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LIGHTWEIGHT AGGREGATE PRODUCTION FROM CLAYSTONE AND SHALE IN BANGLADESH

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LIGHTWEIGHT AGGREGATE PRODUCTION FROM CLAYSTONE AND SHALE IN BANGLADESH

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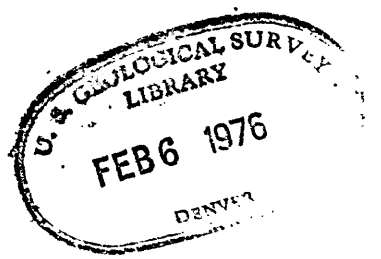

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LIGHTWEIGHT AGGREGATE PRODUCTION FROM CLAYSTONE AND SHALE IN BANGLADESH[1/]

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Muffle furnace tests were made on samples of clay, claystone, and shale collected in the Chittagong and Dacca areas of East Pakistan to determine their amenability to bloating for the commercial production of light-weight aggregate. Several areas, sampled in some detail, were selected for investigation because of their proximity to market, and accessibility to fuel and electricity.

Muffle furnace tests show that the clay, claystone, and shale are natural bloaters at temperatures in the 1700° to 2200° F. range, and do not require additives. The most desirable deposit, insofar as producing a strong aggregate is concerned, can be determined only by pilot-kiln testing and by crushing-strength tests made on concrete test cylinders. Reserves of suitable raw material are large in both the Chittagong and Dacca areas.

1/ The work for this report was done in 1968-69, prior to the separation of Pakistan and Bangladesh (formerly East Pakistan). The name has not been changed in the text.

INTRODUCTION

Purpose and scope of the report[2/]

Nations throughout the world have a rapidly increasing demand for construction materials, including materials that can be used as concrete aggregates. Such aggregates may be prepared from mixutres of sand, gravel, and crushed stone, where such natural aggregate materials are locally available, or may be formed synthetically from alternate raw materials. As building design and construction have become more sophisticated, specifications for concrete aggregates have become more exacting, and synthetic aggregate have been used increasingly to reduce weight and to maintain specifications.

The production of synthetic light-weight aggregate is an outgrowth of work done by a chemist, Hayde, in 1917, who found that by heating certain clay, shale, or slate to incipient fusion he was able to produce an extremely light weight material of high strength and excellent insulating properties. By reason of patents held by Mr. Hayde, only seven plants were licensed under the "Haydite" patents, and the industry did not develop extensively until the expiration of basic patents in 1946. Since that time light-weight aggregate production has grown steadily in the United States and Canada, replacing the use of natural aggregates in certain kinds of construction; reasons for this are the desirable characteristics of strength and lightness of the synthetic aggregates and depletion of local natural aggregates in areas of population growth.

2/ Geographic names, Agency names, and official titles of individuals used in this report reflects usage at the time the work was done in 1968-69, prior to the separation of Pakistan and Bangladesh.

Over most of East Pakistan, the surface geologic formations are unconsolidated alluvial deposits of Quaternary age, or weakly indurated, easily crushed, fine-grained rocks of late Tertiary age. Rocks suitable for use as concrete aggregate are scarce. In such an area, where natural aggregate materials are deficient, but where clay and shale are present, the development of a light-weight aggregate industry offers a means of filling many of the demands for construction material. Much of the material now used in East Pakistan for concrete aggregate is broken brick. Most of the brick manufactured is produced in country kilns fired with wood and coal. Temperature control is not uniform and results in about a 40 percent loss of product either from underfiring or overfiring. In making brick by this method the hand-dug clay is mixed in a paddle-wheel type of churn turned by bullocks; the bricks are hand molded and air dried before firing. This primitive method of brick making probably has been used for hundreds of years.

Two areas near Dacca and Chittagong (fig. 1), were investigated to locate deposits of clay and shale that are amenable to bloating for the production of light-weight aggregate. The work was done as part of a program undertaken cooperatively by the Geological Survey of Pakistan (GSP) and the U. S. Geological Survey (USGS) under the auspices of the Government of Pakistan (GOP) and the Agency for International Development (AID), U. S. Department of State. Factors considered in the study included the location of the deposit in respect to market, transportation, gas or other fuel sources, and the present land use.

Location of study areas

The Chittagong area and adjoining Hill Tracts are between lat $22^{\circ}17'30''$ N. and $22^{\circ}31'20''$ N. and long $91^{\circ}43'$ E. and $92^{\circ}15'$ E. The localities drilled and sampled are within a 30-mile radius of the city of Chittagong and are easily accessible along good roads.

Situated near the mouth of the Karnaphuli River, Chittagong (population 364,205, 1961 census) is a busy international seaport and is the second largest city of East Pakistan. It is connected by rail, road, and air with Dacca and is a growing industrial and manufacturing area.

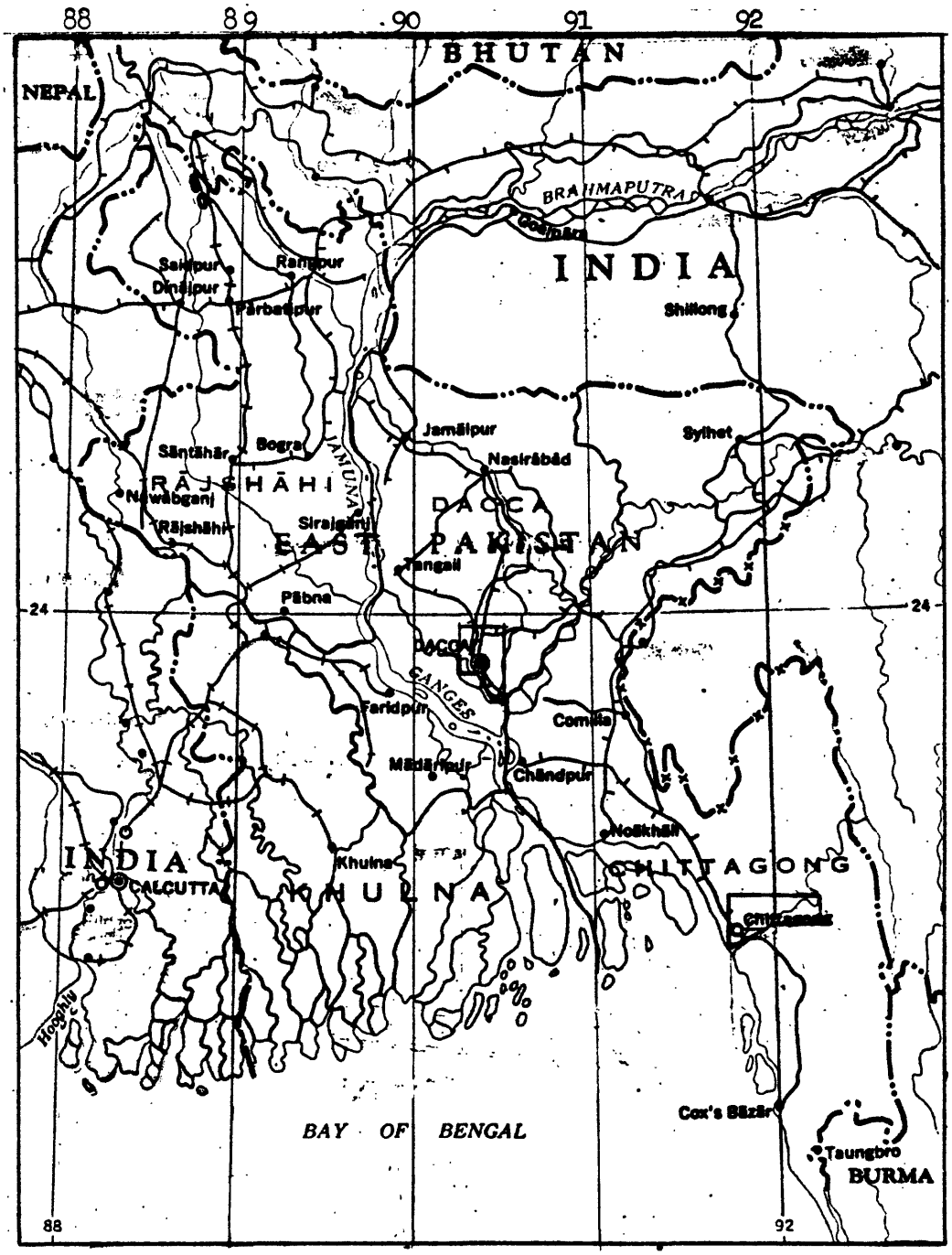

Figure 1. Index map of East Pakistan, showing location of areas studied.

The Kaptai and Chandraghona areas (fig. 2) are under the jurisdiction of Chandraghona Police Station in Chittagong Hill Tracts Districts. Kaptai, on the Karnaphuli River northeast of Chittagong, is the site of the principal hydroelectric project of East Pakistan; it generates 80,000 kw/day for industry. A high-voltage transmission line has been built from Kaptai to Dacca via Chittagong and Comilla. Kaptai and Chandraghona are also linked with Chittagong by an excellent road and by a navigable river. They are 35 and 25 miles to the east of Chittagong, respectively, on the Kaptai road. Regular bus and launch service are maintained between Chittagong and Kaptai.

The Rangunia, Warapara, Nasirabad, Bhatiari, and Ghoramara areas are in Chittagong District. Rangunia and Warapara are on the Chittagong-Kaptai road and are about 21 and 10 miles to the east of Chittagong respectively, whereas Bhatiari and Ghoramara are on the Dacca-Chittagong Trunk Road and are about 10 and 14 miles northwest of Chittagong. The Nasirabad area is about 5 miles to the northwest of Chittagong and is served by good roads.

The area investigated at Dacca is between lat 23°37'5" N. and 23°55' N. and long 90°15' E. and 90°30' E. It is bounded on the north by the 23°55' parallel, by Burhi Ganga River on the south, the Balu River on the east and the Dhaleswari River to the west. The drilled and sampled localities are Panchabati, Aliganj, Philkuni, Demra, Mirpur, Sabhar, and Tungi. The towns of Mirpur and Sabhar are on a concrete-surfaced road and are approximately 7 and 25 miles northwest of Dacca respectively; Tungi is about 20 miles north of Dacca on a pitch-surfaced road. The Panchabati, Philkuni, and Demra areas are herein referred to as Areas A, B, and C, respectively.

The Panchabati, Aliganj, and Philkuni areas fall under the administrative jurisdiction of Fatulla Police Station in Narayanganj subdivision, whereas the Demra area is under the Tejgaon Police Station.

These areas are easily accessible by rail and roads. The Panchabati and Aliganj areas are about 9 and 5 miles southeast of Dacca and lie to the east and northeast respectively of the Dacca-Narayanganj pitch-surfaced road. The Philkuni area is about one-half mile north of Aliganj and is about 1½ miles northeast of the Fatulla Railway Station. The railway line borders the northern side of the Panchabati area and the southern side of the Philkuni area.

The western and eastern limits of the Demra area along the Dacca-Demra pitch-surfaced road are about 2 and 5 miles east of Dacca. A high voltage powerline running northwest and southeast cuts through this area. Regular bus service is maintained on the Dacca-Narayanganj and Dacca-Demra roads.

Geography

Climate

The climate is tropical throughout most of the year and is characterized by high temperatures, heavy rainfall, and excessive humidity. The maximum mean temperature is 70° F. at Dacca and 78° at Chittagong in January and is 92° F. in April at Dacca and 89° at Chittagong in May. The minimum mean temperature is about 54° F. in January and 74° F. in July and August.

The nor'westers and monsoons are the chief sources of rainfall. The nor'westers usually begin in January and continue until March, and are frequently characterized by thunder and hailstorms of relatively short duration. The season of nor'westers generally merges into the monsoon, the major rainy season, with no definite break. The monsoon begins in May and continues into October. The average annual rainfall is about 74 inches at Dacca and 102 inches at Chittagong. The dry winter and spring seasons are from November through March-April.

Topography

Chittagong area.--The Chittagong area is characterized by low hills that form the southern extension of the north-trending Sitakund Range. The maximum height of these hillocks is 420 feet near the point of rise of Sonai Creek. Other hills reach a maximum elevation of 265 feet between Pahartali and Rangunia. The topography is deeply dissected near Pomara, and small sinuous valleys and isolated hillocks are common.

Parallel hills on the Sitapahar Range extending approximately north-northwest and south-southeast lie between Chandraghona and Kaptai. The maximum height of the Sitapahar Range is 1135 feet south of the Karnaphuli River near Silchari. The area west of Chittagong is a plain that slopes gently westward to the sea coast, gradually narrowing in width to the south.

Dacca area.--The Dacca area is characterized by low hills in the vicinity of Sabhar, Mirpur, and Tungi. The low scattered hills rise 20 to 60 feet above sea level, and have a gentle regional slope to the south. To the south the area is mainly a plain. The Demra area is slightly higher in altitude than the Panchabati and the Philkuni areas, Panchabati lying about 16 feet above sea level. The Panchabati, Philkuni, and Demra areas gradually slope toward the south and southwest. A small depression (locally called "bil") of about 3 square miles is present west of the Dacca-Cantonment Railway Station. Another small depression of about one square mile is near the village Begunbari.

Drainage and water supply

Chittagong area.--The Karnaphuli and the Halda are the two principal rivers of the area. The famous man-made Kaptai Reservoir covering 265 square miles was formed by damming the turbulent Karnaphuli River at Kaptai where the river cuts across a series of northwest-trending hills. The Halda River empties into the Karnaphuli near Kaught.

The drainage in Chittagong and its suburbs is dendritic and the streams flow either eastward and drain into the Halda or toward the southwest into the Bay of Bengal. Sonai Creek and the Mitha Khal are the most important streamlets. A small water reservoir used by the Pakistan Eastern Railway is northwest of the wireless station of Chittagong.

An abundant supply of water is available in the streams. However, this supply is reduced during the fall and winter dry season in the hilly areas where streams are the only source of water. The water from ponds, wells and handpumped tubewells is a major source of supply in the plain area. Chittagong has a purified water supply and a distribution system. Most water used elsewhere is untreated.

The Karnaphuli Valley lies in one of the country's heaviest rainfall zones and was subject to floods before the construction of the Kaptai dam. The Halda River has become sluggish owing to silting and is prone to flooding. The Karnaphuli dam has greatly reduced the havoc of annual floods in the Chittagong area.

The Chittagong area is often visited by the tidal bore [3/] which causes great damage to life and property, but a coastal embankment plan under construction will provide protection from it.

3/ The term tidal bore as used here refers to a high wave and tide build-up caused by storms piling water on the windward side of land.

Dacca area.--The Burhi Ganga, Balu, Dhaleswari, and Turag are the main rivers in the area. The East Pakistan Water and Power Development Authority (WAPDA) has constructed a number of canals in the Panchabati and Demra areas for irrigating during the winter, and for flood control during the monsoon season. Rivers, canals, and ponds are widely used as a source of drinking water in the rural areas. Many villages also have drilled wells.

The Sabhar, Mirpur, and Tungi areas are above flood level throughout the year. The Panchabati, Philkuni, and Demra areas, being low, are flooded during the wet season. The Burhi Ganga, Turag, and Balu Rivers are silting up rapidly, which greatly reduces their water-carrying capacity, and they are subject to frequent flooding. The flooding in the vicinity of Panchabati and Demra is partially controlled by recent canal construction.

Vegetation and cultivation

The Chittagong area is covered by thick forest and dense undergrowth, and is in the southern extension of the Sitakund Reserve Forest. The western side is an open deciduous forest, and the eastern part is a mixed evergreen type. The important commercial trees of the area are chapalish (Artocarpus chaplasha) and teak (Tectona grandis).

These forests include evergreen forests and also some tropical moist deciduous and open deciduous forests, along with bamboo brakes and patches of savanhah (Rashid, 1955). The predominant trees are kadam (Kadamba officinale), shimul (Shalmalia Malabarica), champa (Michalia champaca), and chikrasi (Chakrassia tabularis). The ground is covered in places by khagra (Saccharumes spontaneum) grasses. Bamboo brakes are common where the forest has been cleaned by cutting or burning. Teak plantations are located near Kaptai, Chandraghona, Rangunia, and Pomara areas.

Rice is the principal crop of the area. Fruits such as pineapple, banana, and papaw, and various types of vegetables, are grown. Betelnut is grown mainly in the narrow valleys and on the plain near the river; cocoanuts are grown along the coast.

The Dacca area also supports luxuriant vegetation. The mango, jax (artocarpus integrifolia), jam (eugemia jambalana), banana, and the betel-nut palm are the common trees. A small tract of forest is present in the Sabhar and Mirpur areas, and the sal (shorea yobusta) is the most economically important tree for timber.

Previous investigations

A number of clay deposits in East Pakistan have been described that emphasize their possible utilization for ceramic products (Khan, 1962; Roy, 1960). Impurities in ceramic clays are undesirable; however, the presence of certain impurities are necessary to cause clays to bloat, and consequently our investigations were of a different nature than those described by Khan and Roy.

Some investigations of clays and shales amenable to bloating were made in the Chittagong area by Chew (Chew-Walker Associates, written commun., 1965). An economic feasibility and plant cost study was also prepared by Louis Berger Inc. (1966) on the manufacture of synthetic aggregates in East Pakistan. The samples collected by Berger were all in the vicinity of Dacca, and plant cost projections were for a completely mechanized plant.

Present investigations

Reconnaissance surveys were made in the Dacca area in late 1967, followed by more extensive work in the Chittagong area during April and December 1968. Base maps were prepared from existing topographic maps and aerial photographs issued by the Survey of Pakistan. Reconnaissance test holes were located in strategic places along the highways, railways, and power lines, in part on the basis of unpublished information and maps by Chew covering areas in which bloating clays have been found. Another and more significant guide was the presence of operating brick kilns, particularly those where fragments of "Jhama" (accidentally bloated clays) were observed. Stratigraphic nomenclature used herein is taken from the geologic map of Pakistan (Bakr and Jackson, 1964) and from Holland and others (1956).

Following furnace testing of the reconnaissance samples, detailed surveys were made in selected areas to collect samples for quick-firing tests. Samples from auger holes and pits were prepared for quick-firing tests by thorough crushing in an iron pan. After quartering, each sample was placed in an aluminum pan and water added to develop the required plasticity. The plastic clay was then run through a manually driven meat grinder and extruded sufficiently for pelletizing. Approximately 50 small balls and 50 cylindrical pellets were formed by hand from the plastic material from each sample and allowed to air dry for 2 or 3 days.

The outcrop samples were broken into fragments between 1 and 1½ inches in diameter and about 0.2 to 1 inch in thickness. At least 32 pieces were selected for firing from each sample. The balls, the pellets, and the rock fragments were placed in an electric furnace at 200° C. (417° F.) for complete drying before firing. This was necessary to prevent decrepitation when fired at high temperatures.

The term "bloating clays" as used throughout this report refers to the ability of some clay, shale, and slate to produce vesicular structure when they are heated to sufficiently high temperatures for chemical reaction to form gases that expand the material. The size of the vesicles may range from very fine, even microscopic, to a quarter of an inch or larger. Material that contains predominantly large vesicles and is very light in weight is usually termed overbloated; it is structurally weak, owing to the large openings and thin walls. No precise standards have been established as to what material is considered overbloated, and perhaps the best measure would be a balance between the size of the openings, strength of the material, and its intended use.

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METHODS OF LIGHT-WEIGHT AGGREGATE PRODUCTION

Although several materials may be used to make synthetic light-weight aggregates and find markets in industry and construction, those produced from clay, shale, or slate have shown the greatest potential in the construction field; these materials yield a strong concrete aggregate that can be used where other light-weight materials of limited strength are not suitable.

Clays, shales, and slates are chemically similar. When heated to temperatures of 1,600° to 2,400° Farenheit, the usual range of commercial operations, certain of these materials bloat to form a plastic mass that is full of gas bubbles; on cooling, these form a light-weight and strong vesicular material. Clays that will not bloat naturally may commonly be modified by blending with other clays that have strong bloating characteristics, or by addition of small amounts of lime. Chemical analysis is not truly indicative of amenability to bloating but, in general, good bloating clays have 6 percent or more of iron oxides and approximately 6 percent of alkalies and/or alkaline earths (oxides of Ca and Mg). If the alkalies exceed about 6 percent, processing problems arise because the material has a tendency to stick and ball up in the kiln. The amount of iron is not critical, although if present as pyrite (iron sulfide), it appears to be more easily converted to a usable form than if present as hematite (iron oxide). Some free silica is also necessary; this is usually present in clay deposits as disseminated quartz sand grains.

During heating, chemical reactions produce SO_2, H_2O, and CO_2; these gases expand the material to produce the vesicular structure. Although carbon is believed by many to be the bloating agent, many clays containing little carbon have excellent bloating characteristics, whereas others high in carbon will not bloat. The evaluation of the bloating characteristics of a clay, shale, or slate is largely based on heating tests and experimentation rather than on chemical analysis. Thus, it is apparent that bloating in clays requires the presence of a certain amount of impurity, and does not require the pure beneficiated clays we normally associate with ceramic materials. In turn, such impure clay deposits are widespread, and the possibilities of locating suitable deposits are generally very good. Raw clay is normally obtained by strip mining, the equipment used being dependent on the type and location of the deposit. Bulldozers, shovels, pans, and end loaders are commonly employed; Sauerman-type drag scrapers commonly are used if the deposit lies under water. Characteristically, for any aggrégate, the marketing radius of a particular plant is limited by transportation costs. In general, in areas of good transportation with well developed facilities, the range is limited to about 150-200 miles. When determining the economic feasibility of a clay deposit, its proximity to transportation and fuel supply are important. Although kilns may be fired with gas, oil, or powdered coal, coal or oil require additional storage and handling facilities.

Two types of equipment are used for bloating, the rotary kiln, and sintering grates.

Rotary kiln.--Normally the rotary kiln is the same type as used in cement making, though of smaller size, generally ranging from approximately 50 feet to 175 feet in length. The raw material is fed from the high end. The fuel, which may be gas, fuel oil, or powdered coal, is burned with a controlled long flame throughout the length of the kiln, the flame traveling counter to the flow of material. Temperatures range from about 1,600° to 2,400° F. Fuel cost obviously is a limiting economic factor. Materials that will bloat at a minimum temperature and still produce a strong aggregate are most desirable, because lower temperatures require less fuel. The shorter the kiln retention time, the lower the cost and the greater the production; in general the retention time required in the kiln is about 45 minutes.

The majority of synthetic-aggregate producers use rotary kilns, because generally they are more trouble free and produce a higher-quality, more uniform material than sintering grates. For feed for rotary kilns, shale and slate are crushed to 1½ to 2 inches in size; feed may be in the form of pellets, chunks, or lumps. Heated, expanded material from the kiln is poured into a storage pit that may be partly filled with water, where cooling takes place, or into cooling tubes, which are mounted on the discharge as an integral part of the kiln; the cooled material is then crushed and sized for market. Kilns are operated on a 24-hour-a-day, 7-days-a-week schedule, owing to the length of time required for start up and shut down.

Sintering grates.--The sintering method is not dependent on bloating or expanding of the raw material, though these may take place. Rapid heating at sufficient intensity causes individual particles to agglomerate into a coherent, homogeneous, and porous material. Briefly, feed for the sintering process is prepared by crushing shale and slate to ¼ mesh and finer, and mixing with 5 to 10 percent of coal or coke. If clay is used, it must be moist and mixed with fuel. This feed is spread mechanically on a moving grate in a layer 6 to 10 inches thick. The sintering furnace consists of a continuous traveling grate approximately 5 feet wide and 50 feet or more in length. The grate charged with raw materials moves under a fire box where the fuel, mixed with the clay or shale, is ignited; combustion is continued the length of the grate; wind boxes supply forced draft. Sintered material drops off the end of the grate in chunks and is cooled, crushed, and sized, as is the discharge from kilns. Advantages of the sintering process are that some raw materials that will not bloat can be sintered. Sinter grate plants also lend themselves to a start-and-stop or periodic type of operation. A disadvantage is that the high temperatures and the highly abrasive nature of the sintered material require frequent preventative maintenance of the grates; another disadvantage is that the sintered material is generally not as uniform nor as good quality as that produced from kilns.

Uses.--The uses of light-weight aggregates are as varied as those for natural aggregates: concrete of all types for buildings, floor and roof slabs, bridge decking, concrete blocks, prestressed beams, railroad ballast, and highway construction. Crushing strength of concrete made with expanded clay and shale aggregates may reach several thousand pounds per square inch, depending on proper aggregate and mix. Such strength is adequate for most uses, but not for extremely high strength concrete which must sustain multi-thousands of pounds in crushing strengths, and requires very strong, dense aggregate.

In the United States a premium price is paid for light-weight aggregates in competition with natural aggregates because of the more favorable strength-to-weight ratio and the better insulating and acoustical qualities. In the construction of multi-storied steel-framed buildings, bridge decks, etc., concrete made with sand, gravel, or crushed stone weighs 145 to 150 pounds per cubic foot compared with 50 to 90 pounds per cubic foot for expanded-aggregate concrete. This weight reduction results in reduced costs made possible by the use of less steel.

INVESTIGATIONS IN THE CHITTAGONG AREA

Geology

The areas investigated near Chittagong are underlain in part by Holocene flood plain deposits and in part by Tertiary and Pleistocene beds (see fig. 2). The banks of the Karnaphuli River and cuts along the Chittagong-Kaptai road provide excellent cross sections of the rock units. In Chittagong and its suburbs, rocks are exposed mainly along road cuts, and those along the Ghoramara-Hathazari road are the best exposed.

Rocks of the area can be divided into six formations, from top to bottom: Dihing Formation (Pliocene-Pleistocene); Dupti Tila Formation (Miocene-Pliocene); Girujan Clay (Miocene); Tipam Sandstone (early Miocene); Boka Bil (early Miocene); and Bhuban (Oligocene-Miocene) Formations (fig. 2). Formation thicknesses are given in the measured sections below. Rock divisions are based purely on lithologic characteristics, as the extreme paucity of fossils makes it impossible to determine exact ages of the formations.

Tertiary deposits

The Girujan Clay, Tipam Sandstone, Boka Bil, and Bhuban Formations are well exposed on the western limb of the Sitapahar anticline from Silchari to Chandraghona, both along the Chittagong-Kaptai road and along the Karnaphuli River. The Boka Bil and the Bhuban Formations also are exposed on the eastern limb of the anticline, but the Girujan Clay and Tipam Sandstone do not crop out there. The Boka Bil is transitional between the Bhuban and the overlying Tipan Formation. In all formations lateral variations in lithology are great between Chandraghona and Kaptai.

The Dupi Tila Formation is well exposed between Pahahtali and Rangunia along the Chittagong-Kaptai road. It also crops out in and along the Karnaphuli River, and in cuts on the Kaptai road near Chandraghona. The Dupi Tila is principally sandstone. It is easily identified in the field by its massive, thick-bedded, poorly consolidated character and its yellow to yellow-brown color. The contact between the Dupi Tila and the underlying Girujan Clay is sharp and conformable; the lower contact of the Girujan is locally unconformable.

The Dihing Formation consists of sand and clay and is present north of Chittagong.

Section from near Chandraghona village east along the Chittagong-Kaptai Road to the Sitapahar anticlinal axis. /Measured by M. A. Maroof Khan, 1969/.

Lithologic description	Thickness (in feet)
Dupi Tila Formation:	
Sandstone and minor amounts of claystone and silty shale:	
Sandstone is yellowish brown, fine to medium grained, massive, at places thick bedded, cross-bedded, very poorly consolidated; grains sub-angular to subrounded, moderately to poorly sorted; small clay galls and pellets randomly distributed; quartz and rock granules and fine to very coarse (5 to 60 mm) pebbles haphazardly distributed and also concentrated in certain sections; subrounded granules and fine to medium-size pebbles predominate; calcareous shaly pellets and partly silicified wood also observed. Pockets and lenses of shale and claystone within sandstone; very thin (1 to 4 mm) ferruginous bands along bedding planes, some surfaces strained with ferruginous material, shale layers and shale and claystone beds at some places. The rock weathers to dark brown, brown, yellowish brown, whitish yellow, and pinkish brown.	

