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Acid-resistant Bricks

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Acid-resistant bricks for chemical plants are usually made from a mixture of a refractory clay, felspar and some form of silica. Investigations reported here have shown that alluvial soils, which occur widely and are much cheaper, can be used for production of acid-resistant bricks with equal advantage.

ACID-RESISTANT bricks and floor tiles are required in chemical plants for lining vats, chambers and towers, and for paving floors subject to acid attack. The most acid-resistant ceramic materials are hard porcelain and stoneware. Most varieties of fire bricks are sufficiently acid-proof for normal purposes, but for superior acid resistance, a vitrified brick is required. Such bricks are usually made from a mixture of a refractory clay, felspar and some form of silica such as white sand or flint. In the present investigations, acid-resistant bricks have been made from alluvial soils, a raw material which is much cheaper and which occurs widely.

According to Searles and Grimshaw, the degree of acid resistance of bricks or tiles is largely dependent on the porosity or water absorption[1]. Those with a water absorption of less than one per cent will not be attacked by the most concentrated acid even at comparatively high temperatures. Clays containing a high percentage of silica (80 per cent) and a low percentage of lime and iron (Fe_2O_3, max. 1·5 per cent) should be preferred for the manufacture of acid-resistant bricks[2]. However, acid resistance is not to be assessed by chemical composition or water absorption but rather from a direct measure of acid attack. The results obtained in the present investigation confirm this view both in regard to water absorption and chemical composition.

Acid resistance

The effect of the composition of soil on the acid resistance of bricks was investigated by separating the fine and coarse fractions of Dhandhera soil (Roorkee) and then remixing these fractions in suitable proportions. The analysis of the soil is given in Table 1; Tables 2 and 3 show the effect of composition and firing temperature on acid resistance of the bricks made from the soil.

Acid resistance was tested by ASTM Designation C 279-527. According to this specification a good acid-resistant brick, when subjected to acid attack, should show a loss not greater than 8 per cent. The standard method (BS 784: 1953) of testing chemical stonewares was also tried. According to this method the best bricks have a resistance to acid of not less than 98·5 per cent.

The acid resistance of bricks increases with the firing temperature. When fired at a temperature of 950°C, the resistance of brick made from Dhandhera soil is poor. With the exception of soil containing 35 per cent sand, bricks from other earths pass the BS test when fired at 1000°C. At this temperature they do not fulfil the ASTM requirements for acid resistance, but when they are fired at 1050°C and 1080°C they satisfy both the ASTM and BS requirements.

The acid resistance of bricks does not increase with decrease in water absorption. These findings have been confirmed by tests on samples of brick earths collected from different places in the Indo-Gangetic plains (Table 4). Bricks obtained from Moradabad soil when fired at 1050-1060°C have a water absorption of 0·5 per cent

Table 1 — Analysis of Dhandhera soil

Sample No.	Soil	Loss on ignition %	Silica insolubles %	Fe_2O_3 %	Al_2O_3 %	CaO %	MgO %
1	Raw Dhandhera soil*†	6·14	67·49	6·33	16·59	0·70	1·57
2	Fraction passing 200 mesh sieve (A)‡	7·95	60·63	7·65	19·64	0·63	1·96
3	Fraction retained on 200 mesh sieve (B)‡	1·49	85·12	2·94	8·43	0·87	0·59
4	A, 60% mixed with B, 40%†	5·37	70·41	5·77	15·16	0·73	1·41
5	A, 50% mixed with B, 50%†	4·72	72·86	5·30	14·04	0·75	1·28
6	A, 40% mixed with B, 60%†	4·07	75·32	4·82	12·91	0·77	1·14

*Particles retained on 200 mesh BS sieve, 28 per cent; passing 200 mesh BS sieve, 72 per cent.
†Calculated values.
‡Actual analysis.

Table 2 — Properties of bricks made from Dhandhera soil

Firing temperature °C	Composition of soil: Clay and silt %	Composition of soil: Sand %	Compressive strength *lb./sq. in.*	Water absorption %	Bulk density *g./cu. cm.*	Acid resistance %: BS method	Acid resistance %: ASTM method
1000	65	35	8142	4·84	2·17	98·08	89·41
	60	40	7914	6·12	2·07	98·64	89·47
	50	50	7626	8·12	2·00	98·84	89·56
	40	60	6440	9·00	1·94	99·20	90·74
1050	65	35	13705	0·62	2·35	99·08	94·12
	60	40	12828	1·14	2·32	99·40	96·18
	50	50	11030	1·52	2·28	99·44	96·35
	40	60	8751	2·83	2·20	99·44	96·33
1080	65	35	17148	0·23	2·36	99·40	95·82
	60	40	16694	0·53	2·32	99·52	96·47
	50	50	14617	1·12	2·29	99·52	96·59
	40	60	13367	1·13	2·22	99·72	96·60

