PYROCLASTIC AND ASSOCIATED BASALTS OF INDIA IN RELATION TO AAR

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Abstract

The different erruptive layers of deccan traps in the marginal basaltic area in India are demarcated by the presence of pyroclastic rocks. The use of such material as concrete aggregate may affect the stability of structures made with such concrete. Generally aggregates available in the vicinity of the project are used due to economy. Hence testing of raw materials for AAR is unavoidable. The following case history is presented to assist the users.

The Kabbur tunnel in Karnataka state, India, passes through pyroclastic (Agglomarate and tuff) and altered porphyritic basalt rocks. Petrographic analysis, physical and chemical tests were carried out on both the rock types.

The test results indicate that both the rock types consist zeolite, amorphous silica, volcanic glass and chert which are deleteriously reactive. However, they are found in admissible limits (6 to 8% as per BIS 383, 1970) in altered porphyritic basalt while in pyroclastic rocks their percentage is high (10 to 40%). Moreover the altered porphyritic basalt passes the physical test and hence the altered porphyritic basalt is suggsested for its use as aggregate with low alkali cement while agglomarate is not found suitable.

The aggregates in marginal basaltic terrain have to be tested invariably. If aggregates comprising deleterious minerals are found suitable in the physical tests, they can be used with low alkali cement in the concrete.

Keywords

Agglomerate, Altered porphyritic basalt, Petrographic analysis, Plagioclase cluster

Introduction

In India, the deccan traps of Cretaceous- E ocene age are found over an area of more than 500,000 sq.km, particularly in the whole of Maharashtra, a great part of western half of Madhya Pradesh, parts of Gujarat and in small portion of Andhra Pradesh and Karnataka States (Fig.1).

During the formation of deccan traps, in the marginal areas of basalts, in India, where the seismic activity occurred, the pyroclastic ejecta material comprising volcanic ash, tuff, volcanic breccia, red bole and agglomarate occupies greater thicknesses ranging from 10 to 20 m relative to the central basaltic areas. The presence of these rocks indicate the different erruptive layers intermittent to the main basalt flow. These layers comprise deleteriously reactive phases such as zeolite,

