pounds; average ultimate load = 1,755 pounds.
C. End margin = 3/4 inch; average proportional limit load = 1,067 pounds; average ultimate load = 1,992 pounds.
D. End margin = 1 inch; average proportional limit load = 1,025 pounds; average ultimate load = 2,161 pounds.
E. End margin = 1-1/4 inches; average proportional limit load = 1,108 pounds; average ultimate load = 2,022 pounds.

Z M 66508 F



Z M 64237 F

Figure 7.--Graphical summary of bearing stresses of cross-banded compreg.



SUMMARY OF THE RATIOS OF BOLT-BEARING STRESS TO COMPRESSIVE STRESS (SLOPE OF CURVES).

AT PROPORTIONAL LIMIT			
DIAMETER OF BOLT (INCH)	THICKNESS OF COMPREG (INCH)		
	1/4	1/2	1
1/4	2.60	2.65	—
1/2	1.87	2.04	2.50
1	—	1.86	1.93
AT ULTIMATE			
DIAMETER OF BOLT (INCH)	THICKNESS OF COMPREG (INCH)		
	1/4	1/2	1
1/4	1.63	2.06	—
1/2	1.31	1.58	1.85
1	—	1.43	1.47

Z M 64238 F

Figure 8.--Relationship between bearing stress and compressive stress of commercial compregs A, B, and C.

