

Manufacture of Yellow Coloured Bricks From Alluvial Soils

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Introduction

THE colouring of bricks and tiles has become extremely popular during recent years. The manufacture and use of multi-coloured bricks has become quite common in England. In the United States and on the Continent coloured bricks have come into use on a large scale and bricks of numerous colours including blue, green and other shades are produced in large numbers. The manufacture and use of coloured bricks are practically unknown in India. Attempts have been made in this Institute to develop yellow coloured bricks from alluvial soils and the results of the investigation carried out are reported in this paper.

The development of colour in a brick depends on the nature of clay, the type of salt added and the firing condition. Most of the alluvial soils are generally red burning owing to the presence of iron oxide. Lime prevents the development of the usual red colour produced by iron content and the result is pale buff bricks. The addition of sodium chloride to a soil lime admixture helps in the development of deeper shades of yellow mosaic pattern on bricks.

Experimental

Local soils from three brick fields were used for these experiments. The physical properties of these soils are given in table I and their chemical analysis in table II. The soils were powdered to pass a 2 mm. sieve. Laboratory experiments were carried out on soils II and III.

Lime was added to the soils in the form of Limestone. Experiments were carried out to examine if Kankar lime, which is sometimes

associated with alluvial soil, can be used for the purpose. Lime stone and kankar were ground to pass 1/32" sieve. The chemical analysis of lime stone and kankar lime is given in table II.

Different quantities of calcareous materials alongwith sodium chloride were added to the soils. A sample of commercial sodium chloride was used in all these experiments. Briquettes made out of these admixtures were fired at different temperatures. Colour developed in the briquettes was noted by visual observation. Briquettes were tested for compressive strength, water absorption and other properties according to I.S.I. specifications. Results obtained are given in table III and IV.

In addition to the laboratory experiments full size bricks were fired in an oil fired kiln and in a coal-fired down draft kiln.

Discussion of Results

It is seen from the results that addition of lime to soil results in the production of buff coloured bricks. Addition of sodium chloride helps in the development of yellow colour. The results clearly show that lime required to produce buff or yellow depends upon the quantity of clay particles in a soil. The greater the percentage of clay present in a soil, the greater is the quantity of lime required. Results in table III, IV indicate that soils containing above 40% clay and silt, require 7 to 11.0 of CaO for development of buff or yellow colour in bricks. Clayey soils need more of sodium chloride than sandy ones. Mosaic pattern bricks can be produced by lime which is insufficient to produce yellow colour. Thus by a judicious combination of lime and sodium chloride, and firing temperature different patterns of yellow specks on red or buff background can be

produced. High temperature of burning results in the production of deeper shades of yellow. The results also show that kankar lime can also be used for the development of yellow colour in a brick.

Physical properties of bricks

Addition of limestone or kankar lime decreases the strength and increases the water absorption of bricks considerably. In general, the greater the amount of lime added to the soil, the more is the decrease in strength and increase in water absorption of bricks made from it. Fairly good strength bricks are obtained provided they are fired between 950 to 1050°C. Though the increase in strength with firing temperature is not much, still a higher firing temperature is preferable for the manufacture of yellow coloured bricks. However, they may be fired at lower temperature if the colour requirements dictate the choice.

Trial on full size bricks

In the first experiment different quantities of calcareous material were added to the three soils. Twenty bricks were made from each admixture made after treating soils with calcareous material and sodium chloride. These bricks were fired in an oil fired furnace in a temperature range of 950° to 1050°C for a period of five hours. Results obtained are given in table V, which show that maximum strength is obtained from the soils of group C. Thus for outdoor exposure work, yellow coloured bricks may be made from soils of group C. For decorative work where strength is of little importance soils of group B or A may be used for the purpose.