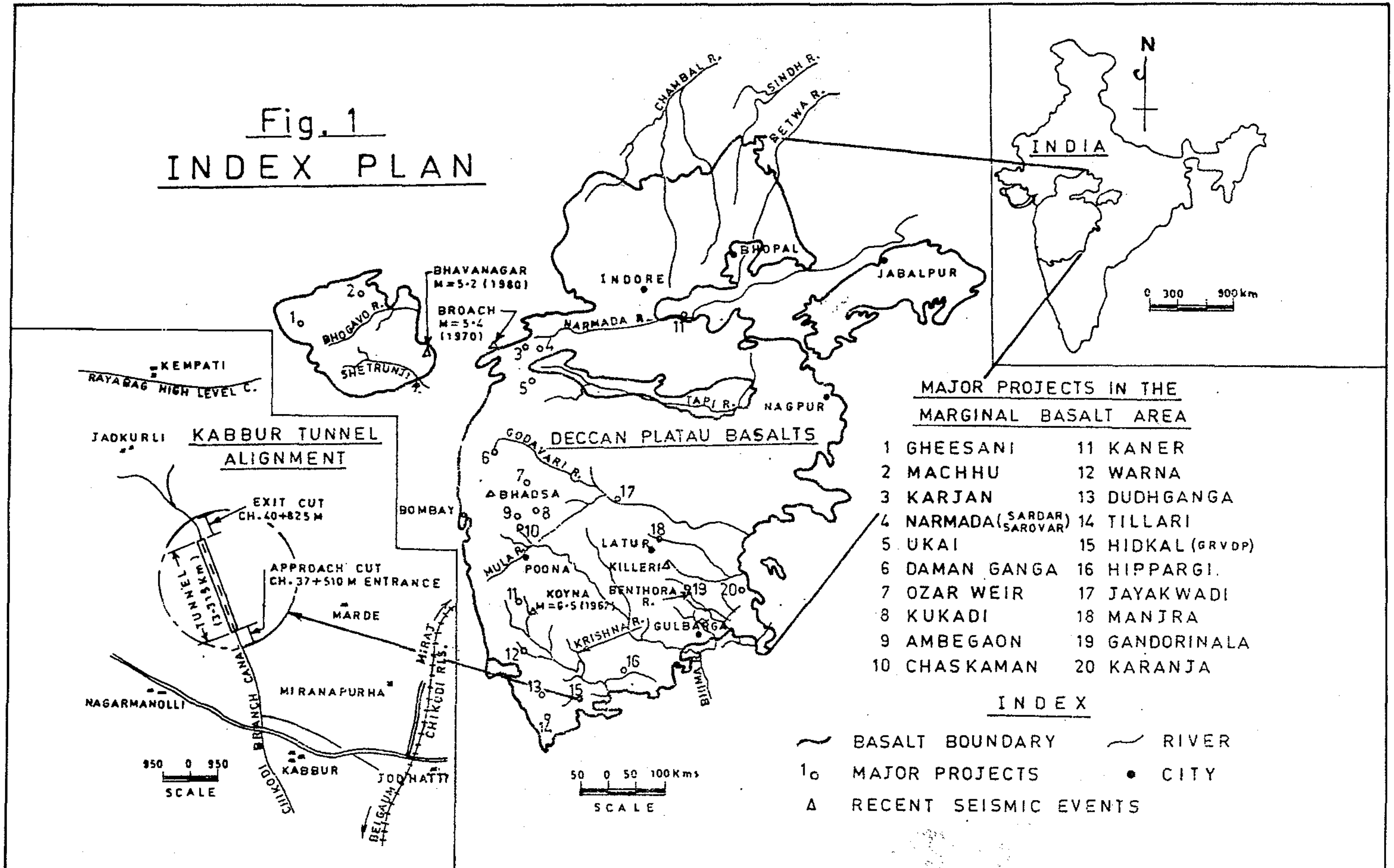

Fig. 1
INDEX PLAN
INDIA
N
0 300 900km
CHAMBAL R.
SINDH R.
BETWA R.
BHOPAL
INDORE
JABALPUR
NARMADA R.
TAPI R.
NAGPUR
BHAVANAGAR M=5·2 (1980)
BROACH M=5·4 (1970)
BHOGAVO R.
SHETRUNJI R.
DECCAN PLATAU BASALTS
GODAVARI R.
BHADSA
BOMBAY
MULA R.
POONA
KOYNA M=6·5 (1967)
LATUR
KILLERI
BENTHORA R.
KRISHNA R.
GULBARGA
BHIMA
50 0 50 100Kms
SCALE
KABBUR TUNNEL ALIGNMENT
KEMPATI
RAYABAG HIGH LEVEL C.
JADKURLI
EXIT CUT CH. 40+825 M
APPROACH CUT CH. 37+510 M ENTRANCE
TUNNEL (3·315Km)
MARDE
MIRAJ CHIKODI RLS.
MIRANAPURHA
NAGARMANOLLI
CHIKODI BRANCH CANAL
KABBUR
JODHATTI
BELGAUM
950 0 950
SCALE
MAJOR PROJECTS IN THE MARGINAL BASALT AREA
1 GHEESANI
2 MACHHU
3 KARJAN
4 NARMADA (SARDAR SAROVAR)
5 UKAI
6 DAMAN GANGA
7 OZAR WEIR
8 KUKADI
9 AMBEGAON
10 CHASKAMAN
11 KANER
12 WARNA
13 DUDHGANGA
14 TILLARI
15 HIDKAL (GRVDP)
16 HIPPARGI
17 JAYAKWADI
18 MANJRA
19 GANDORINALA
20 KARANJA
INDEX
BASALT BOUNDARY
RIVER
MAJOR PROJECTS
CITY
RECENT SEISMIC EVENTS

chert, amorphous silica, tuff, volcanic glass, volcanic ash etc. Many maritime projects are coming up on such geological terrains, for which the demand for aggregate is increasing rapidly . It is common practice for the user to utilise excavated material as aggragate to save on costs. But it is of immense importance to study the suitablity of the aggregate in the light of AAR and ensure the admissible limits of deleteriously reactive minerals as per BIS 383, 1970, failing which there may be a great threat for the safety of the structure in due course. As a case study, the Kabbur tunnel, a part of GRVDP of Karnataka state in India, has been considered in the following section.