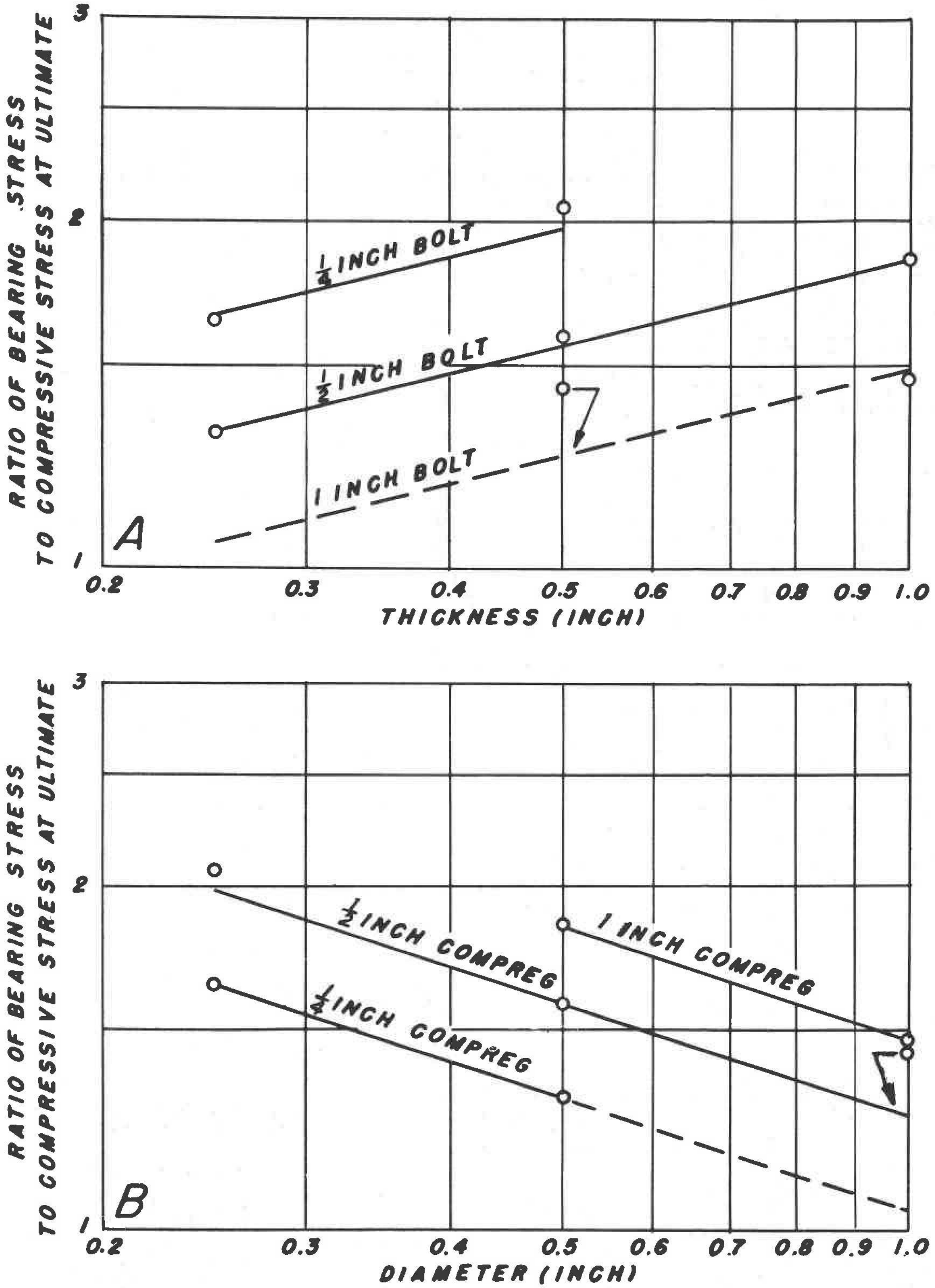


Figure 9.--Effect of variation of thickness (A) and diameter (B) on the ratio of bearing stress to compressive stress at ultimate. Circles are actual average ratios obtained from tests in this investigation.

Z M 65590 F

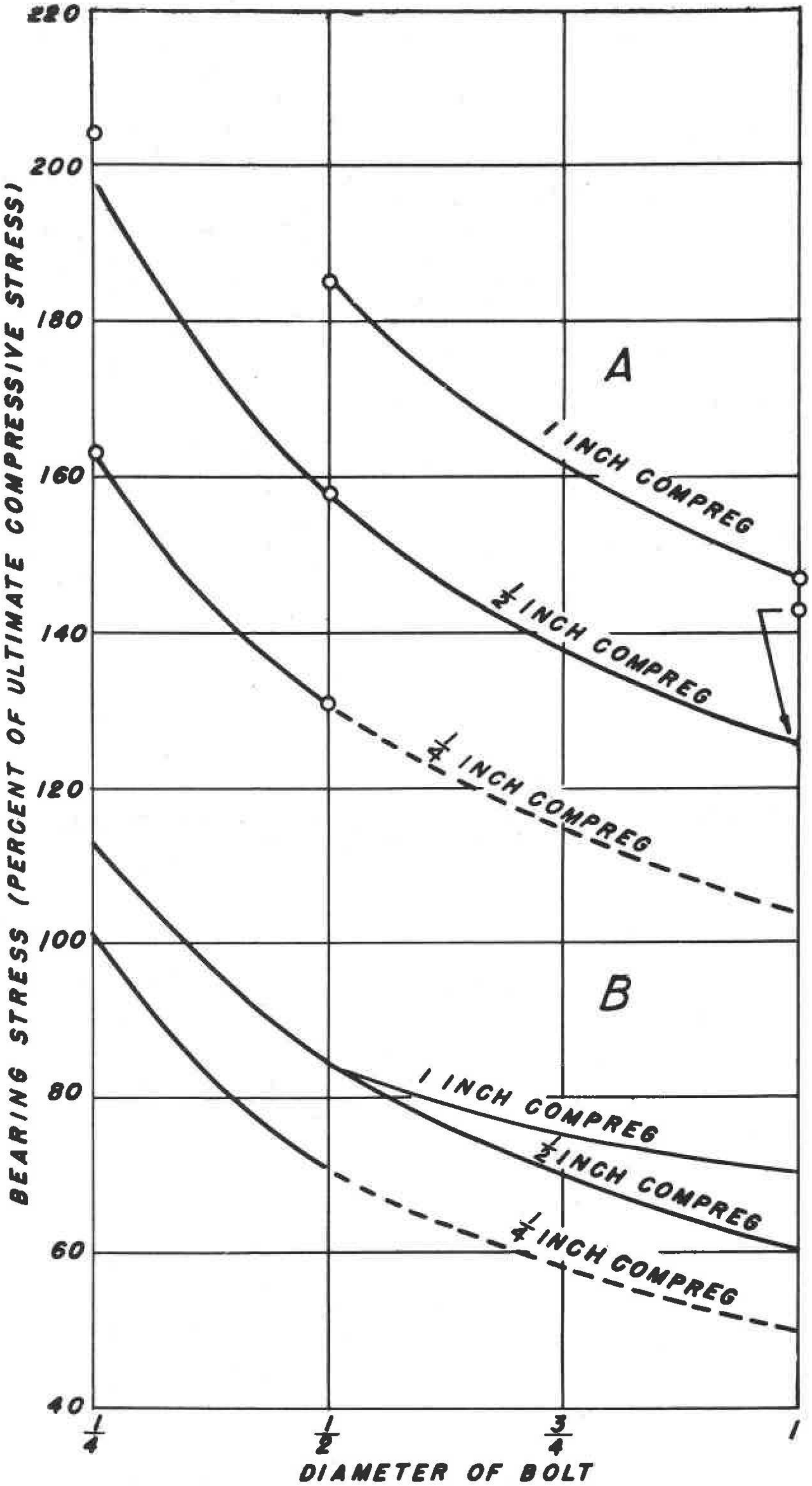


Figure 10.--Ultimate (A) and proportional limit (B) bearing stresses of commercial cross-banded compreg expressed as percent of ultimate compressive stress for three diameters of bolts (1/4, 1/2, and 1-inch) and for three thicknesses of compreg (1/4, 1/2, and 1-inch).

