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CONSTRUCTIONAL MATERIALS & EXPERIMETAL STUDY OF ENGINEERING PROPERTIES, AS POROSITY, DENSITY, SPECIFIC GRAVITY AND WATER ABSORPTION ON ROCK MASS AVAILABLE IN BASTAR REGION OF CHHATTISGARGH STATE

[1]Khare, G.P. & [2] Tiwari R. P.
[1]Department of Civil Engineering, Government Engineering College Jagdalpur, Chhatish Gargh, India
[2]Department of Civil Engineering, Rewa Engineering College Rewa Madhya Pradesh, India

ABSTRACT
Bastar is a **Tribal belt region** of Chhattisgarh state and is known for enriched **Culture of tribes**. The region is also known for its Natural forests, Rivers and Topographical features like **Plateau, Caves and Water Falls**, which are always being attraction for tourist across the Country. Apart from tourist, the Mineral and underlying Rock Formations are proved to be abundance Sources for Mineralogist and Construction Industries. Chhattisgarh is promising state to set-up heavy, medium and small scale Mineral based Industries without importing any major raw minerals from other state. Besides workable economic deposits of almost all major and minor minerals, the state is reach in power, Water and Human Resources. Bastar is a Tribal belt region of Chhattisgarh state and is also known for its Natural forests, Rivers and Topographical features like Plateau, Caves and Water Falls. Minerals and underlying Rock Formations are proved to be abundance Sources for Mineralogist and Construction Industries. Apart from extraction of valuable Ores from the area many other Major Civil Engineering activities are being conducted in this region related to underground construction for defense, underground tunnel for Water Power project, underground Mining of rock slopes, Roads, Bridges, three big Steel and Iron Industries and so many small scale industries. The use of such rocks as building material, road metals, raw material for cement can also be made with much economy and stability. The suitability of rocks for construction of different type of structures including Industrial Building, Bridges, Towers, Over head and Under ground Water Tank and Roads etc may checked by conducting systematic study Engineering properties of rocks and locating their area of occurrence.

KEYWORDS:

INTRODUCTION

A wide variety rocks as Igneous, Sedimentary and Metamorphic are available in Chhattisgarh state. The large amount of Coal, Iron Ore, Limestone, Bauxite, Dolomite and Tin ore are located in different parts of the state. The diamondiferous kimberlite in which substantial quantity of diamonds are likely to be found are identified at Raipur district. The medium to small deposits of Gold base-metals, Quartzite, Soapstone, Steatite, Fluorite, Corundum, Graphite, Lepidolite, Amblygonite of workable size are also prospecting in the area. Occurrences of Garnet, Amethyst, Beryl, Andalucite, Kainite, Sillimanite and rare precious Mineral Alexandrite are reported from different parts of the State.

CHHATTISGARH STATE

A few of these may prove to be of sizable deposit. Deposits grey, pink, red and black granites (Dolerite, Amphibolite and Gabbro), and Flagstone of grey, black and purple shades are widely distributed and that are suitable for dimension stone and decorative purposes. In the Chhattisgarh state more than 28 Minerals are found and it is one of the richest resource of

minerals. During the year 2005-06 state has produced minerals worth Rs. 5600 Crores (excluding Atomic Minerals, Oil and Natural Gases). The mineral revenue contributed Rs. 737.85 Crores to the state exchequer during the year 2005-2006.

The classification of rock mass and Engineering properties of different types rocks available in the particular area, could also be undertaken to suggest the structural stability aspects of underground constructions and mining activities the areas. Apart from extraction of valuable Ores from the area many other Major Civil Engineering activities are being conducted in this region related to **underground construction for defense, underground tunnel for Water Power project, underground Mining of rock slopes, Roads and Bridges**.

GEOLOGICAL FEATURES

The state of Chhattigarh constitution one of the important geological terrains of the Indian shield exposing rock sequences from Archaean to Recent. A crustal scale Central Indian Shear Zone (CIS) trending E-W and passing through the central part, subdivides the state into two distinct geological provinces Viz., the Southern Bastar Province and the northern Satpura Province.