Kabbur Tunnel

The 3.315 km long 3.2 m x 3.2 m size tunnel (N 22°W of FB 338°) has been excavated as a part of Chikkodi Branch Irrigation Canal (Fig. 1). The area around the tunnel comprises varients of basalt of Cretaceous to Eocene age overlying recent thin pile of black cotton soil. The deccan trap lava flows of altered porphyritic basalt and porphyritic amygdular basalt are separated by agglomerate with a layer of red bole above it.

Geology

Based on the geological observations made at different working faces and also exposed sections of the tunnel, the following lithostratigraphic sequence is established.

Rock type	Thickness (m)	Age
Soil	0.5 to 1.5	Recent
Porphyritic Amygdular Basalt	+ 24	Eocene
Red bole	0.5 to 2.5	
		to
Agglomerate	+ 20	
Altered Porphyritic Basalt	Encountered in patches	Cretaceous

Of the different geological formations in the area, the tunnel passes through agglomarate and altered porphyritic basalt where the altered porphyritic basalt occurs as irregular bodies.

The proposal to use the tunnel muck as concrte aggregate has been examined and to assertain its suitability with respect to AAR as per the provisions of BIS 383, 1930, chemical and physical tests and petrographic analysis were carried out on some representative samples as follows.

Laboratory studies

For laboratory tests 28 samples from the rock mass along the tunnel and 70 samples from the excavated rock were collected. All these samples indicated that there are two main rock types viz. agglomerate and altered porphyritic basalt. The test results of both the rock types is as follows.

Physical tests

Apart from physical tests mentioned in Table-1, the compressive strength has been measured on 3 specimens of agglomerate. It was evaluated by testing oven dried specimens and specimens immersed in water for 72 hours. The specimens used for dry and wet test were identical and the load was applied in the same orientation. The dry strength varied from 527 to 2040 kg/cm^2 while the wet strength varied from 520 to 596 kg/cm^2. The drop in strength is high, probably due to loss of intergranular bond. Hence, it is unacceptable. The results of different physical tests carried out on two agglomerate samples and on an altered porphyritic basalt are as follows.

Table-1 Physical tests of agglomerate and altered porphyritic basalt

Sr. No.	Test	Agglomerate		Altered Porphyritic Basalt	BIS Specifications (2386, 1963 and 383, 1970)
		Rock of Approach Cut and Shaft-1	Rock of Exit and Shaft-2		
1	Specific gravity	1.99	2.33	3.05	--
2	Absorption (%)	6.51	6.83	1.52	--
3	Aggregate impact value (% loss)	20.51	14.3	--	30% for wearing surface; 45% for non-wearing surface
4	Aggregate crushing value (% loss)	25.1	26.8	--	30% for wearing surface; 45% for non-wearing surface
5	Los Angeles abrasion value (% loss)	44.4 composite rock sample (Agglomerate + Porphyritic Basalt)	--	18.1	30% for wearing surace; 50% for non-wearing surface
6	Sodium sulphate Soundness of aggregate 5 cycles (% loss)	56.0	32.0	10.12	12% of conrete-surface subject to frost action

Chemical test

Representative samples of agglomerate and altered perphyritic basalt from tunnel muck were selected for the test. The results of the chemical test carried out at Karnataka Engineering Research Station, shows that the reduction in alkalinity and the concentratin of silica on two trials for agglomerate and altered porphyritic basalt ranges from 195 to 230 millimoles/ltr, 89 to 138 millimoles/ltr and 174 to 177 millimoles/ltr, 233 to 238 millimoles/ltr respectively. These are near the zone of deleterious aggragates as per the graph in page 24 of BIS 2386 (Part VIII)