Lithologic description	Thickness (in feet)
Dupi Tila Formation (continued):	
Near the top, the rock is very much weathered; feldspar and mica are largely removed and the rock becomes grayish white to yellowish white.....	1540
Girujan Clay:	
Silty shale is light to dark gray, laminated, jointed; whitish-gray silt particles along the bedding planes, calcareous shaly concretions elongated parallel to bedding at places; silty shale weathers to yellowish gray and silt particles weather to brown.	
Sample Ch-1 I, II, III	700
Sandstone and subordinate shale:	
Sandstone is grayish yellow, medium-grained, subrounded, clay gall pockets at places; massive to thick bedded, weathers brown.....	295
Shale is gray, thin-bedded, whitish-gray silt particles along the bedding planes; weathers bluish gray.	
Sample Ch-2 I, II, III	155
Total Girujan Clay----------	1150

Lithologic description	Thickness (in feet)
Tipam Sandstone:	
Sandstone and subordinate shale:	
Dominant sandstone at the base and at the middle, thick-bedded sandstone and shale, laminations near top. About 12 foot-thick bed of broken shale pieces, clay galls, and pellets are interbedded in sand grains near the top; some of the clay galls are also broken.	
Sandstone is yellow, fine- to medium-grained subrounded, moderately to well sorted; massive, soft, crossbedded; weathers brown.	
Shale is gray, thin-bedded, weathers grayish yellow. Sample Ch-3 II .	
Unit thickness.....	375
Alternating sandstone and shale:	
Sandstone is 2 inches to 2 feet thick, regularly interbedded with shale; weathers brown.	
Shale is gray, beds range in thickness from 2 to 6 inches; weathers grayish brown (thick sandstone at the base).	
Unit thickness.....	325

Lithologic description	Thickness (in feet)
Tipam Sandstone (continued):	
Alternating shale, silty shale, and sandstone:	
Shale and silty shale is gray, laminated to thin bedded; fine light-gray silt particles between beds; beds range in thickness from 4 to 6 inches; jointed; weathers whitish gray, grayish brown and yellowish brown.	
Sandstone is light yellow to light brown, fine to medium grained; grains are subangular to subrounded; beds range in thickness from 4 inches to 1 foot. Weathers brown.	
Unit thickness.....	505
Sandstone, yellowish brown to grayish brown, massive to thick-bedded, fine- to medium-grained; grains are subangular to subrounded, moderate to well sorted; moderately hard, highly crossbedded; contains ferruginous sandy concretions, infrequent clay galls and pellets, and weathers brown.....	325
Total Tipan Sandstone----------	1530
Boka Bil Formation:	
Shale is gray, fissible, highly cleaved, weathers light yellow.....	93

Lithologic description	Thickness (in feet)
Boka Bil Formation (continued):	
Alternating silty shale and sandstone:	
Silty shale is gray, thinly bedded, silt particles at the parting of beds; weathers light brown. Sandstone is yellow, fine-grained, subangular, massive to thick bedded, weathers brown.	
Unit thickness.....	177
Silty shale, gray, laminated, fissle, highly cleaved; silt particles between laminae; weathers grayish yellow.	
Sample Ch-5 II	88
Alternating silty shale and sandstone:	
Silty shale, gray, laminated, interbedded with yellow to gray fine-grained sandstone that ranges in thickness from ¼ to ½ inch and weathers brown.....	84
Shale, dark-gray, laminated, fissle, highly cleaved; silt particles along the layers; weathers whitish gray; silty shale at the top.	
Sample Ch-6 II	116
Sandstone, yellow, fine-grained; grains subangular; massive, weathers brownish yellow.....	82

Lithologic description	Thickness (in feet)
Boka Bil Formation (continued):	
Shale, gray, laminated, fissile, highly cleaved; interbedded with fine-grained yellow sandstone which ranges in thickness from ¼ to ½ inch. These alternating beds occupy a 50-foot interval above the base. Shale weathers bluish gray and light yellow.	
Sample Ch-7 I-III, 8 I-III, and 9 I-III.....	1785
Sandstone is greenish gray, fine-grained, massive ridge forming; grains subangular; moderately hard, very crossbedded; claystone pockets near the top; a few calcareous concretions and calcareous bands (1 foot thick) parallel to bedding; weathers light brown.....	144
Alternating shale, silty shale, and sandstone.....	582
Silty shale, gray, laminated, fissile; fine sand grains between the layers; weathers yellow, silt and shale in equal amounts.	
Sample Ch-10.....	730
Siltstone, shaly siltstone and sandstone.....	432
Total Boka Bil Formation----------	4313

Lithologic description	Thickness (in feet)
Bhuban Formation:	
Sandstone is greenish gray, very fine grained, medium to thick bedded, moderately hard; grains subangular; weathers light gray and whitish gray; shale beds 2 to 3 inches thick at places.....	214
Alternating siltstone and shaly siltstone, gray, thin-bedded, moderately hard; cliff forming; weathers yellowish gray and whitish gray.....	576
Shale, yellowish gray to bluish gray, thin-bedded, highly cleaved, jointed; some surfaces coated with black material; weathers light yellow and whitish gray.	
Sample Ch-12 I, II, III	540
Alternating sandstone and shale.....	86
Shale, bluish gray, bedded, minor joints along the dip direction; weathers yellowish gray.	
Sample Ch-13 I, III	215
Shale and silty shale, bluish gray, thin-bedded, brittle; fine sand grains between the layers; cleaved; moderately hard siltstone and shaly siltstone toward the bottom. Rocks weather to yellowish brown.	
Sample Ch-14	274

Lithologic description	Thickness (in feet)
Bhuban Formation (continued):	
Alternating thin-bedded sandstone, siltstone, silty shale, and claystone:	
Sandstone, yellow to grayish yellow, very fine grained; grains are subangular; thin- to medium-bedded, moderately hard, weathers brown.	
Siltstone, gray, medium-bedded, moderately hard; very fine sand grains and mica flakes between bedding planes; weathers yellowish brown to light brown.	
Silty shale, bluish gray, laminated; very fine sand grains in the beds, mica flakes between the parting of layers; weathers yellowish brown.	
Sample Ch-16	
Claystone, bluish gray; 1 to 2 inches thick; has concoidal fracture; brittle, weathers dark gray.	
Unit thickness.....	52
Total Bhuban Formation----------	1957

Section from the Toll Gate, Kaptai, west along the Kaptai-Chittagong anticlinal axis. /Measured by M. A. Maroof Khan, 1969/.

Lithologic description	Thickness (in feet)
Girujan Clay:	
Shale, silty shale, and claystone with calcareous bands: Shale and silty shale: Light gray, thin- to thick-bedded; light gray fine sand grains along the bedding planes which weather brown; calcareous bands 1 to 4 inches thick occur at places and weather to light brown; in some places, shale becomes calcareous in the same horizon. The shale weathers yellowish gray. The calcareous bands stand out prominently where weathered.	
Samples K-1 to K-8.....	430
Alternating siltstone and sandstone:	
Siltstone, light gray, thin-bedded, ranges in thickness from ½ to 1½ inches, weathers brown.	
Sandstone, yellow, fine-grained, poorly consolidated, weathers brown. Grains subangular.	
Unit thickness.....	690
Total Girujan Clay----------	1120
Tipam Sandstone:	
Sandstone, gray to greenish gray, massive, hard, fine-grained; grains are subangular; crossbedded, forms cliffs; occasional ferruginous concretions parallel to bedding; weathers yellowish brown.....	1550

Lithologic description	Thickness (in feet)
Boka Bil Formation:	
Silty shale, gray, thin-bedded, highly cleaved; silt particles between the beds, a few calcareous bands of about 2½ inches thick parallel to bedding; claystone horizon about 28 feet thick at the base. The silty shale weathers yellowish gray.	
Sample K-10 Ia, Ib, II, III	399
Sandstone, gray, fine-grained, massive, crossbedded; grains subangular; weathers yellow to yellowish brown; composed of quartz, feldspar, mica, and black and green accessory minerals.....	60
Claystone, gray, bedded; has concoidal fracture; contains calcareous concretions; weathers whitish gray.....	12
Sandstone, gray, fine-grained, crossbedded, weathers yellow to yellowish brown, composed of subangular grains of quartz, feldspar, mica, and black and green accessory minerals.....	6
Shale, gray, thin- to medium-bedded; some claystone balls ellipsoidal in shape, with axis parallel to bedding; silt particles between the laminae; weathers whitish gray.	
Sample K-11 II	70

Lithologic description	Thickness (in feet)
Boka Bil Formation (continued):	
Sandstone, light gray, massive, fine-grained; grains are subangular, crossbedded; weathers brown.....	200
Shale and claystone, gray, laminated, highly cleaved, jointed; weathers whitish gray and grayish yellow. Sample K-12; K-13 I, II, III.....	202
Sandstone, shale and claystone:	
Sandstone, yellow, fine-grained, massive to thick-bedded, weathers brown. Interbedded with shale. Shale, gray, laminated, weathers bluish gray. Shale and claystone, about 200 feet thick; occurs between the massive sandstone-shale and silty shale alternating units. Sample K-14 II Unit thickness.....	500
Silty shale, gray, thin-bedded, fissile, highly cleaved; weathers whitish gray and yellowish gray. Sample K-16 II, III.....	666
Sandstone and subordinate siltstone:	
Sandstone, light yellow, fine- to medium-grained; grains are subangular to subrounded; massive to thick bedded, soft; ferruginous cementing material; weathers light brown.	

Lithologic description	Thickness (in feet)
Boka Bil Formation (continued):	
Siltstone, light gray, medium-bedded, moderately hard; mica flakes along the bedding planes; weathers yellowish brown.	
Unit thickness.....	615
Shale and silty shale:	
Shale, gray, fissile, highly cleaved, brittle; some surfaces coated with black material; weathers yellow.	
Sample K-17 I, III.....	150
Alternating shale and sandstone: Thickness of shale and sandstone ranges from 6 inches to 1 foot and 1 to 3 inches respectively.....	400
Siltstone, sandstone, and subordinate silty shale and shale.....	230
Shale, silty shale and shaly siltstone alternations (silty shale at the top).....	500
Shale and silty shale:	
Shale, gray, laminated, fissile, cleaved; weathers yellowish brown.....	
Silty shale, yellowish gray, laminated, moderately hard, jointed, weathers brown.	
Sample K-18 I, III .	
Unit thickness.....	190
Total Boka Bil Formation----------	4200

Lithologic description	Thickness (in feet)
Bhuban Formation:	
Sandstone and subordinate shaly siltstone:	
Sandstone, yellow, fine-grained, medium- to thick-bedded, moderately hard; grains subangular; calcareous and ferruginous cementing material, mica flakes along bedding planes; some surfaces stained with black material, weathers yellowish brown and dark blackish brown; shaly siltstone horizon approximately in the middle of the sandstone bed...	420
Shale, silty shale and subordinate shaly siltstone:	
Shale, bluish gray, laminated, highly cleaved, brittle, well jointed, weathers gray to light brown.	
Shaly siltstone, light gray, medium-bedded, moderately hard to hard; some surfaces coated with brown ferruginous materials along the bedding planes; very fine sand grains within the layers; stands against weathering; weathers brown.	
Samples K-19, K-20, K-21, K-22, K-23, and K- 24 I, II, III.	
Unit thickness.....	1325
Total Bhuban Formation----------	1745

The alternating beds of shale, siltstone and fine- to medium-grained sandstone exhibiting crossbedding, current ripple marks, and concretions suggests that the Bhuban and Boka Bil Formations were deposited in a deltaic environment. The textural variations and the great thickness of the formations are suggestive of an unstable basin that was subsiding concurrently with sedimentation. The fissility and the fine grain size of the shale of the Bhuban Formation are indicative of relatively quiet water deposition. The highly cross laminated, massive, thick sandstone was deposited in shallow water having high current velocities.

The yellowish-brown, massive, poorly consolidated, fine- to medium-grained sandstone, together with pellets and clay galls and quartz and rock granules of the Dupi Tila Formation suggest continental fluviatile deposition in a flood-plain environment. The yellow and brown color of the sandstone seems to indicate well-drained areas in a tropical, wet climatic region that was characterized by hot summers and heavy rainfall where sediments were thoroughly oxidized and dehydrated. The light-gray sandstone generally seen at the top of the section indicates that the deposition took place in stagnant water with limited oxidation. The pink and white color of shale beds found in a few places are probably the results of localized oxidation. Clay galls, probably formed where the meandering streams undercut flood plain deposits, were deposited with the next cycle of sand deposition in flooded streams.

Holocene deposits

Holocene flood-plain alluvium covers the Warapara area. It was penetrated by all holes augered in the Rangunia and the Bhatiari areas and by auger hole N4 in the Nasirabad area. The Holocene sediments were deposited on the eroded surface of the late Tertiary sedimentary rocks. The Holocene sediments are generally gray to yellowish gray, loosely compacted, and have a moderate water content. Sediments can be separated into three beds as follows:

Upper bed: Clay and clayey silt are the main constituent of this bed; the color ranges from light gray to gray. Silt and clay are loosely compacted and contain humus; thickness ranges from 0.2 to 3 feet.

Middle bed: The middle bed is mainly clayey silt and its color ranges from yellow to brownish yellow. It is loosely compacted and contains abundant yellowish-brown ferruginous material. Thickness ranges from 1.5 to 9 feet.

Lower bed: The lower bed is mainly silty clay; in some holes it is predominantly clay. It is greenish gray to light yellow; very fine grained sand is present at the bottom of this bed in holes Bh_{11} and Bh_{13}. Thickness ranges from 1 to 8.9 feet. Small amounts of vegetable matter of blackish to peat-brown color are found in some holes. The clay is sticky and has a soapy feel.

Structure

The area mapped contains three major anticlines and two synclines. The Sitapahar anticline on the east side of the mapped area is asymmetrical; its axis trends north-northwest. The crest of the anticline is broad and the limbs are steep. The western limb has fairly uniform high dips ranging from 50° to 75°. The beds generally dip toward the southwest; on the eastern flank they dip northeast. Near Kaptai Toll Gate the beds dip from 4° to 12°, near Prankhiang Creek they dip 70°, whereas from Jamai Creek to Silchari, the dip ranges from 5° to 38°. The Bhuban Formation, at the center of the anticline, is the oldest formation exposed.

The axis of the asymmetrical Pomara anticline trends north-northwest. The beds generally dip from 6° to 24° northeast on the eastern flank and from 4° to 52° on the western flank. The center of the anticline is very broad, and siltstone of the Dupi Tila Formation and the Girujan Clay are exposed.

The axis of the asymmetrical Chittagong anticline strikes north-northwest and plunges southward. The dips on the eastern and western limbs range from 4° to 53° and from 10° to 64° respectively. Near the axis the dip ranges from 4° to 9° southeast. The Bhuban Formation is exposed in the center of the anticline.

Between the Chittagong and the Pomara anticlines is the broad Halda syncline in which the Halda River flows. The rocks near the synclinal axis are completely concealed by Holocene alluvium. The Rangunia syncline lies between the Sitapahar and the Pomara anticlines. On the west limb the beds dip about 4^{o} west, whereas near Rangunia dips are from 12^{o} to 24^{o} northeast. The center of the syncline is composed of claystone and sandstone of the Dupi Tila Formation, but between Rangunia and Chandraghona the synclinal axis is concealed by alluvium.

Three faults cut the Sitapahar anticline; two are near the Karnaphuli Toll Gate and one is on the western flank in the vicinity of Chandraghona.

A major fault on the west flank of the Chittagong anticline strikes approximately north, and the downthrown side is on the west. Several minor faults are roughly parallel to the major fault near Ghoramara. The southwest flank of the Chittagong anticline is cut by numerous minor faults that trend at approximately right angles to the dip of the beds.

Field and laboratory procedures

A reconnaissance survey was made on April 19, 1968, and from December 15 to 29, 1968, to locate clay and shale deposits. Reconnaissance samples were taken along the highways, railway lines, and power lines within a radius of 35 miles of Chittagong (fig. 2), and also from outcrops exposed along the Chittagong-Kaptai road. Selection of the rocks samples was made on the basis of information by Chew (written commun., 1965).

During the reconnaissance work three auger holes were drilled and one pit was dug in the Rangunia area; another pit was dug in the Warapara area, and one also in the Bhatiari area. The depth of the auger holes ranged from 8 to 12 feet and the pits from 7 to 14.5 feet. Seven samples from outcrops were collected from the Kaptai area and 8 from the Chandraghona area. Reconnaissance samples were tested in an oil-fired muffle furnace to determine amenability to bloating.

On completion of the reconnaissance studies, the five most favorable areas, Kaptai, Chandraghona, Rangunia, Warapara, and Bhatiari, were selected for detailed sampling. The Nasirabad and Ghoramara areas were sampled after the completion of the geologic mapping of the Chittagong anticline revealed the lithologic similarity of formations there to those of the Sitapahar anticline.

The holes in the Rangunia area were spaced from 240 to 4,640 feet apart. The minimum and maximum spacing between adjacent holes in the Warapara and the Bhatiari areas is 2,200 to 2,800 feet and 1,000 to 1,400 feet, respectively. Seven auger holes were drilled in the Rangunia area, five in the Warapara area, and six in the Bhatiari area. In addition three pits were dug in the Rangunia area, one in the Warapara area, one in the Nasirabad area, and one in the Bhatiari area. The depth of auger holes ranges from 8 to 12 feet in the Rangunia area, 10 to 16 feet in the Warapara area, and 7 to 14 feet in the Bhatiari area. Thirty-four samples were taken from outcrops in the Kaptai area, 25 from the Chandraghona area, 10 from the Rangunia area, 6 from the Nasirabad area, 6 from the Bhatiari area, and 8 from the Ghoramara area. Logs of all the auger holes and pits and descriptions of outcrops are given in table 1.

Sampling method

Samples were collected from the claystone, shale, and silty shale beds of appreciable thickness in the formations exposed along the road and the creeks. Samples were collected in cloth bags 9 inches by 12 inches and were approximately of 5 pounds in weight. At least one sample was taken from the top, middle, and bottom of the same rock unit; additional samples were taken where any change in lithology occurred. An individual unit, if thin and of uniform composition, was sampled from the middle; if it were comparatively thick, two samples were taken, from the top and from the bottom.

As it is desirable in commercial operations to mine the entire deposit with a minimum of selective spoiling of any layer, only a composite sample was taken from all the auger holes and pits; this composite, which was tested, represents the entire section. The authors recognize that the blend used in these composite samples (equal amounts of sediment from each layer) may not be the optimum mix to produce the strongest bloated material, but such an optimum mix can be determined only by use of a pilot kiln to produce enough aggregate for making concrete test cylinders.

Numbering of samples

The sample numbering system is tied to the geographic area; the letter K designates the Kaptai area and the letter R indicates that the auger holes, pits, and outcrops were within the vicinity of Rangunia (see table 1 for other designations). Auger holes or pits are designated by the area letter and a subscript (R_1); if followed by the number 3 (R_1-3), the sample is a composite for the entire section of that hole or pit. Outcrop samples are designated by area letter plus a number, for example K-10. The number K-10 followed by I, II, or III indicates the position of the sample within a rock unit, as top, middle, and bottom respectively. If two samples were taken from the same unit because of a lithologic difference, they are differentiated by a or b.

Table 1.--Description of samples tested, Chittagong and Chittagong Hill Tracts.

Sample number	Depth of sample for pit and auger holes[1/] (in feet)	Description
	Kaptai area	
K- 1	0	Silty shale: light gray, thin bedded.
K- 2	0	Claystone: light gray, thick bedded
K- 3	0	Silty shale: light gray, thin bedded.
K- 4	0	Silty shale: light gray, thin bedded.
K- 5	0	Shale: light gray, thin to thick bedded.
K- 6	0	Shale and claystone: light gray, thick to medium bedded.
K- 7	0	Silty shale: light gray, thin bedded.
K- 8	0	Shale: light gray, thin to medium bedded.
K- 9	0	Shale: light gray, laminated.

Table 1. Description of samples tested, Chittagong and Chittagong Hill Tracts (continued)

Sample number	Depth of sample for pit and auger holes[1/] (in feet)	Description
	Kaptai area (cont'd)	
K-10 Ia, Ib, II, III	0	Silty shale: gray laminated. Claystone: gray.
K-11 II	0	Shale: gray, thin to medium bedded.
K-12	0	Shale: light gray, thin to medium bedded.
K-13 I, II, III	0	Shale and claystone: gray, laminated.
K-14 II	0	Claystone: gray.
K-16 II, III	0	Silty shale: gray laminated, fissle.
K-17 I, III	0	Shale: gray, fissle. Silty shale: gray, laminated.
K-18 I, III	0	Shale and silty shale: gray, laminated.
K-19	0	Shale: bluish gray, brittle.
K-20	0	Silty shale: gray, laminated.
K-21	0	Shale: bluish gray, thin to medium bedded.
K-22	0	Shale: bluish gray, thin bedded.

Table 1. Description of samples tested, Chittagong and Chittagong Hill Tracts (continued)

Sample number	Depth of sample for pit and auger holes[1/] (in feet)	Description
	Kaptai area (cont'd)	
K-23	0	Shaly siltstone and shale: gray, medium bedded.
K-24 I II III	0	Shale, silty shale and shaly siltstone: gray, thin to medium bedded.
	Chandraghona area	
CH-1 I II III	0	Silty shale: light gray to bluish gray, laminated.
CH-2 I II III	0	Shale: gray, laminated.
CH-3 II	0	Shale: gray, thin bedded.
CH-5 II	0	Silty shale: gray, thin bedded.
CH-6 II	0	Silty shale: gray, thin bedded.
CH-7	0	Shale: gray to bluish gray, thin bedded.
CH-8	0	Shale: gray, laminated, fissile.

Table 1. Description of samples tested, Chittagong and Chittagong Hill Tracts (continued)

Sample number	Depth of sample for pit and auger holes[1/] (in feet)	Description
	Chandraghona area (cont'd)	
CH- 9 I, II, III	0	Shale: gray to yellowish gray, laminated.
CH-10	0	Shale: blackish gray, to bluish gray, laminated.
CH-12 I, II, III	0	Shale: yellowish gray to bluish gray, thin bedded.
CH-13 I, III	0	Shale: bluish gray
CH-14	0	Shale: gray, laminated, fissile.
CH-16	0	Silty shale: gray, thin bedded.
	Rangunia area	
R_1-3	P, 0.0 - 6.0	Silty clay: light gray.
R_2-3	A, 0.0 - 8.0	Silty clay: light yellowish gray.
R_3-3	A, 0.0 - 7.3	Silty clay: yellowish gray.
R_4-3	A, 0.0 - 0.5	Clay: gray.
	0.5 - 7.0	Silty clay: yellowish gray.
	7.0 - 12.0	Silty clay: gray.

Table 1. Description of samples tested, Chittagong and Chittagong Hill Tracts (continued)

Sample number	Depth of sample for pit and auger holes[1/] (in feet)	Description
	Rangunia area (cont'd)	
R_5 - 3	A, 0.0 - 8.5	Silty clay: whitish yellowish.
	8.5 - 12.0	Silty clay: dark gray.
R_6 - 3	A, 0.0 - 0.5	Silty clay: yellowish gray to gray.
	0.5 - 6.5	Silty clay: yellowish gray.
	6.5 - 10.0	Silty clay: gray
R_7 - 3	A, 0.0 - 7.3	Silty clay: grayish yellow.
	7.3 - 12.5	Silty clay: yellowish gray.
R_8 - 3	P, 0.0 - 8.0	Silty clay: whitish yellow.
	8.0 - 12.5	Silty clay: dark gray.
R-10 II	0	Shale and silty shale: gray, thin bedded.
III		Claystone: light gray to gray.
R-12	0	Silty shale and claystone: light gray to gray.
R_{13}-3	A, 0.0 - 0.2	Silty clay: yellowish gray.
	0.2 - 5.0	Silty clay: yellow.
	5.0 - 8.0	Silty clay: gray, sticky.
R_{14}-3	P, 0.0 - 7.0	Silty clay: yellowish gray.

Table 1. Description of samples tested, Chittagong and Chittagong Hill Tracts (continued)

Sample number	Depth of sample for pit and auger holes[1/] (in feet)	Description
	Rangunia area (cont'd)	
R-15 II	0	Shale and claystone: gray, laminated.
R-16	0	Silty shale: gray, laminated.
R-17	0	Silty shale: yellowish gray.
R-19 II	0	Silty shale: light gray, thin bedded.
	Warapara area	
W_1-3	A, 0.0 - 8.0	Silty clay: light yellow.
	8.0 - 15.0	Silty clay: gray to blackish gray.
W_2-3	P, 0.0 - 9.0	Silty clay: light yellow.
	9.0 - 14.5	Silty clay: dark gray.
W_3-3	A, 0.0 - 9.0	Silty clay: light yellow to grayish yellow.
	9.0 - 16.0	Silty clay: gray to greenish gray.
W_4-3	A, 0.0 - 8.5	Silty clay: light yellow.
	8.5 - 15.5	Silty clay: gray to greenish gray.
W_5-3	A, 0.0 - 0.5	Silty clay: gray.
	0.5 - 7.5	Silty clay: yellowish gray.
	7.5 - 10.0	Silty clay: greenish gray.

Table 1. Description of samples tested, Chittagong and Chittagong Hill Tracts (continued)

Sample number	Depth of sample for pit and auger holes[1/] (in feet)	Description
	Nasirabad area	
N - 1	0	Silty claystone: light gray.
N - 2 Ia	0	Claystone: gray, bedded.
Ib	0	Silty shale: gray, thin bedded.
N - 3	0	Silty claystone: light gray.
N_4 - 3	P, 0.0 - 8.0	Silty clay: light yellow.
N - 5	0	Silty claystone: light gray, thin bedded.
N - 6	0	Claystone: light gray, medium bedded.
	Bhatiari area	
Bh- 1	0	Shale and claystone: gray to blackish gray, thin to medium bedded.
Bh- 2	0	Shale: gray, fissile.
Bh- 3	0	Shale: gray, fissile.
Bh- 4	0	Shale: gray, laminated.
Bh- 5	0	Claystone and shale: gray, thin bedded.
Bh- 6	0	Claystone: light gray, bedded.

Table 1. Description of samples tested, Chittagong and Chittagong Hill Tracts (continued)

Sample number	Depth of sample for pit and auger holes[1/] (in feet)	Description
	Bhatiari area (cont'd)	
Bh $_{7}$- 3	A, 0.0 - 1.5	Silty clay: light gray.
	1.5 - 3.0	Silty clay: yellowish gray.
	3.0 - 8.0	Silty clay: gray to bluish gray.
	8.0 - 14.0	Clay: bluish gray, sticky.
Bh $_{8}$- 3	A, 0.0 - 3.0	Silty clay: yellowish gray.
	3.0 - 6.0	Silty clay: brownish gray.
	6.0 - 14.0	Silty clay: bluish gray, sticky.
Bh $_{9}$- 3	A, 0.0 - 1.2	Clay silt: grayish yellow.
	1.2 - 3.5	Silty sand: yellow, very fine grained.
	3.5 - 5.0	Silty clay: brownish gray.
	5.0 - 13.0	Clay: bluish gray, sticky.
Bh$_{10}$- 3	A, 0.0 - 1.2	Silty clay: grayish yellow.
	1.2 - 4.1	Silty sand: yellow, very fine grained.
	4.0 - 13.0	Clay: bluish gray, sticky.
Bh$_{11}$- 3	P, 0.0 - 6.0	Silty clay: whitish yellow.
	6.0 - 6.5	Sand: yellow, fine grained.
	6.5 - 7.0	Sand: gray, fine grained.

Table 1. Description of samples tested, Chittagong and Chittagong Hill Tracts (continued)

Sample number	Depth of sample for pit and auger holes[1/] (in feet)	Description
	Bhatiari area (cont'd)	
Bh_{12} - 3	A, 0.0 - 2.5	Clay silt: yellow.
	2.5 - 5.0	Silty clay: brownish yellow.
	5.0 - 11.0	Silty clay: bluish gray.
Bh_{13} - 3	A, 0.0 - 3.0	Silty clay: light yellow.
	3.0 - 6.0	Silty clay: yellowish gray.
	6.0 - 7.0	Sand: light yellow, very fine grained.
	Ghoramara area	
G - 1	0	Silty shale: light gray, bedded.
G - 2	0	Silty shale: light gray, thin bedded.
G - 3	0	Shale and claystone: light gray, thin to medium bedded.
G - 4	0	Shale: gray, laminated.
G - 5	0	Shale: gray, fissile.
G - 6	0	Shale and claystone: light gray, thin to medium bedded.
G - 7	0	Shale: light gray, thin bedded.
G - 8	0	Shale: gray, laminated.

1/ P, pit; A, auger hole sample

Quick-firing tests

A total of 998 individual muffle furnace tests were made, the results of which are compiled in table 2. Quick-firing tests following procedures outlined by Hamlin and Templin (1962), and those of South West Research Institute, San Antonio, Texas, (written commun., 1957) were used. Two dried balls and two cylinderical pellets were placed in fireclay crucibles in an oil-fired muffle furnace. For the outcrop sample 8 pieces of rock fragments were placed in the furnace at a time. The periods of exposure for each sample were 15, 20, 25, and 30 minutes at temperatures ranging from 1700° to 2200° F. When a particular sample began to overbloat and fuse together or to the crucible, no further tests were run. After cooling, samples were broken and examined with a hand lens to determine the degree of bloating for each of the temperatures to which they had been exposed (see quick firing tests, p. 58). Fired samples from the Nasirabad and Ghoramara areas are shown in figures 3 and 4.

