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The effect of glaze fit upon the strength of Missouri Zadock

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THE EFFECT OF GLAZE FIT UPON THE STRENGTH OF MISSOURI ZADOCK

BY

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A

THESIS

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TABLE OF CONTENTS

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INTRODUCTION

The length of service a piece of dinnerware or china gives is very often determined by its fragileness; frequently the piece is broken or chipped long before it has given average service. If the potter can make his product more resistant to mechanical shock, the users of chinaware and dinner plate will be the gainers. They will experience fewer breakage losses, and will consequently draw longer average life from the ware they use.

The problem of making dinnerware less fragile can not be solved by a single investigation. What factors affect fragileness? In what measure is it a function of brittleness; in what measure, of lack of mechanical strength? How may brittleness be decreased? How may mechanical strength be increased? The answers to these questions will add to the knowledge of the potter, and will undoubtedly throw some light upon the problem of increasing the length of service of dinnerware.

We know that, in the case of a beam, the really effective part of the cross-sectional area is that part farthest from the neutral axis. The I-beam, with most of the central area eliminated, is just as strong as is the rectangular beam of similar outside dimensions. Why should not the glaze on a piece of ceramic ware play as important a part in the strength of the piece as does the outermost area in a beam? Microscopic cracks in the flanges of an I-beam weaken it appreciably. Might not a parallel case exist in a piece of glazed pottery in which the glaze has crazing tendencies?

REVIEW OF LITERATURE

This investigation is not the first of this general nature to be carried out. Riddle and Laird[1], with a view to controlling glaze fit in production by a simple mechanical test, investigated the tensile strengths of one-fire porcelains (cone 13 and cone 18) bearing different glazes. They found that one porcelain body with a good compressive glaze had a tensile strength 375% that of the same body with a crazed glaze. Gerold[2] found that, of three glazes applied to high-tension porcelain insulators, two decreased both modulus of rupture and

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1. Riddle, F. H., and Laird, J. S., "The control of glaze-fit by means of tensile test specimens", Jour. Amer. Ceram. Soc., 5:500-503 (1922)

2. Gerold, E., "Influence of the glaze upon the physical properties of porcelain", Ceram. Abs. 4:169 (1925)

tensile strength; the third increased both. Grinding off the glaze restored the original strength of the body, showing that the state of the glaze was the important factor in the change of strength. Rowland[3] and Thiess[4] verified Gerold's findings: porcelain with poor glaze fit had a mechanical strength lower than the unglazed body; porcelains with a good glaze fit had a strength higher than the unglazed body. Bettany and Webb[5] made a rather thorough test of the effect of glazes upon the mechanical strength of electrical porcelain, and concluded that the mechanical strength depends upon at least six factors: (1) the composition and method of compounding of the glaze; (2) the contraction of the glaze in cooling, relative to that of the body; (3) the thickness of the glaze; (4) the characteristics of the buffer layer between glaze and body; (5) the texture of the surface; and (6) the firing treatment. Their glaze increased the mechanical strength of the test piece as it became

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3. Rowland, D. H.,"The influence of glaze on insulator strength", Gen. Elec. Rev. 32:136-138 (1929)

4. Thiess, L. E., "Influence of glaze composition on the mechanical strength of electrical porcelain", Jour. Amer. Ceram. Soc. 19:70-73 (1936)

5. Bettany, C., and Webb, H. W., "Some physical effects of glazes", Trans. Brit. Ceram. Soc. 39:312-334 (1940)

more and more compressive, up to a limiting value. Beyond this value, no further increase of strength could be obtained. One crazable glaze cut the bisque strength of a body in half. They decided that the "general results of modulus of rupture and tensile tests on ceramic bodies can be explained on a hypothesis of the presence of minute surface cracks."[6]

INVESTIGATION

Object: The purpose of this investigation was to determine what effect the state of the glaze has upon the transverse strength of fired clay bars.