In an other trial about 1300 bricks were fired in a down draft kiln. Soil No. 3 was used for this experiment. It was mixed with 37% of Kankar lime which was ground to a size less than 1/32" B.S. Sieve. Two per cent sodium chloride calculated on the weight of admixture was dissolved in water and mixed with the

soil. The soil admixture was then passed through a pan mill to ensure thorough mixing. Bricks were pressed by a Land Crete Machine at the optimum moisture content, and were then dried, and fired in a rectangular down draft kiln (internal dimension 7.5×6.5 ft. between long walls), provided with 4 fire holes and bag walls. They were stacked five on two. Trials were left in setting at various courses which were drawn by a pair of tongs when required. The following firing schedule was adopted :

| | |
|-------------------|--------|
| 0—150°C | 6 hrs. |
| 150—350°C | 6 hrs. |
| 350—600°C | 8 hrs. |
| Soaking at 600°C | 6 hrs. |
| 600—850°C | 6 hrs. |
| 850—1050°C | 6 hrs. |
| Soaking at 1050°C | 4 hrs. |

Attempts were made to fire bricks under reducing conditions. The kiln was cooled slowly upto 900°C and then rapidly.

Test Results

About fifty bricks, selected at random from different parts of the kiln, were tested for their crushing strength which ranged from 2500 lbs./sq. in. to 4075 lb/sq. in. whereas water absorption varied from 16% to 19.6%. The bricks obtained were mostly of yellow colour.

However, on some parts of the bricks which were exposed to SO₃, reddish tinge appeared. This tinge could be removed from the surface of brick by rubbing under wet conditions. It is, therefore, very desirable that the bricks should be fired under reducing conditions if the coal containing sulphur is used as a fuel.

Conclusions

1. The addition of calcareous materials like limestone or kankar lime helps in bleaching the colour due to iron content and results in the production of buff coloured bricks. Addition of sodium chloride helps in the development of yellow colour in a brick.

2. Soils containing above 40% clay and silt require about 7 to 11% of CaO, and about 1 to 2% sodium chloride for the development of yellow colour.

3. Mosaic pattern bricks can be produced by suitable adjustment of the quantities of calcareous material and sodium chloride.

These are the tentative conclusions reached on the basis of preliminary studies so far completed.

Acknowledgement

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TABLE I
Showing the Physical Properties of the Soils

| Soil from | Mechanical Analysis | | | Soil Group | Liquid limit | Plastic limit | Plastic Index |
|--------------------------|---------------------|--------|--------|------------|--------------|---------------|---------------|
| | % clay | % silt | % sand | | | | |
| C.B.R.I. Roorkee Kiln I | 13.6 | 16.2 | 70.2 | A | 24.1 | 16.5 | 7.5 |
| Mangal Sain Kiln Soil II | 20.4 | 26.4 | 53.2 | B | 26.5 | 17.8 | 8.7 |
| Danderah Soil III | 23.3 | 42.15 | 34.55 | C | 42 | 19.4 | 22.6 |

TABLE II
Chemical Analysis of Soils and Calcareous Materials

| | Soil No. I | Soil No. II | Soil No. III | Kankar lime | Kotah lime |
|--|------------|-------------|--------------|-------------|------------|
| Loss on Ignition | 4.55 | 6.41 | 7.95 | 25.7 | 38.81 |
| Silica | 77.84 | 69.42 | 60.63 | 35.84 | 9.99 |
| R ₂ O ₃ Al ₂ O ₃ | 10.00 | 14.00 | 19.64 | | |
| Fe ₂ O ₃ | 4.08 | 5.79 | 7.65 | 6.78 | — |
| CaO | 0.80 | 0.68 | 0.63 | 27.56 | 45.85 |
| MgO | 1.28 | 1.45 | 1.96 | 8.77 | 2.44 |
| Alkalis | N.D. | N.D. | N.D. | — | — |