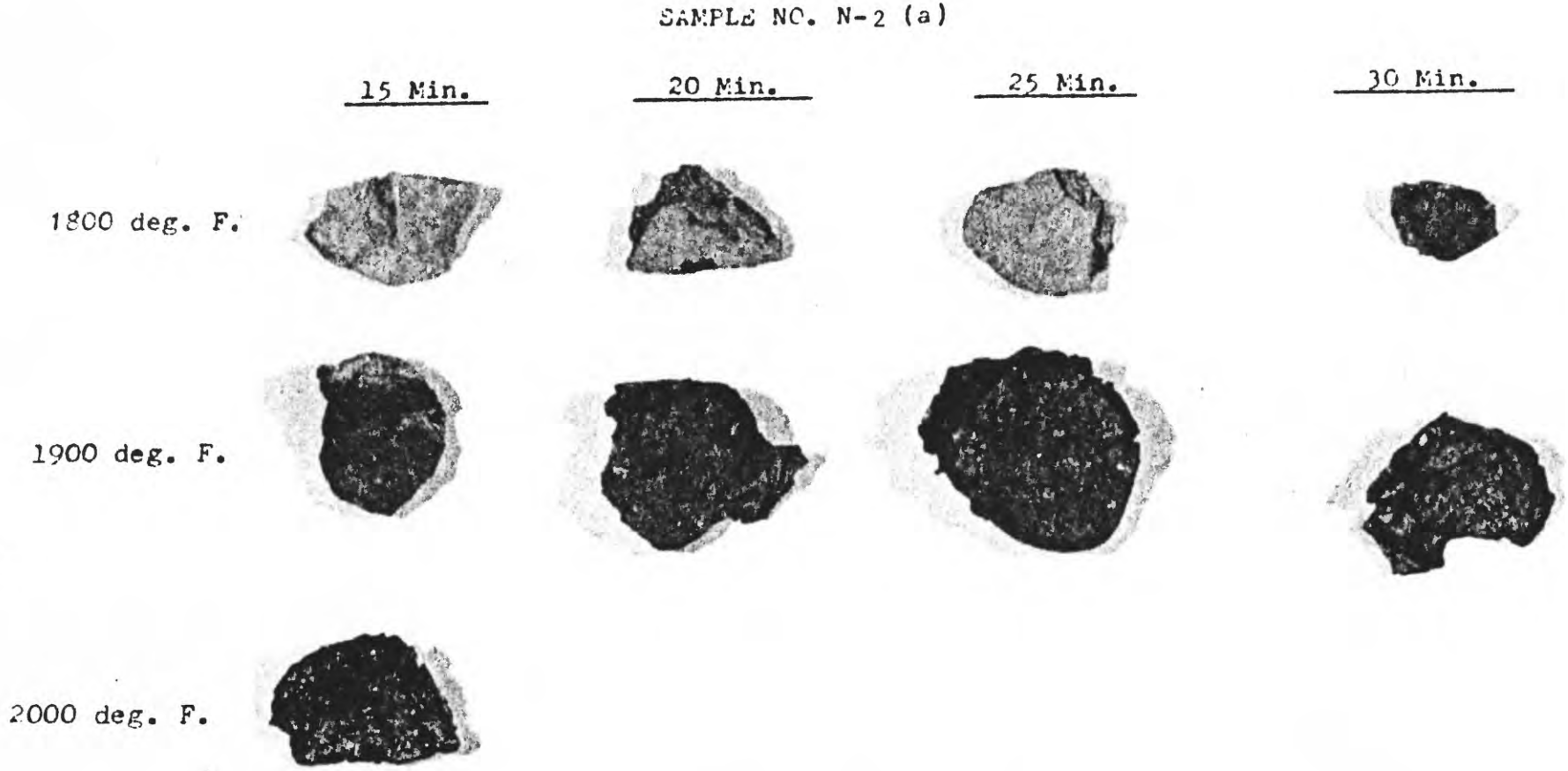

Figure 3. Development of bloating in claystone samples from Nasirabad area in relation to time and temperature. A, 1 inch

SAMPLE NO. N-5

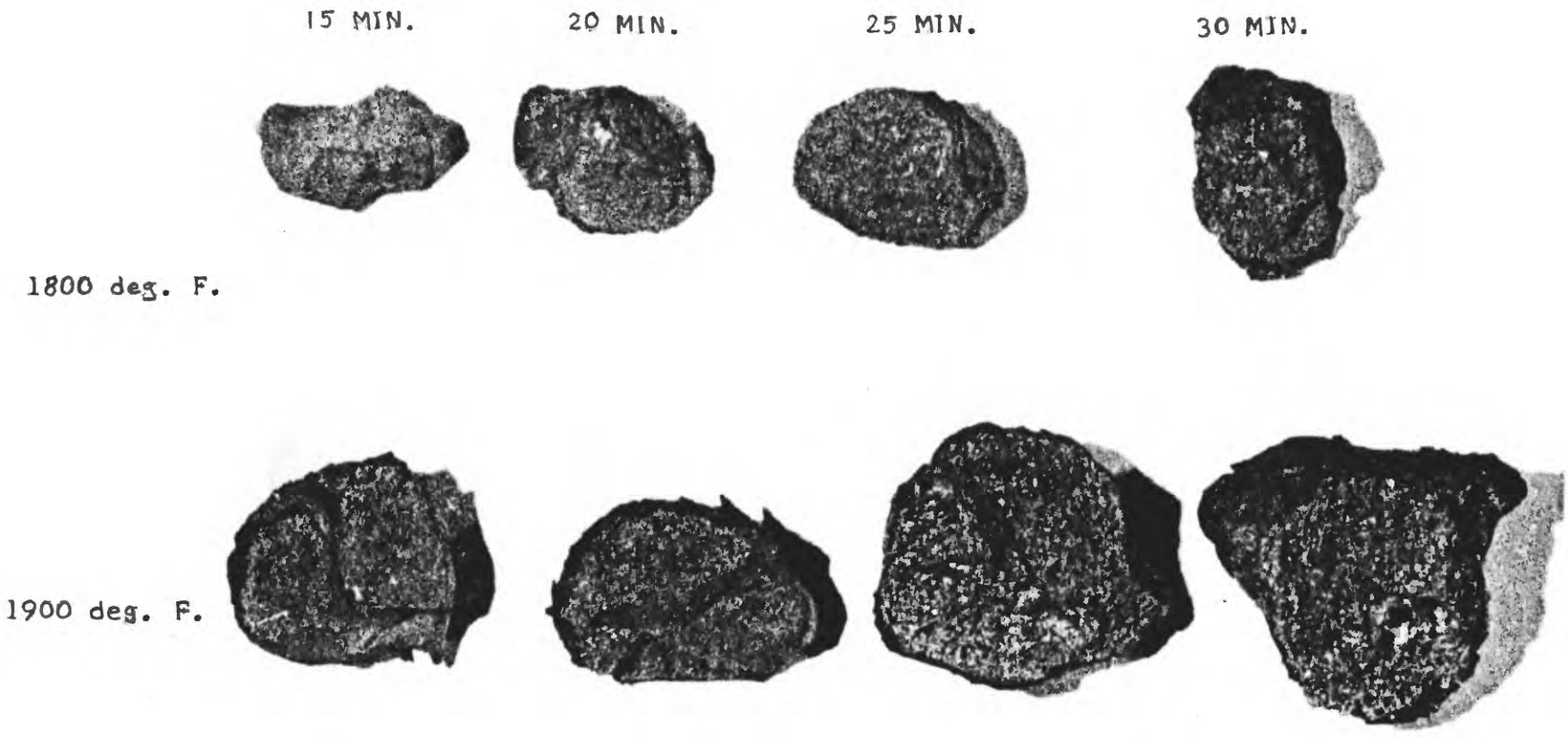

Figure 3, continued.

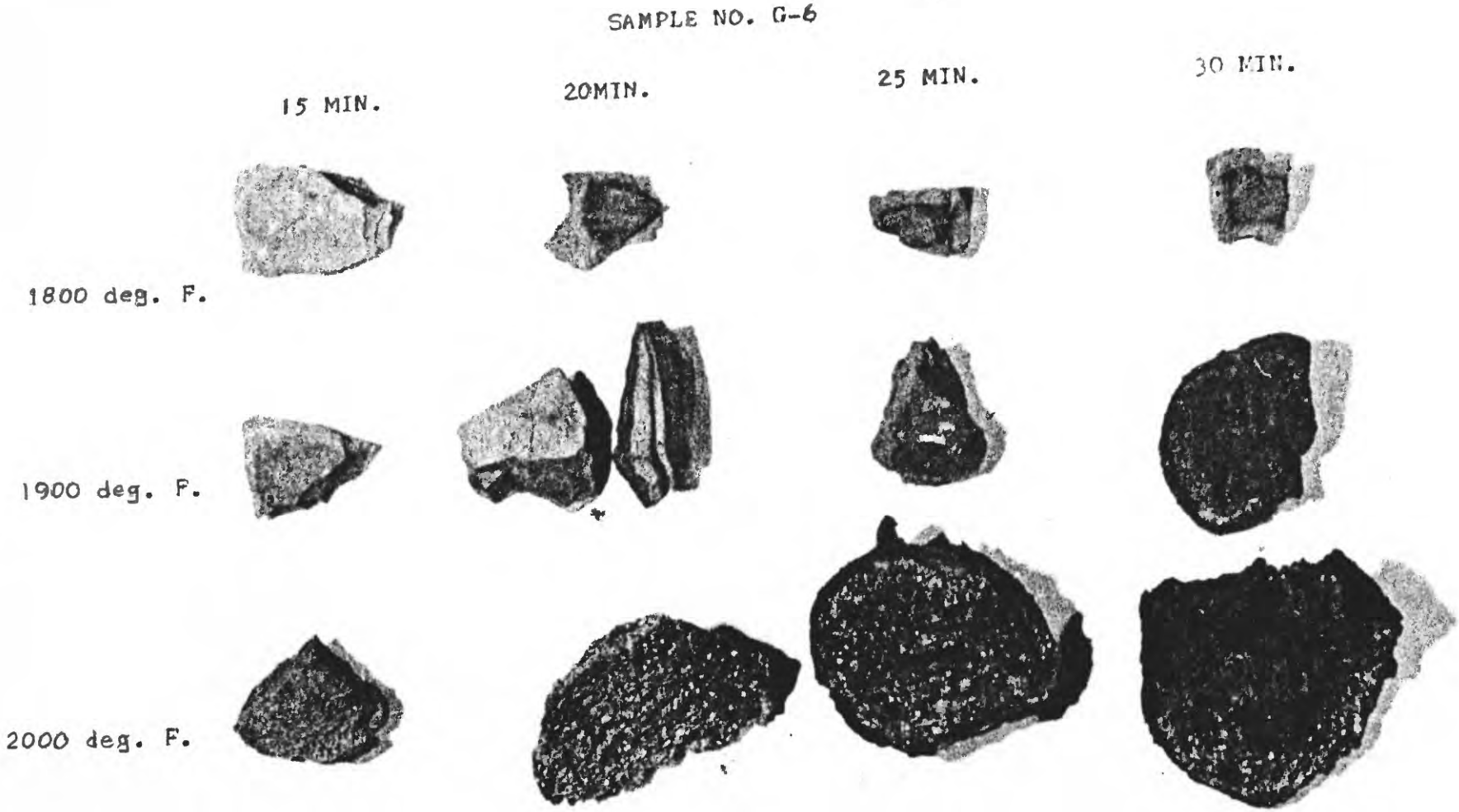

Figure 4. Development of bloating in shale from Ghoramara area in relation to time and temperature.

Bloating of the samples was achieved at temperatures ranging from 1700° F. to a maximum of 2200° F., but the majority of the samples bloated between 1800° to 1900° F. This is a favorable temperature range for a commercial operation. The Bhuban Shale of the Ghoramara area and the Girujan Clay of the Nasirabad area have bloated well and are recommended for further examination for commercial exploitation.

The strength of the material bloated in the quick firing tests was arbitrarily determined by its hardness and resistance to breaking by a hammer blow. The results obtained in this manner provide, at best, an approximation of the suitability of a material for making light-weight aggregate. Reliable strength tests, including the bloating of sufficient material to make and test concrete pieces, should be made before serious consideration is given for plant construction.

Table 2.--Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts.

Kaptai area

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
K-1	1800°F	Reddish brown some gray centre, weak, no bloat.	Reddish brown a few gray centre, weak, no bloat.	Reddish brown throughout, moderately strong,	Brownish red throughout, weak, no bloat.
	1900°F	Reddish brown a few gray centre, moderately strong, no bloat.	Light brown outside, gray centre, moderately strong, no bloat.	Light brown outside, gray centre, moderately strong, well bloat.	Tan outside, gray centre, moderately strong, well to over bloat.
	2000°F	Dark brown outside creamy brown inside, weak, over bloat, (sticks together)	Dark brown outside creamy brown inside, weak, over bloat, (sticks together)		
K-2	1800°F	Reddish brown outside, gray centre, moderately strong, no bloat.	Dark tan outside, gray centre, moderately strong, no bloat.	Brown outside, gray centre, strong, fine bloat.	Brown outside, gray centre, strong, fine bloat.
	1900°F	Tan outside, gray inside, moderately strong, well bloat.	Tan outside, gray inside, moderately strong, fine medium bloat.	Tan outside, pink gray inside, moderately strong, well to over bloat.	Tan outside, pink gray inside, moderately strong, fine to well bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
K-3	1800°F	Brown outside, gray centre, no bloat.	Brown outside, gray centre, moderately strong, even fine bloat.	Brown outside, gray centre, strong, well bloat.	Brown outside, gray centre, strong, fine bloat.
	1900°F	Dark tan outside, pink gray inside, weak, over bloat, (sticks together)	Dark tan outside, pink gray inside, weak, over bloat, (sticks together)	Dark tan outside, pink gray inside, weak, over bloat, (sticks together)	tan outside, gray white inside, weak over bloat, (sticks together).
K-4	1800°F	Light brown outside, gray inside, weak, no bloat.	Light reddish brown outside, gray inside, weak, no bloat.	Reddish brown outside, gray centre, moderately strong, no bloat.	Brown outside, gray inside, fairly strong, no bloat.
	1900°F	Brown outside, gray inside, fairly strong, no bloat.	Brown outside, pink gray inside, fairly strong, fine bloat.	Dark brown outside, pink gray inside, fairly strong medium bloat.	Dark brown outside, pink gray inside, fairly strong, well bloat.
	2000°F	Dark brown outside, pink gray inside, fairly strong, well bloat.	Dark brown outside, pink gray inside, weak, over bloat, sticks together.	No sample run.	No sample run.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
K-5	1800°F	Light brown outside, light gray inside, very hard, no bloat.	Light brown outside, light gray inside, very hard, no bloat.	Light brown outside, light gray inside, very hard, no bloat.	Brown outside, light gray inside, very hard, fine bloat.
	1900°F	Buff colored outside, light gray inside, very hard, no bloat.	Light brown outside, light gray inside, very hard, a little bloat.	Light brown outside, light gray inside, very hard, very fine bloat.	Light brown outside, pink gray inside, fairly hard, medium to well bloat.
	2000°F	Brown outside, gray inside, strong, fine bloat.	Dark brown outside, pink gray inside, strong, well bloat.	Dark brown outside, pink gray inside, fairly strong, well bloat.	Dark brown outside, pink and creamy gray inside, fairly strong, well over bloat.
K-6	1800°F	Light brown throughout, fairly hard, no bloat.	Light brown throughout, fairly hard, no bloat.	Light brown outside, light gray inside, fairly hard, no bloat.	Brown outside, light gray inside, fairly hard, no bloat.
	1900°F	Light brown, outside, light gray inside, fairly hard, no bloat.	Brown outside, gray inside, hard, a little bloat.	Brown outside, gray inside, hard, very fine bloat.	Brown outside, gray inside, hard, fine bloat.
	2000°F	Brown outside, gray inside, hard, fine bloat.	Brown outside, gray inside, hard, medium bloat.	Brown outside, gray inside, hard, medium bloat.	Brown outside, light pink inside, fairly hard, well bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
K-7	1800°F	Light brown throughout, fairly hard, no bloat.	Light brown throughout, fairly hard, no bloat.	Light brown throughout, fairly hard, no bloat.	Light brown outside, brown inside, fairly hard, no bloat.
	1900°F	Light brown outside, gray inside, hard, no bloat.	Light brown outside, gray inside, hard, very fine bloat.	Brown outside, gray inside, hard, fine bloat.	Brown outside, pink gray inside, fairly hard, medium to well bloat.
	2000°F	Light brown outside, gray inside, hard, a little bloat.	Light brown outside, black inside, hard, fine bloat.	Brown outside, black inside, fairly hard, well bloat.	Brown outside, pink whitish black inside, fairly hard, well bloat.
K-8	1800°F	Brick red outside, light gray inside, hard, no bloat.	Dark red outside, gray inside, hard, no bloat.	Brown outside, pink gray inside, fairly hard, fine bloat.	Brown outside, pink gray inside, fairly hard, fine bloat
	1900°F	Light brown outside, gray inside, fairly hard, fine bloat.	Light brown outside, pink inside, fairly hard, fine to medium bloat.	Brown outside, pink gray inside, fairly hard, fine bloat.	Brown outside, pink gray inside, fairly hard, fine bloat
	2000°F	Light brown outside, pink gray inside, fairly hard, fine bloat.	Brown outside, pink gray inside, fairly hard, medium bloat.	Brown outside, pink gray inside, fairly hard, well bloat.	Brown outside, pink gray inside, weak well bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
K-9	1800°F	Tan outside, gray inside, moderately strong, no bloat.	tan outside, gray inside, moderately strong, a little bloat.	tan outside, gray inside, moderately strong, very fine bloat.	tan outside, gray centre, moderately strong, very fine to fine bloat.
	1900°F	Tan outside, pink gray inside, weak, well bloat (begins sticking)	Tan outside, pink gray inside weak, well bloat (sticks together)	Sample not recovered.	Tan outside, pink cream inside, very weak, over bloat. (Fused together
K-10, Ia	1800°F	Brown outside, blackish gray inside, moderately strong, very fine bloat, slightly hollow inside.	Brown outside, gray inside, moderately strong, fine bloat, slightly hollow inside.	Brown outside, gray inside, moderately strong, fine bloat, slightly hollow inside,	Brown outside, gray inside, weak, hollow, fine bloat around the broken edge.
	1900°F	Light brown outside, gray inside, weak, a little bloat, slightly hollow.	Brown outside, gray inside, weak, hollow fine bloat.	Dark brown outside, gray inside, weak, hollow, fine bloat above the edge.	Blackish brown outside, whitish gray inside, weak hollow, fine to medium bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
K-10 Ib	1800°F	Light brown outside, gray inside, moderately hard, fine to medium bloat.	Reddish brown outside, gray inside, moderately hard, very fine bloat.	Light brown outside, gray inside, moderately hard, fine fine bloat.	Light brown outside, gray inside, moderately strong, medium bloat.
	1900°F	Dark brown outside, gray inside, not strong, medium bloat.	Tan outside, pink gray inside moderately hard, well bloat.	Dark brown outside, gray inside, weak, over bloat, (slightly sticks together).	Dark brown outside, gray inside, weak, over bloat, (sticks together.
K-10 II	1800°F	Brown outside, gray inside, weak, slightly hollow inside, fine bloat, shatters.	Brown outside, gray inside, weak, hollow inside, fine bloat.	Brown outside, blackish gray inside, hollow inside, fine bloat.	Brown outside, gray inside, slightly hollow inside, weak fine bloat.
	1900°F	Brownish red outside, gray inside, strong a little bloat.	Reddish brown outside, gray inside, weak, slightly hollow, very fine bloat.	Reddish brown outside, gray inside, weak, slightly hollow, fine bloat.	Dark brown outside, gray inside, weak very fine to fine bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
K-10 III	1800°F	Brown outside, pink gray inside, hard medium bloat.	Reddish brown outside, pink gray inside, hard, fine bloat.	Brown outside, pink gray inside, hard, fine to medium bloat.	Reddish brown outside, pink gray inside, hard, medium bloat.
	1900°F	Brown outside, pink gray inside, moderately hard, fine bloat.	Brown outside, pink gray inside, moderately hard, medium bloat.	Dark brown outside, pink gray inside, moderately hard well bloat.	Dark brown outside, pink gray inside, moderately hard, medium bloat, (begins sticking
K-11 II	1800°F	Light brown outside, gray inside, fairly hard, very fine bloat.	Light brown outside, pink gray inside, fairly hard, fine bloat.	Brown outside, pink gray inside, fairly hard, medium bloat.	Brown outside, pink gray inside, fairly hard, medium bloat.
	1900°F	Brown outside, light gray inside, fairly hard, fine bloat.	Brown outside, pink gray inside, fairly hard, well bloat, begins sticking.	Dark brown outside, pink gray inside, fairly hard, well bloat, sticks together.	Dark brown outside pink gray inside, fairly hard, well bloat, sticks together.
K-12	1800°F	Reddish brown outside, gray inside, moderately strong, no bloat. bloat.	Tan outside, gray inside, moderately strong, a little bloat.	Tan outside, gray inside, moderately strong, fine to medium bloat.	Tan outside, gray centre, moderately strong, medium bloat. (sticks together)
	1900°F	Tan outside, pink gray inside, weak, well bloat. (sticks crucible)	Tan outside, cream gray inside, weak, well bloat. (sticks crucible)	Dark tan outside, cream inside, weak, over bloat. (sticks together)	Dark tan outside, pink cream inside weak, over bloat. (Fused together)

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
K-13 I	1800°F	Light brown outside, gray inside, hard, no bloat.	Light brown outside, gray inside, hard, a little bloat.	Light brown outside, gray inside, hard, a little bloat.	Brown outside, gray inside, hard, very fin to fine bloat.
	1900°F	Light brown outside, gray inside, fairly hard, no bloat.	Light brown outside, gray inside, fairly hard fine bloat.	Brown outside, gray inside, fairly hard, fine bloat.	Brown outside, gray inside, fairly hard, fine to medium bloat.
K-13 II-	1800°F	Light brown outside, gray inside, very hard, no bloat.	Light brown outside, gray inside, very hard, fine bloat.	Brown outside, gray inside, very hard, fine bloat.	Br[illegible] outside, gray [illegible]e, hard, fi[illegible] to medium bloat.
	1900°F	Dark brown outside, pink gray inside, fairly hard, well bloat.	Dark brown outside, pink gray inside, weak, over bloat, begins sticking.	Dark brown outside, pink gray inside, hard, well bloat.	Dark brown outside, pink gray inside, weak, well to over bloat, slightly sticks together.
K-13 III	1800°F	Light brown outside, gray inside, hard, no bloat.	Light brown outside, gray inside, hard, no bloat.	Light brown outside, gray inside, hard, a little bloat.	Li[illegible] brow[illegible] outside, gray inside hard, a little bloat.
	1900°F	Light brown outside, gray inside, fairly hard, a little	Brown outside, gray inside, fairly hard, medium bloat.	Brown outside, pink gray inside, fairly hard, medium bloat.	Brown outside, pink gray inside, weak, well t over bloat, sli[illegible]tly stick together.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
K-14 II-	1800°F	Dark red outside, gray inside, no bloat.	Dark red outside, gray inside, hard no bloat.	Brown outside, gray inside, hard, no bloat.	Brown outside, gray inside, hard, no bloat.
	1900°F	Light brown outside, gray inside, hard, no bloat.	Light brown outside, gray inside, hard, no bloat.	Brown outside, gray inside, hard, very fine bloat.	Brown outside, gray inside, hard, fine bloat.
	2000°F	Light brown outside, gray inside, hard, no bloat.	Light brown outside, gray inside, hard, a little bloat.	Brown outside, gray inside, hard, fine bloat.	Brown outside, pink gray inside, fairly hard mediu to well bloat.
K-16 II -	1800°F	Light brown outside, gray inside, weak, no bloat, shatters.	Light brown outside, gray inside, weak, no bloat.	Light brown outside, gray inside, weak, a little bloat.	Light brown outside, gray inside, weak, a little bloat.
	1900°F	Light brown outside, gray inside, weak, fine bloat, slightly shatters.	Light brown outside, gray inside, weak, fine bloat, slightly hollow inside.	Light brown outside, gray inside, weak, fine to medium bloat.	Brown outside, gray inside, weak, medium bloat.
K-16 III	1800°F	Brick red outside, gray inside, fairly hard, no bloat, shatters.	Reddish brown outside, gray inside, fairly hard, no bloat.	Brown outside, gray inside, fairly hard, fine bloat.	Light brown outside, gray inside, fairly hard, very fine bloat.
	1900°F	Brown outside, gray inside, fairly hard, very fine bloat, slightly shatters.	Brown outside, gray inside, weak, fine bloat, slight hollow inside.	Brown outside, gray inside, weak, fine to medium bloat.	Brown outside, gray inside, weak, medium bloat, hollow inside.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample Number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
K-17 I	1800°F	Light brown throughout, fairly hard, no bloat.	Light brown throughout, hard, no bloat.	Light brown outside, gray inside, hard, no bloat.	Brown throughout fairly hard, no bloat.
	1900°F	Light brown outside, blackish gray inside, weak no bloat, slightly splits.	Light brown outside, blackish gray inside, weak no bloat.	Brown outside, black inside, hollow, weak fine bloat.	Brown outside, black inside, hollow, weak fine bloat.
K-17 III	1800°F	Light brown throughout, fairly hard, no bloat.	Light brown outside, gray centre, fairly hard, no bloat.	Brown outside, gray centre, fairly hard, no bloat.	Brown outside, gray centre, fairly hard, no bloat.
	1900°F	Light brown outside, gray inside, fairly hard, no bloat, slightly shatter.	Light brown outside, black inside, weak, hollow, fine bloat along the edge.	Brown outside, black inside, weak, hollow, fine bloat, along edge.	Brown outside, black inside, hollow, weak, bloated along edge.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
K-18 I	1800°F	Light brown outside, gray inside, hard, no bloat.	Brown outside, gray inside, hard, some very fine bloat.	Brown outside, gray inside, hard, very fine bloat.	Brown outside, gray inside, hard, fine bloat.
	1900°F	Light brown outside, pink gray inside, fairly hard, fine bloat.	Brown outside, pink gray inside, fairly hard, medium bloat.	Dark brown outside, pink gray inside, fairly hard, well bloat.	Dark brown outside, pink gray inside, weak, well to over bloat, slightly sticks together.
K-18 III	1800°F	Light brown outside, gray inside, very hard, no bloat.	Light brown outside, gray inside, very hard, no bloat.	Light brown outside, gray inside, very hard, no bloat.	Light brown outside, gray inside, very very fine bloat.
	1900°F	Dark brown outside, pink gray inside, fairly hard, well bloat.	Dark brown outside, pink gray inside, fairly hard, well bloat.	Brown outside, grayish, white inside, hard, very fine bloat.	Brown outside, creamy white inside, hard, fine bloat.
K-19	1800°F	Light brown outside, gray inside, weak, no bloat, shatters.	Light brown outside, gray inside, weak, no bloat.	Brown outside, gray inside, weak, a little bloat.	Brown outside, gray inside, weak, fine bloat.
	1900°F	Light brown outside, pink gray inside, fairly hard, medium bloat.	Brown outside, pink gray inside, fairly hard, medium bloat.	Brown outside, pink gray inside, fairly hard, well bloat.	Brown outside, pink gray inside, weak o... bloat, sticks together.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
K-20	1800°F	Reddish brown outside, gray inside, hard, no bloat.	Reddish brown outside, pink gray inside, hard, fine bloat.	Brown ouside, pink gray inside, fairly strong, medium bloat.	Brown outside, pink gray inside, fairly strong, medium bloat.
	1900°F	Reddish brown outside, gray inside, hard, no bloat.	Reddish brown outside, gray inside, hard, very fine bloat.	Brown outside, pink gray inside, fairly hard, well bloat.	Dark brown gray and pinkish gray, inside, fairly hard, well bloat.
K-21	1800°F	Light brown outside, gray inside, moderately strong, a little bloat.	Brown outside, pink gray inside, moderately strong, well bloat.	Brown outside, pink gray inside, moderately strong, well bloat.	Brown outside, pink gray inside, moderately strong, medium to well bloat.
	1900°F	Reddish brown outside, gray inside, fairly strong, no bloat.	Brown outside, gray inside, fairly strong, very fine bloat.	Brown outside, creamy gray inside, weak, medium bloat.	Dark brown outside, creamy brown and gray inside, weak, over bloat.
K-22	1800°F	Light brown outside, gray inside, moderately hard, a little bloat.	Brown outside, gray inside, moderately hard, fine bloat.	Brown outside, gray inside, moderately hard, medium bloat.	Brown outside, gray inside, moderately hard, medium bloat.
	1900°F	Brown outside, gray inside, fairly hard, fine bloat, splits.	Brown outside, pink gray inside, fairly hard, fine bloat.	Brown outside, pink gray inside, fairly hard, medium bloat.	Dark brown outside, pink gray inside, fairly hard, well bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
K-23	1800°F	Tan outside, gray inside, moderately strong, no bloat.	Tan outside, gray inside, moderately strong, fine bloat.	Tan outside, gray inside, moderately strong, fine bloat.	Tan outside, gray inside, moderately strong, very very fine to fine bloat.
	1900°F	Dark tan outside, creamy brown inside, very weak, over bloat. (sticks together)	Dark tan outside, creamy brown inside, very weak, over bloat. (sticks together)	Dark tan outside, pink cream inside, very weak, over bloat. (sticks together)	Dark tan outside, grayish pink inside, very weak, over bloat. sticks together)
K-24 (I op)	1800°F	Reddish Brown outside, gray inside, hard, a little bloat.	Brown outside, pink gray inside, hard, fine bloat.	Brown outside, gray inside, hard, no bloat.	Brown outside, pink gray inside, fairly hard, well bloat.
	1900°F	Light brown outside, gray inside, hard, no bloat.	Light brown outside, gray inside, hard, very fine bloat.	Brown outside, pink gray inside, hard, fine bloat.	Dark brown outside, pink gray inside, fairly hard, medium bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
K-24 II	1800°F	Light brown outside, pink gray inside, hard, very fine bloat.	Light brown outside, pink gray inside, hard, fine bloat.	Brown outside, pink gray, inside, fairly hard, well bloat.	Brown outside, pink gray inside, fairly hard, well bloat.
	1900°F	Light brown outside, pink gray inside, fairly hard, medium	Brown outside, pink gray inside, fairly hard, medium bloat.	Dark brown outside, pink gray inside, weak, well to over bloat.	Dark brown outside, pink gray inside, weak, well to over bloat, slightly sticks together.
K-24 III	1800°F	Light brown outside, pink gray inside, hard, a little bloat.	Light brown outside, pink gray inside, hard, very fine bloat.	Brown outside, pink gray inside, fairly hard, medium bloat.	Brown outside, pink gray inside, fairly well bloat.
	1900°F	Light brown outside, gray inside, hard, fine bloat.	Light brown outside, gray pink inside, hard, fine bloat.	Brown outside, pink gray inside, fairly hard, well bloat.	Dark brown outside, pink gray inside, weak, well to over bloat, begins sticking.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Chandraghona area