Petrographic analysis

The petrographic analysis of 10 agglomerate and 16 altered porphyritic basalt rock samples from different locations was carried out. It shows that the fragments of basalt and volcanic material are embedded in pyroclastic glassy matrix (Fig.2). The plagioclase laths are seen decomposed at higher magnification which may be due to the reaction between volcanic glass and sodium in plagioclase (Fig.3). Porphyritic basalt with volcanic glass, the plagioclase as a predominant mineral, altered minerals and iron oxides are shown in Fig.4. The porphyritic basalt with predominant plagioclase (cluster and laths) having corroded boundaries is shown in Fig.5 & 6 and plagioclase with reaction rim is shown in Fig.6. The sparsely spaced amygdules in porphyritic basalt are filled up with zeolites Fig.7.

Conclusions

The entire 3.315 km long tunnel passes through pyroclastic rocks, mainly agglomerate (volcanic breccia and lithic tuff). The two main rock types encountered and tested are agglomerate and altered porphyritic basalt.

The agglomerate rock has the specific gravity ranging from 1.99 to 2.33 which is rather low, moreover the percentage absorption ranges from 6.51 to 6.83 while permissible limit is less than 5% for rubble (BIS 1597, Part I, 1967) and it has failed in soundness test (Table-1).

The agglomerate contains excessive (10 to 40%) deletereously reactive material as matrix rendering it to be potentially reactive rock. Inview of the above, agglomerate is not acceptable as a concrete aggregate.

The porphyritic basalt has a specific gravity of 3.05, percentage absorption is 1.52, los angeles abrasion value is 18.1% and the soundness of aggregate (5 cycles) is 10 to 12% (Table-1). i.e. it passes through soundness test. Hand specimens show concoidal fractures which is indicative of the presence of volcanic glass. The volcanic glass patches with vitreous lustre is also observed with naked eye.

Petrographic analysis indicates the presence of 6 to 8% deletereously reactive minerals. Among these, the volcanic glass, which forms a portion of ground mass of basalt is unstable and very reactive as its micro structure is mostly similar to that of opal. Hence, it is classified as potentially reactive rock.

However, the use of aggregate with low alkali cement can be considered only after testing the aggregate either in concrete or in mortar because of the following reasons.

The petrographic analysis carried out for 16 samples from different locations has not shown any hetereogenity in mineralogical compostion and texture. It occurs as irregular bodies within pyroclastic rocks and the alteration of minerals in all the samples tested suggest homogeneous characteristics of rockmass. The predominant mineral in porphyritic basalt is plagioclase in the form of laths and clusters, which is susceptible to alteration. Its main chemical constituents are mainly soda and calcic oxides. As indicated in Reference 8 (pp.443-444), "It is now known that the trouble is due to reaction between silica in the aggregate and alkalies in the cement. In some cases alkalies, mainly from the cement but they may be suplemented by alkalies in the aggregate, react with carbonates in aggregate to produce similar results". The alkalies

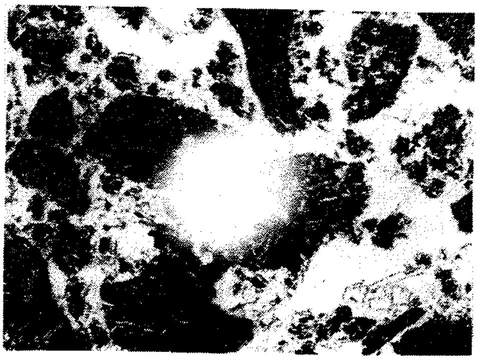

Fig.2 Agglomerate - angular fragments embedded in pyroclastic glassy groundmass

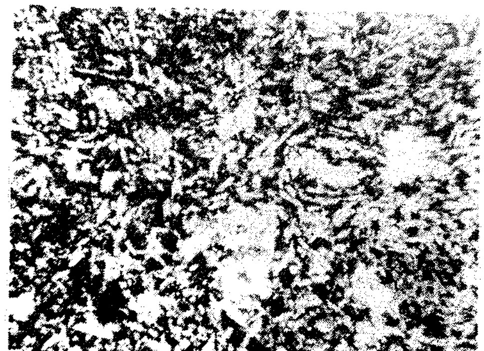

Fig.3 Agglomerate - decomposed plagioclase laths with volcanic glass in a litho-fragment