TABLE No. 3

Showing Physical Properties of Bricks after Different Treatments

| Soil No. | Additions | | | Crushing Strength | | % Water Absorption | | Bulk Density | | Total Firing Shrinkage | | Colour Effect |
|----------|--------------|-------|--------|-------------------|---------|--------------------|----------|--------------|--------|------------------------|--------|---|
| | Kotah lime % | CaO % | NaCl % | 1000°C | 1050°C | 1000°C | 1050°C | 1000°C | 1050°C | 1000°C | 1050°C | |
| | Nil | Nil | Nil | 3,827 | 5,217 | 12.1% | 7.8 % | 1.90 | 1.98 | 27.2 | 33.7 | |
| Soil No. | 16.7% | 7.65% | 0.0 | 2,572.0 | 2,814.5 | 16.08% | 15.01% | 1.70 | 1.74 | 20.46 | 21.60 | Buff + 10% yellow specks |
| | | | 1.0 | 2,617.0 | 2,786.0 | 17.8 .. | 14.05 .. | 1.71 | 1.72 | 17.97 | 19.60 | Few violet specks on yellow background. |
| | | | 1.5 | 2,208.0 | 3,458.3 | 17.37 .. | 13.46 .. | 1.70 | 1.75 | 15.64 | 19.53 | -do- |
| | | | 2.0 | 2,617.0 | 4,425.3 | 17.18 .. | 12.74 .. | 1.72 | 1.78 | 17.05 | 19.53 | Almost Yellow |
| | | | 3.0 | 1,882.0 | 4,578.0 | 17.15 .. | 13.31 .. | 1.70 | 1.79 | 19.52 | 26.57 | Yellow |
| ,, | 14.9% | 6.83 | 0.0 | 2,715.0 | 3,555.0 | 16.72 .. | 14.62 .. | 1.72 | 1.75 | 21.69 | 22.23 | Buff |
| | | | 1.0 | 2,421.0 | 3,239.0 | 16.72 .. | 14.68 .. | 1.71 | 1.74 | 22.50 | 22.35 | Slightly yellow specks |
| | | | 1.5 | 2,407.0 | 3,261.0 | 16.5 .. | 14.11 .. | 1.72 | 1.72 | 20.50 | 22.60 | 15% yellow specks |
| | | | 2.0 | 2,540.0 | 3,385.3 | 16.50 .. | 14.28 .. | 1.72 | 1.73 | 23.35 | 22.73 | 80% yellow specks + 20% red |
| | | | 3.0 | 2,327.0 | 3,494.0 | 15.06 .. | 14.32 .. | 1.72 | 1.73 | 22.85 | 25.80 | 90% yellow + 10% red |
| ,, | 13.0% | 5.96% | 0.0 | 2,586.0 | — | 15.65 .. | — | 1.72 | — | 19.83 | — | Buff colour |
| | | | 1.0 | 2,612.0 | 3,160.0 | 15.52 .. | 14.48 .. | 1.72 | 1.75 | 19.57 | 19.10 | Buff colour |
| | | | 1.5 | 2,612.0 | 3,188.0 | 16.2 .. | 14.68 .. | 1.74 | 1.74 | 16.85 | 19.00 | 20% yellow + 80% red & purple |
| | | | 2.0 | 2,079.0 | 2,926.6 | 15.4 .. | 14.58 .. | 1.72 | 1.73 | 21.25 | 22.63 | 25% yellow + 75% red & purple |
| | | | 3.0 | 1,933.0 | 3,118.0 | 15.83 .. | 14.68 .. | 1.70 | 1.70 | 20.46 | 24.87 | 30% yellow + 70% red & purple |