Sample number	Temperature - Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
Ch-1 I	1800°F	Light brown outside, gray inside, moderately strong, medium bloat, shatters.	Light brown outside, gray inside, moderately strong well bloat.	Brown outside, gray inside, moderately hard, well bloat.	Brown outside, gray inside, weak, well bloat.
	1900°F	Light brown outside, pink gray inside, moderately strong, fine bloat.	Brown outside, pink gray inside, moderately strong, medium bloat.	Brown outside, pink gray inside, moderately strong, well bloat.	Brown outside, pink gray inside, weak, well to over bloat.
Ch-1 II	1800°F	Light brown outside, gray inside, moderately, strong fine bloat.	Brown outside, pink gray inside, moderately strong well bloat.	Brown outside, pink gray inside, moderately strong weal bloat.	Brown outside, pink gray inside, moderately strong medium to well bloat.
	1900°F	Light brown outside, pink gray inside moderately, strong, medium bloat.	Light brown outside, pink gray inside, moderately strong, medium bloat.	Dark brown outside, pink gray inside, weak, well to over bloat.	Brown outside, pink gray inside, weak, well bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
Ch-1 III	1800°F	Light brown outside, gray inside, not strong, fine bloat, shatters.	Brown outside, gray inside, moderately strong, medium bloat.	Brown outside, pink gray inside, moderately strong, well bloat.	Brown outside, pink gray inside moderately strong, well bloat.
	1900°F	Light brown outside, pink gray inside, moderately strong, fine bloat.	Brown outside, pink gray inside, moderately strong, medium bloat.	Brown outside, pink gray inside, fairly strong, well bloat.	Dark brown outside, pink inside, weak well to over bloat.
Ch-2 I	1800°F	Light brown outside, whitish gray inside, fairly strong, a little bloat.	Brown outside, whitish gray inside, fairly strong, fine bloat.	Brown outside, pinkish gray inside, fairly strong, fine bloat.	Dark brown outside, light gray inside, fairly strong, medium bloat.
	1900°F	Brown outside, gray inside, moderately strong, fine bloat.	Brown outside, gray inside, moderately strong, well bloat, slightly sticks together.	Dark brown outside, gray inside, moderately strong, well bloat, moderately sticks together.	Dark brown outside, gray inside, moderately strong, well bloat, moderately sticks together.
	2000°F	Dark brown outside, gray inside, moderately strong, well bloat, begins sticking.	Dark brown outside, gray inside, weak, well to over bloat, sticks together.	No sample run.	No sample run.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
Ch-2 II	1800°F	Brown outside, light gray inside, fairly strong, fine bloat, slightly shatters.	Brown outside, gray inside, fairly strong, medium bloat.	Light brown outside, pinkish gray inside, fairly strong, medium bloat.	Dark brown outside, pinkish gray inside, fairly strong, medium bloat.
	1900°F	Brown outside, pink gray inside, fairly strong, well bloat.	Brown outside, gray inside, fairly strong, well bloat.	Brown outside, pink gray inside, fairly strong, well bloat.	Brown outside, pink gray inside, weak to fairly hard, fine to well bloat.
	2000°F	Dark brown outside, pink gray inside, fairly strong, medium bloat.	Dark brown outside, pink gray inside, fairly strong, well bloat.	Dark brown outside, pink gray inside, fairly strong, well bloat, sticks together.	No sample run.
Ch-2 III	1800°F	Light brown outside, gray inside, strong, no bloat.	Brown outside, gray inside, strong, a little bloat.	Brown outside, gray inside, strong, fine bloat.	Dark brown outside, gray inside, strong, fine bloat.
	1900°F	Brown outside, gray inside, strong, no bloat.	Brown outside, pink gray inside, fairly strong, medium bloat.	Brown outside, pink gray inside, fairly strong, well bloat.	Dark brown outside, pink gray inside fairly strong, well bloat.
	2000°F	Dark brown outside, pink gray inside, fairly strong, well bloat, begins sticking	Dark brown outside, pink gray inside Weak to moderately strong, well to over bloat, sticks together.	No sample run.	No sample run.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
Ch-3 II	1800°F	Light brown outside, gray inside, fairly hard, no bloat.	Brown outside, gray inside, fairly, hard, no bloat.	Brown outside, greenish gray inside, fairly hard, very fine bloat.	Dark brown outside, greenish gray inside, fairly hard, very fine bloat.
	1900°F	Brown outside, gray inside, fairly hard, no bloat.	Light brown outside, pinkish gray inside, fairly hard, very fine bloat.	Brown outside, gray inside, fairly hard, fine bloat.	Brown outside, pink gray inside, fairly hard, fine bloat.
Ch-5 II	1800°F	Light brown outside, light gray inside, fairly hard, very fine bloat.	Light brown outside, light gray inside, fairly hard, very fine bloat.	Light brown outside, pink gray inside, fairly hard, fine bloat.	Brown outside, pink gray inside, fairly hard, fine bloat.
	1900°F	Brown outside, pink gray and greenish gray inside, fairly hard, fine to medium bloat.	Light brown outside, pinkish gray inside, fairly hard, fine bloat.	Brown outside, pink gray and greenish gray inside, fairly hard, fine to medium bloat.	Light brown outside, greenish gray inside, fairly hard, fine bloat.
Ch-6 II	1800°F	Light brown outside, gray inside, moderately hard, no shatters.	Light brown outside, gray inside, weak, fine bloat.	Brown outside, gray inside, not weak, fine bloat.	Brown outside, gray inside, weak, fine bloat.
	1900°F	Brown outside, gray inside, weak, fine bloat.	Brown outside, pink gray inside, weak, medium bloat.	Brown outside, whitish gray inside, weak, fine bloat.	Brown outside, pinkish gray inside, weak, fine bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
Ch-7	1800°F	Tan outside, gray inside, weak, very fine bloat.	Tan outside, gray inside, weak, bloated.	Tan outside, gray inside, weak, bloated.	Tan outside, gray inside, weak, fine to medium bloat.
	1900°F	Tan outside, gray inside, moderately strong, fine bloat.	Tan outside, gray inside, weak, well bloat.	Brown outside, gray inside, weak, well bloat, sticks together.	Dark brown outside, gray inside, weak over bloat, sticks together.
Ch-8	1800°F	Brick red outside, gray inside, moderately, strong, no bloat.	Brick red outside, gray inside, moderately, strong, no bloat.	Brown outside, dark gray inside, moderately, strong, a little bloat.	Sample discarded.
	1900°F	Brick red outside, blackish gray inside, strong, no bloat.	Brick red outside, blackish gray inside, strong, no bloat.	Brown outside, blackish gray inside, strong, a little bloat.	Brown outside, blackish gray inside, strong, very fine bloat.
	2000°F	Tan outside, pink gray inside, weak, well bloat,	Tan outside, pink gray inside, weak, over bloat, begins sticking.	Tan outside, pink gray inside, weak, over bloat, slightly sticks together.	Tan outside, creamy gray inside, weak, over bloat, slightly sticks together.

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Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
Ch-9 I	1800°F	Light brown outside, gray inside, weak, no bloat shatters.	Light brown outside, gray inside, weak, very fine bloat.	Brown outside, gray, inside weak, very fine bloat.	Brown outside, pink gray inside, fairly hard, fine bloat.
	1900°F	Light brown outside, gray inside, hard, a few bloat.	Brown outside, gray inside, hard, very fine bloat.	Brown outside, gray inside, fairly hard, medium bloat.	Brown outside, gray inside, fairly hard, medium bloat.
	2000°F	Brown outside, gray inside, fairly hard, fine bloat.	Dark brown-outside, gray inside, fairly hard, medium bloat.	Dark brown outside, pink gray inside, fairly hard, well bloat.	Dark brown outside, pink gray inside, weak, over bloat, slightly sticks together.
Ch-9 II	1800°F	Reddish brown outside, gray inside, weak, no bloat shatters.	Reddish brown outside, gray inside, weak, fine bloat.	Brown outside, gray inside, weak, very fine bloat.	Brown outside, pink gray inside fairly hard, fine bloat.
	1900°F	Light brown outside, gray inside, hard, a little bloat.	Light brown outside, gray inside, hard, very fine bloat.	Dark brown outside, gray inside, fairly hard fine bloat.	Dark brown outside, pink brown outside, fairly hard fine bloat.
	2000°F	Brown outside, pink gray inside, fairly hard, fine bloat.	Brown outside, pink gray inside, fairly hard, medium bloat.	Dark brown outside, pink gray inside, fairly hard, well bloat.	Dark brown outside, pink gray inside, weak to fairly hard, well bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
Ch-9 III	1800°F	Dark red outside, light gray centre, strong, no bloat.	Dark red throughout, strong, no bloat.	Dark red throughout, strong, no bloat.	Dark red throughout, strong, no bloat.
	1900°F	Dark red outside, a little gray inside, very strong, no bloat.	Dark red outside, gray inside, very strong, no bloat.	Dark red outside, gray inside, very strong, no bloat.	Brownish red outside, a little gray inside, very strong, no bloat.
	2000°F	Reddish brown outside, gray inside, very hard, no bloat.	Brown outside, gray inside, very strong, a little bloat.	Dark brown outside, greenish gray inside, strong, very fine bloat.	Dark brown outside, pink gray inside, fairly strong, medium bloat.
Ch-10	1800°F	Brown outside, gray inside, moderately strong, no bloat.	Brown outside, gray inside, moderately strong, a little bloat.	Brown outside, gray inside, moderately strong, a little bloat.	Brown outside, gray inside, moderately strong, a little bloat.
	1900°F	Tan outside, gray inside, moderately strong, well bloat, sticks together.	Brick red outside gray inside, moderately strong, no bloat.	Tan outside, gray inside, weak, well bloat, sticks together.	Dark brown outsid gray inside, weak over bloat, sticks together.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
Ch-12 I	1800°F	Reddish brown outside, gray inside, moderately hard, a little bloat, shatters.	Light brown outside, gray inside, moderately strong, fine bloat.	Light brown outside, gray inside, moderately strong, medium bloat.	Brown outside, gray inside, weak, fine to medium bloat.
	1900°F	Light brown outside, gray inside, fairly strong, fine bloat.	Brown outside, gray inside, fairly strong, medium bloat, slightly sticks together.	Brown outside, pink gray inside, weak, well bloat, slightly sticks together.	Brown outside, pink gray inside, weak, well bloat, slightly sticks together.
Ch-12 II-	1800°F	Brown outside, gray inside, moderately strong, fine bloat, shatters.	Light brown outside, gray inside, moderately strong, a little bloat.	Brown outside, gray inside, moderately strong, medium bloat.	Brown outside, gray inside, moderately strong, medium bloat.
	1900°F	Light brown outside, pink gray inside, fairly strong, medium bloat.	Light brown outside, pink gray inside, fairly strong, medium bloat, sticks together.	Brown outside, pink gray inside, weak well to over bloat slightly sticks together.	Brown outside, pink gray inside, weak, over bloat slightly sticks together.
Ch-12 III	1800°F	Brownish red outside, blackish gray inside, hard a little bloat.	Reddish brown outside, blackish gray inside, hard a little bloat.	Reddish brown outside, gray inside hard, very fine bloat.	Reddish brown outside, gray inside hard, fine bloat.
	1900°F	Light brown outside, greenish gray inside, hard a little bloat.	Reddish brown outside, greenish gray inside, hard very fine bloat.	Brown outside, greenish gray inside, hard fine bloat.	Light brown outside, greenish gray inside, hard fine bloat.
	2000°F	Brown outside, greenish gray inside, hard a little bloat.	Brown outside, greenish gray and pinkish gray inside, fairly hard fine to medium bloat.	Brown outside, light greenish inside, fairly hard, fine to well bloat.	Brown outside, greenish gray inside, fairly strong, fine bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
Ch-13 I	1800°F	Light brown outside, gray inside, strong, no bloat.	Brown outside, gray inside, strong, some fine bloat.	Brown outside, gray inside, hard, very fine bloat.	Dark brown outside, pink gray inside, strong, fine bloat.
	1900°F	Tan outside, pink gray inside, fairly strong, fine bloat, shatters.	Tan outside, gray inside, fairly strong, fine bloat. bloat.	Tan outside, pink gray inside, fairly strong, medium bloat.	Tan outside, pink gray inside, fairly strong, medium bloat.
	2000°F	Dark brown outside, pink gray inside, fairly strong, medium bloat.	Dark brown outside, pink gray inside, fairly strong, well bloat, sticks together.	Dark brown outside, pink gray inside, weak, well to over bloat, sticks together.	No sample run.
Ch-13 III	1800°F	Reddish brown outside, dark gray inside, very strong, a little bloat.	Brown outside, gray inside, very strong, no bloat.	Brown outside, light gray inside, very fine bloat.	Brown outside, light gray inside, very hard, very fine bloat.
	1900°F	Dark brown outside, pink gray inside, fairly strong, fine bloat.	Dark brown outside, pink gray inside, fairly strong, a little bloat.	Dark brown outside, greenish gray inside, fairly strong, medium bloat.	Dark brown outside, greenish gray and pink gray inside, fairly strong, medium bloat.
	2000°F	Dark brown outside, pink gray inside, fairly strong, medium to well bloat.	Dark brown outside, pink gray inside, fairly strong, well bloat, begins sticking.	Dark brown outside, pink gray inside, fairly strong, well to over bloat, slightly sticks together.	Dark brown outside, pink gray inside, weak, over bloat, sticks together

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
Ch-14	1800°F	Brown outside, gray inside, weak, no bloat.	Dark brown outside gray inside, weak fine bloat.	Dark brown outside pink gray inside, weak, well bloat.	Sample not recovered.
	1900°F	Tan outside, pink gray inside, weak, very fine bloat, splits in furnace.	Tan outside, gray inside, weak, fine bloat.	Tan outside, gray inside, weak, well bloat, sticks together.	Tan outside, pink gray inside, weak well bloat.
Ch-16	1800°F	Light red outside, light gray inside, hard, no bloat.	Brown outside, light gray inside, hard, very fine bloat.	Brown outside, light gray inside, hard, no bloat.	Brown outside, gray inside, hard, very fine bloat.
	1900°F	Light brown outside, light gray inside, hard, no bloat.	Brown outside, pink gray inside, fairly hard, very fine bloat.	Dark brown outside, pink gray and greenish gray inside, fairly hard, fine to medium bloat.	Dark brown outside, pink gray inside, hard, fine bloat.
	2000°F	Brown outside, pink gray inside, fairly hard, fine bloat.	Brown outside, pink gray inside, fairly hard, medium bloat.	Dark brown outside, pink gray inside, fairly hard, well bloat.	Dark brown outside, pink gray inside, weak to fairly hard, well to over bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Rangunia area

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
R_1-3	1800°F	Brick red throughout, moderately strong, no bloat.	Brick red outside, gray centre, moderately strong, no bloat.	Brick red outside, gray centre, moderately strong, no bloat.	Brick red outside, gray centre moderately strong, no bloat.
	1900°F	Brick red outside, pink gray inside, strong, very fine bloat.	Brown outside, pink gray centre, strong, very fine bloat.	Brown outside, pink gray inside, strong, very fine bloat.	Dark brown pink gray inside, strong, fine bloat.
	2000°F	Brown outside, pink gray inside, moderately strong, well bloat.	Brown outside, pink gray inside, moderately strong, well bloat.	Dark brown outside, pink gray inside, moderately strong, well bloat.	Dark brown outside, pink gray inside, moderately strong, well bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
R_2-3	1800°F	Red throughout, fairly hard, no bloat.	Brick red throughout, fairly hard, no bloat.	Red outside, some gray centre, fairly hard, no bloat.	Brick red outside, gray inside, fairly hard, no bloat.
	1900°F	Brick red outside, gray inside, fairly hard, a little bloat.	Brown outside, gray inside, fairly hard, very fine bloat.	Brown outside, gray inside, fairly hard, very fine bloat.	Dark brown outside, pink gray inside, fairly hard, fine to medium bloat.
	2000°F	Brown outside, pink gray inside, fairly hard, medium bloat.	Dark brown outside, pink gray inside, not hard, medium bloat.	Dark brown outside, pink gray inside, not hard, well bloat.	Dark brown outside, pink gray inside, weak, well bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
R_3-3	1800°F	Brick red throughout, moderately hard, no bloat.	Brick red throughout, moderately hard, no bloat.	Brick red outside, some gray centre, moderately hard, no bloat.	Light brown outside, gray inside, moderately strong, no bloat.
	1900°F	Light brown outside, light pinkish gray inside, hard, little bloat.	Brown outside, pink gray inside, chard, very fine bloat.	Brown outside, pink gray inside, hard, very fine bloat.	Dark brown outside, pink gray inside, hard, fine bloat.
	2000°F	Brown outside, pink gray inside, fairly hard, fine bloat.	Dark brown outside, pink gray inside, fairly hard, medium bloat.	Dark brown outside, pink gray inside, fairly hard, medium bloat.	Dark brown outside, pink gray inside, fairly hard, well bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
R_4-3	1800°F	Brick red throughout, moderately hard, no bloat.	Brick Red throughout, moderately hard, no bloat.	Brick red outside, some gray centre, moderately hard, no bloat.	Brick red outside, gray centre, moderately hard, no bloat.
	1900°F	Light brown outside, gray inside, moderately hard, no bloat.	Brown outside, gray inside, moderately hard, very fine bloat.	Brown outside, gray inside, moderately hard, fine fine bloat.	Brown outside, pink gray inside, moderately hard, medium bloat.
	2000°F	Brown outside, pink gray inside, moderately hard, medium bloat.	Dark brown outside, pink gray inside, moderately hard, well bloat.	Dark brown outside, pink gray inside, weak, well bloat, slightly sticks together.	Dark brown outside, pink gray inside, weak, well bloat, sticks together.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
R_5-3	1800°F	Brick red throughout, moderately strong, no bloat.	Brick red outside, light gray inside, moderately strong, no bloat.	Brick red outside, gray inside, moderately strong, no bloat.	Brick red outside, gray centre, moderately strong, no bloat.
	1900°F	Light brown outside, pink gray inside, moderately strong, very fine bloat.	Light brown outside, pink gray inside, moderately strong, very fine bloat.	Brown outside, pink gray inside, moderately strong, fine bloat.	Dark brown outside, pink gray inside, moderately strong, medium bloat.
	2000°F	Dark brown outside, pink gray inside, moderately strong, medium bloat.	Dark brown outside, pink gray inside, moderately strong, well bloat.	Dark brown outside, pink gray inside, weak, well bloat, slightly sticks together.	Dark brown outside, pink gray inside, weak well bloat, sticks together.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
R_6-3	1800°F	Brick red throughout, moderately strong, no bloat.	Brick red throughout, moderately strong, no bloat.	Brick red outside, light gray inside, moderately, hard, no bloat.	Brick red outside, light gray inside, moderately, strong, no bloat.
	1900°F	Light brown outside, gray inside, moderately strong, very fine bloat.	Brown outside, pink gray inside, moderately strong, fine bloat.	Brown outside, pink gray inside, moderately strong, fine bloat.	Dark brown outside, gray centre moderately strong, medium bloat.
	2000°F	Dark brown outside, gray inside, moderately strong, fine to medium bloat.	Dark brown outside, pink gray inside, weak, well bloat.	Dark brown outside, pink gray inside, weak, well bloat.	Dark brown outside, pink gray inside, weak, well to over bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
R_7-3	1800°F	Red outside, gray inside, weak, no bloat.	Red outside, gray inside, weak, no bloat.	Red outside, gray inside, weak, no bloat.	Red outside, gray inside, weak, no bloat.
	1900°F	Light brown outside, gray inside, weak, no bloat.	Brown outside, gray inside, weak, very fine bloat.	Brown outside, gray inside, weak, fine bloat.	Brown outside, gray inside, weak, medium bloat.
	2000°F	Dark brown outside, pink gray inside, weak, medium bloat.	Dark brown outside, pink gray inside, weak, medium bloat.	Dark brown outside, pink gray inside, weak, well bloat, slightly sticks together.	Dark brown outside, pink gray inside, weak, well bloat, sticks together.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
R_8-3	1800°F	Red outside, dark gray inside, not strong, no bloat.	Red outside, dark gray inside, not strong, no bloat.	Red outside, gray inside, not strong, no bloat.	Red outside, dark gray inside, not strong, no bloat.
	1900°F	Red outside, dark gray inside, weak, no bloat.	Tan outside, dark gray inside, weak, fine bloat.	Tan outside, dark gray inside, weak, fine to medium bloat.	Tan outside, dark gray inside, weak, fine to medium bloat.
	2000°F	Tan outside, gray inside, weak, medium bloat, slightly sticks together.	Tan outside, dark gray inside, weak, medium bloat, slightly sticks together.	Tan outside, dark gray inside, weak, medium bloat, sticks together.	Tan outside, dark gray inside, weak, medium bloat, slightly sticks together.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
R-10 II	1800°F	Light brown outside, gray inside, fairly hard, no bloat.	Light brown outside, gray inside, fairly hard, no bloat.	Light brown outside, gray inside, fairly hard, no bloat.	Brown outside, gray inside, fairly hard, no bloat.
	1900°F	Light brown outside, gray inside, fairly hard, no bloat.	Light brown outside, pink inside, fairly hard, fine bloat.	Brown outside, light pink inside, fairly hard, well bloat.	Brown outside, light creamy pink inside, fairly, hard well to over bloat.
R-10 III	1800°F	Brown outside, dark gray inside, fairly hard, no bloat.	Brown outside, gray inside, fairly hard, very fine bloat.	Brown outside, pink gray inside, fairly hard, very fine bloat.	Brown outside, gray inside, fairly hard, very fine bloat.
	1900°F	Dark brown outside, light pink inside, fairly hard medium bloat.	Dark brown outside, light pink inside, fairly hard, medium bloat.	Brown outside, grayish pink inside, fairly hard, medium bloat.	Dark brown outside, black and light pink inside, fairly hard, well bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
R-12	1800°F	Light reddish brown outside, light gray centre, hard, no bloat.	Light brown outside, gray inside, very hard, no bloat.	Light reddish brown, outside, gray inside, hard, no bloat.	Brown outside, black inside, hard, no bloat.
	1900°F	Light brown outside, gray inside, very hard, no bloat.	Dark brown outside, dark gray inside,, very hard, fine bloat.	Dark brown outside, dark gray inside, hard, fine bloat.	Dark brown outside, grayish black inside hard, very fine to fine bloat.
R-13-3	1800°F	Brick red throughout, moderately strong, no bloat.	Brownish red outside, gray inside, strong, no bloat.	Brick red throughout, moderately strong, no bloat.	Tan throughout, moderately strong, no bloat.
	1900°F	Tan outside, whitish gray inside, strong, fine bloat.	Tan outside, gray inside, strong, fine bloat.	Tan outside, pink gray inside, strong, fine to medium bloat.	Tan outside, pink gray inside, strong, medium bloat.
	2000°F	Tan outside, cream inside, moderately strong, medium bloat.	Tan outside, cream inside, moderately strong, medium bloat.	Tan outside, whitish gray inside, moderately strong, fine to medium bloat.	Tan outside, grayish white inside, moderately strong, medium bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
R_{14}-3	1800°F	Brick red throughout, moderately strong, no bloat.	Brick red throughout, moderately strong, no bloat.	Tan red throughout, moderately strong, no bloat.	Tan outside, gray centre, moderately strong, no bloat.
	1900°F	Tan outside, blackish gray inside, moderately strong, no bloat.	Tan outside, blackish gray inside, strong, no bloat.	Tan outside, gray inside, strong, a little bloat.	Tan outside, gray inside, strong, very fine bloat.
	2000°F	Tan outside, cream inside, moderately strong, medium-bloat.	Dark tan outside, cream inside, moderately, strong, medium bloat.	Dark tan outside, whitish gray inside, moderately strong, fine bloat.	Sample not recovered.
R-15 II	1800°F	Light brown outside, gray inside, moderately strong, medium bloat.	Light brown outside, pink gray inside, moderately strong, fine bloat.	Brown outside, blackish gray inside, fairly hard, well bloat.	Brown outside, gray and blackish gray inside, moderately strong, well bloat.
	1900°F	Dark brown outside, whitish gray inside, moderately strong, medium bloat.	Dark brown outside, blackish gray inside, moderately strong, medium bloat.	Dark brown outside, grayish black inside, fairly strong, well bloat, slightly sticks together.	Dark brown outside, pink gray inside, moderately strong, to weak, well to over bloat, sticks together.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
R-16	1800°F	Light red outside, gray inside, moderately strong, no bloat.	Blackish red outside, gray inside, moderately strong, no bloat.	Tan outside, gray inside, moderately strong, no bloat.	Tan outside, gray inside, moderately strong, well bloat.
	1900°F	Tan outside, pink gray inside, weak, well to over bloat, sticks together.	Tan outside, pink gray inside, weak well to over bloat, sticks together.	Tan outside, pink gray inside, moderately strong, over bloat, sticks together.	Dark tan pinkish gream inside, weak, over bloat, sticks together.
	2000°F	Dark tan outside, gray inside, weak, over bloat, fused together.	Dark tan outside, gray inside, weak, over bloat, fused together.		