Table 3 — Effect of calcium carbonate in soil on the properties of bricks

Soil No.	Composition: Soil %	Composition: $CaCO_3$ %	Firing temp. °C.	Compressive strength *lb./sq. in.*	Water absorption %	Bulk density *g./cu. cm.*	Acid resistance: BS method	Acid resistance: ASTM method
4*	99·00	1·00	1000	5316	10·68	1·91	94·40	85·06
	98·00	2·00	do	4345	15·70	1·84	94·20	83·59
5*	99·80	0·20	1050	12444	1·78	2·28	99·00	95·44
	99·70	0·30	do	11256	1·93	2·27	98·84	95·41
	99·60	0·40	do	10603	1·99	2·27	98·72	95·12
	99·50	0·50	do	10540	2·08	2·25	98·60	95·00
	99·00	1·00	do	10092	2·20	2·24	98·00	91·94
	99·00	2·00	do	8977	2·35	2·20	96·48	87·20
6*	99·00	1·00	1080	8959	0·39	2·32	99·36	94·71
	98·00	2·00	do	8497	2·17	2·24	98·60	95·35

*These refer to soil sample Nos. 4, 5 and 6 in Table 1.

Table 4 — Properties of bricks made from soils of Indo-Gangetic plains

	Bijnore	Morada-bad	Bareilly	Patna	Chapra	Hardoi	Monghyr	Burdwan
Composition of soil (%)								
Clay	30·3	42·8	23·6	25·1	21·4	20·6	30·2	20·1
Silt	39·8	33·3	21·1	29·1	26·2	22·2	36·3	16·8
Sand	29·9	23·9	55·7	45·8	52·4	57·2	34·5	62·1
Calcium carbonate, %	0·20	0·56	0·13	1·98	2·23	0·15	6·08	0·06
Compressive strength (lb./sq. in.)								
1000°C	6733	11399	4993	3694	3342	3116	3615	2050
1060°C	8879	14230	6969	4445	7148	6069	5158	3431
1120°C	11941	652	16562	11711	9494	9391	6940	8017
Water absorption (%)								
1000°C	12·2	4·8	10·3	15·0	14·1	12·8	15·5	14·1
1060°C	3·8	0·5	7·4	13·9	9·9	9·6	15·2	10·8
1120°C	0·1	0·5	1·1	2·2	1·4	1·42	1·0	5·3
Acid resistance (%)								
BS method								
1000°C	97·84	96·96	97·60	95·28	96·60	96·87	94·60	98·16
1050°C	98·52	97·68	98·72	96·36	98·60	98·24	95·08	98·52
1080°C	98·80	98·52	99·24	99·36	99·44	99·40	99·60	99·36
A.S.T.M. method								
1000°C	90·59	87·47	88·79	83·68	85·89	87·94	82·36	90·89
1050°C	92·76	89·26	93·63	86·31	93·53	90·65	83·55	91·77
1080°C	93·94	92·44	96·62	97·65	97·85	97·65	99·56	97·50

but they were not acid-resistant. On the other hand, bricks made from Bareilly soil when fired at the same temperature have a water absorption of 7 per cent but are resistant to acid attack.

Optimum conditions

Soils containing as much as 6·33 per cent iron oxide (Fe_2O_3) and 67·49 per cent silica give acid-resistant bricks when fired at a temperature of 1050°C. As the percentage of silica increases and that of iron oxide decreases, acid resistance increases. Soils containing above 0·5 per cent calcium carbonate do not give acid-resistant bricks when fired at 1050°C. Calcareous soils must, therefore, be fired at 1080°C, in order to get acid-resistant bricks (Table 3).

It is, therefore, recommended that alluvial soils containing more than 40 per cent sand and less 0·5 per cent calcium carbonate should be preferred for the manufacture of acid-resistant bricks. The firing temperature should be so adjusted that bricks with high compressive strength and low water absorption are obtained. In any case the firing temperature should be above 1050°C.

References

1. Searles, A. B. & Grimshaw, R. W., *The Chemistry and Physics of Clays* (Ernest Benn Ltd, London), 1959, 653.
2. Clews, F. H., *Heavy Clay Technology* (British Ceramics Research Association, Stoke-on-Trent, England), 1955, 270.