| | | | | | | | | | | | | |
|----|-----------------|---------|-----|----------|---------|----------|----------|------|------|-------|-------|--|
| | Kankar Lime% | | 1.5 | 1,935.3 | 4,702.3 | 19.03 .. | 12.93 .. | 1.65 | 1.77 | 19.47 | 26.93 | Yellow |
| .. | 33% | 9.09% | 2.0 | 1,797.0 | 3,079.3 | 18.97 .. | 15.61 .. | 1.65 | 1.74 | 19.30 | 24.13 | Yellow |
| | | | 3.0 | 1,949.0 | 5,976.0 | 19.71 .. | 10.92 .. | 1.63 | 1.83 | 19.73 | 31.73 | Yellow |
| | | | 1.5 | 1,988.0 | 4,920.0 | 17.89 .. | 13.46 .. | 1.68 | 1.79 | 17.53 | 23.93 | 30% Red specks + 70% yellow specks. |
| .. | 28.5 .. | 7.87 .. | 2.0 | 2,152.7 | 3,282.7 | 17.13 .. | 13.91 .. | 1.69 | 1.77 | 22.17 | .73 | Dark yellow with violet specks. |
| | | | 3.0 | — | 4,169.0 | — | 11.87 .. | — | 1.82 | — | 30.17 | -do- |
| | | | 1.5 | 2,203.7 | 3,012.3 | 17.23 .. | 15.21 .. | 1.70 | 1.74 | 19.23 | 22.07 | 40% red + 60% yellow |
| .. | 26 .. | 7.14 .. | 2.0 | 2,021.3 | 2,934.7 | 17.35 .. | 14.78 .. | 1.72 | 1.76 | 21.33 | 24.3 | 80% yellow + 20% (red + violet) specks |
| | | | 3.0 | 1,670.3 | 2,773.5 | 16.79 .. | 13.25 .. | 1.74 | 1.79 | 20.67 | 24.75 | -do- |
| | | | 1.5 | 2,655.0 | 3,539.7 | 16.18 .. | 13.87 .. | 1.74 | 1.79 | 20.07 | 23.03 | 50% yellow + 50% violet |
| .. | 23 .. | 6.35 | 2.0 | 2,093.0 | 3,229.0 | 16.32 .. | 14.48 .. | 1.71 | 1.72 | 21.00 | 23.83 | 60% yellow + 40% violet & red |
| | | | 3.0 | 2,061.7 | 3,124.0 | 16.49 .. | 14.08 .. | 1.72 | 1.79 | 21.73 | 25.10 | 80% yellow + 20% violet & pink |
| | | | 1.5 | 2,345.0 | 3,970.7 | 15.78 .. | 13.91 .. | 1.74 | 1.78 | 19.6 | 23.20 | 20% yellow + 80% red |
| .. | 20 .. | 5.51 .. | 2.0 | 2,136.7 | 3,047.0 | 15.89 .. | 14.32 .. | 1.72 | 1.76 | 20.97 | 24.23 | 25% yellow + 75% red |
| | | | 3.0 | 2,227.0 | 3,124.0 | 16.88 .. | 13.88 .. | 1.74 | 1.79 | 21.18 | 24.07 | 25% yellow + 75% red & violet |
| | | | 1.5 | 2,825.42 | 3,217.0 | 15.22 .. | 14.71 .. | 1.75 | 1.76 | 19.17 | 20.67 | 10% yellow + 90% red |
| .. | 16.5 .. | 4 | 2.0 | 2,794.7 | 3,482.0 | 15.35 .. | 13.23 .. | 1.76 | 1.79 | 20.07 | 25.63 | -do- |
| | | | 3.0 | 2,652.3 | 4,403.0 | 15.08 .. | 10.60 .. | 1.74 | 1.84 | 20.48 | 27.47 | 10% yellow + 25% red + 65% violet |