Materials: The clay used was Zadock, a mixture of tan-burning clay, sand, and mica, mined near Dexter, Mo.

Procedure: The clay was first blunged for three hours, filter-pressed, and allowed to age. Test bars, 6" x 1½" x 13/32", were hand-moulded from the clay and carefully dried. They were then bisqued to cone 4, on a six-hour firing schedule.

In selecting the glaze, it was desired to find one basic glaze which could be varied from absolute tension to absolute compression by merely changing the amounts of clay and flint. A clear, fritted glaze was found

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6. Ibid.

which fitted the Zadock body fairly well, and the clay and flint percentages were varied to give a series of seven glazes which it was thought would fulfill the requirements.

The test bars were divided into eight groups: one group was left unglazed and each of the others was sprayed with one of the seven glazes. These bars were fired to cone 02, the unglazed bars being also placed in the kiln so as to receive the same heat treatment as the glazed bars. The fired bars were then examined for crazing and peeling, and broken in a Riehle testing machine to determine the moduli of rupture.

GLAZE RECIPES

	1	2	3	4	5	6	7
Frit	481	481	481	481	481	481	481
Pb_3O_4	150	150	150	150	150	150	150
$CaCl_2$	3	3	3	3	3	3	3
Flint	225	200	175	150	125	100	75
English China Clay	75	100	125	150	175	200	225

Frit:	Potash feldspar	25.8
	$CaCO_3$	9.3
	Pb_3O_4	42.3
	Flint	11.1
	Borax	11.5

RESULTS

Examination of the glazed bars indicated that glazes 1 and 2 were too small for the body. Glaze 1 exhibited many small crazings; glaze 2 showed fewer and larger crazings. Glazes 3, 4, and 5 were apparently all good fits, showing no crazing at all. The Hind punch test[7] had to be applied to these three groups of bars to determine the state of the glaze. Glaze 3 gave neutral results; glaze 4 showed definite compression. Glaze 5 was too thin to give any satisfactory results with the punch. Glazes 6 and 7 were completely taken into solution by the body, so that no glaze remained on the surface.

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7. Trans. Brit. Ceram. Soc. 35:431 (1935-36)

The average breaking loads and the average moduli of rupture for each of the seven glazed groups and for the unglazed bars are shown in the table. Each value represents the average of approximately 35 test bars.