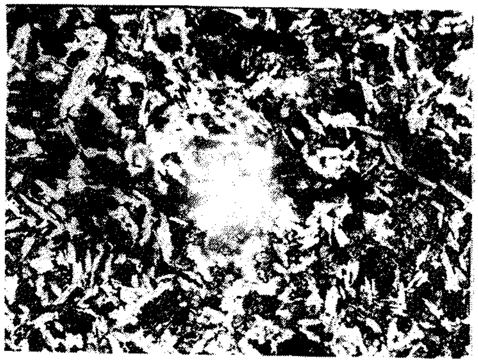

Fig.4 Porphyritic basalt - decomposed plagiocase, glass, altered minerals and iron oxides

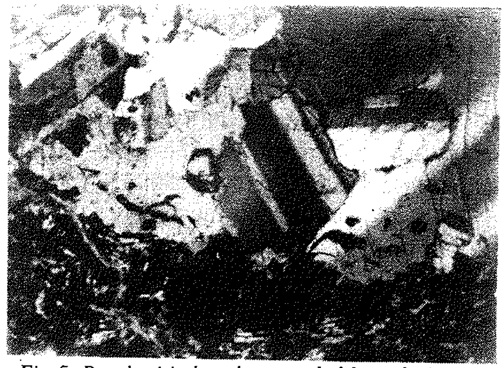

Fig.5 Porphyritic basalt - coroded boundaries of plagioclase and altered minerals with volcanic glass

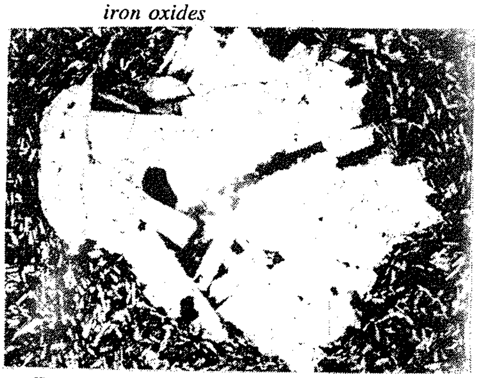

Fig.6 Porphyritic basalt - plagioclase cluster and laths having corroded border and reaction rim

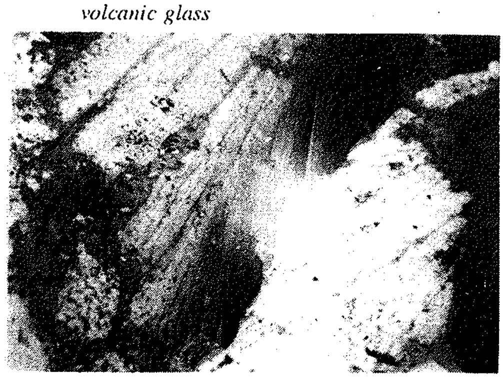

Fig.7 Porphyritic basalt - amygdules filled with zeoloites

from plagioclase of altered porphyritic basalt may take part in alkali aggregate reaction.

The decomposed plagioclase laths (Fig. 4), the corrossion on its boundaries (Fig. 5 & 6) and the formation of reaction rim in plagioclase of altered prophyritic basalt (Fig. 6) are indicative of decomposition due to the presence of volcanic glass in the rock.

In view of recommendation of BIS 383, 1970 under note in para 3.2 (Page 6), "The aggregates which have reactive tendency should be avoided or used only with cement of low alkali content (not more than 0.6 percent as Na_2O) after detailed laboratory studies" .

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