TABLE IV
Physical Properties of Bricks After

| Soil No. | % age of kankar lime | Additions | | Compressive Strength | | | | % age Water Absorption | | | |
|--------------|----------------------|------------------------|--------|----------------------|-------|--------|--------|------------------------|--------|--------|--------|
| | | % of CaO | % NaCl | 900°C | 950°C | 1000°C | 1050°C | 900°C | 950°C | 1000°C | 1050°C |
| | nil | nil | nil | 3,011 | 4,226 | 8,117 | 12,122 | 16.19% | 12.63% | 6.75% | 1.82% |
| Soil No. III | | | 0.0 | 2,522 | 2,500 | 2,854 | 3,370 | 19.53% | 20.6% | 19.46% | 18.47% |
| | | | 1.0 | 2,427 | 2,325 | 3,126 | 3,436 | 19.98% | 20.45% | 18.15% | 17.23% |
| | 33% | 9.09% | 1.5 | 2,288 | 1,944 | 2,348 | 2,984 | 19.73% | 19.75% | 19.5% | 18.58% |
| | | | 2.0 | 2,015 | 2,017 | 2,209 | 2,897 | 19.95% | 20.27% | 19.81% | 18.72% |
| | | | 3.0 | 1,603 | 2,054 | 2,133 | ... | 20.04% | 20.45% | 19.9% | .. |
| Soil No. III | | | 0.0 | 2,888 | 2,806 | 3,160 | 3,264 | 18.62% | 20.25% | 18.78% | 17.76% |
| | | | 1.0 | 2,468 | 2,739 | 2,612 | 3,115 | 19.39% | 18.9% | 18.68% | 18.37% |
| | 26% | 7.14% | 1.5 | 2,662 | 2,669 | 2,748 | 3,000 | 18.65% | 18.48% | 17.47% | 17.31% |
| | | | 2.0 | 2,375 | 2,426 | 2,572 | 2,997 | 18.92% | 18.76% | 17.6% | 17.82% |
| | | | 3.0 | 2,244 | 1,906 | 1,763 | .. | 19.78% | 19.57% | 18.94% | .. |
| Soil No. III | | | 0.0 | 3,017 | 2,925 | 2,995 | 3,608 | 18.47% | 19.79% | 17.85% | 16.28% |
| | | | 1.0 | 2,934 | 2,668 | 2,873 | 3,525 | 18.32% | 19.28% | 17.37% | 16.12% |
| | 20% | 5.51% | 1.5 | 2,837 | 2,625 | 2,725 | 3,491 | 18.63% | 19.17% | 17.47% | 16.05% |
| | | | 2.0 | 2,627 | 2,527 | 2,657 | 3,627 | 19.1% | 18.98% | 17.93% | 16.63% |
| | | | 3.0 | 2,412 | 2,373 | 2,515 | 3,538 | 18.91% | 18.68% | 17.77% | .. |
| Soil No. III | 16.5% | 4.59% | 1.0 | 2,842 | 2,526 | 3,035 | 3,454 | 19.09% | 18.59% | 17.59% | 16.35% |
| | | | 1.5 | 3,012 | 3,135 | 3,299 | 4,206 | 18.23% | 18.2% | 16.2% | 15.52% |
| Soil No. III | | % of Kotah limes stone | CaO % | | | | | | | | |
| | 23% | | 1.5% | 3,525 | 3,639 | 3,275 | 4,875 | 19.6% | 19.5% | 19.82% | 17.05% |
| | 19.5% | | " | 2,992 | 2,782 | 3,628 | 3,971 | 21.11% | 23.15% | 19.90% | 19.95% |
| | 16.5% | | " | 3,200 | 3,549 | 3,776 | 5,246 | 18.00% | 16.6% | 18.09% | 16.50% |
| | 13.0% | | " | 3,500 | 3,370 | 4,256 | 4,456 | 17.12% | 17.34% | 17.14% | 16.22% |
| | 11.1% | | " | 3,440 | 3,937 | 4,120 | 4,638 | 16.53% | 15.83% | 16.45% | 16.60% |
| 9.0% | | " | 3,087 | 3,279 | 4,180 | 5,180 | 16.0% | 16.31% | 15.85% | 12.50% | |