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
R-17	1800°F	Brown red throughout, moderately strong, no bloat.	Reddish brown throughout, moderately strong, no bloat.	Reddish brown throughout, moderately strong, no bloat.	Tan outside, black inside, moderately strong, a little bloat.
	1900°F	Tan outside, black inside, inside, strong, no bloat.	Tan outside, grayish black inside, strong, a little bloat.	Tan outside, grayish black inside, strong, a little bloat.	Tan outside, black inside, strong, very fine bloat.
	2000°F	Tan outside, black inside, moderately strong, medium bloat.	Tan outside, black inside, moderately strong, medium bloat.	Dark tan outside, black inside, moderately strong, medium bloat.	Dark tan outside, black inside, moderately strong, fine to medium bloat.
R-19 II	1800°F	Light red throughout, weak, no bloat.	Light brown throughout, weak, no bloat.	Light brown outside, gray fairly hard, no bloat.	Brown outside, pink gray inside, fairly hard, medium bloat.
	1900°F	Light brown outside, grayish black inside, fairly hard, no bloat.	Light brown outside, black inside, fairly hard, very fine bloat.	Brown outside, black, inside, fairly hard, very fine, bloat.	Dark brown outside, black inside, fairly hard, medium bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Warapara area

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
W_1-3	1800°F	Red throughout, moderately strong, no bloat.	Red throughout, moderately strong, no bloat.	Brick red throughout moderately strong, no bloat.	Red outside, a few gray centre, moderately hard, some very fine bloat.
	1900°F	Tan outside, gray centre, fairly strong, ver fine bloat.	Tan outside, gray centre, fairly strong, very fine bloat.	Tan outside, gray centre, fairly strong, very fine bloat.	Tan outside, gray centre, fairly strong, fine bloat.
	2000°F	Dark red outside, gray inside, fairly strong, medium bloat.	Dark red outside, cream inside, fairly strong, medium bloat.	Dark brown outside, cream inside, fairly strong, medium bloat.	Dark brown outside, gray inside, fairly strong, medium bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
W_2-3	1800°F	Brick red throughout, moderately strong, no bloat.	Brick red throughout, moderately strong, no bloat.	Brick red throughout, moderately strong, no bloat.	Red outside, a few gray centre, moderately strong, a little bloat.
	1900°F	Tan outside, gray inside, strong, a little bloat.	Tan outside, gray inside, strong, very fine bloat.	No sample run.	Tan outside, gray inside, strong, fine bloat.
	2000°F	Dark cream outside, cream inside, moderately strong, medium bloat.	Dark tan outside, cream inside, moderately strong, fine bloat.	Tan outside, light creamy, gray inside, moderately strong, fine bloat.	Tan outside, a few gray inside, moderately strong, a little bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
W_3-3	1800°F	Brick red throughout, fairly hard, no bloat.	Brick red throughout, fairly hard, no bloat.	Brick red throughout, fairly hard, no bloat.	Light brown outside, gray inside, fairly hard, a little bloat.
	1900°F	Light brown outside, light gray inside, fairly hard, a little bloat.	Light brown outside, gray inside, fairly hard, very fine bloat.	Brown outside, gray inside, fairly hard, very fine bloat.	Brown outside, gray inside, fairly hard, fine bloat.
	2000°F	Light brown outside, gray inside, fairly hard, fine bloat.	Brown outside, gray inside, fairly hard, medium bloat.	Brown outside, gray inside, fairly hard, fine bloat.	Brown outside, gray inside, fairly hard, fine bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
W_4-3	1800°F	Brick red throughout, fairly strong, no bloat.	Dark red throughout, fairly strong, no bloat.	Dark red throughout, fairly strong, no bloat.	Dark red throughout, fairly strong, no bloat.
	1900°F	Light brown outside, light gray inside, fairly strong, a little bloat.	Brown outside, light gray inside, fairly strong, fine bloat.	Brown outside, gray inside, fairly strong, fine bloat.	Brown outside gray inside, fairly hard, fine bloat.
	2000°F	Brown outside, gray inside, fairly strong, fine bloat.	Brown outside, gray inside, fairly strong, medium bloat.	Dark brown outside, gray inside, fairly strong, medium bloat.	Dark brown outside, pink gray inside, weak well bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature. Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
W_5-3	1800°F	Brick red throughout, fairly strong, no bloat.	Brick red throughout, fairly strong, no bloat.	Brick red outside, some light gray centre. fairly strong, a little bloat.	Light brown outside, light gray centre, fairly strong, a little bloat.
	1900°F	Light brown outside, light gray inside, fairly strong, very fine bloat.	Light brown outside, light gray inside, fairly strong, very fine bloat.	Brown outside, gray inside, fairly strong, fine bloat.	Brown outside, gray inside, fairly strong, fine bloat.
	2000°F	Brown outside, gray centre, fairly strong, medium bloat.	Dark brown outside, gray centre, fairly strong, medium bloat.	Dark brown outside, gray inside, fairly strong, medium bloat.	Dark brown outside, pink gray inside, weak, well bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
		Nasirabad area			
N-1	1800°F	Light red outside, gray inside, moderately strong, no bloat.	Light red outside, gray inside, moderately strong, trace of fine bloat.	Light red outside, gray inside, moderately strong, fine bloat.	Light red outside, gray inside, moderately strong, fine bloat.
	1900°F	Light brown outside, gray inside, moderately strong, a few bloat.	Dark brown outside, pink gray inside, weak, over bloat, sticks together.	Dark brown outside, pink gray inside, weak, well to over bloat.	no sample run.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
N-2 [a]	1800°F	Light red outside, light gray inside, moderately strong, no bloat.	Light red throughout, moderately strong, no bloat.	Red throughout moderately strong, no bloat.	Brown outside, gray inside, moderately strong, no bloat.
	1900°F	Light brown outside, pink gray inside, fairly strong, fine bloat.	Brown outside, pink gray inside, strong, medium bloat.	Dark brown outside, pink gray inside, fairly strong, well bloat.	Dark brown outside, pink gray inside fairly strong, well bloat.
	2000°F	Brownish gray outside, pink gray to gray inside, weak, over bloat, sticks together.	Brownish gray outside, pink gray to gray inside weak, over bloat, sticks together.	No sample run.	No sample run.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
N-2Ib	1800°F	Light red outside, a little gray inside, no bloat.	Light red throughout, no bloat.	Dark red outside, gray inside, a little bloat.	Light brown outside, gray inside, fairly hard, no bloat.
	1900°F	Red brown outside, gray inside, fairly hard, no bloat.	Light brown outside, gray inside, fairly hard, fine bloat.	Light brown outside, gray inside, fairly hard, fine bloat.	Reddish brown outside, gray inside, fairly hard, very fine bloat.
	2000°F	Dark brown outside, blackish gray inside, fairly hard, medium bloat.	Dark brown outside, blackish gray inside, fairly hard, medium bloat.	Dark brown outside, pink gray inside, fairly hard, well bloat.	Dark brown outside, gray inside, hard, medium bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
N-3	1800°F	Light red outside, gray inside, moderately strong, no bloat.	Light red outside, gray inside, moderately strong, some fine bloat, shatters.	Light red outside, gray trace inside, trace of fine bloat, shatters.	Light red throughout, no bloat, shatters.
	1900°F	Brown outside, gray inside, strong, fine bloat, shatters.	Light brown outside, gray inside, strong, medium bloat, shatters.	Reddish brown throughout, strong, no bloat, shatters.	Light brown outside, pink gray inside, strong, medium bloat.
	2000°F	Brown outside, black inside, weak, over bloat, sticks together.	No sample run.	No sample run.	No sample run.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
N_4-3	1800°F	Light red throughout, fairly hard, no bloat.	Light red throughout, fairly hard, no bloat.	Red outside, light gray inside, fairly hard, a little bloat.	Red outside, gray inside, fairly hard, fine bloat.
	1900°F	Brown outside, gray inside, fairly hard, fine bloat.	Brown outside, gray inside, fairly hard, fine bloat.	Brown outside, pink gray inside, fairly hard, medium bloat.	Brown outside, pink gray inside, fairly hard, medium bloat.
	2000°F	Dark brown outside, pink gray inside, fairly hard, medium bloat.	Dark brown outside, pink gray inside, fairly hard, well bloat.	Dark brown outside, pink gray inside, weak, well to over bloat, slightly sticks together.	Dark brown outside, pink gray inside, weak, over bloat, sticks together.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
N-5	1700°F	Light brown outside, Light gray inside, moderately strong, no bloat.	Brown outside, gray inside, moderately strong, no bloat.	Brown outside, gray inside, moderately strong, no bloat.	Brown outside, gray inside, moderately strong, no bloat.
	1800°F	Brown outside, gray inside, moderately strong, some fine bloat.	Brown outside, gray inside, moderately strong, fine bloat.	Brown outside, gray inside, moderately strong, fine bloat.	Brown outside, gray inside, moderately strong, fine to medium bloat.
	1900°F	Brown outside, gray inside, moderately strong, fine to medium bloat.	Brown outside, gray inside, hollow centre, moderately strong, medium bloat.	Dark brown outside, pink gray inside, weak, well to over bloat.	Dark brown outside, pink gray inside, weak, over bloat, sticks together.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
N-6	1800°F	Light red outside, some gray inside, weak, no bloat, shatters.	Light red throughout, weak, no bloat, shatters.	Light red throughout, weak, no bloat, shatters.	Light red outside, some gray inside, weak, some fine bloat, shatters.
	1900°F	Dark red outside, gray inside, moderately strong, some very fine bloat.	Brown outside, gray inside, moderately strong, fine bloat.	Brown outside, gray inside, moderately strong, fine bloat.	Brown outside, light brown inside, moderately strong, no bloat.
	2000°F	Brown outside, pink gray inside, weak, to moderately strong, over bloated outside, fine to medium bloat, inside, sticks together.	No sample run.	No sample run.	No sample run.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Bhatiari area

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
Bh-1	1800°F	Reddish brown outside, gray inside, moderately strong, fine bloat.	Brown outside, gray inside, moderately strong, fine to medium bloat.	Brown outside, gray inside, moderately strong, medium bloat.	Tan outside, gray inside, moderately strong, medium bloat.
	1900°F	Brown outside, pink gray inside, moderately strong, well bloat.	Light brown outside, pink gray inside, moderately strong, medium bloat.	Dark brown outside, pink gray inside, moderately strong, well bloat, begins sticking.	Dark brown outside, pink gray inside, weak, well to to over bloat, sticks together.
Bh-2	1800°F	Light brown outside, gray inside, not hard, no bloat shatters.	Light brown outside, gray inside, not hard, very fine bloat, shatters.	Light brown-outside, gray inside, not hard, fine bloat, shatters.	Light brown outside, gray inside, moderately hard, medium bloat.
	1900°F	Reddish brown outside, gray inside, moderately hard, fine bloat.	Light brown outside,pink gray inside, moderately hard, medium bloat.	Brown outside, pink gray inside, moderately hard, medium bloat.	Brown outside, pink gray inside, moderately hard, well bloat.
	2000°F	Brown outside, pink gray inside, not hard, well bloat, sticks together.	Brown outside, pink gray inside, weak, well to over bloat, sticks together.	No sample run.	No sample run.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
Bh-3	1800°F	Light brown outside, gray inside, weak, very fine bloat, shatters.	Light brown outside, gray inside, weak, a little bloat, shatters.	Light brown outside, gray inside, weak, very fine bloat, shatters.	Brown outside, gray inside, weak, fine bloat, shatters.
	1900°F	Reddish brown outside, pink gray inside, moderately hard, fine bloat.	Light brown outside, pink gray inside, moderately hard, medium bloat.	Brown outside, greenish gray inside, moderately hard, fine bloat.	Brown outside, pink gray inside, moderately hard, well bloat.
	2000°F	Brown outside, pink gray inside, moderately hard, well bloat.	Brown outside pink gray inside, weak well to over bloat, sticks together.	No sample run.	No sample run.
Bh-4	1800°F	Light brown outside, gray inside, weak trace bloat shatters.	Light brown outside, gray inside, weak trace bloat shatters.	Brown outside, gray inside, moderately hard, very fine bloat, shatters.	Brown outside, gray inside, moderately hard, fine to medium bloat, shatters.
	1900°F	Light brown outside, greenish gray inside, moderately hard, fine bloat.	Light brown outside greenish gray inside, moderately hard, medium bloat.	Light brown outside, pink gray inside, moderately hard, fine bloat.	Brown outside, pink gray inside, moderately hard, medium bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
Bh-5	1800°F	Light brown outside, gray inside, moderately hard, fine bloat.	Light brown outside, gray inside, moderately hard, medium bloat.	Light brown outside, gray inside, moderately hard, very fine bloat.	Brown outside, gray inside, moderately hard, well bloat.
	1900°F	Brown outside, pink gray inside, weak to moderately hard well to over bloat.	Brown outside, pink gray inside, weak, over bloat, sticks together.	Brown outside, pink gray inside, weak, over bloat, sticks together.	Brown outside, pink gray inside, weak to moderately hard, well to over bloat, sticks together.
Bh-6	1800°F	Light brown outside, gray inside, strong fine bloat.	Light brown outside, gray inside, strong, fine to medium bloat.	Brown outside, gray inside, strong, medium medium bloat.	Brown outside, gray inside, moderately strong, medium bloat.
	1900°F	Brown outside, pink gray inside, weak, well to over bloat, sticks together.	Brown outside, pink gray inside, weak, over bloat, sticks together.		

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
Bh_7-3	1800°F	Brown outside, pink gray, inside, fairly hard, fine bloat.	Brown outside, pink gray inside, fairly hard, fine bloat.	Brown outside, pink gray inside, fairly hard, medium bloat.	Brown outside, light gray centre, fairly hard, fine bloat.
	1900°F	Brown outside, pink gray inside, fairly hard, medium bloat.	Dark brown outside, pink gray inside, fairly hard, well bloat.	Dark brown outside, pink inside, fairly hard, medium bloat.	Dark brown outside, black inside, fairly hard, fine to medium bloat.
Bh_8-3	1800°F	Light brown outside, gray inside, fairly hard, no bloat.	Brown outside, light gray inside, fairly hard, fine bloat.	Brown outside, gray inside, fairly hard, fine bloat.	Dark brown outside, pink gray inside, fairly hard, fine bloat.
	1900°F	Brown outside, light gray inside, fairly hard, fine bloat.	Dark brown outside, light pink inside, fairly hard, medium bloat.	Dark brown outside, grayish pink inside, fairly hard, well bloat.	Dark brown outside, whitish pink inside, fairly hard, well bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
Bhg-3	1800°F	Light brown outside, pink gray fairly hard, very fine bloat.	Brown outside, pink gray inside, fairly hard, very fine bloat.	Brown outside, pink gray inside, fairly hard, fine bloat.	Brown outside, pink gray inside, fairly fine bloat.
	1900°F	Light brown outside, grayish pink inside, fairly hard, very fine bloat.	Brown outside, grayish pink inside, fairly hard, medium bloat.	Dark brown outside, whitish pink inside, fairly hard, medium bloat.	Brown outside, whitish gray inside, fairly hard, medium bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
Bh_{10}-3	1800°F	Light brown outside, gray inside, fairly hard, a little bloat.	Light brown outside, gray inside, fairly hard, very bloat.	Brown outside, pink gray inside, fairly hard, fine bloat.	Brown outside, pink gray inside, fairly hard, fine bloat.
	1900°F	Light brown outside, pink gray inside, fairly hard, fine bloat.	Brown outside, pink gray inside, fairly hard, medium bloat.	Dark brown outside, pink inside, fairly hard, medium bloat.	Dark brown outside, pink inside, fairly hard, well bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
Sh_{11}-3	1800°F	Brownish red outside, gray inside, moderately strong, very fine bloat.	Brownish red outside, gray inside, moderately strong, a few bloat.	Brick red outside, gray inside, moderately strong, no bloat.	Brown outside, gray inside, moderately strong fine bloat.
	1900°F	Reddish brown outside, gray inside, moderately strong, fine to medium bloat.	Tan outside, pink gray inside, moderately strong, well bloat.	Tan outside, pink gray inside, moderately strong, well bloat.	Tan outside, dark gray inside, moderately strong, well bloat.
	2000°F	Tan outside, pink gray inside, weak, over bloat, begins sticking.	Tan outside, pink gray inside, weak, over bloat, sticks together.	Tan outside, pink gray inside, weak, well to over bloat, sticks together.	Tan outside, pink gray inside, well to over bloat, sticks together.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
Bh_{12}-3	1800°F	Light brown outside, gray inside, moderately strong, no bloat.	Light brown outside, gray inside, moderately strong, a little bloat.	Brown outside, gray inside, moderately hard, fine bloat.	Brown outside, gray inside, moderately strong, fine bloat.
	1900°F	Dark brown outside, pink gray inside, moderately hard, fine bloat.	Dark brown outside, pink gray inside, moderately strong, medium bloat.	Dark brown outside, pink inside, moderately strong, well bloat.	Dark brown outside, light pink inside, fairly hard, well bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature-Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
Bh_{13}-3	1800°F	Light brown outside, gray inside, fairly hard, some very fine bloat.	Light brown outside, gray inside, fairly hard, very fine bloat.	Brown outside, gray inside, fairly hard, fine bloat.	Brown outside, gray inside, fairly hard, fine bloat.
	1900°F	Brown outside, gray inside, fairly hard, fine bloat.	Brown outside, pink gray inside, fairly hard, medium bloat.	Dark brown outside, pink gray, inside, fairly hard well bloat.	Dark brown outside, pink gray inside, fairly hard medium bloat.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Ghoramara area					
Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
G-1	1800°F	Brick red outside, gray centre, moderately hard, no bloat.	Brick red outside, gray centre, moderately hard, very little bloat.	Tan outside pink gray inside, moderately hard, well bloat.	Tan outside pink gray inside, moderately hard, medium bloat.
	1900°F	Dull red outside, Moderately hard no bloat.	Dark tan outside, moderately hard medium bloat.	Tan outside, gray inside, hard, a little bloat.	Dark tan outside, gray inside, not strong, well to over bloat.
	2000°F	Dark tan outside, gray inside, fairly hard, fine to well bloat.	Dark tan outside, gray inside, weak, well to over bloat.	Blackish brown outside, pink gray, inside, over bloat, sticks together	Blackish brown outside, pink gray, inside, over bloat strongly sticks together.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
G-2	1800°F	Brick red outside, gray inside, strong, no bloat.	Brick red outside, gray inside, strong, no bloat.	Tan red outside gray inside, moderately a few little bloat.	Tan red outside gray inside, moderately very fine bloat.
	1900°F	Brick red outside, pinkish gray, inside, fairly strong, no bloat.	Tan outside, pink gray inside, fairly strong, well bloat.	Tan outside, pink gray inside, fairly strong, well bloat.	Tan outside, pink gray inside fairly strong, well bloat.
	2000°F	Dark tan outside pink gray inside, fairly strong, mostly well bloat.	Blackish brown outside, pink gray inside, weak, over bloat, strongly sticks together	Blackish brown outside, pink gray inside, weak, over bloat, strongly sticks together	Blackish brown outside, pink gray inside, weak, over bloat, strongly sticks together.
G-3	1800°F	Brick red outside, gray inside, fairly strong, no bloat.	Brick red outside, gray inside, fairly strong, no bloat.	Tan outside, gray inside, fairly strong, no bloat.	Tan outside, gray inside, fairly strong, well bloat.
	1900°F	Brick red outside, gray inside, fairly strong, a few well bloat.	Tan outside, pinkish gray inside, fairly strong, well to over bloat, sticks crucible.	Dark tan outside, pinkish gray inside, fairly strong, well bloat, sticks crucible.	Dark tan outside, pinkish gray inside, weak over bloat, sticks together.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
G-4	1800°F	Light red outside, light gray inside, moderately strong, no bloat.	Light red outside, light gray inside, moderately strong, no bloat.	Light red outside, gray inside moderately strong, no bloat.	Light brown outside, gray inside, moderately strong, no bloat.
	1900°F	Light red outside, moderately strong, no bloat.	Red outside, gray inside, moderately strong, a little bloat.	Red outside, gray inside, moderately strong, fine bloat.	Light brown outside, gray inside, moderately strong, bloated.
	2000°F	Light brown outside, pink gray inside, fairly strong, well bloat.	Brown outside, pink gray inside, weak, over bloat, sticks together.	Blackish brown outside, pink gray inside, weak, over bloat, sticks together	Blackish brown, outside, pink gray, inside, weak, over bloat, strongly sticks together.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
G-5	1800°F	Light red outside, light gray inside, moderately strong. no bloat.	Light red outside, light gray inside, moderately strong. no bloat.	Light red outside, gray inside, moderately strong, no bloat	Red outside gray inside, moderately strong no bloat.
	1900°F	Red outside, gray inside, moderately strong, no bloat.	Red outside, gray inside, moderately strong, a little bloat.	Tan outside, pink gray, inside, moderately strong, well bloat.	Dark tan outside, pink gray inside, moderately strong, well bloat.
	2000°F	Light brown outside, gray inside, moderately strong, a little bloat.	Brown outside pink gray inside, moderately strong well bloat.	Blackish brown outside, pink gray inside weak, over bloat strongly sticks together.	Blackish brown outside pink gray inside, weak, over bloat sticks together.

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
G-6	1800°F	Light red outside, Light gray inside, moderately strong, no bloat.	Light red outside light gray inside moderately strong, no bloat	Light red outside, light gray inside, moderately strong, no bloat.	Light brown outside, gray inside, moderately strong, no bloat.
	1900°F	Light red outside, gray inside, moderately strong, no bloat.	Light red outside, gray inside, moderately strong, a little bloat.	Red outside gray inside, moderately strongm very fine bloat.	Red outside, gray inside, moderately strong, fine bloat.
	2000°F	Light brown outside, pink gray inside, moderately strong, bloated.	Blackish brown outside, pink gray inside, weak, over bloat, sticks together.	Blackish brown outside, pink gray inside, weak, over bloat, sticks together.	Tan outside, pink gray inside, very weak, over bloat, strongly sticks together

Table 2. Quick-firing tests of samples from Chittagong and Chittagong Hill Tracts (continued)

Sample number	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
G-7	1800°F	Light red outside, light gray inside, fairly strong, no bloat.	Light red outside, light gray inside, fairly strong, no bloat.	Red outside, gray inside fairly strong, a little bloat.	Red outside, gray inside, fairly strong, fine bloat.
	1900°F	Light red outside, gray inside, moderately strong, fine bloat.	Brown outside, pink gray inside, moderately strong, well bloat.	Brown outside, gray inside, moderately strong, well bloat.	Dark brown outside, pink gray inside, moderately strong, well to over bloat.
G-8	1800°F	Light red outside, light gray inside, moderately strong, no bloat.	Light red outside, light gray inside, moderately strong, no bloat.	Light brown outside, gray inside, moderately strong, a little bloat.	Light brown outside, gray inside, moderately strong, fine bloat.
	1900°F	Light red outside, gray inside, moderately strong, fine bloat.	Dark brown outside, pink gray inside, moderately strong, medium bloat.	Brown outside, pink gray inside, weak, over bloat sticks together	Brown outside, pink gray inside, very weak, over bloat, strongly sticks together.

Reserves

Reserve estimates (in cubic yards) are given for the Rangunia, Warapara, and the Bhatiari areas (table 3) on the basis that 1 cubic yard of raw material would produce 1 cubic yard of expanded aggregate. The areal extent of favorable material was scaled from figure 2, and the average depth of holes augered in a particular area was used to estimate cubic yardage. Undoubtedly the reserves could be increased both in depth and laterally by further exploration because auger holes and pits were generally completed in clay, and area boundaries were not established laterally.

Table 3.--Reserves of raw material for Rangunia, Warapara, and Bhatiari areas.

Area	Dimensions (yards)			Volume
	Length	Width	Depth	(cubic yards)
Rangunia	4000	2400	3	28,800,000
Warapara	1400	1200	3	5,040,000
Bhatiari	1400	1200	3	5,040,000

A commercial plant producing 1000 cubic yards per day of lightweight aggregate, and operating 330 days per year would require 330,000 cubic yards of raw material per year. A 20-year clay reserve would require 6,600,000 cubic yards of proven reserves. On this basis, the Rangunia area would have reserves for 87 years, and the Warapara and Bhatiari areas for approximately 15 years each. It should be kept in mind that the entire amounts estimated may not be minable owing to encroachment of village sites or other cultural features; however, there is no doubt that sufficient reserves can be confirmed for a commercial plant; almost certainly these areas can be extended, and other areas containing bloatable materials can be found.

No attempt has been made to give a firm figure as to cubic yardage available for the areas of sampled shale and claystone outcrop. As we were not attempting to pinpoint a definite plant location, the great amount of preliminary trail cutting and clearing that would be needed in the thick jungle growth was not justified in the time available. However, as the character of such shale and claystone beds normally would not be expected to change abruptly, it can be assumed that most bloatable material exists over a large area, and that further exploration would prove ample reserves.

Exploitation

The areas explored in the vicinity of Chittagong, although subject to heavier annual rainfall than the vicinity of Dacca, have better natural drainage and would not be subject to flooding during the monsoon season. An exception might be the possible flooding of the Warapara area by the Halda River or by high storm tides from the sea at Bhatiari.

Shale or claystone may have some processing advantages over clay in making light-weight aggregate because they can be crushed and screened to the appropriate size for kiln feed without the complications of pelletizing required for clay.

The countryside in the area of shale and claystone outcrops is generally thinly populated and most of it is hilly and brush- or jungle-covered. The clay in the vicinities of Rangunia, Warapara, and Bhatiari is in agricultural land, and these areas are densely populated.

The desirable next step prior to a full-scale commercial operation is evaluation of these materials by establishing a standard method of rotary-kiln processing through use of a pilot kiln. The information secured by pilot-kiln testing is necessary to design a full-size commercial installation and operating procedure. Pilot-kiln testing will determine the following variables: kiln slope, rate of feed, retention time, kiln speed, required draft, type of flame (oxidizing, reducing, natural), range of bloating temperatures, and processing qualities such as agglomeration, adherence to the kiln, decrepitation, etc.

In addition, the proper blending of different clay, claystone, or shale materials to produce an optimum product can be determined. Sufficient aggregate can also be produced to test such characteristics as weight per cubic foot, crushing strength, water absorbtion for mix design, or other desired tests.

Although no pilot-kiln facilities exist in East Pakistan at the present time, a kiln has been fabricated and is in experimental operation in Lahore, West Pakistan. This kiln was designed, fabricated, and operated through the mutual cooperation of the Building and Road Research Laboratory, Lahore, and Packages Ltd. The kiln is located on the plant grounds of Packages Ltd., on Ferozpore Road, east of Lahore.

The Lahore kiln is 15 feet long and has an internal diameter of 12 inches, expanding to 20 inches at the discharge end. It is fired with gas; temperatures are determined with an optical pyrometer. It is the author's understanding that this kiln facility will be available to other government agencies or private industry for test work in cooperation with the operators. Advantage should be taken of this opportunity to further evaluate deposits by pilot-kiln work and generally increase knowledge of the light-weight aggregate industry.

As an alternative, samples could be shipped abroad to pilot-kiln facilities, or a kiln similar to the kiln in Lahore could be built at Dacca. Samples for shipment abroad would require approximately 4 cubic yards per sample.

Cost estimates for the construction of a full-scale commercial light-weight aggregate plant cover a wide range. The variables and alternatives are numerous; materials range from a clay that must be pelletized to shale that could be crushed and screened as kiln feed. Two or more smaller kilns are favored by some operators over a single large one. The purchase of a used kiln in good condition would be a considerable saving, as would other used equipment, such as conveyors, and fabrication locally of equipment items when possible. In a country of abundant cheap labor, the merit of mining the clay or shale by hand as compared to the foreign exchange purchase and operating cost of a dragline or slack-line scraper deserves consideration.

Investigations in the Dacca area

Geology

The areas investigated in the vicinity of Dacca (fig. 5) are underlain in part by Holocene flood plane alluvium and in part by Pleistocene sediments. The Mirpur, Sabhar, and Tungi areas are in Pleistocene deposits, whereas the Panchabati, Philkuni, and Demra areas are on the flood plain. Late Pleistocene sediments were also encountered in some auger holes.

Pleistocene deposits

The Madhupur Clay is regarded as a highly weathered flood plain deposit of the earlier Ganges, Brahmaputra, and Meghra River systems, and it is of Pleistocene age. It forms very low hills in the Sabhar area and in most places in the Mirpur and Tungi areas underlies a mantle a few inches to a few feet thick of Holocene sediments. It stands topographically above the level of present active flood plains in the Sabhar and Tungi areas.

Material eroded from the Madhupur Clay has been transported and redeposited in some places. Thus, in auger holes numbers A_5, A_6, A_7, C_6, C_{12}, C_{13}, C_{14}, C_{15}, C_{19}, and C_{20}, in the Panchabati and Demra areas, reworked material believed to be from the Madhupur Clay has been observed.

Clay is the chief constituent of the Madhupur, although clayey silt is common. The clay is bluish gray, whitish gray, yellowish gray and yellowish brown to dark brown and red; ferruginous nodules are randomly distributed through it. Organic material is confined to the surface soil profile. When wet, the clay becomes very sticky; when dry, it becomes very hard and feels soapy. The maximum thickness penetrated in the auger holes was 16 feet, but the Madhupar is undoubtedly much thicker.

Results of analyses of seven samples of Madhupur Clay from different localities in East Pakistan are as follows: SiO_2, 59.88 to 77.40 percent; R_2O_3[1/], 20.20 to 36.00 percent; Fe, 3.34 + 8.90 percent; $CaCO_3$, 1 to 2 percent, and Na plus K, 1.50 + 3.60 percent (Khan, 1962).

1/ R_2O_3= Al_2O_3, Fe_2O_3, and traces TiO_2.

Holocene flood-plain deposits

Holocene flood-plain deposits cover the Panchabati, Philkuni, and Demra areas except near auger holes A_5, A_6, A_7, A_8, C_{12}, C_{13}, C_{14}, C_{15}, C_{19}, and C_{20}. They are also found in the Mirpur and Sabhar areas in auger holes number M_2 and S_3 respectively. These sediments were deposited on the eroded surface of Pleistocene material. The Holocene sediments are typically dark, loosely compacted, and have a moderate water content and an appreciable quantity of organic material. The Holocene sediments penetrated by the auger holes are generally divisible into three distinct beds, as follows:

Bed 1: Clayey silt is the main material comprising this bed, and the color ranges from light gray to yellowish gray. The silt is loosely compacted and contains humus; thickness ranges from 0.2 to 4.0 feet.

Bed 2: Bed 2 is mainly clayey silt; the color ranges from yellow to brownish yellow. The bed is loosely compacted and contains abundant yellowish-brown ferruginous material. Root openings and small decayed wood particles are also found. Thickness of the bed ranges from 2.5 to 12.5 feet.

Bed 3: Bed 3 is mainly silty clay, but in some holes it is clay. Very fine grained bluish-gray silty sand is found at the bottom of this bed in holes C_2 and C_4. The thickness of the bed ranges from 5 to 18 feet. The bed contains small buff-colored ferruginous pisolites; partly decomposed wood trunks and small rotten wood particles are randomly distributed. Vegetal matter of brownish-black color is concentrated locally. The clay has a soapy feel.

Field and laboratory procedure

Four reconnaissance auger holes were drilled in the Panchabati area, two in the Aliganj area, three in the Demra area, two in the Mirpur area, three in the Sabhar area, and one in the Tungi area. The depths of the auger holes range from 11 to 26.6 feet. Samples from the reconnaissance holes were tested for bloating characteristics in a muffle furnace. The areas of samples that bloated in these initial tests were considered favorable for further study by additional auger hole drilling.

