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TURRET GUN GIRDER STRESSES

By

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Report

on

Turret Gun Girder Stresses

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
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ABSTRACT

Stresses were measured in a celluloid model of a turret gun girder for three angles of recoil - 0, $22^{\circ}30'$, and 45°. For all angles of fire the powder hoist section showed high tension normal to the recoil compression over nearly the entire panel. This was least for recoil at $22^{\circ}30'$, averaging about 53 per cent of the compression stress across the forward and after edges of the panel and greater for 45° recoil, averaging 75 per cent of the compression. These high transverse tensions were accompanied by compression values much higher than necessary to balance the recoil of the gun. Compression across the forward edge of the powder hoist panel was least for 45° recoil when it was 50 per cent greater than the initial force, and greatest for $22^{\circ}30'$ recoil when it was 66 per cent greater than the initial load.

There was a concentration of stress compression on the top edge of the powder hoist panel near the forward fillet. This was least 150 tons per foot for horizontal recoil, and greatest 240 tons per foot for $22^{\circ}30'$ recoil. The girder plate near the rear roller path ring support showed a concentration of shear, P-Q, which reached maxima of 280 tons per foot for 45° recoil, 320 tons for $22^{\circ}30'$, and 375 tons for horizontal recoil. This concentration for horizontal recoil was reduced to 150 tons per foot by running a stiffener from the forward point of the roller path ring support forward and up at an angle of 55°.

AUTHORIZATION

1. A photoelastic investigation of the stresses in a turret gun girder was authorized by Bureau of Construction and Repair letter NN/L1-(1) EN7/A2-11(F) of 21 June 1939.

INTRODUCTION

2. A celluloid model of the gun girder was built on a scale of 1.25 inches to the foot with celluloid 0.175 inch thick used to represent 65 pound steel plate. A photograph of the model with the loading frame is shown in Plate 1. The double plate of the steel girder was replaced in the model by a single plate reinforced by stiffeners on each side. A short section of the curved turret wall is replaced by a straight strip of celluloid (kk) and the circular roller path ring is replaced by celluloid brackets (b, c) with a pivot to represent the point of support. The different recoil loads were combined with the weight resting on the trunion for a single component load which was applied by a spring scale through the center of the trunion (m). A tension equal to two-fifths of the horizontal component of recoil was applied to the forward roller path bracket through the loading pin (b), as shown in the photograph. The vertical load on the forward roller path bracket was assumed by the top or bottom wall of a slot in the aluminum supporting frame and transmitted to the girder through the loading pin. The load through the back roller path bracket (c) was taken through a similar pin. The girder was held in the line of the load by guides (d) and by the aluminum channel (e). Neither of these supported an appreciable part of the recoil load. It was not possible to load the model to failure in the powder hoist panel as was originally planned because of the limiting strength of the roller path support (c).

EXPERIMENTAL MEASUREMENTS

3. Plate 2 shows an isoclinic and stress flow map for the gun girder under horizontal recoil. Plate 3 is the P-Q or shear map for the same conditions. The figures on the map multiplied by 10,000 give the shear per linear foot in the steel girder. The initial load for this study is a recoil compression. For this reason compression stresses are called positive, while tensions are marked negative. Over nearly all of the girder one of the principal stresses is a compression and is designated as the P stress, while the other, which is generally a tension, is called the Q stress. Integration of P and Q values was made along the scaled lines in the powder hoist section of each plate. Plates 4 and 5 are stress maps for 22°30' recoil and Plates 6 and 7 give the results for 45° recoil.

4. Plates 3, 5 and 7 show concentrations of shear near the forward attachment of the rear roller path support (a), Plate 1. A stiffener (s), Plate 8, was attached to the girder at this point to reduce this concentration. Plate 8 shows stress maps of this section made for horizontal recoil. The lower map of P-Q values shows that

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the concentration is almost completely eliminated by the stiffener used.