Different Treatments

| 900°C | Bulk Density | | | Total Drying & Firing Shrinkage | | | | Colour Effect |
|-------|-------------------|--------|--------|---------------------------------|-------|--------|--------|--|
| | 950°C | 1000°C | 1050°C | 900°C | 950°C | 1000°C | 1050°C | |
| 1.75 | 1.84 ^a | 2.01 | 2.32 | 33.6 | 39.63 | 49.21 | 57.20 | Red |
| 1.66 | 1.64 | 1.66 | 1.67 | 27.06 | 27.06 | 27.00 | 27.7 | Pale Buff |
| 1.65 | 1.63 | 1.68 | 1.69 | 26.7 | 26.82 | 25.6 | 27.4 | 30—50% yellow specks |
| 1.66 | 1.64 | 1.65 | 1.66 | 24.54 | 24.84 | 25.9 | 25.53 | 60 to 70% yellow specks |
| 1.64 | 1.64 | 1.64 | 1.67 | 24.54 | 25.2 | 25.4 | 26.20 | 70 to 90% yellow specks |
| 1.63 | 1.63 | 1.63 | .. | 24.37 | 24.00 | 25.25 | .. | Completely yellow with a few red specks. |
| 1.67 | 1.67 | 1.68 | 1.69 | 26.00 | 27.28 | 27.10 | 28.20 | Buff colour |
| 1.65 | 1.66 | 1.65 | 1.66 | 27.50 | 27.70 | 27.75 | 28.46 | Slightly yellow |
| 1.68 | 1.68 | 1.68 | 1.70 | 26.30 | 25.70 | 25.50 | 28.50 | 30 to 40% yellow and 60 to 70% red. |
| 1.66 | 1.66 | 1.67 | 1.68 | 26.85 | 26.74 | 25.93 | 28.27 | 40 to 50% yellow and 60 to 40% red. |
| 1.66 | 1.64 | 1.66 | ... | 28.50 | 28.05 | 27.20 | ... | 50% yellow—50% redish |
| 1.66 | 1.66 | 1.67 | 1.69 | 25.26 | 28.60 | 28.80 | 29.96 | Buff |
| 1.65 | 1.66 | 1.67 | 1.68 | 26.02 | 27.27 | 28.80 | 29.07 | Buff |
| 1.66 | 1.66 | 1.66 | 1.69 | 25.89 | 28.03 | 29.0 | 29.0 | 6 to 7% yellow Specks |
| 1.66 | 1.67 | 1.67 | 1.68 | 26.0 | 28.47 | 28.27 | 29.13 | 7 to 10% yellow specks |
| 1.68 | 1.67 | 1.67 | ... | 26.21 | 28.36 | 28.29 | ... | 10 to 15% yellow specks. |
| 1.67 | 1.66 | 1.68 | 1.69 | 28.10 | 26.91 | 28.50 | 29.06 | A few yellow specks |
| 1.68 | 1.70 | 1.71 | 1.72 | 27.10 | 27.0 | 27.20 | 30.00 | 5% yellow specks |
| 1.66 | 1.66 | 1.64 | 1.66 | 23.01 | 23.00 | 23.87 | 23.62 | Completely yellow |
| 1.63 | 1.62 | 1.64 | 1.65 | 23.45 | 22.89 | 23.68 | 25.20 | 80% yellow—20% buff |
| 1.65 | 1.67 | 1.66 | 1.64 | 22.00 | 22.60 | 23.70 | 22.75 | 60% yellow—40% buff |
| 1.72 | 1.71 | 1.72 | 1.74 | 26.53 | 26.60 | 27.14 | 26.67 | 40% yellow—60% buff |
| 1.73 | 1.72 | 1.71 | 1.72 | 25.07 | 25.10 | 25.44 | 25.63 | 30% yellow—70% buff |
| 1.73 | 1.75 | 1.76 | 1.78 | 28.0 | 29.03 | 27.83 | 32.20 | 20% yellow 80% buff |

TABLE NO. 5

Yellow Coloured Bricks from Alluvial Soils Fired in Oil Gas Furnace

(Full Scale Results)

| Soil belonging to group | Mechanical Analysis | | | %age of CaCO ₃ and CaO in | | | | %age of Nace in case of | | Colour | Firing Temperature | Compressive strength range lbs/sq. in. |
|-------------------------|---------------------|-------|-------|--------------------------------------|-------|-------------------|------|-------------------------|------------|-------------------|--------------------|--|
| | Clay% | Silt% | Sand% | Kankar lime | | Kotah lime | | Kankar lime | Kotah lime | | | |
| | | | | CaCO ₃ | CaO | CaCO ₃ | CaO | | | | | |
| A. | 18% | 20% | 62% | 20 | 5.5 | 10 | 4.58 | 1.5 | 1.0 | 40% yellow specks | 950°C to 1050°C | 900 to 1400 lb/sq. in. |
| | | | | 22 | 5.65 | 11 | 5.04 | 1.5 | 1.0 | 70% yellow specks | | |
| | | | | 25 | 6.8 | 13 | 5.96 | 1.5 | 1.0 | Completely yellow | | |
| B. | 22% | 24% | 54% | 24 | 6.6 | 13 | 5.96 | 2.0 | 1.5 | 40% yellow specks | 950°C to 1050°C | 1600 to 2500 lb./sq. in. |
| | | | | 27 | 7.42 | 15 | 6.87 | 2.0 | 1.5 | 70% yellow specks | | |
| | | | | 31 | 8.5 | 17 | 7.79 | 2.0 | 1.5 | completely yellow | | |
| C. | 23% | 43% | 34% | 30 | 8.25 | 17 | 7.79 | 2.5 | 2.0 | 40% yellow specks | 950°C to 1050°C | 2000 to 3000 lb/sq. in. |
| | | | | 33 | 9.07 | 19 | 8.71 | 2.5 | 2.0 | 70% yellow specks | | |
| | | | | 37 | 10.17 | 21 | 9.63 | 2.5 | 2.0 | completely yellow | | |

Note (1) The higher the temperature, the brighter the colour obtained.
 (2) Reducing atmosphere is favourable.