The Bastar Province constitutes cratonic nuclei comprising Archaean Gneissic Complex with tectonic silvers of older Sukma supracrustals and flanked by Kondagaon and Bhopalpatnam granulite belts in the northeast and southweast respectively. In the center part of the gneissic complex Bailadila Group representing Neo-Archaean to palaeoproterozoic greenstone belt, occupies linear North and South trending ridges in Bastar, Kanker and Durg district. Palaeoproterozoic volcanic rocks of Nandgaon Group extend in the North and South over a length of around 250km and width of 50-60km in the western part of the state bordering Maharastra between chilpi ghats in the north to the fringes of Abujhmar in the south. The volcano-sedimentary sequence in the eastern part in Raipur and Mahasamund district is included in the Palaeoproterozic Sonakhan Group. The Nandgaon volcanic belt is intruded by batholithic Dongargarh Grantie. The Dongargarh Granite and its equivalent granites in Madanbera and Kanker- Manpur areas occupy major portion of south-center part of the state. Mafic dyke swarms conspicuously occupy Bhanupratapur-Keskal, Narayanpur-Kondagaon Bijapur-Sukma and Geedam-Tongpal areas. Volcano-sedimentary sequence of the Khairagarh and Abujhmar groups and sediment of Chilpi Group belonging to Palaeo-Mesoproterozoic unconformably overlie the older sequence and the granite in the Maikala range and Abujhmar plateau region. Pakhal Super group belonging to Mesoproterozoic occupies the Godavari Valley region in the southwestern part of the state bordering Andhra Pradesh. Meso-Neoproterozoic plateformal cover sequence of the Chhattisgarh Plains. The cover sediments of Indravati, Sabri and Pairi Groups, occupy Jagdalpur Plateau, Sabri and Pairi groups, which are equivalents of Chhattigarh Group, occupy Jagdalpur Plateau, Sabri basin and Khariar highlands respectively. Laterite with pockets of bauxite forms capping at a number of places over these rocks in Keskal-Amabera area.

North and North Eastern part of the state is covered with Gondwana sediments of Mesozoic period and Deccan Traps. Traps often capped by laterites of Cainozoic age. Quaternary alluvium is mostly confined to major river valleys in the State. The granulite facies rocks could clearly be delineated to form separate belt in southern bastar including the Bhopalpatnam, Kondagaon and and the younger Konta Granulite Belt.

Mineral Resources:

The perfect geological setups are available in the Chhattisgarh state and numbers of economic mineral deposits are allocated at different part of state. In the different part of state has observed multiple major thermo tectonic events, covering principal Metallogenic and Mineralogenic episodes. The state is the richest state in mineral wealth and important 28 well known minerals are available in the state. The common important minerals in which the name of the state is intimately are Diamond, Coal, Iron ore, Limestone, Dolomite, Bauxites and Tin ore etc. Within the India Tin ore occurs only in the Chhattisgarh state. Atomic minerals and precious metal gold are also found in the different part of Chhattisgarh state. Other minerals like Corundum, Clay, Quartzite, Fluorite, Beryl, Andalusite, Kyanite, Sillimanite, Talc, Soapstone and Garnet. are also available in the state. Vast reserves of granites of various attractive shades, which can be used as decorative purposes for different kind of woks are also available in the state of Chhattisgarh.

Reserve of important minerals in Chhattisgarh:

S. No	Mineral	Reserves in Chhattisgarh MT	Percentage in India
1.	Iron ore	2336	18.96 %
2.	Coal	39545	16.10 %
3.	Bauxite	198	6.44 %
4.	Lime stone	8225	4.73 %
5.	Cassiterite	31.84	99.93 %
6.	Dolomite	935	12.75 %
7.	Gold	3	2.58 %
8.	Corundum	50	0.15 %
9.	Quartzite	26.10	2.32 %

IRON ORE

The world-class iron ore deposits (up to 68% Fe) are available in the Chhattisgarh state. About 2300 million tones of superior quality of iron ore as Hematitie are available in the state, which is one fifth of total amount available in the country. The 23 million tones iron ore was produced in the 2004-2005 ranked 3rd in the country, and accounting for 16 % of the national production. Tata Steel, ESSAR Steel and NMDC Iron and Steel plants are going set-up in the Chhattisgarh state very soon.