5. Values of P, Q and P-Q for all edges of the powder hoist and for the three angles of recoil are shown in Plate 9. Values plotted up or to the left are compression and those plotted down or to the right are tension.

DISCUSSION OF THE PLATES

6. Isoclinic lines cross in Plates 2, 4, 6 and 8 at points where P-Q = 0. These are called critical points in the stress field. The critical point near the lower edge of each plate marks the region where Q tension from the forward support reverses to the P compression from the back support. For horizontal loading this point is located about a foot forward of the powder hoist and about a foot above the base. The other angles of recoil place this reversal of stress on the lower edge of the girder plate and near the center of the powder hoist panel. The forward part of this edge is under tension and the after part is under compression.

7. Plates 3, 5 and 7 show low shear, 10 or less for the lower radial stiffener on the trunion block (f) except near the end. The end stresses would probably be of about the same magnitude independent of the length of this stiffener. The low stresses along this stiffener for all angles of recoil indicate that it is not contributing materially to the strength of the girder.

8. These plates all show a concentration of compression on the upper edge of the powder hoist panel near the forward fillet (g). This concentration is greatest for 45^{o} recoil, Plate 7, where it is equal to 400,000 pounds per foot of plate. The girder under recoil loads reacts to a certain extent like a beam loaded in the center and supported at the two ends. The top is under compression for almost its entire length, but the bottom of the beam is under tension for almost two-thirds of its length in spite of the fact that the horizontal component of compression on the back support is 50 per cent greater than the horizontal tension applied to the forward support. This beam-like reaction of the girder results in the high compression at (g). It is thought that the high compression at this point can be avoided by omitting the fillet at this point and by rearranging the stiffeners in line with the recoil load from the trunion to the after roller path ring.

9. Additional indication of the importance of the stiffeners in the distribution of load in the powder hoist panel is given by the direction of the compression across the center of the hoist panel as shown in Plates 2, 4 and 6. In each case the direction is approximately 40^{o}, although the angle from aft support to trunion center is 31^{o}. Plate 9 shows that the Q tension is very high and averages nearly 60 per cent of the compression load. The net result of both of these

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components is that the total compression load summed along the forward edge of the powder hoist panel averages about 60 per cent greater than the total recoil load from the trunion.

10. Distortion in the direction of P stress is proportional to P - 1/3 Q. The P and Q curves of Plate 9 indicate that distortion in the direction of the P compression averages about 100 per cent greater over the entire panel than it should. It is 80 per cent greater than it would be if the entire recoil acted across the panel without developing any transverse tension. Since the forward roller path support assumes 40 per cent of the total horizontal component of recoil, it should be possible theoretically to reduce the compression component across the powder hoist panel to 60 per cent of the recoil load on the trunion.

11. The figures in the P and Q areas in Plate 9 give the areas representing the P compression and the Q tension along the edges indicated.

RECOMMENDATIONS

12. The gun girder model tested showed high compression at the forward fillet on the upper edge of the powder hoist panel; it showed transverse tension across the powder hoist panel which averaged about 60 per cent of the compression stress across the panel; and it showed a high concentration of shear at the point of attachment of the after roller path support to the girder. The compression near the fillet might be avoided by omitting the fillet. The two other troubles might be avoided by introducing two stiffeners in the direct line from the center of the trunion to the point of support of the after roller path, one from the trunion support to the powder hoist and the other from the powder hoist to the after roller path support.

13. Stiffeners as suggested might reduce the displacement of the trunion center with reference to the roller path support during recoil by 50 per cent. Recoil displacement in the girder tested would be about 0.15 inch and this in the steel turret would result in very high stresses in (h) (see Plate 1) which is rigidly attached to the great mass of the turret armor. Oscillating stresses in (h) might make the dynamic stress problem in the steel turret decidedly different from the static problem in the celluloid model. This danger might be avoided by dropping the point of attachment of (h) and the turret frame (k) to a foot or more below the point of attachment of the turret armor plate.

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