Z M 65591 F

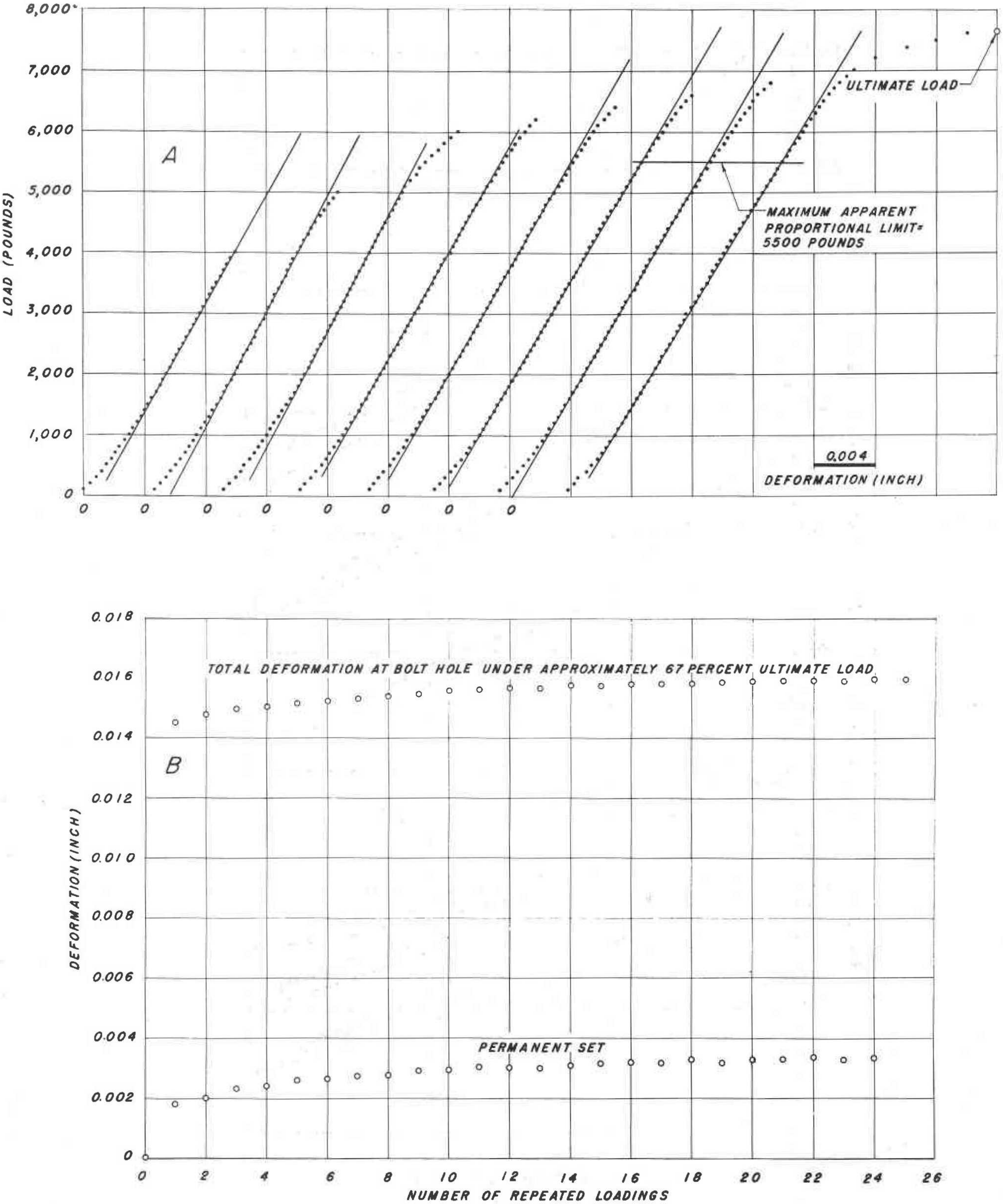


Figure 11.--Data from two repeated-loading bolt-bearing tests plotted on rectangular coordinates to show (A) selection of maximum apparent proportional limit and (B) verification of selected maximum apparent proportional limit by 24 repeated loads showing little increase in total deformation or permanent set.

Z M 65592 F