The three most favorable areas, Panchabati, Philkuni, and Demra, are referred to herein as Area A, B, and C, respectively. In area A the auger holes are spaced from 670 to 1,680 feet apart. The minimum and maximum spacing between adjacent holes in Area B was 1,350 and 2,365 feet, respectively. The spacing in Area C was greater; the distance between two holes is about 3,380 feet. All the auger holes drilled in Areas A, B, and C are shown on figure 5. In all, 12 auger holes were drilled in Area A, 7 in Area B, and 22 in Area C (including the reconnaissance drill holes). The depth of auger holes ranges from 13.5 to 21 feet in Area A, 16 to 26.6 feet in Area B, and 11 to 23.5 feet in Area C. The total footage of the auger holes of Area A, B, and C is 184, 147, and 350 feet, respectively. The auger holes were drilled manually; logs are given in table 4.

Sampling methods

Samples were taken from the reconnaissance auger holes in areas of Holocene clay deposits. Because of the relative thinness of Bed 1, and as much of it would be spoiled preparatory to mining, Bed 1 and Bed 2 were sampled as a single unit, predominantly yellow in color, and designated Sample 1. Bed 3 or gray organic clay was sampled separately and designated Sample 2. In reconnaissance holes where the clay deposit appeared to be uniform and was of Pleistocene age, only a single composite sample was taken; it represented the entire section for furnace testing. Distribution of samples according to geologic age and lithologic units is shown in table 4.

The sample numbering system is tied to the geographic area; the letter A designates Area A as referred to herein; the letter T indicates the holes in the vicinity of Tungi; M indicates Mirpur and S indicates Sabhar. A_1 means hole 1 in Area A. A_1 followed by a dash and the number 1, 2, or 3 (A_1-1) indicates the sample within that hole. A_1-1 is a sample from Bed 1; A_1-2 is from Bed 2; A_1-3 is a composite sample from Bed 1 and Bed 2 in areas of Holocene clays, or a single composite sample representing the entire section in areas of Pleistocene clays (see table 4).

Table 4. Description of auger-hole samples, Dacca area.

Auger hole no.	Sample no.	Depth of sample (in feet)	Description of sample	Age
			Tungi area	
T_1	T_1-3	0.0 - 0.5	Silty clay, grayish yellow	Pleistocene
		0.5 - 3.5	Silty clay, yellowish brown	
		3.5 - 7.2	Silty clay, brownish yellow	
		7.2 - 8.0	Silty clay, reddish brown	
		8.0 - 12.0	Silty clay, brownish yellow	
			Sabhar area	
S_2	S_2-3	0.0 - 4.0	Silty clay, red	Do.
		4.0 - 13.0	Clay, white and reddish brown mottled	
			Mirpur area	
M_1	M_1-3	0.0 - 0.3	Clay silt, whitish gray	Do.
		0.3 - 4.3	Clay, chocolate colored	
		4.3 - 6.8	Clay, light chocolate color	
		6.8 - 11.0	Silty clay, brownish chocolate	

Table 4. Description of auger-hole samples, Dacca area (continued)

Auger hole no.	Sample no.	Depth of sample (in feet)	Description of sample	Age
		Panchabati, Area A		
A_2	A_2-1	0.0 - 2.0	Clayey silt, yellowish gray	Holocene
		2.0 - 7.5	Clayey silt, light yellow	
	A_2-2	7.5 - 21.0	Silty clay, bluish gray	
	A_2-3	Composite sample of A_2-1 and A_2-2		
A_4	A_4-1	0.0 - 3.5	Silt, yellowish gray and grayish yellow	Do.
		3.5 - 4.0	Clayey silt, yellowish gray	
		4.0 - 6.0	Silt, yellow	
		6.0 - 8.0	Clayey silt, brownish yellow	
		8.0 - 8.5	Clayey silt, light grayish yellow	
	A_4-2	8.5 - 11.0	Clayey silt, grayish blue	
		11.0 - 21.0	Silty clay, grayish blue	
	A_4-3	Composite of A_4-1 and A_4-2		
A_5	A_5-1	0.0 - 2.5	Clayey silt, gray	Pleistocene
		2.5 - 5.2	Clayey silt, yellowish gray	
		5.2 - 8.5	Silty clay, brownish yellow	
	A_5-2	8.5 - 13.5	Clay, chocolate	
	A_5-3	Composite of A_5-1 and A_5-2		

Table 4. Description of auger-hole samples, Dacca area (continued)

Auger hole no.	Sample no.	Depth of sample (in feet)	Description of sample	Age
		Panchabati, Area A (cont'd)		
A_6	A_6-1	0.0 - 4.3	Clayey silt, yellowish gray	Pleistocene
		4.3 - 9.0	Clayey silt, yellow	
	A_6-2	9.0 - 13.5	Clay, chocolate	
	A_6-3	Composite of A_6-1 and A_6-2		
A_7	A_7-1	0.0 - 4.0	Clayey silt, yellowish gray	Do.
		4.0 - 7.5	Clayey silt	
	A_7-2	7.5 - 13.5	Clay, chocolate	
	A_7-3	Composite of A_7-1 and A_7-2		
A_8	A_8-1	0.0 - 3.5	Clayey silt, gray to yellowish gray	Do.
		3.5 - 6.0	Silty clay, yellowish brown	
		6.0 - 7.5	Clay, light chocolate	
	A_8-2	7.5 - 16.0	Clay, yellowish gray	
	A_8-3	Composite of A_8-1 and A_8-2		
A_9	A_9-1	0.0 - 1.0	Clayey silt, light gray	Holocene
		1.0 - 4.0	Clayey silt, light yellow	
		4.0 - 5.0	Clayey silt, blackish gray	
		5.0 - 5.5	Clayey silt, light yellowish gray	

Table 4. Description of auger-hole samples, Dacca area (continued)

Auger hole no.	Sample no.	Depth of sample (in feet)	Description of sample	Age
		Panchabati, Area A (cont'd)		
A_9	A_9-2	5.5 - 8.5	Silty clay, grayish black	Holocene
		8.5 - 16.0	Silty clay, grayish blue	
	A_9-3	Composite of A_9-1 and A_9-2		
A_{10}	A_{10}-1	0.0 - 0.3	Clayey silt, gray	Do.
		0.3 - 2.9	Clayey silt, yellow	
		2.9 - 3.4	Clayey silt, blackish gray	
		3.4 - 6.4	Clayey silt, yellow	
	A_{10}-2	6.4 - 12.4	Clayey silt, grayish blue	
		12.4 - 13.8	Clay, grayish black, carbonaceous	
		13.8 - 18.5	Silty clay, gray	
		18.5 - 21.0	Clay, blackish gray	
	A_{10}-3	Composite of A_{10}-1 and A_{10}-2		
A_{11}	A_{11}-1	0.0 - 0.5	Silty clay, gray	Do.
		0.5 - 1.7	Clayey silt, gray and yellow	
		1.7 - 6.2	Clayey silt, yellowish brown	
	A_{11}-2	6.2 - 10.0	Clayey silt, greenish blue	
		10.0 - 10.3	Clay, blackish gray, carbonaceous	
		10.3 - 17.0	Silty clay, ash gray	
	A_{11}-3	Composite of A_{11}-1 and A_{11}-2		

Table 4. Description of auger-hole samples, Dacca area (continued)

Auger hole no.	Sample no.	Depth of sample (in feet)	Description of sample	Age
		Panchabati, Area A (cont'd)		
A_{12}	A_{12}-1	0.0 - 0.5	Silty clay, gray	Holocene
		0.5 - 1.7	Clayey silt, gray and yellow	
		1.7 - 11.0	Clayey silt, yellow	
	A_{12}-2	11.0 - 11.5	Silty clay, blackish gray, carbonaceous	
		11.5 - 15.6	Clayey silt, grayish blue	
		15.6 - 16.0	Silty clay, blackish gray, carbonaceous	
	A_{12}-3	Composite of A_{12}-1 and A_{12}-2		
		Philkuni, Area B		
B_{-1}	B_1-1	0.0 - 2.5	Clayey silt, gray to yellowish gray	Do.
		2.5 - 5.0	Silt, yellow to brownish yellow	
		5.0 - 5.8	Silty clay, blackish gray	
		5.8 - 10.1	Silt, yellow to brownish yellow	
		10.1 - 10.8	Clayey silt, blackish gray	
		10.8 - 14.1	Clayey silt, brownish yellow	

Table 4. Description of auger-hole samples, Dacca area (continued)

Auger hole no.	Sample no.	Depth of sample (in feet)	Description of sample	Age
		Philkuni, Area B (cont'd)		
$B-_1$	B_1-2	14.1 - 14.6	Clay, carbonaceous, black	Holocene
		14.6 - 24.1	Clay, bluish gray	
		24.1 - 26.6	Clay, light yellow to yellow	
	B_1-3	Composite of B_1-1 and B_1-2		
$B-_2$	B_2-1	0.0 - 3.0	Clayey silt, gray	Do.
		3.0 - 3.5	Silty clay, yellowish gray	
		3.5 - 9.0	Clayey silt, yellow	
	B_2-2	9.0 - 11.5	Clayey silt, grayish blue	
		11.5 - 14.7	Silty clay, dark gray	
		14.7 - 21.0	Clay, blackish gray, carbonaceous	
	B_2-3	Composite of B_2-1 and B_2-2		
$B-_3$	B_3-1	0.0 - 1.0	Clayey silt, light gray	Do.
		1.0 - 8.5	Clayey silt, yellow to brownish yellow	
		8.5 - 13.5	Silty clay, brownish yellow	
	B_3-2	13.5 - 18.5	Clay, blue and brown	
	B_3-3	Composite of B_3-1 and B_3-2		

Table 4. Description of auger-hole samples, Dacca area (continued)

Auger hole no.	Sample no.	Depth of sample (in feet)	Description of sample	Age
		Philkuni, Area B (cont'd)		
B-4	B_4-1	0.0 - 1.2	Clayey silt, gray	Holocene
		1.2 - 4.0	Clayey silt, gray and yellow	
		4.0 - 8.5	Clayey silt, yellow to brownish yellow	
	B_4-2	8.5 - 11.0	Clayey silt, grayish blue	
		11.0 - 13.5	Clay, black to grayish blue	
		13.5 - 21.0	Silty clay, gray to bluish gray	
	B_4-3	Composite of B_4-1 and B_4-2		
B-5	B_5-1	0.0 - 1.2	Clayey silt, gray	Do.
		1.2 - 3.5	Clayey silt, grayish yellow	
		3.5 - 7.0	Clayey silt, yellow	
	B_5-2	7.0 - 13.5	Clayey silt, dark gray	
		13.5 - 14.0	Silty clay, dark gray, carbonaceous	
		14.0 - 21.0	Silty clay, gray to bluish gray	
	B_5-3	Composite of B_5-1 and B_5-2		

Table 4. Description of auger-hole samples, Dacca area (continued)

Auger hole no.	Sample no.	Depth of sample (in feet)	Description of sample	Age
		Philkuni, Area B (cont'd)		
B_6	B_6-1	0.0 - 0.5	Clayey silt, gray	Holocene
		0.5 - 4.0	Clayey silt, dark gray	
		4.0 - 6.0	Clayey silt, light yellow	
		6.0 - 6.5	Silty clay, grayish white	
		6.5 - 12.3	Silty clay, dark yellow	
	B_6-2	12.3 - 13.5	Silty clay, grayish blue	
		13.5 - 16.0	Silty clay, bluish yellow	
	B_6-3	Composite of B_6-1 and B_6-2		
B_7	B_7-1	0.0 - 0.5	Clayey silt, light gray	Do.
		0.5 - 2.5	Clayey silt, grayish yellow	
		2.5 - 5.5	Clayey silt, yellow	
		5.5 - 6.5	Silty clay, brownish gray	
		6.5 - 8.0	Clayey silt, yellow	
	B_7-2	8.0 - 16.0	Clayey silt, bluish gray	
		16.0 - 21.0	Silty clay, grayish blue	
	B_7-3	Composite of B_7-1 and B_7-2		

Table 4. Description of auger-hole samples, Dacca area (continued)

Auger hole no.	Sample no.	Depth of sample (in feet)	Description of sample	Age
		Demra, Area C		
C_1	C_1-1	0.0 - 0.2	Clayey silt, blackish gray	Holocene
		0.2 - 5.0	Clayey silt, yellow	
		5.0 - 6.5	Silty clay, grayish yellow	
	C_1-2	6.5 - 12.0	Silty clay, blackish gray	
		12.0 - 16.0	Clay, grayish blue	
C_2	C_2-1	0.0 - 2.2	Silty clay, blackish gray	Do.
		2.2 - 6.9	Clayey silt, yellow	
	C_2-2	6.9 - 13.4	Clay, grayish blue	
		13.4 - 14.1	Silty sand, bluish gray, very fine grained	
C_3	C_3-1	0.0 - 2.5	Clayey silt, gray	Do.
		2.5 - 6.5	Silty clay, brownish chocolate and yellowish gray	
	C_3-2	6.5 - 14.5	Clay, gray to grayish blue	
	C_3-3	Composite of C_3-1 and C_3-2		
C_4	C_4-1	0.0 - 1.5	Silty clay, dark gray	Do.
		1.5 - 3.5	Clayey silt, grayish yellow	
		3.5 - 7.2	Silt, brownish yellow	

Table 4. Description of auger-hole samples, Dacca area (continued)

Auger hole no.	Sample no.	Depth of sample (in feet)	Description of sample	Age
		Demra, Area C (cont'd)		
C_4	C_4-2	7.2 - 8.4	Silty clay, grayish blue	Holocene
		8.4 - 9.6	Clay, black, carbonaceous	
		9.6 - 16.0	Silty clay, blackish blue	
		16.0 - 21.0	Silty clay, greenish blue	
	C_4-3	Composite of C_4-1 and C_4-2		
C_6	C_6-3	0.0 - 0.2	Silty clay, gray	Pleistocene
		0.2 - 1.5	Silty clay, yellow	
		1.5 - 11.0	Silty clay, chocolate	
C_7	C_7-1	0.0 - 2.5	Clayey silt, yellowish gray	Holocene
		2.5 - 3.5	Silty clay, gray	
		3.5 - 4.0	Silty clay, light yellow	
		4.0 - 8.5	Clayey silt, light yellow	
	C_7-2	8.5 - 13.5	Clayey silt, bluish gray	
		13.5 - 16.0	Silty clay, blackish gray	
		16.0 - 21.0	Silty clay, light bluish gray	
	C_7-3	Composite of C_7-1 and C_7-2		

Table 4. Description of auger-hole samples, Dacca area (continued)

Auger hole no.	Sample no.	Depth of sample (in feet)	Description of sample	Age
		Demra, Area C (cont'd)		
C_8	C_8-1	0.0 - 2.5	Clayey silt, dark gray	Holocene
		2.5 - 5.0	Clayey silt, yellowish gray	
		5.0 - 8.5	Silt, yellowish brown	
	C_8-2	8.5 - 21.0	Clayey silt, bluish gray, micaceous	
	C_8-3	Composite of C_8-1 and C_8-2		
C_9	C_9-1	0.0 - 2.0	Clayey silt, dark gray	Do.
		2.0 - 5.0	Clayey silt, yellowish gray	
		5.0 - 8.5	Silt, yellowish brown	
	C_9-2	8.5 - 21.0	Clayey silt, bluish gray	
	C_9-3	Composite of C_9-1 and C_9-2		
C_{10}	C_{10}-3	0.0 - 3.5	Silty clay, blackish gray	Do.
		3.5 - 9.0	Silty clay, light bluish yellow	
		9.0 - 16.7	Silty clay, bluish yellow	
		16.7 - 21.0	Silty clay, brownish yellow	

Table 4. Description of auger-hole samples, Dacca area (continued)

Auger hole no.	Sample no.	Depth of sample (in feet)	Description of sample	Age
		Demra, Area C (cont'd)		
C_{-12}	C_{12}-1	0.0 - 0.5	Silty clay, yellowish gray	Pleistocene
		0.5 - 2.5	Silty clay, light yellow	
		2.5 - 9.5	Silty clay, yellowish gray	
		9.5 - 14.5	Silty clay, dark yellow	
		14.5 - 17.0	Silty clay, brownish red	
	C_{12}-2	17.0 - 19.0	Silty clay, grayish blue	
		19.0 - 21.0	Clayey silt, bluish gray	
	C_{12}-3	Composite of C_{12}-1 and C_{12}-2		
C_{-13}	C_{13}-1	0.0 - 1.0	Silty clay, dark yellow	Do.
		1.0 - 3.5	Silty clay, light grayish chocolate	
		3.5 - 8.0	Silty clay, gray	
	C_{13}-2	8.0 - 18.5	Silty clay, grayish yellow	
	C_{13}-3	Composite of C_{13}-1 and C_{13}-2		
C_{-14}	C_{14}-1	0.0 - 3.1	Silty clay, yellow	Do.
		3.1 - 10.0	Silty clay, grayish yellow	
	C_{14}-2	10.0 - 18.5	Silty clay, light brownish yellow	
	C_{14}-3	Composite of C_{14}-1 and C_{14}-2		

Table 4. Description of auger-hole samples, Dacca area (continued)

Auger hole no.	Sample no.	Depth of sample (in feet)	Description of sample	Age
		Demra, Area C (cont'd)		
C_{15}	C_{15}-3	0.0 - 3.0	Silty clay, yellow	Pleistocene
		3.0 - 8.0	Silty clay, light yellowish gray	
		8.0 - 13.5	Silty clay, bluish yellow	
C_{16}	C_{16}-3	0.0 - 0.5	Clayey silt, dark gray	Holocene
		0.5 - 6.5	Silt, yellow	
		6.5 - 19.0	Clayey silt, light blackish gray, micaceous	
C_{17}	C_{17}-3	0.0 - 0.7	Clayey silt, gray	Do.
		0.7 - 6.7	Silt, yellow	
		6.7 - 21.0	Clayey silt, dark gray	
C_{18}	C_{18}-1	0.0 - 0.6	Clayey silt, gray	Do.
		0.6 - 5.6	Clayey silt, yellow	
		5.6 - 6.4	Silty clay, yellowish gray	
	C_{18}-2	6.4 - 10.9	Clay, dark gray	
		10.9 - 12.4	Clay, black, carbonaceous	
		12.4 - 21.0	Clay, grayish blue	
	C_{18}-3	Composite of C_{18}-1 and C_{18}-2		

Table 4. Description of auger-hole samples, Dacca area (continued)

Auger hole no.	Sample no.	Depth of sample (in feet)	Description of sample	Age
		Demra, Area C (cont'd)		
C_{19}	C_{19}-3	0.0 - 3.0	Silty clay, yellow	Pleistocene
		3.0 - 8.0	Silty clay, yellow and brownish gray	
		8.0 - 15.0	Silty clay, bluish gray	
C_{20}	C_{20}-3	0.0 - 1.5	Silty clay, gray	Do.
		1.5 - 23.5	Silty clay, yellowish brown, with bluish gray	
C_{21}	C_{21}-1	0.0 - 0.5	Clayey silt, gray	Holocene
		0.5 - 4.5	Clayey silt, light yellow	
		4.5 - 5.5	Silty clay, light yellowish gray	
	C_{21}-2	5.5 - 10.5	Clay, gray	
		10.5 - 12.5	Clay, dark black, carbonaceous	
		12.5 - 21.5	Clay, grayish blue	
	C_{21}-3	Composite of C_{21}-1 and C_{21}-2		
C_{22}	C_{22}-1	0.0 - 0.5	Clayey silt, gray	Do.
		0.5 - 3.5	Clayey silt, light yellow	
		3.5 - 4.0	Silty clay, yellowish gray	

Table 4. Description of auger-hole samples, Dacca area (continued)

Auger hole no.	Sample no.	Depth of sample (in feet)	Description of sample	Age
		Demra, Area C (cont'd)		
C_{-22}	C_{22}-2	4.0 - 8.5	Clay, blackish gray	Holocene
		8.5 - 11.0	Clay, dark gray, carbonaceous	
		11.0 - 21.0	Clay, grayish blue	
	C_{22}-3	Composite of C_{22}-1 and C_{22}-2		

Some physical properties of 10 clay samples as determined in the laboratories of CSIR, Dacca, are listed in table 5.

Quick-firing tests

Samples 1 and 2 from each reconnaissance hole were tested individually in the muffle furnace to obtain specific bloating characteristics for each sample. Muffle furnace tests were also made on composite samples from each reconnaissance hole; the composite sample consisted of equal amounts of clay from samples 1 and 2.

As it is desirable to mine the entire deposits in actual commercial operations with a minimum of selective spoiling of any layer, only composite samples from the exploration holes in Areas A, B, and C were tested. The authors recognize that the blend used in these composite samples (equal amounts of clay from each layer) may not be the optimum mix to produce the strongest bloated material, but such an optimum mix can be determined only by use of a pilot kiln to produce enough aggregate for making concrete test cylinders.

Table 5. Physical properties of clay samples.

Sample No.	Plasticity (percent)	Dry shrinkage (percent at 110° C)	Final shrinkage (percent at 1000° C)
A_5-3	26.6	8	12
A_8-3	15.9	5	10
A_{11}-3	26.9	6	15
B_2-3	20.8	2	7
B_7-3	26.1	9.4	12
C_6-3	28.3	6.2	13.6
C_7-3	27.8	5	13
C_{13}-3	24.6	8	12
C_{15}-3	21.6	7	11.4
C_{22}-3	26.9	4.8	13

Quick-firing tests following procedures outlined by Hamlin and Templin (1962), and those of South West Research Institute, San Antonio, Texas (written commun., 1957) were used. Two dried balls and two cylindrical pellets were placed in a fireclay crucible in an electric muffle furnace. The periods of exposure for samples were 15, 20, 25, and 30 minutes at temperatures ranging from 1800° to 2300° F. When a particular sample began to overbloat and fuse together or to the crucible, no further tests were run. After cooling, samples were broken and examined with the naked eye and with a hand lens to determine the degree of bloating for each of the temperatures to which they had been exposed (see table 6). Fired samples from areas A, B, and C are shown in figures 6, 7, and 8. The estimate of strength for each bloated sample as given in table 6 is an arbitrary one based on hardness and resistance to breaking with a hammer; reliable strength tests can be made only after the preparation of sufficient aggregate for the making and crushing of concrete test cylinders.

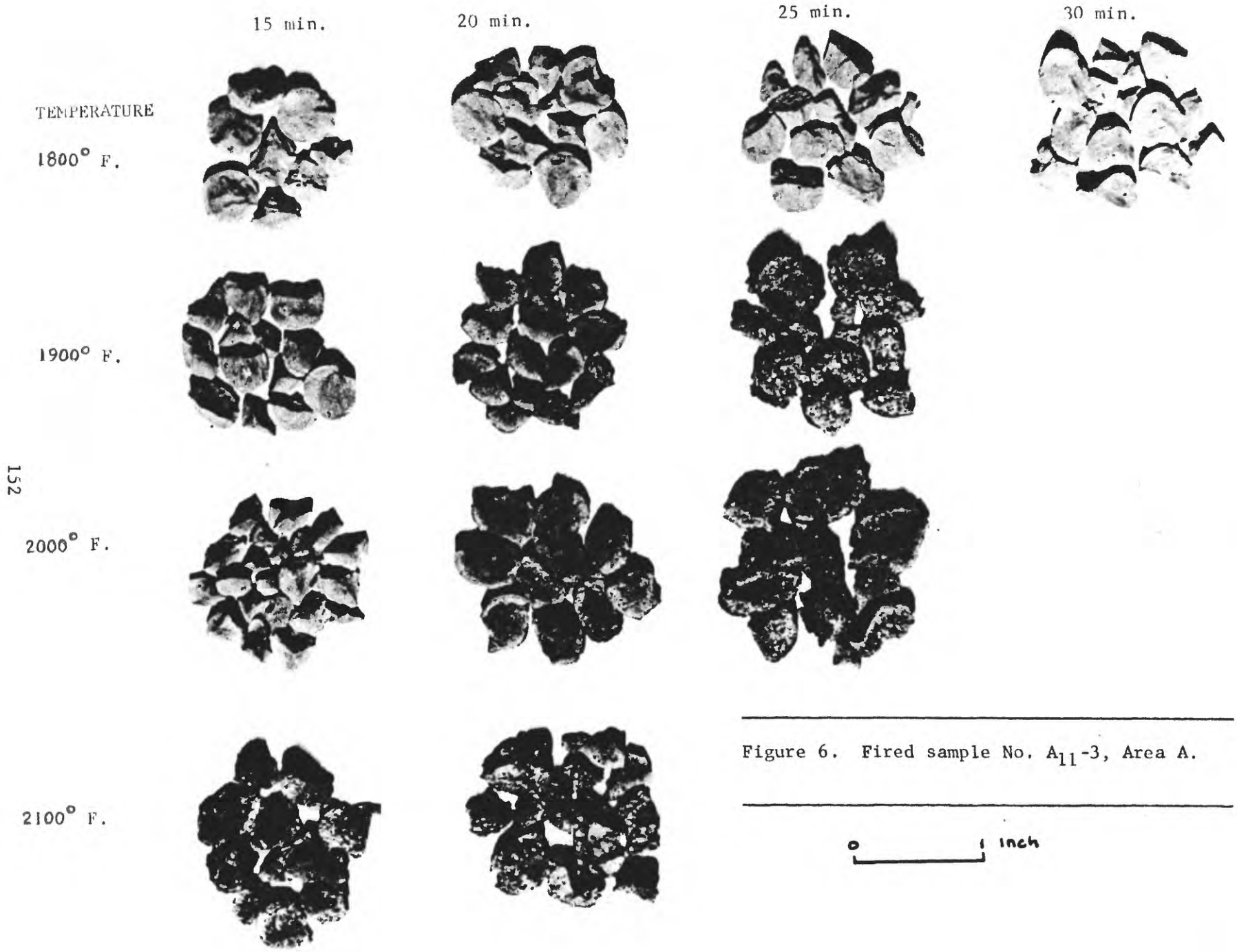

Figure 6. Fired sample No. A_{11}-3, Area A.

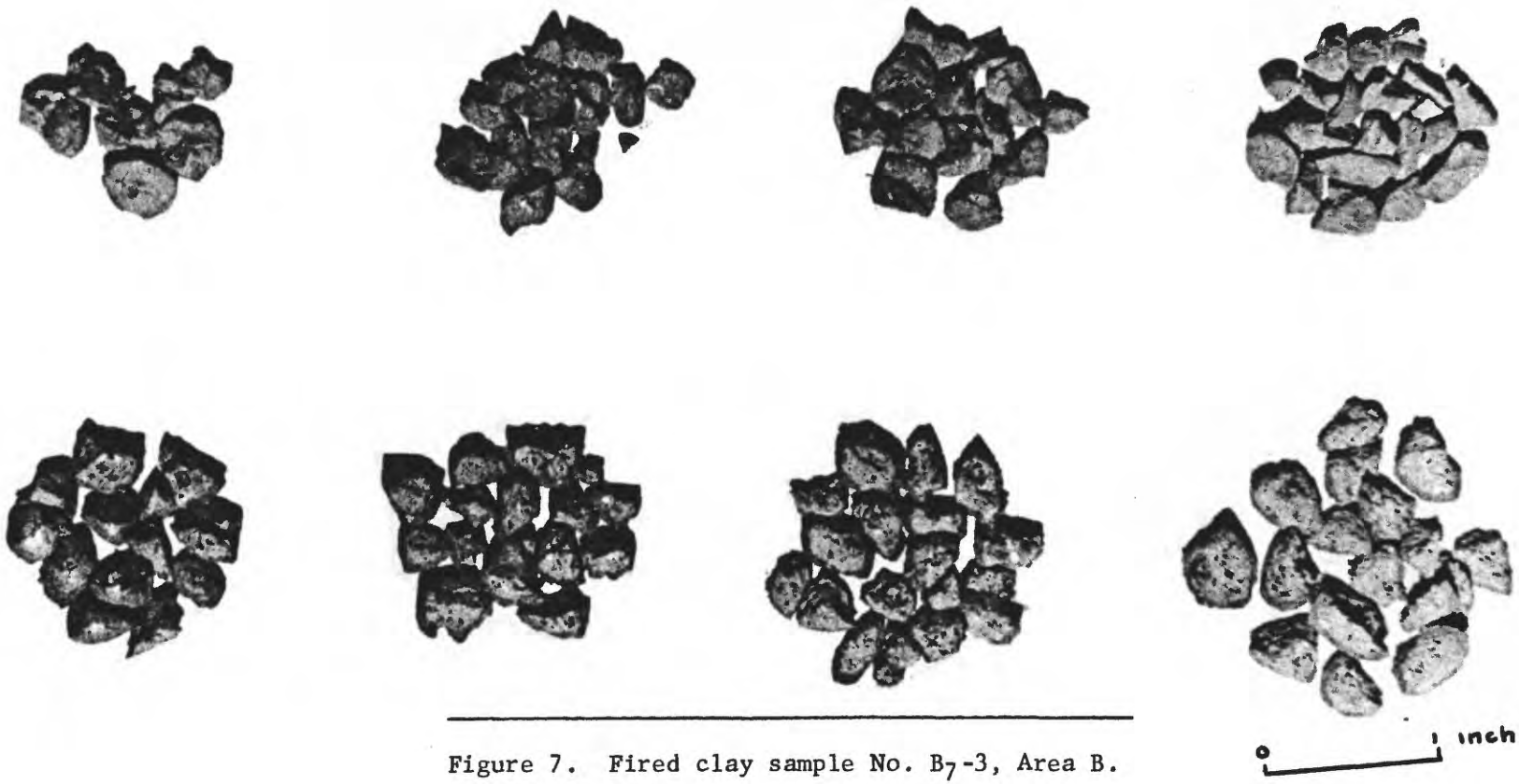

Figure 7. Fired clay sample No. B_7-3, Area B.