Figure-1 Iron Ore

BAUXITE

The state has about 198 million tones bauxite and it is approximately 7% of the national reserves. The state, ranking is 5th in the country in extracting bauxite and contributing about 9.5% to the national production. The reserve of state supports, aluminum extraction units of BALCO in Chhattisgarh and Hindalco in Uttar Pradesh. The BALCO Plant is also producing more than 100 units of various aluminum produces.

S.No	Locality	Reserve MT	Grade
1.	Mainpat area, Surguja	31.23	Metal grade
2.	Kandraja Mainpat, Surguja	10.10	Metal grade
3.	Jamirpat area Surguja	40.50	44.22-56 % Al_2O_3
4.	Pendrapat area,Jashpur	12.93	Metal grade
5.	BodaiDaldali, Kabirdham	6.12	Metal grade
6.	Keshkal area, Kanker	6.44	Refractory grade
7.	AsnaTarapur, Bastar	1.50	Metal grade

Figure-2 Bauxite

LIMESTONE

Over 8225 million tones of cement grade limestone are available in the Chhattisgarh state and it is 5% of total reserve of national level. The state ranks 5th in the production of 5th limestone sharing 10 % of the total national level production. Since world class lime stone are available in the state 7 major and 4 minor Cement production units are working.

The Cement grade limestone deposits of various magnitudes have been identified in the several parts of state. The Kanger valley limestone belt are extended over a length of 30 K.M. Pekela limestone belt are about 5.0 K.M. in the length and Potanar limestone beltare about 8 K.M. stretch located near Jagdalpur in bastar district. Extensive deposits of BF grade limestone are present in the Bilaspur district. The estimated recoverable reserves of lime stone in Raipur district are about 2373 million tones and it cement class.

S. No	Locality	Reserve MT	Grade (Cao %)
1.	Maldi Mopar Karmadih, Raipur	309	44.93 %
2.	Chandi area, Raipur	87	45.10 %
3.	Gaitra area, Raipur	105	45.62 %
4.	Mohra area, Raipur	97	45 %
5.	Pharsabhader, Raipur	216	46.03 %
6.	Kukradih, Raipur	210	45.31 %
7.	Bharwadih, Pausri uma, Raipur	426	44 %
8.	Achhoti area, Durg	80	48.03 %
9.	Matre Gota, Durg	121	45 %
10.	Semaria, Durg	98	45.73 %
11.	Ghotwani, Durg	21	45.58 %
12.	PotanarBaranji, Bastar	22	45.32 %
13.	Deorapal, Bastar	19	BE grade
14.	Sivni-Alnar, Bastar	48	45.36 %
15.	Bargaon, Janjgir	47	81% Corbonate
16.	Tendua, Bilaspur	12	46.13 %
17.	Tumribor, Rajnandgaon	7	44.82 %
18.	Ranjitpur-Manpur, Kawardha	20	45.27 %

Figure-2 Lime Stone

DOLOMITE

The contribution of state is about 13% of the total national deposits of dolomite and total deposit is about 935 million tones of reserve. The state holds 2nd position in the country in dolomite production and sharing over 26% of national production. Available dolomite in the state is mostly of the flux and refractory grade.

Figure-4 Dolomite

COAL

The 9545 million tones coal has been estimated in 12 coalfields of the different parts of state. The state holds 2nd rank in coal production in the total national output. Most of the coal deposits are of power grade. NTPC and CSEB are two old major producer of thermal power in the State and situated at Korba district and a new National Thermal Power Plant NTPC have been recently started at Seepat, in the Bilaspur district

Figure-5 Coal

S. No	Coal Field	Reserve MT	District
1.	Sohagpur coalfields	104	Sarguja
2.	Sonhat coalfields Semicoking Non-coking	73675	Surguja Sarguja
3.	Jhilimili coalfields	267	Koria
4.	Chirimiri coalfields	362	Koria
5.	bishrampur coalfields	1450	Sarguja
6.	Lakhanpur coalfields	451	Sarguja
7.	Panch, Bahini coalfields	11	Sarguja
8.	Hasdeo Arand coalfields	4964	Sarguja-Koria
9.	Sendurgarh coalfields	279	Koria-Korba
10.	Korba coalfields	10002	Korba
11.	Mand Raigarh coalfields	17987	Raigarh
12.	Tatapani Ramkota coalfields	1507	Sarguja-koria