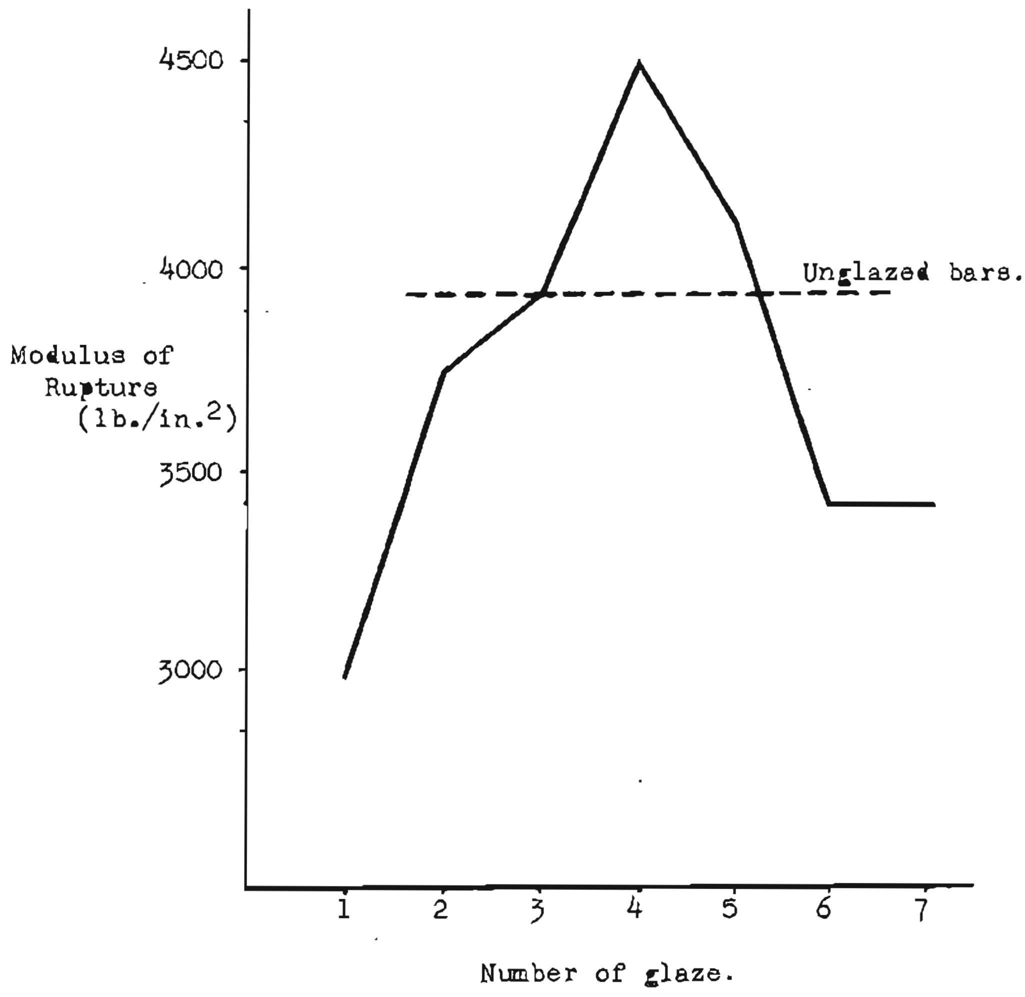
	Average breaking load. Pounds.	Average modulus of rupture. Pounds per square inch.
Unglazed	81	3915
Glaze 1	61	2950
Glaze 2	77	3720
Glaze 3	81	3915
Glaze 4	93	4495
Glaze 5	85	4110
Glaze 6	70	3380
Glaze 7	70	3380

Average cross-sectional area: 1 5/16" x 11/32"

DISCUSSION OF RESULTS

The series of glazes covered a range greater than was required. Glaze 1 was evidently the smallest glaze of the series, for it crazed very badly and with very small checks. Glaze 2 was somewhat larger than glaze 1, and fitted the body better. The crazings in the case of glaze 2 were fewer and larger in size. Glazes 3 and 4 were neutral and too large respectively, as shown by the punch test. In the case of glaze 5, which was very thin after firing, the punch test was useless. However, since glazes 6 and 7, low in flint and high in clay, were robbed completely by the body, we reason that glaze 5 was partially taken into solution by the body. The useful glazes for the investigation are then glazes 1, 2, 3, and 4, ranging from absolute tension to absolute compression.

An examination of the table giving the results of the modulus of rupture tests will show that the bars bearing glaze 1 were but 75% as strong as was the unglazed body; the bars bearing glaze 2 were but 95% as strong. The bars bearing glaze 4, on the other hand, were 115% as strong as were the unglazed ware. Glaze 3 apparently had no effect upon the strength of the bisqued body.



CHANGE IN MODULUS OF RUPTURE WITH CHANGE IN GLAZE COMPOSITION.

CONCLUSIONS

1. The state of the glaze does affect the transverse strength of fired clay bars.
2. A compressive glaze will increase the strength of the bisque body.
3. A glaze in tension can decrease the bisque strength appreciably.

SUGGESTIONS FOR FURTHER STUDY

An investigation into the relationship of mechanical strength and resistance to mechanical shock would increase the potter's knowledge of the problem of turning out less fragile ware, and would perhaps make useful to him the recent findings on mechanical strength and glaze fit.

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<u>INDEX</u>