TURE

15 min.

20 min.

25 min.

30 min.

TEMPERATURE

1800° F.

1900° F.

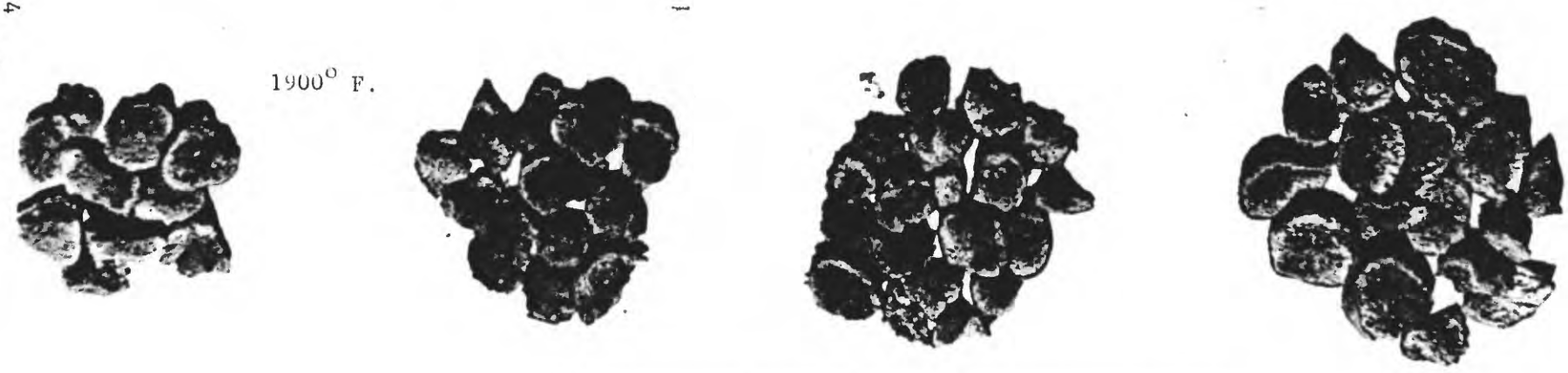

Figure 8. Fired sample No. C_7-3, Area C.

0 1 inch

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
T_1-3	1800° F.	Light red inside, red outside, moderately strong, no bloat.	Light red inside, red outside, moderately strong, no bloat.	Light red inside, red outside, moderately strong, no bloat.	Light red inside, red outside, moderately strong, no bloat.
	1900° F.	Red throughout, moderately strong, no bloat.	Light red inside dark red outside, moderately strong, no bloat.	Dark red throughout, moderately strong, no bloat.	Dark red throughout, moderately strong, no bloat.
	2000° F.	Dark red throughout, fairly strong, no bloat.	Dark red throughout, fairly strong, no bloat.	Dark red throughout, fairly strong, no bloat.	Dark red throughout, fairly strong, no bloat.
	2100° F.	Dark red throughout, fairly strong, no bloat.	Dark red throughout, fairly strong, no bloat.	Light brown throughout, very strong, no bloat.	Light brown throughout, very strong, no bloat.
	2200° F.	Dark red throughout, fairly strong, no bloat.	Dark red throughout, fairly strong, no bloat.	Light brown throughout, fairly strong, no bloat.	Brown throughout, fairly strong, no bloat.
	2300° F.	Light brown throughout, fairly strong, no bloat.	Brown throughout, fairly strong, no bloat.	Light brown inside, dark brown outside, very strong, no bloat.	Light brown inside, dark brown outside, very strong, very fine bloat.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
S_2-3	1800° F.	Red throughout, Moderately strong	Red throughout, Fairly strong, No bloat.	Red throughout, Fairly strong, No bloat.	Red throughout, Fairly strong, No bloat.
	1900° F.	Red throughout, Moderately strong, No bloat.	Red throughout, Fairly strong, No bloat.	Red throughout, Fairly strong, No bloat.	Red throughout, Fairly strong, No bloat.
	2000° F.	Red throughout, Fairly strong, No bloat.	Dark red throughout Fairly strong, No bloat.	Light brown throughout, Fairly strong, No bloat.	Brown throughout, Fairly strong, No bloat.
	2200° F.	Dark red throughout, Fairly strong, No bloat.	Light brown throughout, Fairly strong, No bloat.	Brown throughout, dense, vitreous edge, very strong, No bloat.	Brown throughout, dense, vitreous edge, very strong, No bloat.
	2300° F.	Dark red throughout, Moderately strong, No bloat.	Red outside, brown inside, Chocolate outside, Fairly Strong, No bloat.	Brown throughout, Fairly strong, Very fine bloating.	Dark brown throughout, Fairly strong, Slightly sticks together, Fine bloating.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
M_1-3	1800° F.	Red throughout, Moderately strong, no bloat.	Red throughout, Moderately strong, no bloat.	Red throughout, Moderately strong, no bloat.	Red throughout, Moderately strong, no bloat.
	1900° F.	Red throughout, Moderately strong, no bloat.	Dark red throughout, Moderately strong, no bloat.	Dark red throughout, Moderately strong, very little bloat.	Dark red throughout, Moderately strong, very little bloat.
	2000° F.	Red throughout Moderately strong, no bloat.	Red throughout Moderately strong, no bloat.	Dark red throughout, Fairly strong, no bloat.	Dark red throughout, Fairly strong, no bloat.
	2100° F.	Red throughout, Moderately strong, no bloat.	Dark red throughout, Fairly strong, no bloat.	Dark red throughout, Fairly strong, no bloat.	Dark red throughout, Fairly strong, no bloat.
	2200° F.	Dark red throughout, Fairly strong, no bloat.	Light chocolate, throughout, Fairly strong, no bloat.	Chocolate throughout, dense, very strong, no bloat.	Chocolate through out, dense, very strong, no bloat.
	2300° F.	Chocolate throughout, Fairly strong, very fine bloat.	Chocolate throughout, Fairly strong, slightly sticks together, very fine bloat.	Chocolate throughout, Fairly strong, slightly sticks together, fine bloating.	Dark chocolate throughout, Fairly strong, slightly sticks together, fine bloat.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
A_2-3	1800° F.	Central portion finely bloated, dark red inside, light red outside moderately strong.	Central portion very finely bloated, dark red inside, red outside, moderately strong.	Central portion very finely bloated, dark gray inside, red outside, moderately strong.	Some finely bloated, dark gray inside, red outside, fairly strong.
	1900° F.	Finely bloated, dark gray inside, red outside, fairly strong.	Finely bloated, dark gray inside, red outside, fairly strong.	Well bloated, dark gray inside, red outside, fairly strong.	Well bloated, dark gray inside, red outside, fairly strong.
	2000° F.	Finely bloated, dark gray inside, red outside, fairly strong.	Well bloated, gray inside, dark red outside, fairly strong.	Over bloated, gray inside, dark brown outside, not strong, sticks together.	Over bloated, gray inside, brown outside, weak, sticks in crucible.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
A_4-1	1800° F.	Some finely bloated, light red throughout, moderately strong, dark brown specks, fine mica flakes throughout.	Some very finely bloated, red throughout, moderately strong, dark brown specks, fine mica flakes throughout.	Some finely bloated, red outside, dark red outside, moderately strong, dark brown specks, fine mica flakes.	Finely bloated, red outside, dark red inside, moderately strong, dark brown specks.
	1900° F.	Some finely bloated, red outside, dark gray inside, moderately strong, fine mica flakes throughout.	Finely bloated,tan red outside, dark gray inside, fairly strong.	Well bloated, tan red outside, dark gray inside, fairly strong.	Finely bloated, red to tan red outside, dark gray inside, fairly strong.
	2000° F.	Some very finely bloated, red outside, dark red inside, moderately strong, a few white spots.	Fine even bloating, dark red outside, gray inside, fairly strong, a few brownish cream spots.	Well bloated, some overbloated, dark brown outside, light gray inside, moderately strong, sticks together.	Well bloated, some overbloated, brown outside, gray inside, moderately strong, slightly sticks together.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
A_4-2	1800° F.	Not bloated, light red outside, grayish red inside, moderately strong.	Central portion very finely bloated, light red outside, gray inside, fairly strong.	Central portion very finely bloated, light red outside, gray inside, fairly strong.	Central portion very finely bloated, light red outside, dark red inside, fairly strong.
	1900° F.	Central portion very finely bloated, light red outside, dark gray inside, moderately strong.	Finely bloated red to light red outside, dark gray inside, moderately strong.	Finely bloated, red outside, dark gray inside, fairly strong.	Fine to medium bloated, light red outside, dark gray inside, fairly strong.
	2000° F.	Central Portion a little bloated, red outside, light gray inside, moderately strong.	Fine evenly bloated, dark red outside, gray inside, fairly strong.	Well bloated, some overbloated, dark brown outside, whitish gray inside, moderately strong, sticks together	Overbloated, brown outside, gray inside, moderately strong, sticks together.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
A_4-3	1800° F.	Central portion very finely bloated, dark red inside, light red outside moderately strong, red brown specks.	Central portion very finely bloated, dark red inside red outside, moderately strong dark brown specks.	Central portion finely bloated, dark gray inside, red outside moderately strong, dark brown specks.	Some finely bloated, dark gray inside, red outside fairly strong, dark brown specks.
	1900° F.	Finely bloated, dark gray inside, red outside, fairly strong, black specks.	Finely bloated, dark gray inside, red outside, fairly strong.	Well bloated, dark gray inside, red outside, fairly strong.	Well bloated, dark gray inside, red outside, fairly strong, black specks.
	2000° F.	Finely bloated, dark gray inside, red outside, fairly strong, a few brown specks.	Well bloated, gray inside, dark red outside, fairly strong.	Over bloated, gray inside, dark brown outside, not strong, sticks together.	Over bloated, gray inside, brown outside, not strong, sticks together.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
A_5-3	1800° F.	Red, medium hard, no bloat.	Reddish brown, medium hard, no bloat.	Reddish brown, medium hard, no bloat.	Reddish brown, medium hard, no bloat.
	1900° F.	Reddish brown, medium hard, gray centre, no bloat.	Reddish brown, medium hard, no bloat.	Brownish red, medium hard, some gray centre, trace very fine bloat.	Brownish red, medium hard, gray centre, fine bloat.
	2000° F.	Reddish brown, medium hard, gray centre, no bloat.	Reddish brown, medium hard, trace gray centre, no bloat.	Brownish red, medium hard, gray centre, very fine bloat.	Brownish red, medium hard, gray centre, fine bloat.
	2100° F.	Reddish brown, medium hard, some light gray centre, no bloat.	Brownish red, medium hard, light gray centre, no bloat.	Brownish red, medium hard, gray centre, fine bloat.	Brownish red, medium hard, gray centre, fine to medium bloat.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
A_6-3	1800° F.	Brick red, medium strong, no bloat.	Brick red, medium strong, no bloat.	Dark brick red, medium strong, no bloat.	Dark brick red, medium strong, no bloat.
	1900° F.	Brick red, medium strong, no bloat.	Brick red, medium strong, no bloat.	Dark brick red, medium strong, no bloat.	Dark brick red, medium strong, no bloat.
	2000° F.	Reddish brown, strong, no bloat.	Dark reddish brown, strong, some dark gray centre, no bloat.	Dark reddish brown, strong, dark gray centre, very fine bloat.	Dark reddish brown, strong, no bloat.
	2100° F.	Reddish brown, strong, no bloat.	Dark reddish brown, strong, trace gray centre, some fine bloat.	Dark brown, strong, dark gray centre, fine to medium bloat.	Dark brown, strong, no bloat.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
A_7-3	1800° F.	Brownish red, medium hard, no bloat.	Reddish brown, medium hard, no bloat.	Reddish brown, medium hard, no bloat.	Reddish brown, medium hard, no bloat.
	1900° F.	Brownish red, medium hard, gray centre, no bloat.	Reddish brown, medium hard, no bloat.	Brownish red, medium hard, gray in centre, fine bloat.	Brownish red, medium hard, gray centre, fine bloat.
	2000° F.	Brownish red, medium hard, gray centre, no bloat.	Brownish red, medium hard, gray centre, no bloat.	Brownish red, medium hard, gray centre, fine bloat.	Brownish red, medium hard, gray centre, fine bloat.
	2100° F.	Reddish brown, medium hard, some light gray centre, no bloat.	Brownish red, medium hard, gray centre, some very fine bloat.	Brownish red, medium hard, gray centre, good fine bloat.	Brownish red, medium hard, gray centre, fine to medium bloat.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
A_8-3	1800° F.	Reddish brown, medium hard, gray in centre, no bloat.	Reddish brown, hard, no bloat.	Reddish brown, hard, trace gray centre, no bloat.	Reddish brown, hard, no bloat.
	1900° F.	Reddish brown, hard, light gray centre, no bloat.	Reddish brown, hard, gray centre, no bloat.	Reddish brown, hard, gray centre, no bloat.	Reddish brown, hard, gray centre, trace fine bloat.
	2000° F.	Reddish brown, medium hard, trace gray centre, no bloat.	Brownish red, medium hard, gray centre, some fine bloat.	Brownish red, medium hard, gray centre, fine bloat.	Brownish red, medium hard, gray centre, fine bloat.
	2100° F.	Reddish brown, medium hard, gray centre, some fine bloat.	Reddish brown, medium hard, light gray centre, fine bloat.	Dark reddish brown, medium hard, light gray centre, fine to medium bloat.	Dark reddish brown, medium hard, light gray, centre fine bloat.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
A_9-3	1800° F.	Brownish red, Medium strong, gray centre, no bloat.	Brownish red, medium strong, gray centre, no bloat.	Brownish red, medium strong, dark gray centre, no bloat.	Brownish red, medium strong, dark gray centre, trace fine bloat.
	1900° F.	Light brown color, medium strong, gray centre, no bloat.	Brownish red, medium strong, dark gray centre, trace fine bloat.	Brownish red, medium strong, dark gray centre, fine bloat.	Brownish red, medium strong, dark gray centre, fine bloat.
	2000° F.	Light brown color, medium strong, dark gray centre, fine to medium bloat.	Dark brown, weak, dark gray centre, fine to medium bloat.	Dark brown, weak, dark gray centre, fine to medium bloat, sticking the crucible.	Dark brown, weak, dark gray centre, fine to medium bloat, sticking in crucible.
	2100° F.	Tan color, medium strong, dark gray centre, fine bloat.	Dark brown, weak, dark gray centre, fine to medium bloat.	Dark brown, weak, dark gray centre, over-bloated, sticking in crucible.	No sample run.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
A_{10-3}	1800° F.	Light brown color, medium strong, gray centre, no bloat.	Brownish red, medium strong, gray centre, very vine bloat.	Brownish red, weak, grey centre, fine bloat.	Brownish red, weak, brittle, gray centre, fine bloat.
	1900° F.	Light brown color, medium strong, gray centre, some very fine bloat.	Brownish red, medium strong, gray centre, fine bloat.	Dark brownish red, medium strong, light to dark gray centre, fine to medium bloat.	Dark brick red, weak, dark gray centre, fine bloat.
	2000° F.	Light brown, medium strong, gray centre, fine to medium float.	Dark brown, weak, grey centre, medium bloat.	Dark brown, weak, dark gray, medium to overbloat.	No sample run.
	2100° F.	Reddish brown, medium hard. dark gray centre, fine bloat.	Dark brown, weak, dark gray centre, medium bloat.	Dark brown, weak, dark gray centre, overbloat, sticking in crucible.	No sample run.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
A_{11}-3	1800° F.	Light brown color, medium strong, some gray centre, no bloat.	Light brown color, medium strong, some gray centre, no bloat.	Light brown color, medium strong, no bloat.	Light brown color, medium strong, no bloat.
	1900° F.	Light brown medium strong, dark gray centre, some very fine bloat.	Brown color, medium strong, dark gray centre, fine to medium bloat.	Dark brown, weak, dark gray centre, overbloat, fusing in crucible.	No sample run.
	2000° F.	Light brown color, medium strong, gray centre, very fine to medium bloat.	Dark brown, medium strong, gray centre, medium bloat.	Dark brown, weak, gray centre, overbloated, fusing in crucible.	No sample run.
	2100° F.	Dark brown, weak, gray centre, fine to overbloat, beginning to stick and fuse.	Dark brown, weak, gray centre, fine to overbloat, beginning to to stick and fuse.	No sample run.	No sample run.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
A_{12}-3	1800° F.	Light brown color, medium strong, some gray centre, no bloat.	Light brown color, medium strong, some gray centre, no bloat.	Light brown color, medium strong, no gray centre, no bloat.	Light brown color, medium strong, no gray centre, no bloat.
	1900° F.	Light brown color, medium strong, dark gray centre, no bloat.	Brown color, medium strong, dark gray centre, fine to medium bloat.	Dark brown, weak, dark gray centre, overbloat, fusing in crucible.	No sample run.
	2000° F.	Darkbrown, weak, brown centre, poor to overbloat, sticking in crucible.	Dark brown, weak, dark gray, overbloat, sticking in crucible.	No sample run.	No sample run.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
B_1-1	1800° F.	Red throughout, weak, not bloated.	Red throughout, weak, not bloated.	Dark red throughout, moderately strong, not bloated.	Red throughout, moderately strong, not bloated.
	1900° F.	Red throughout, moderately strong, not bloated.	Dark red throughout, moderately strong, not bloated.	Dark red throughout, moderately strong, not bloated.	Dark red through, moderately strong, not bloated.
	2000° F.	Reddish brown, fairly strong, light gray centre, not bloated.	Dark brownish red, fairly strong, light gray centre, not bloated.	Dark red throughout, fairly strong, not bloated.	Light chocolate throughout, very hard, not bloated.
	2100° F.	Red throughout, moderately strong, not bloated.	Light brown throughout, fairly strong, not bloated.	Brown throughout, dense, vitreous edge, very hard, not bloated.	Brown throughout, dense vitreous edge, very hard, not bloated.
	2200° F.	Dark red throughout, fairly strong, not bloated.	Brown throughout, very hard, very fine irregular bloating.	Brown throughout, fairly strong, slightly sticks together, well bloated.	Dark brown throughout, moderately strong, sticks together, well to overbloated.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
B_1-2	1800° F.	Red, Moderately strong, dark red centre, very fine bloating.	Red, moderately strong, light red centre, very fine to fine bloating.	Red, moderately strong, light red centre, fine bloating.	Red throughout, moderately strong, fine bloating.
	1900° F.	Red, fairly strong, dark gray centre, well bloated.	Dark red, fairly strong, dark gray centre, well bloated.	Dark red, fairly strong, dark gray centre, well bloated.	Dark red, fairly strong, dark gray centre, well bloated.
	2000° F.	Dark red, fairly strong, dark gray centre, well bloated.	Dark red, fairly strong, dark gray centre, well bloated.	Dark red, fairly strong, dark gray centre, well bloated.	Dark red, fairly strong, dark gray centre, slightly sticks together, well bloated.
	2100° F.	Red, fairly strong, gray centre, well bloated.	Red, fairly strong, dark gray centre, well bloated.	Brown, weak dark gray centre, sticks together, over bloated.	Brown, weak, whitish gray centre, sticks together, over bloated.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
B_1-3	1900° F.	Red through, moderately strong, not bloated.	Red through, moderately strong, not bloated.	Red throughout, moderately strong, some finely bloated.	Red throughout, moderately strong, some finely bloated.
	2000° F.	Dark red, fairly strong, light gray centre, finely bloated.	Dark red, fairly strong, light gray centre, finely bloated.	Chocolate, fairly strong, light gray centre, well bloated.	Chocolate, moderately strong, light gray centre, slightly sticks together, well to over bloated.
	2100° F.	Red, fairly strong, light gray centre, finely bloated.	Red, fairly strong, light gray centre, well bloated.	Brown, fairly strong, light gray centre, slightly sticks together, well bloated.	Brown, moderately strong, light gray centre, sticks together, well to over bloated.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
B_2-3	1800° F.	Reddish brown, medium hard, no bloat.	Reddish brown, medium hard, no bloat.	Reddish brown, medium hard, some gray centre, trace fine bloat.	Reddish brown, medium hard, no bloat.
	1900° F.	Reddish brown, medium strong, some gray centre, no bloat.	Reddish brown, medium strong, gray centre, fine bloat.	Brown, medium strong, gray centre, fine bloat.	No recovery.
	2000° F.	Reddish brown, medium strong, some gray centre, no bloat.	Brown, medium strong, gray centre, fine bloat.	Dark brown, medium strong, gray centre, medium bloat.	Dark brown, medium strong, light gray centre, medium bloat.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
B_3-1	1800° F.	Red outside, dark red inside, moderately strong, very fine bloating.	Red outside, dark red inside, moderately strong, very fine uneven bloating.	Red outside, dark red inside, moderately strong, very fine uneven bloating.	Red outside, dark red inside, moderately strong, very fine uneven bloating.
	1900° F.	Red outside, dark red inside, fairly strong, very fine bloating.	Red outside, dark red inside, fairly strong, very fine bloating.	Red outside, dark red inside, fairly strong, very fine bloating.	No sample run.
	2000° F.	Red outside, dark red inside, moderately strong, no bloating.	Light brown throughout, fairly strong, a little bloating.	Brown throughout, very strong, very fine bloating.	Brown throughout, very strong, very fine bloating.
	2100° F.	Dark brown, outside, light gray inside, fairly strong, well bloated.	Dark brown throughout, fairly strong, vitreous edge, a little bloating.	Brown throughout, fairly strong, no bloating.	Dark brown outside, light gray inside, very strong, well bloated.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
B_3-2	1800° F.	Red throughout, moderately strong, no bloating.	Red outside, dark red inside, moderately strong, no bloating.	Red outside, dark red inside, moderately strong, no bloating.	Red outside, light red inside, fairly strong, no bloating.
	1900° F.	Red outside, dark red inside, moderately strong, no bloating.	Dark red throughout, fairly strong, no bloating.	Dark red throughout, fairly strong, no bloating.	Dark red throughout, fairly strong, no bloating.
	2000° F.	Red outside, dark red inside, moderately strong, no bloating.	Dark red throughout, fairly strong, no bloating.	Dark red throughout, very hard, no bloating.	Light brown outside, dark gray inside, very hard, a little irregular bloating.
	2100° F.	Dark brown outside, light gray inside, fairly strong, well bloated.	Dark brown outside, gray spots inside, fairly strong, a little bloating.	Dark brown outside, gray spots inside, fairly strong, a little bloating.	Dark brown throughout, fairly strong, a little bloating.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
B_3-3	1800° F.	Red outside, dark red inside, moderately strong, no bloating.	Red outside, dark red inside, moderately strong, no bloating.	Red outside, red inside, moderately strong, no bloating.	Red outside, light red inside, fairly strong, no bloating.
	1900° F.	Red outside, light red inside, fairly strong, no bloating.	Red outside, light red inside, fairly strong, no bloating.	Red outside, light red inside, fairly strong, no bloating.	Red outside, light red inside, fairly strong, no bloating.
	2000° F.	Red outside, dark red inside, fairly strong, no bloating.	Dark red to light brown throughout, very hard, no bloating.	Brown throughout, very hard, no bloating.	Brown throughout, very hard, a little bloating.
	2100° F.	Brownish red, fairly strong, black centre, no bloating.	Dark red throughout, fairly strong, no bloating.	Brown throughout, fairly strong, no bloating.	Dark brown throughout, fairly strong, no bloating
	2200° F.	Dark red throughout, very strong, no bloating.	Brown throughout, very hard, slightly sticks together, no bloating.	Brown throughout, very hard, very fine irregular bloating.	Brown throughout, fairly strong, fine bloating.
	2300° F.	Dark red throughout, very strong, no bloating.	Brown throughout, very strong, very fine irregular localized bloating.	Brown throughout, fairly strong, slightly sticks together, fine bloating.	Brown outside, light brown inside, fairly strong, sticks together, good bloating.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
B_4-3	1800° F.	Reddish brown, medium hard, no bloat.	Reddish brown, medium hard, no bloat.	Reddish brown, medium hard, some gray centre, trace fine bloat.	Reddish brown, medium hard, no bloat.
	1900° F.	Reddish brown, medium hard, no bloat.	Reddish brown, medium hard, dark gray centre, fine bloat.	Brown, medium hard, dark gray centre, fine bloat.	No sample run.
	2000° F.	Reddish brown, medium hard, gray centre, fine bloat.	Dark brown, medium hard, gray centre, medium bloat.	Dark brown, medium hard, gray centre, medium bloat.	Dark brown, medium hard, gray centre, medium bloat.
B_5-3	1800° F.	Brownish red, medium strong, light gray centre, no bloat.	Brownish red, medium strong, no bloat.	Brownish red, medium strong, no bloat.	Reddish brown, medium strong, some gray centre, no bloat.
	1900° F.	Reddish brown, medium strong, gray centre, no bloat.	Brown, medium strong, gray centre, fine bloat.	Dark brown, medium strong, gray centre, fine to medium bloat.	Dark brown, medium strong, gray centre, fine to medium bloat.
	2000° F.	Dark brown, medium strong, light to dark gray centre, medium to large bloat.	Reddish brown, medium strong, light gray centre, fine to medium bloat.	Brick red, medium strong, light gray centre, fine to medium bloat.	Dark brown, medium strong, light gray centre, fine to medium bloat.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
B_6-3	1800° F.	Red, medium strong, gray centre, no bloat.	Red, medium strong, gray centre, no bloat.	Brownish red, medium strong, gray centre, no bloat.	No recovery.
	1900° F.	Reddish brown, medium strong, gray centre, no bloat.	Reddish brown, medium strong, gray centre, some fine bloat.	Brown, medium strong, gray centre, fine bloat.	Dark brown, medium strong, light gray centre, medium bloat.
B_7-3	1800° F.	Brick red, weak, trace gray center, no bloat.	Brick red, weak, trace gray center, trace fine bloat.	Brick red, weak, some gray centre, trace fine bloat.	Brick red, weak, trace grey center, no bloat.
	1900° F.	Brown, moderately strong, light gray centre, fine bloat.	Brown, moderately strong, light gray centre, fine to medium bloat.	Brown, moderately strong, light gray centre, medium bloat	Dark brown, moderately strong, light gray centre, well bloated.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
C_1-1	1800° F.	Light red throughout, moderately strong, not bloated.	Red throughout, moderately strong, not bloated.	Red throughout, moderately strong, not bloated.	Red throughout, moderately strong, not bloated.
	1900° F.	Brownish red inside, light red outside, moderately strong, not bloated.	Brownish red inside, light red outside, moderately strong, not bloated.	Light brown inside, light red outside, moderately strong, not bloated.	Dark red throughout, moderately strong, not bloated.
	2000° F.	Dark red throughout, moderately strong, not bloated.	Dark red throughout, fairly strong, not bloated.	Dark brownish red throughout, fairly strong, not bloated.	Dark brownish red throughout, fairly strong, not bloated.
	2100° F.	Light red throughout, moderately strong, not bloated.	Dark red throughout, fairly strong, not bloated.	Light brown throughout, dense, very strong, not bloated.	Brown throughout, dense, vitreous edge, very strong, not bloated.
	2200° F.	Dark red throughout, fairly strong, not bloated.	Brown throughout, fairly strong, dense, vitreous edge, not bloated.	Light brown throughout, fairly strong, very finely bloated.	Brown throughout, very strong, finely bloated.
	2300° F.	Brownish red, moderately strong, black centre, sticks together, well to over bloats.	Reddish brown, moderately strong, black centre, sticks together, well to over bloated.	Shining black outside, black inside, not strong, completely fused together, over bloated.	Lustrous black outside, black inside, not strong, completely fused together over bloated.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
C_1-2	1800° F.	Light cream inside, cream outside, moderately strong, not bloated.	Light cream inside, cream outside, moderately strong, not bloated.	Light cream inside, cream outside, moderately strong, not bloated.	Cream throughout, moderately strong, not bloated.
	1900° F.	Cream throughout, moderately hard, not bloated.	Dark cream throughout, moderately strong, not bloated.	Light red inside, reddish cream outside, moderately strong, not bloated.	Light red inside, reddish cream outside, moderately strong, not bloated.
	2000° F.	Cream red throughout, moderately hard, not bloated.	Red throughout, fairly strong, not bloated.	Red throughout, fairly strong, not bloated.	Red throughout, fairly strong, not bloated.
	2100° F.	Gray to red inside, light red outside, moderately strong, a little bloated.	Gray inside, red outside, fairly strong, finely bloated.	Gray inside, dark red outside, fairly strong, finely bloated.	Light gray inside, dark red outside, fairly strong, slightly sticks together, well bloated.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
C_2-1	1800° F.	Dark red inside, light red outside, moderately strong, no bloating.	Dark red inside, red outside, moderately strong, no bloating.	Dark red inside, red outside, moderately strong, no bloating.	Dark red inside, red outside, moderately strong, no bloating.
	1900° F.	Dark red inside, red outside, moderately strong, no bloating.	Dark red inside, red outside, moderately strong, no bloating.	Gray spots inside, red outside, moderately strong, no bloating.	Gray spots inside, dark red outside, moderately strong, no bloating.
	2000° F.	Black to dark gray inside, dark brownish red outside, moderately strong, very fine bloating.	Gray inside, dark brownish red outside, moderately strong, fine bloating.	Gray inside, dark brownish red outside, fairly strong, well bloated.	Light gray inside, brownish red outside, fairly strong, well bloated.
	2100° F.	Dark gray inside, brownish red outside, moderately strong, fine bloating.	Gray inside, dark brownish red outside, fairly strong, fine bloating.	Gray inside, dark brownish red outside, fairly strong, well bloated.	Light gray inside, dark brownish red outside, fairly strong, well bloated.
	2200° F.	Gray inside, dark red outside, fairly strong, some finely bloated.	Light gray inside, brown outside, very strong, well bloated.	Gray inside, brown outside, very strong, well to over bloated.	Light gray inside, brown outside not strong, slightly sticks together, over bloated.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
C_2-2	1800° F.	Dark cream inside, light cream outside, weak, no bloating.	Dark cream inside, cream outside, weak, no bloating.	Dark cream inside, cream outside, moderately strong, no bloating.	Dark cream inside, light cream outside, moderately strong, no bloating.
	1900° F.	Cream color throughout, moderately strong, no bloating.	Dark cream inside, cream outside, moderately strong, no bloating.	Gray inside, light red outside, moderately strong, very fine bloating.	Dark gray inside, red outside, moderately strong, very fine bloating.
	2000° F.	Gray inside, dark red outside, fairly strong, well bloated.	Gray inside, dark red outside, fairly strong, well bloated.	Gray inside, brownish red outside, fairly strong bloated.	Gray inside brownish red outside, fairly strong, fine bloating.
	2100° F.	Black inside, red outside, fairly strong, fine bloating.	Black inside, brown outside, fairly strong, sticks together, bloated.	Black inside, brown outside, fairly strong, sticks together, bloated.	Black inside, brown outside, fairly strong, sticks together, bloated.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
C_3-1	1800° F.	Light red, moderately strong, very fine bloating.	Light red, moderately strong, very fine bloating.	Light red, moderately strong, very fine bloating.	Light red, moderately strong, a little bloating.
	1900° F.	Cream, moderately strong, a little bloating.	Light red moderately strong, very fine bloating.	Dark red, fairly strong, dark gray center, very fine bloating.	Dark red, fairly strong, dark gray center, very fine bloating.
	2000° F.	No recovery.	Dark red, fairly strong, gray center, very fine bloating.	Dark gray, fairly strong, gray center a little bloating.	Dark red, fairly strong, gray center, a little bloating.
	2100° F.	Light red, fairly strong, gray center, very fine bloating.	Dark red, fairly strong, gray center, very fine bloating.	Light red, fairly strong, red center, no bloating.	Light red, fairly strong, red center, no bloating.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
C_3-2	1800° F.	Cream, moderately strong, no bloating.	Cream, moderately strong, no bloating.	Cream moderately strong, no bloating.	Cream, moderately strong, no bloating.
	1900° F.	Cream, fairly strong, light gray center, very fine bloating.	Cream, fairly strong, light gray center, very fine bloating.	Dark red, fairly strong, gray center, very fine bloating.	No recovery.
	2100° F.	Dark red, fairly strong, light gray center, dense, bloating at edge.	Red, fairly strong, black center, dense, edge finely bloated.	Red outside, fairly strong, grayish black center, dense, no bloating.	Light red, fairly strong, blackish gray center, dense, no bloating.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
C_3-3	1800° F.	Light red, Moderately strong, Light gray centre, Very fine bloating.	Light red, Moderately strong, Light gray centre, Very fine bloating.	Light red Moderately strong, No bloating.	Light red, Moderately strong, No bloating.
	1900° F.	Light red, Fairly strong, Gray centre, very fine bloating.	Light red, Fairly strong, Gray centre, very fine bloating.	Light red, Fairly strong, Gray centre, very fine bloating.	Light red, Fairly strong, Gray centre, very fine bloating.
	2000° F.	Light red, Fairly strong, Gray centre, very fine bloating.	Light red, Fairly strong, Gray centre, very fine bloating.	Dark red, Fairly strong, Gray centre, very fine bloating.	Dark red, Fairly strong, dark Gray centre, very fine bloating.
	2100° F.	Light red, Fairly strong, Light gray centre, Fine bloating.	Dark brown, Fairly strong, Light gray centre, Good bloating.	Dark brown, fairly strong, gray centre, good bloating.	Brown, fairly strong, gray centre, good bloating.
	2200° F.	Brown, Strong, No bloating.	Brown, Very strong, No bloating.	Brown, Very strong, Blackish gray centre, a little bloating.	Brown, Very strong, Whitish gray centre Good bloating.
	2300° F.	Dark brown, Fairly strong, No bloating.	Light brown, Fairly strong, No bloating.	Brown, Fairly strong, gray centre, fine to well bloated.	Light brown, Fairly strong, Well bloated.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
C_4-3	1800° F.	Light brown colour, weak, dark gray centre, some very fine bloat.	Light brown colour, weak, dark gray centre, trace very fine float.	Brick red, Weak, dark gray centre, Trace very fine bloat.	Brick red, Weak, dark gray centre, Trace very fine bloat.
	1900° F.	Light brown, Weak, dark gray centre, some fine bloat.	Light brown, Weak, dark gray centre, fine to medium bloat.	Light brown, Weak, dark gray centre, slightly sticks together, fine to medium bloat.	Light brown, Weak, dark gray centre, slightly sticks, together, fine to medium bloat.
C_6-3	1800° F.	Brick red, Weak, trace dark gray centre, No bloat.	Brick red, Weak, no bloat.	Brick red, Weak, no Bloat.	Brick red, Weak no bloat.
	1900° F.	Brown, moderately strong, trace gray centre, no bloat.	Brown, moderately strong, some fine gray spots at centre, no bloat.	Brown, moderately strong, trace gray centre, no bloat	Brown, moderately strong, some gray centre, some very fine bloat.
C_7-3	1800° F.	Light red, moderately strong, gray centre, no bloat.	Brownish red, moderately strong, gray centre, very fine bloat.	Reddish brown, moderately strong, gray centre, fine bloat.	Reddish brown, moderately strong, gray centre, fine bloat.
	1900° F.	Dark brown, Weak, gray centre, medium bloat.	Dark brown, Weak, gray centre, medium bloat.	Dark brown, Weak, gray centre, medium bloat.	Dark brown, Weak, gray centre, sticking in crucible, over bloat.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
C_8-3	1800° F.	Brownish red, Weak, some trace gray, centre, no bloat.	Brownish red, moderately strong, gray centre, very fine bloat.	Brownish red, moderately strong, Trace gray centre, Trace very fine. bloat.	Brownish red, Moderately strong, Gray centre, very fine to fine bloat
	1900° F.	Dark brown, medium strong, light gray, Medium bloat.	Dark brown, Medium strong, light gray, Medium to well bloat.	Dark brown, Medium strong, light gray, Well to over bloat.	Dark brown, weak, light gray, begins to stick, well to over bloat.
C_9-3	1800° F.	Brownish red, Weak, Some gray centre, no bloat.	Brownish red, Weak, some gray centre, no bloat.	Brownish red, Moderately strong, gray centre, very fine bloat.	Brownish red, moderately strong, gray centre, very fine bloat.
	1900° F.	Brown, medium strong, pinkish gray centre, medium bloat.	Brown, medium strong, light gray centre, medium bloat.	Dark brown, weak, light gray centre, well bloat.	Dark brown, Weak, gray centre, well bloat.
C_{10}-3	1800° F.	Brick red, Moderately strong, Light gray centre, No bloat.	Brick red, Moderately strong, Light gray centre, No bloat.	Brick red, Moderately strong, Light gray centre, No bloat.	Brick red, Moderately strong, Light gray centre, No bloat.
	1900° F.	Brown, Moderately strong, Light gray centre, fine bloat.	Brown, moderately strong, Light gray centre, fine bloat.	Brown, moderately strong, Light gray centre, fine bloat.	Brown, moderately strong, Light gray centre, fine bloat.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
C_{12}-3	1800° F.	Light red, Moderately strong, No bloat.	Light red, Moderately strong, No bloat.	Light brownish red, moderately strong, No bloat.	Light brownish red, moderately strong, No bloat.
	1900° F.	Brown, strong, Some light black centre, No bloat.	Brown, strong, Trace light black centre, No bloat.	Brown, strong, Trace black centre, No bloat.	Brown, strong, No bloat.
C_{13}-3	1800° F.	Light red, Moderately strong, Trace gray centre, No bloat.	Light brownish red, moderately strong, No bloat.	Brownish red, Moderately strong, No bloat.	Brownish red, Moderately strong, No bloat.
	1900° F.	Light brown, Strong, black centre, No bloat.	Light brown, Strong, Some light black, centre, No bloat.	Brown, strong, Trace Black centre, No bloat.	Dark brown, Strong, black centre, No bloat.
C_{14}-3	1800° F.	Light red, Strong, Trace light gray centre, No bloat.	Light red, Strong, No bloat.	Brownish red, Strong, No bloat.	Brownish red, Strong, No bloat.
	1900° F.	Brown, Moderately strong, Some light black centre, No bloat.	Brown, Moderately strong, No bloat.	Brown, Moderately strong, Trace black centre, No bloat.	Brown, moderately strong, Trace black centre, No bloat.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
C_{15}-3	1800° F.	Light brown, Moderately strong, No bloat.	Light brown, Moderately strong, No bloat.	Light brown, Moderately strong, No bloat.	Brown, Moderately strong, No bloat.
	1900° F.	Light brown, Moderately strong, No bloat.	Light brown, Moderately strong, No bloat.	Brown, Moderately strong, No bloat.	Dark brown, Moderately strong, No bloat.
C_{16}-3	1800° F.	Light red, Weak, No bloat.	Light red, Weak, No bloat.	Light red, Weak, No bloat.	Light red, Weak, No bloat.
	1900° F.	Light red, Moderately strong, Gray centre, fine bloat.	Brown, Moderately strong, Gray centre, medium bloat.	Brown, Moderately strong, Gray centre, medium bloat.	Dark brown, Moderately strong, Gray centre, well bloat.
C_{17}-3	1800° F.	Light brown, Weak, dark gray centre, No bloat.	Light brown, Weak, Trace dark gray centre, No bloat.	Light brown, Moderately strong, Gray centre, Very fine to fine bloat.	Light brown, Moderately strong, Some gray centre, Some very fine to fine bloat.
	1900° F.	Light brown, Moderately strong, Light gray centre, Medium bloat.	Light brown, Moderately strong, Light gray centre, Medium bloat.	Dark brown, Moderately strong, Light gray centre, Medium bloat.	Dark brown, Moderately strong, Light gray centre, Medium to over bloat.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
C_{18}-3	1800° F.	Light red, Weak, gray centre, No bloat.	Light red, Weak, gray centre, No bloat.	Red, Moderately strong, Gray centre, very fine bloat.	Brown, Moderately strong, Gray centre, fine bloat.
	1900° F.	Light red, Weak, gray centre, very fine bloat.	Brownish red, Moderately strong, gray centre, medium bloat.	Brown, Moderately strong, Gray centre, medium bloat.	Dark brown, Moderately strong, Gray centre, well bloat.
C_{19}-3	1800° F.	Light brown, Moderately strong, No bloat.	Light brown, Moderately strong, No bloat.	Light brown, Moderately strong, No bloat.	Brown, Moderately strong, No bloat.
	1900° F.	Light brown, Moderately strong, No bloat.	Light brown, Moderately strong, No bloat.	Brown, Moderately strong, No bloat.	Dark brown, Moderately strong, No bloat.
C_{20}-3	1800° F.	Light cream red, moderately strong, no bloat.	Light red, moderately strong, no bloat.	Light red, moderately strong, no bloat.	Light red, moderately strong, no bloat.
	1900° F.	Red, moderately strong, no bloat.	Red, moderately strong, no bloat.	Brick red, moderately strong, no bloat.	Brick red, moderately strong, no bloat.