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The 12 numbers of coalfields have been identified in the state and about 9545 million tones amount of coal has been estimated in the different parts of state. The state holds 2nd rank in the coal production of the total national output. Most of the coal deposits are of power grade and most parts it is being used in power production. NTPC and CSEB is the two old major thermal power producers in the State and situated at Korba district. A new National Thermal Power Plant NTPC has been recently started at Seepat, in the Bilaspur district 15 K. M. form Bilaspur City.

TIN ORE

Chhattisgarh is the one of the state produces about 9.90 % of the total national production of Tin ores. About 31.84 million tones of tin are available in the different parts of sate. The main deposits in southern part of the state are Tongpal, Katekalyan and Padapur-Bacheli area of Dantewada district. A tin smelter unit is also working at Jagdalpur City. Tin is the very well known ore for tribes and explored from very long back by local tribes of Bastar division. .

DIAMOND

The occurrence of diamond in the rivers of the state and discovery of diamondiferous kimberlite in the Manipur area of Raipur district the main causes of the global attraction. In the Chhattisgarh state eight blocks are identified for availability of kimberlites. The diamondiferous kimberlites have been also identified in Behradih- Payalikhand area of Raipur district. De Beers, ACC Rio Tinto, BHP Billiton and Geo Mysore Services are already engaged in reconnaissance operations and prospecting of minerals.

Figure-6-Diamond

DIMENSION STONES

The different kind of Multicolored and texturally granites are widely distributed in the different parts of state. The attractive color and design of Limestone and Dolomite are extensively available in the Chhattisgarch state. Quartzite, Sandstone and Shale are also widely exposed in the different parts of state, which can be suitable as dimension stones.

GOLD

The gold bearing rocks are available in the Raipur and Mahasamund district of the state of Chhattisgarh. Placer gold panning is widely recorded from different parts of state as Jashpur, Kanker, Mahasamund and Bastar district. The reserves of gold about three tones are estimated in the state. The global mining companies like ACC Rio, Tinto and Geo Mysore Services are working in reconnaissance and prospecting operations of gold deposits in the different parts of state.

Figure-7 Gold

MINERAL EXPLORATIONS

The huge amount of Iron Ore are excavated and supplied to different part of country and abroad every year from the state. Other ores as Bauxite etc are also excavated and supplied for use of aluminum and other factories in large quantity every year. So many rocks and coal quarries are in operation and huge amount of rocks and coals are using for different purposes in the state and outside of state also.

MINERAL BASED INDUSTRIES

Without importing any major raw minerals from other states he number of heavy, medium and small scale mineral based industries is working in the state. Almost all major and minor minerals are available in the state. The state is reach in all respect particularly Power, Water and Human resources.

ESSAR pipe line Industry is also working at Kirandul for transportation of Iron Ore from Kirandul to Vishakhapatnan. Three Mineral based major Steel and Iron ore Industries, NMDC Iron and Steel plant at Nagar Jagdalpur, Tata Steel Plant at Lohandiguda Jagdalpur and ESSAR Iron and Steel Plant at Bacheli Dantewada to be established in the Bastar division of Chhattisgarh state. More than hundred mineral based small scale industries, Sponge Iron plant are working in the Chhattisgarh state.

National Mineral Development Corporation (NMDC) Bacheli, Kirandul Chhattisgarch is the one of the biggest Mineral Exploration Industry of the India. The requirement of Iron Ore throughout of the India is fulfillment by NMDC Kirandul Chhattisgarh and beside it self export of Iron Ore to the Japan. NMDC Kirandul also supplies the Iron Ore to the hundred of Small Scale Industries like Sponge Iron etc throughout the state.

Figure-8 Industry

POROSITY

The shape size and nature of packing of grains of a rock give the rise to development of pore space within the rock. Numerically it is expressed as the ratio between the total volume of pore spaces and the total volume of the rock sample and it is commonly given in percentage term. The porosity is an important engineering property in the sense that it accounts for the absorption, density and specific gravity of the stone sample in the most cases.

