NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT
3120625
312.01/G-38269

NBS REPORT
9546

CAST ALUMINUM ALLOY BRIDGE HANDRAIL POST

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Submitted by

Bureau of Design, Engineering and Research
Department of Highways and Traffic
Government of the District of Columbia

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

FORM NBS-259
(3/66)

312.01/G-38269

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
WASHINGTON, D.C. 20234

REPORT OF TEST

on

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Reference: Government of the District of Columbia, Department of Highways and Traffic, Bureau of Design, Engineering and Research letter; Luther G. Martin, Jr., Engineer of Materials and Research, dated April 7, 1967.
D. C. Lab No. 2972

The reference requested that yield strength, ultimate tensile strength, and elongation tests be performed on nine specimens machined from the submitted handrail post (fig. 1) as follows:

(1) One specimen machined from integrally cast test coupon on base plate (Specimen T-1).

(2) Two specimens machined from base plate away from fracture (Specimens T-2 and T-3).

(3) Three specimens machined from one side of the post on which there are no brackets for attaching handrail, one from top portion (Specimen T-4), one from middle portion (Specimen T-5), and one from bottom portion (Specimen T-6).

(4) Three specimens from side of post opposite to (3) (top - Specimen T-7, middle - Specimen T-7, bottom - Specimen T-9).

In addition, hardness measurements and a microscopic examination were made.

Tensile Tests

Round tensile specimens with a diameter of 0.20 inch in the reduced section and a gauge length of one inch were machined from the handrail post at the locations mentioned above. The ultimate tensile strength and elongation values for these specimens are given in the following table.

Specimen No.	Ultimate Tensile Strength (psi) [a]	Elongation (percent) [b]
T-1	42300	6.5
T-2	36100	2.0
T-3	35800	2.0
T-4	24500	0.5
T-5	33600	1.5
T-6	17200	0 [c]
T-7	38900	4.5
T-8	30900	1.0
T-9	22500	1.0 [c]

(a) Value given to nearest 100 psi according to ASTM specification B108-59T.
(b) Value given to nearest 0.5% according to ASTM specification B108-59T.
(c) Failure occurred outside gauge length.

ASTM specification B108-59T gives the following minimum requirements for alloy SG70B in the T61 condition:

Yield Strength (psi) (0.2% offset)	26000
Tensile Strength (psi)	38000
Elongation (%)	5

Only specimens T-1 and T-7 met specifications for ultimate tensile strength, and only specimen T-1 met elongation specifications. (ASTM specification B108-59T calls for elongation to be determined from a 2 inch gauge length, but the material available for specimens T-1, T-2, and T-3 permitted only a one inch gauge length. For consistency, all specimens were made with this gauge length.)

Only specimens T-2 and T-3 exhibited a proportional limit which would enable the calculation of yield strength and, unfortunately, there was a recorder malfunction during the test on T-3. A yield strength of 2900 psi was obtained for specimen T-2 which meets specifications.

Hardness Tests

Although not specified in the request, it was deemed advisable in view of the poor tensile strength of the material to make hardness measurements and a microscopic examination.

Using a 500 Kg load and ten millimeter ball, Brinell hardness was as follows:

Location	Brinell Hardness
Base plate	84
Side of post	85

There is no hardness requirement contained in ASTM specification B108-59T, but the 1962 edition of the Alcoa Aluminum Handbook gives a Brinell hardness of 90 as being typical for this alloy. Thus the hardness is lower than would be expected.

Microscopic Examination

Four specimens, one each from the test coupon, the base adjacent to specimen T-3, the center of the railing post side adjacent to specimen T-5, and specimen T-6 at the bottom of the post side, were examined microscopically (figures 2 through 5 respectively). For each of the specimens examined, the photomicrograph shows areas which exhibit a greater than average degree of porosity compared to the entire specimen. A good deal of porosity was exhibited, however, in all areas examined. Of the four specimens examined, the porosity was greatest in specimen T-6 and the dendritic structure was much coarser than that of both the test coupon and the base and slightly coarser than that at the rail post center. Specimen T-6 also exhibited the poorest tensile strength.

Discussion and Conclusions

This bridge rail post exhibited generally poor mechanical properties and a great lack of uniformity in the material in different parts of the casting. Of the nine tensile specimens tested, only the test coupon was found to have both adequate tensile strength and elongation. The poorest area appeared to be in the side of the post just above the base. Some porosity is expected in these castings, but the porosity is judged to be excessive in some areas such as shown in figures 4 and 5. While ASTM specification B108-59T does not specify hardness requirements, the hardness of the casting is lower than would be expected. This can be attributed to excessive gas porosity.

In summary, there appears to have been very poor quality control during the casting of this bridge handrail post.

Figure 1. Cast aluminum alloy bridge handrail post. (Approx. 1/4 actual size.)

Figure 2. Section of test coupon showing gas porosity and dendritic structure. Unetched, X 50.

Figure 3. Section of rail post base adjacent to specimen T-3. Unetched, X 50.

Figure 4. Section of rail post adjacent to specimen T-5 (center of post) showing excessive porosity. Unetched, X 50.

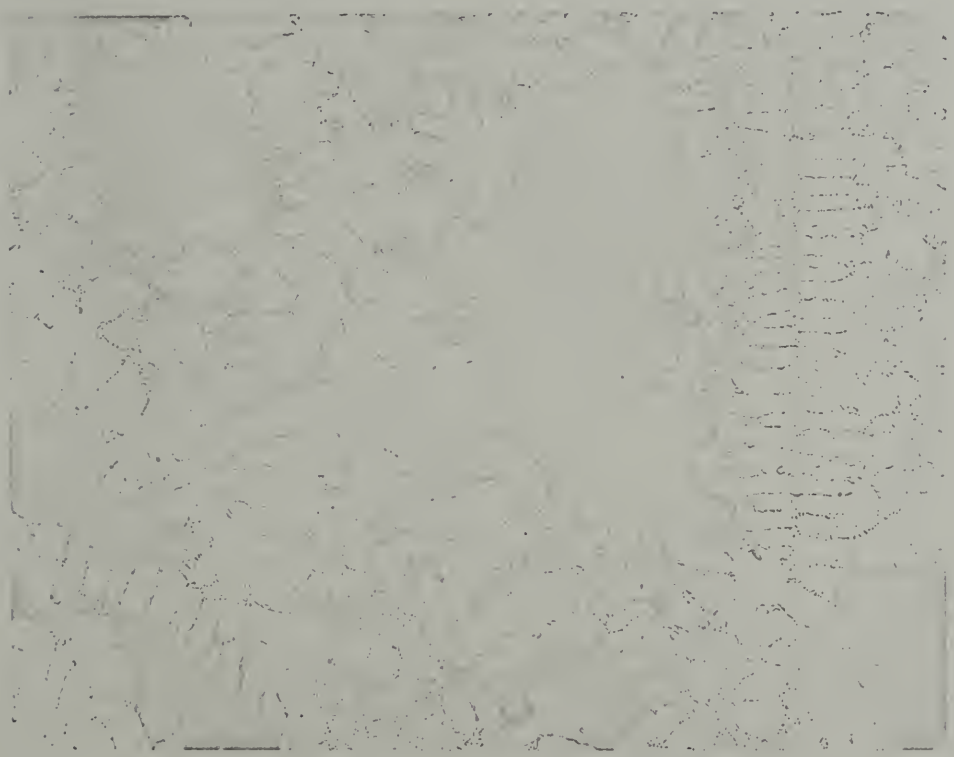

Figure 5. Section of rail post just above base (specimen T-6) showing extreme porosity and coarse dendritic structure. Unetched, X 50.