Table 6.--Quick-firing tests on samples from Dacca area.

Sample no.	Temperature Fahrenheit	Firing time			
		15 minutes	20 minutes	25 minutes	30 minutes
C_{21}-3	1800° F.	Light red, Weak, gray centre, no bloat.	Light red, Weak, gray centre, very fine bloat.	Light red, Moderately strong, gray centre, fine bloat.	Brown, Moderately strong, gray centre, fine bloat.
	1900° F.	Light red, Weak, Light gray centre, fine bloat.	Reddish brown, Moderately strong, light gray centre, Medium bloat.	Brown, Moderately strong, light gray centre, Medium bloat.	Dark brown, Moderately strong, light gray centre, well bloat.
C_{22}-3	1800° F.	Light red, Weak, gray centre, no bloat.	Light red, Moderately strong, gray centre, no bloat.	Light brown, Moderately strong, gray centre, very fine bloat.	Brown, Moderately strong, dark gray centre, fine bloat.
	1900° F.	Brown, Weak, gray centre, fine to medium bloat.	Brown, Weak, gray centre, fine to medium bloat.	Brown, Weak, light gray centre, medium bloat.	Brown, Moderately strong, light gray centre, Well bloat.

Bloating was achieved in the samples collected at temperatures ranging from 1800° F. to a maximum of 2300° F., but the majority of the samples bloated between 1800° and 2000° F.; this is a favorable temperature range for a commercial operation. It was not possible to test some samples through the entire range of temperatures desired, owing to failure of the electric furnace used.

A total of 604 individual muffle furnace tests were made (table 6).

Crushing tests

Through the courtesy and cooperation of the Hydraulic Research Laboratory of WAPDA in Dacca it has been possible to secure a preliminary estimate of crushing strengths attainable with light-weight aggregates produced from Dacca clays. Again, the writers wish to emphasize that the aggregate used or the concrete mix design probably do not represent the optimum results attainable; however, the performed tests provided an indication of possible crushing strengths.

In many of the country brick kilns, clays of the Dacca area commonly bloat by accident (fig. 9) owing to the unevenness of firing temperatures. Some of this material, called Jhama (Bengali meaning tough and deformed bricks), was collected and broken to be used as aggregate. Physical properties of Jhama aggregate sample 1 are as follows:

Sample location	Specific gravity	Absorption (S.S.D.) (saturated surface dried)	Unit weight (lb./cu.ft.)	
			Loose	Rodded
Mr. Ghafoor's brick field, Panchabati, Fatullah, Dacca	1.41	6.05	40.00	45.75

A concrete mix was designed for 5,000 pounds per square inch by WAPDA and cast into standard concrete test cylinders (fig. 10) 6 in. x 12 in. in size, and subjected to 3-, 7-, and 28-day crushing tests.

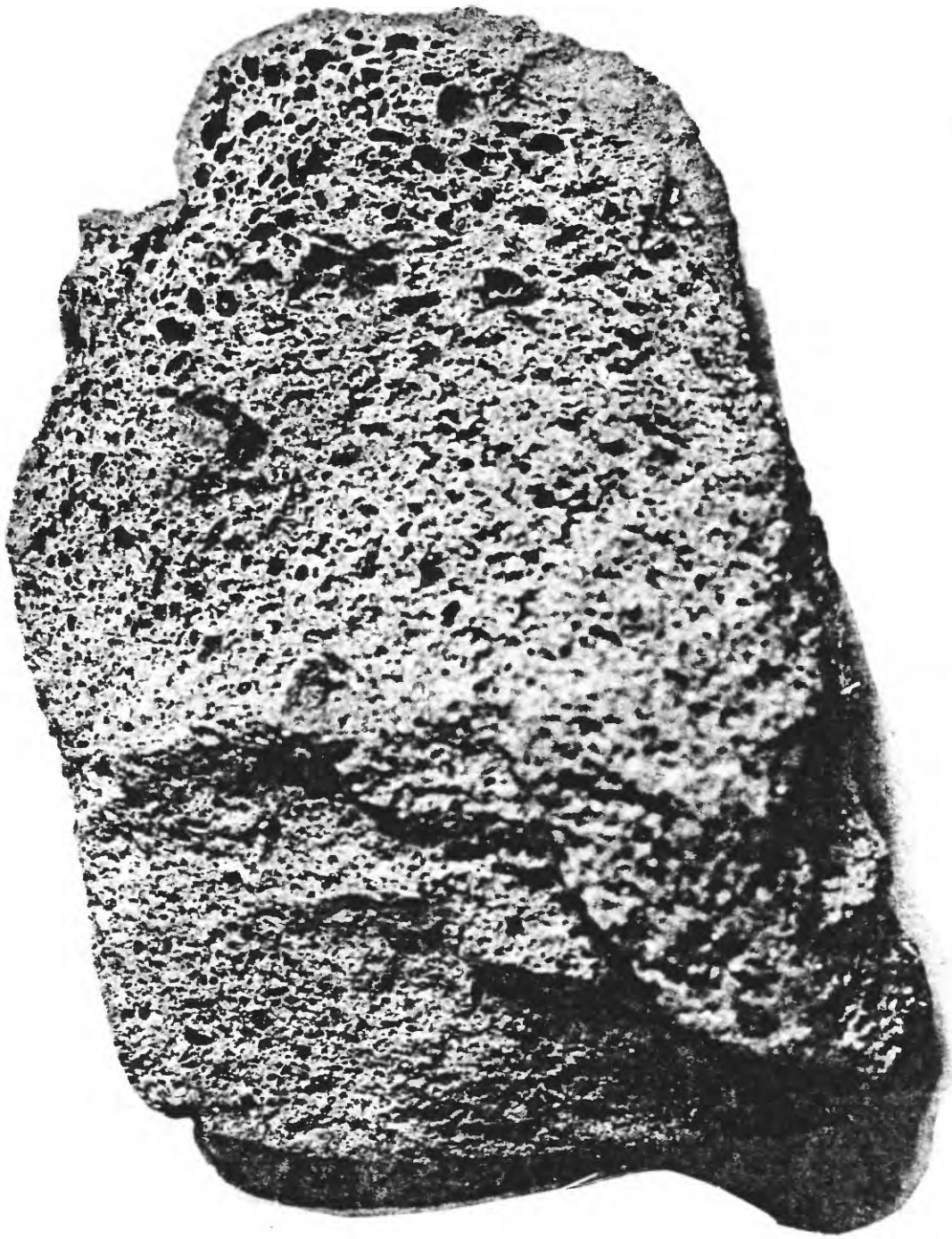

Figure 9. Jhama bloated by accident in brick kiln.

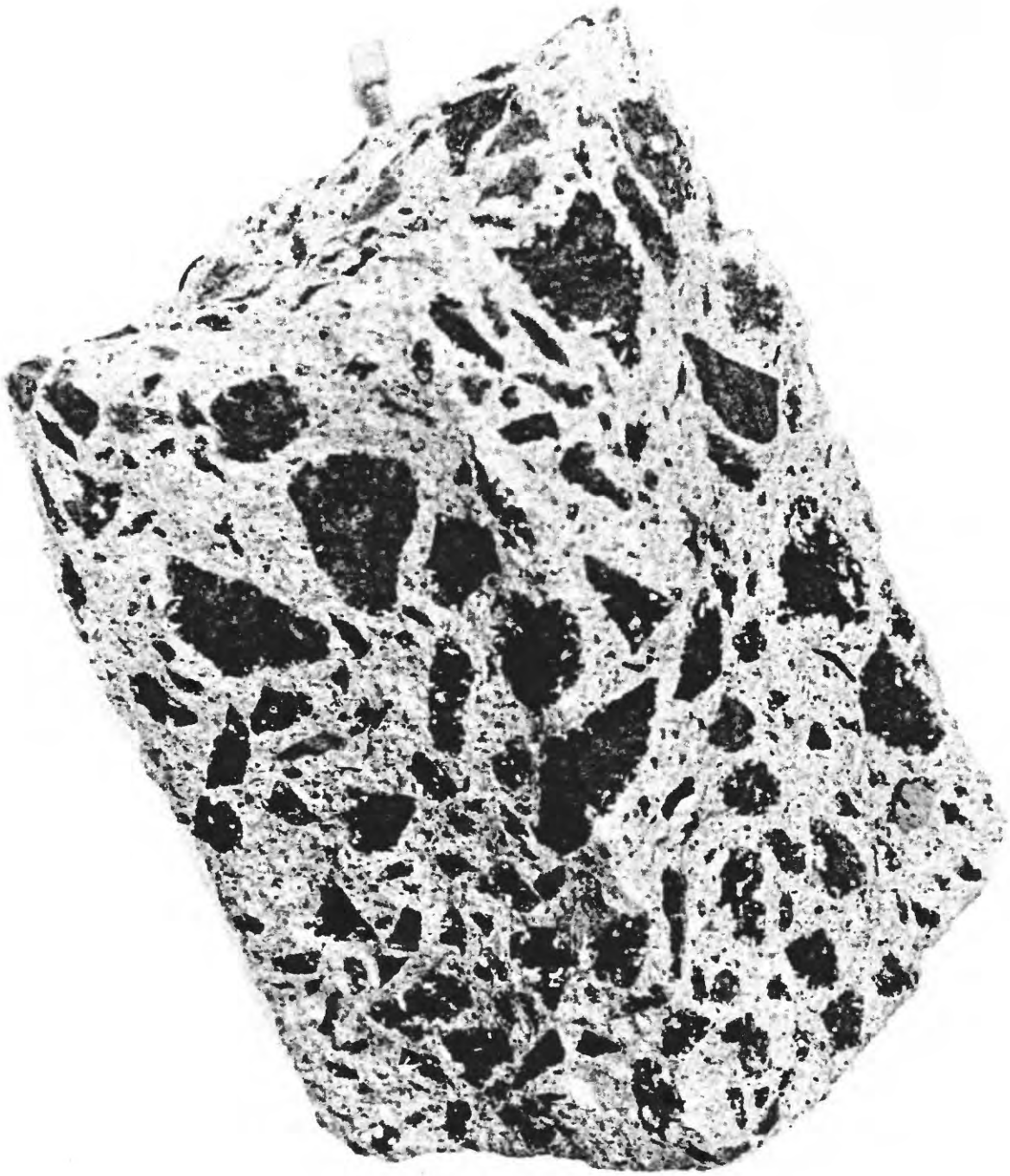

Figure 10. Section of Jhama aggregate concrete test cylinder, showing fractured surfaces.

One trial mix was run in the Hydraulic Research Laboratory to observe the development of compressive strengths of concrete test cylinders using a good quality Type 1 cement, coarse sand, and the supplied light-weight aggregates at a water-cement ratio of 0.44. The object of this trial mix was to determine the compressive strength of the concrete at 3, 7, and 28 day curing. The mix was a good and workable one designed for test cylinders of 5000 psi in 28 days. Results obtained are given in table 7.

Some comparative information on compressive strength tests of cylinders containing commercially produced light-weight aggregates is given in table 8. However, it is necessary to bear in mind that these results are with a different concrete mix design and were designed for 3000 psi in 28 days.

From the foregoing it can be seen that the compressive strength of the light-weight aggregate test cylinders of this investigation compare favorably with those of commercially produced light-weight aggregates.

The unit weight of the Jhama aggregate given by WAPDA at 45.75 lbs. per cu. ft. is comparable to commercially produced light-weight aggregate. The average weight of concrete made from conventional aggregate is 150 lbs. per cu. ft.; that of the Jhama aggregate is 117.5 lbs. per cu. ft., a difference of 32.5 lbs. per cu. ft., a weight reduction of approximately 22 percent.

Table 7.--Compressive strength of Jhama-aggregate concrete test cylinder.

No. of days	Compressive strengths (psi)	Unit weight of fresh concrete (lbs./cu.ft.)	Water cement ratio	Slump (inches)	Remarks
3	1344	117.50	0.44	1-3/4	The break was through both mortar and aggregate
7	2688	117.50	0.44	1-3/4	Do.
28	4352	117.50	0.44	1-3/4	Do.
	4104	117.50	0.44	1-3/4	Do.

Table 8.--Compressive strength of concrete test cylinders made of commercially produced light-weight aggregate.

Sample No.	Slump (inches)	Compressive strength (psi) 7 days aging	28 days aging
1 (4 cylinders)	4 (mixture rather wet)	2087	3643
		2122	3537
		2122	3537
		2158	3608
2 (2 cylinders)	4	2759	3572
		2653	3502
3 (4 cylinders)	3-1/2	2618	4103
		2688	4157
		2546	4103
		2582	4068
4 (4 cylinders)	4	2405	3219
		2193	3290
		2211	3325
		2193	3360

Reserves

Reserve estimates are listed below (table 9) for areas A, B, and C, in cubic yards and on the basis of 1 cubic yard of raw material to produce one cubic yard of expanded aggregate. The areal extent has been scaled from maps and the average depth of all the holes augered in a particular area was used to estimate cubic yardage. Undoubtedly, the reserves in any particular area could be expanded by further augering. All the auger holes ended in clay, and deeper drilling would undoubtedly increase the established depth of the clay deposit with consequent increase of reserves.

A commercial plant producing 1000 cubic yards per day of lightweight aggregate and operating 330 days per year would require 330,000 cubic yards of raw material per year. A 20-year clay reserve would require 6,600,000 cubic yards of proven reserves. On this basis, Area A would have a life of 40 years; Area B, 35 years; and Area C approximately 300 years. In estimating the above reserves it should be kept in mind that they are not necessarily all minable reserves, owing to encroachment on village sites or other cultural features; however, there is no doubt that sufficient reserves for a commercial plant can be confirmed, as well as the reasonable belief that any of these areas can be extended or new deposits found equal in quality to those tested.

Table 9.--Reserves of raw material for selected areas near Dacca.

Area	Dimensions (in yards)			Volume
	Length	Width	Depth	(Cubic yards)
A	2000	1500	5	15,000,000
B	2500	700	7	12,250,000
C	6000	2700	6	97,200,000
C	3600	500	6	10,800,000
Total.....				135,250,000

Development and recommendations

Areas A, B, and C were selected for exploration drilling because, in addition to containing clay amenable to bloating, they are within a radius of 10 miles from central Dacca. Presently existing highways, river fronts, railways, power and gas lines are all in the near vicinity of the described deposits. The country side is flat agricultural land, the only relief being local mounds occupied by villages and houses, and is entirely flooded during the monsoon season.

The maximum depth of presently existing clay pits dug by hand to supply the country kilns has been reported to be 35 feet, and we have seen them as deep as 23 feet. During the dry season water entering the pit does not appear to be a problem, and can be bailed out with buckets. During the rainy season the pits are completely flooded and abandoned and new pits are dug the next dry season. Clay pits could be diked to keep out flood waters and reduce pumping to the actual rain falling into the pit; or mining could be done under water with equipment such as a slack-line scraper. The seasonal flooding of clay pits requires careful consideration in any mining plans.

It is the writers' belief from the tests made that the higher the percentage of gray organic clay in the sample, the lower the bloating temperature will be, but such clays tend to produce a weaker and overbloated product. An increase in the amount of yellow or red clays will produce a stronger aggregate with wider range of bloating temperatures, but will also necessitate higher temperatures.

The next step in the evaluation of these clays is the establishment of a standard method of rotary-kiln processing through access to a pilot kiln. The information secured by pilot-kiln testing is necessary for design and operating procedure for a full size commercial installation. Pilot kiln testing will determine the following kiln variables: kiln slope, rate of feed, retention time, kiln speed, required draft, type of flame (oxidizing, reducing, natural), range of bloating temperatures, and processing qualities such as agglomeration, adherence to the kiln, decrepitation, etc.

In addition, the proper blending of different clay horizons to produce an optimum product can be determined. Sufficient aggregate can also be produced for all testing purposes required such as weight per cubic foot, crushing strength, water absorption for mix design, or other desired tests.

Pilot kilns used for such testing are in the general dimensions of 6 to 14 inches in internal diameter, and 10 to 15 feet in shell length.

SUMMARY

Large reserves of clay, claystone, and shale suitable for the production of light-weight aggregate lie to the east and north of Chittagong within a radius of 35 miles. Seven areas are known to contain sizeable reserves, and it is reasonable to expect uniformity of the horizon over sufficiently large areas and depths to assure adequate additional reserves. Before a decision as to the most suitable raw material and plant location can be determined, additional drilling and sampling are necessary. Concurrent with this exploration, testing of large samples in a pilot kiln would be necessary.

Large reserves of clays in the immediate vicinity of Dacca are also amenable to bloating for the production of light-weight aggregate. In the three areas tested, however, auger holes were widely spaced, and no attempt was made to locate a specific site for a commercial operation. Before building a commercial light-weight aggregate plant, some additional drilling and sampling at closer intervals would be necessary. Following this drilling, it would be necessary to test large samples in a pilot kiln.

Production of light-weight aggregates from clay and shale appears to be an answer for the shortage of natural aggregates in areas such as East Pakistan. Synthetic aggregates can be produced at prices comparable to or less than those for "Jhama" (broken brick) now commonly used in East Pakistan; at the same time the synthetic aggregates produce a stronger, more uniform, and superior product. The future of aggregate plants in East Pakistan seems assured because 1) they will not be faced with competition from natural aggregates; 2) they produce a quality product; and 3) the projected economic growth of the area should result in continually increasing demands for aggregate materials.

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