ABSORPTION VALUE

It is defined as that, the capacity of stone to absorb moisture when immersed in the water for 24 hours or till saturation. It is generally expressed in percentage term of original dry weight of the stone sample.

Density

It is defined, as usual, weight per unit volume of a substance, rocks being included. But, in the case of rock it is not only the solid mineral matter which wholly accounts for the total volume of a given specimen. A part of the rock may be comprises of a pores or open spaces, which may be empty, partly filled or wholly filled with water. Accordingly, three types of density may be distinguished in the rock.

Buck density

It is the weight per unit volume of a rock sample with natural moisture content where pores are only partially filled with water.

Dry density

It is the weight per unit volume of an absolutely dried rock specimen. Obviously, it includes the volume of the pore spaces present in the rock.

Saturated density

It is the density of saturated rock sample or weight per unit volume of a rock in which all the pores are completely filled with water.

Specific gravity

Specific gravity is defined as the ratio of the weight of a given volume of solid rock at a given temperature to the weight of an equal volume of distilled water at that temperature. In other words, it is the ratio of the unit weight of solid to that of water.

COLLECTION OF SAMPLE

The presence of different Rock Strata in the Bastar region of Chhattisgarh state and their geological distribution has been reported by many Researchers, Agencies including Geological survey of India. The suitability of rocks for construction of different type of structures including Industrial Building, Bridges, Towers, Over head and Under ground water tank and Roads etc may checked by conducting systematic study of Engineering properties of rocks and locating their area of occurrence. As per the area of occurrence and quarries of rock mass, in the different region of Bastar, it is divided in the nine zones and sample were collected from each zones for present study are:

Zone -1 Tongpal, Sukma-Kont Region
Zone -2 Bhansi, Bailadila Region
Zone -3 Geedam, Geegdam Region
Zone -4 Kalepal, Bastanar Region
Zone -5 Lohandiguda, Lohandiguda Region
Zone -6 Balenga, Bastar Region
Zone -7 Kanker, Kanker Region
Zone -8 Narayanpur, Naraynpur Region
Zone -9 Bhanupratappur, Bhanupratappur Region

EXPERIMENTAL PROGRAM

Water Absorption {As per IS 2386 (Part III) 1963}

The standard samples of three batches as S_1, S_2, S_3 of each zone were washed thoroughly and then placed in the wire basket one sample at a time and immersed in distilled water at a temperature 26^0C with a cover of 5 cm of water above the top of basket. Immediately after immersion, to removed entrapped air from sample, lifted basket 25 mm above the base of the tank and allowed it to drop 25 times at the rate of about one drop per second. Finally the basket and the aggregates ware immersed in water for a period of 24 hours.

The basket and aggregate were then removed from water and allow to drains for few minutes, after which transferred to dry absorbent clothes. After 20 minutes the surface dried sample then weighed (W_1). The sample was placed in a shallow plate and kept in an oven, maintained at a temperature of 110^0C for 24 hours. It was then removed from oven, cooled an air tight container and weighed (W_2).

Water Absorption Value = $(W_1 - W_2) * 100/W_2$

Where, W_1 = Surface dried saturated Weight of Rock sample
W_2 = Dry weight of Rock sample

The water absorption value of each sample of different quarries were calculated and tabulated here.

Table-I

Zone	Water Absorption Value in Percentage			Average value
	S_1	S_2	S_3	
1	1.94 %	2.18 %	1.88 %	2.00 %
2	1.78 %	1.77 %	1.81 %	1.79 %
3	1.68 %	1.61 %	1.63 %	1.64 %
4	1.34 %	1.29 %	1.31 %	1.31 %
5	1.69 %	1.71 %	1.68 %	1.69 %
6	2.23 %	2.14 %	2.07 %	2.15 %
7	1.82 %	1.76 %	1.86 %	1.82 %
8	1.79 %	1.76 %	1.77 %	1.77 %
9	1.83 %	1.81 %	1.82 %	1.82 %

DRY DENSITY {As per IS 2386(Part III) 1963}:

Just like water absorption test the prepared samples kept in the basket were immersed in the water for a period of 24 hours. The basket and the sample were then weighed while suspended in water at a temperature of 26^0C. The weight was noted (W_1). The basket and aggregate were then removed from water and allow to drains for few minutes, after which transferred to dry absorbent clothes. The basket alone weighed while suspended in water (W_2). 20 minutes later, surface dried aggregates weighed (W_3). The aggregates was placed in a shallow plate and kept in an oven,

maintained at a temperature of 110^0C for 24 hours. It was then removed from oven, cooled an air tight container and weighed (W_4).

Dry density, $\gamma_d = W_4/\{(W_3-(W_1-W_2)\}$
Where, W_4 = Weight of dry rock
$\{W_3-(W_1-W_2)\}$ = volume of the rock Sample

The dry density of each sample of different quarries were calculated and tabulated here.

Table -II

Zone	Dry Density in g/cc			Average value
	S_1	S_2	S_3	
1	2.61	2.63	2.62	2.62
2	2.67	2.65	2.63	2.65
3	2.64	2.63	2.66	2.64
4	2.67	2.69	2.71	2.69
5	2.68	2.66	2.68	2.67
6	2.60	2.63	2.63	2.62
7	2.65	2.64	2.66	2.65
8	2.69	2.67	2.66	2.67
9	2.64	2.61	2.62	2.62

SPECIFIC GRAVITY {As per IS 2386(Part III) 1963}:
Same as above test, the prepared samples kept in the basket were immersed in the water for a period of 24 hours. The basket and the sample were then weighed while suspended in water at a temperature of 26^0C. The weight was noted (W_1). The basket and aggregate were then removed from water and allow to drains for few minutes, after which transferred to dry absorbent clothes. The basket alone weighed while suspended in water (W_2). 20 minutes later, surface dried aggregates weighed (W_3). The aggregates was placed in a shallow plate and kept in an oven, maintained at a temperature of 110^0C for 24 hours. It was then removed from oven, cooled an air tight container and weighed (W_4).

Specific gravity = $W_4/\{(W_3-(W_1-W_2)\}$

Where, W_4 = Dry weight of rock
$\{W_3-(W_1-W_2)\}$ = Weight of equal volume of water

The Specific Gravity of each sample of different quarries were calculated and tabulated here:

Table -III

Zone	Specific Gravity			Average value
	S_1	S_2	S_3	
1	2.64	2.68	2.64	2.65
2	2.78	2.77	2.74	2.76
3	2.77	2.75	2.79	2.77
4	2.84	2.81	2.83	2.83
5	2.71	2.75	2.73	2.73
6	2.72	2.75	2.71	2.73
7	2.77	2.78	2.80	2.78
8	2.81	2.80	2.79	2.80
9	2.68	2.63	2.67	2.66

SCOPE OF WORKS

The Chhattishgargh state has the plenty of mineral resources and sources of construction material throughout the state. The construction material is obtained from different rocks lying in region and each rock formation has a unique 'character' that not only bears the imprint of its geological history, but also control its future behavior in Engineering construction works. Some of these, such as colour and grain size can be observed directly, where as others characters like Density, Specific gravity, Water absorption etc. can be measured by testing only. Chhattisgarh state has immense potential for prospecting exploitation of minerals for industrial use and export. The tabulated test results of Engineering properties of Rocks and Minerals available in the different quarries of state will help to the construction works to be held in the areas.

CONCLUSIONS

The Rock mass classification and Geological and Engineering properties of rocks available in the different area could undertaken to suggest the stability aspects of underground constructions and mining activities of that areas and suitability of excavated rocks & Minerals from different quarries for the construction works going and to be carried out in the future in the areas.

The results of the test of Engineering Properties Density, Specific gravity, Water absorption are tabulated in the table No. I, II and III. The minor variation is seen in the test result of samples of different quarries. All most same above Engineering Properties bears the rock mass available in the area. For the major construction works, the quarry approval certificate is required, for the suitability of construction materials available in the quarry and that purposes the test result can be used. Further works to be needed to find out other Engineering Properties like Compressive Strength, Impact value, Abrasion value Elongation Index etc.

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