Recycling of Raw Bauxite-Residue from Alumina Industry for Production of Chequered Tile

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Abstract: **The worldwide production of cement accounts for almost 7% of total world CO_2 emmision. Global cement composites consumption has crossed the mark of 20 billion tons per annum. Production of cement is characterized by large energy consumption to the tune of 4GJ per ton. An equivalent quantum of carbon dioxide is liberated while producing one ton of cement. There is an urgent need to explore alternative substitute for cement. During Bayer's process of production of alumina, a large quantity of dust-like alkaline bauxite residue (Red mud) is discharged into the environment. At a global level, 120 million tonnes of red mud is produced per annum. According to an estimate 3 billion tonnes of red mud is already awaiting in the industrial backyards for its utilization. This huge quantum of red mud is likely to contaminate soil and water. Hence bulk utilization of red mud is a big challenge before the agencies associated with management of bauxite residue. An attempt is made here to substitute cement with red mud in varying proportions such as 0, 5, 10, 15 and 20 % of the cement content in production of chequered tile.**

Keywords: Bayer's process, red mud, concrete, bauxite residue, chequered tile.

1. INTRODUCTION

Cement composites are the second largest consumables on the earth, next to water. Annual consumption of concrete and allied products has crossed a mark of odd 20 billion tons per year at level. Cement production is energy intensive process and it liberates an equivalent quantity of carbon dioxide, thus increasing more pressure on utilization of energy sources. It is pertinent to find the alternative energy-saving material which will replace the cement partly or fully in cement composites and would reduce carbon footprints on the earth.

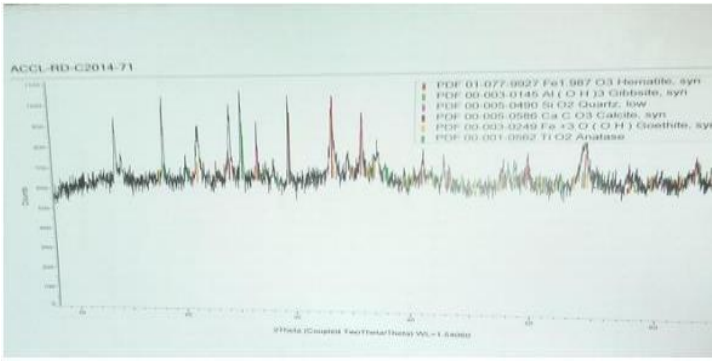
India has a huge population and has a relatively small land area to give an overall population density of 368 per sq. km. This exerts a great pressure on the systems of environmental management and waste treatment. Every year about 120 million tonnes of bauxite residue (red mud)is freshly disposed off into stock-piling yards. Bulk utilization of Red mud has been, and continue to be a great challenge for the researchers and other stake-holders. Utilization of bauxite residue for some constructive purpose will also reduce the burdon of waste on land and related pollution effects.

Thus if an industrial waste, bauxite residue, is used to replace cement in various construction products would certainly help to conserve lot of energy and will also reduce carbon emmissions. Chemical properties of red mud indicates low percentage of CaO as compared to percentage cement and gypsum. Low cementatious properties putforth limitations on the use of red mud as binder in composite. Red mud primarily consists of oxides of aluminium and Iron. Red mud ,water and cement together develops calcium silicate hydrate(CSH) gel that improves strength characterstics of composites upto certain extent. Presence of alumina,silica,iron oxides and a variety of oxides and alkalis,each in varying degrees imparts pozollanic properties to the concrete. Pozzolanas are materials containing reactive silica and/or alumina which on their own have little or no binding property but,when mixed with lime in presence of water,will set and harden like a cement. Due to presence of allumina and silica content in red mud, it behaves as pozzolanic material in secondery reaction. It reacts with calcium hydroxide in presence of water to form ettringate.

Sr No	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
Content	*Al_2O_3*	*Fe_2O_3*	*Na_2O*	*CaO*	*SiO_2*	*K_2O*	*TiO_2*	*P_2O_5*	*MgO*	*SO_3*	*Ca_2O_3*	*LOI*
%	*20.5*	*34.3*	*4.0*	*4.8*	*11.6*	*0.17*	*8.35*	*0.32*	*0.4*	*0.33*	*0.15*	*15*

TABEL 1:Chemical composition of red mud

Graph 1 ; *The XRD of red mud from Hindalco, Belgaon,Karnataka*, India (A.C.C. lab,Thane)



2. MATERIAL AND METHODS:

Chequered tiles are the tiles having grooves on the surface of the tile making it anti-slippery. The area of chequered grooves should not be less than 2 per cent of the total surface area of the tile. The chequered groove can be in any shape and length, but the depth of grooves should not be less than 3 mm. Chequered cement concrete flooring titles are used for footpaths, entrance and stair- cases of public buildings, passages of auditoriums and storage go-downs, etc. Large number of cement concrete chequered tiles are being manufactured and used in our country.

The materials used in the presented research are described as the following:

Cement: 53 Grade, OPC-Associate Cement companies (specific gravity-3.15).

Red mud: Hindalco,Belgaon,Karnataka, India,(specific gravity-3.10).

Fine aggregate: CFA from Tata,Bhainderpada, Thanewith specific gravity 2.65.,

Dolomite-crushed from Chhota Udaipur,Rajasthan with specific gravity 2.8.

Dolomite powder from Chhota Udaipur ,Rajasthan with specific gravity 2.89.

Colouring pigments from N.R.Traders and enterprises, Ahmedabad,Gujarat.

Chequered tile consists of two courses- Bottom course (base layer) and wearing course (top layer). Bottom course consists of mix of cement and crushed fine aggregates in the ratio 1:5. Top wearing course consist of colouring pigment, crushed dolomite,cement,dolomite powder, naphtha-based superplasticizer,crushed fine aggregate and water in a specified proportion.

3. EXPERIMENTAL WORK:

Casting of 60 Cement concrete chequered tiles of size 300*300*30 mm.is proposed. Top wearing course of chequered tile is 7.5 mm thick.Bottom part of chequered tile is 22.5 mm thick. The experimental part of replacement of cement with red mud is exclusively done for bottom part. For this 12 tiles each were cast for controll (0%), 5%,10%,15% and 20% replacement trials. Batch size of 60 Kg.each is prepared separately for each replacement trial. Experimental work was carried out were in three stages;

Stage 1

Top wearing course material of 90 Kg. is mixed in mixer with all the necessary ingredients.

Cement,dolomite powder,crushed dolomite,colouring pigments,water,etc are added and mixed in a mixed. Chequered tile moulds mounted on machinery are cleaned and oil is applied to inside of the mould.

Stage 2

Bottom course material of 60 Kg batch size is taken separately for each replacement trial. Controll trial (0% replacement) is carried out without adding any red mud and subsequent trials of replacement of cement with 5%,10%,15%,20% of red mud respectively. Naphtha based chemical admixture is added to achieve workability and flowability to the composite mass.

Stage 3

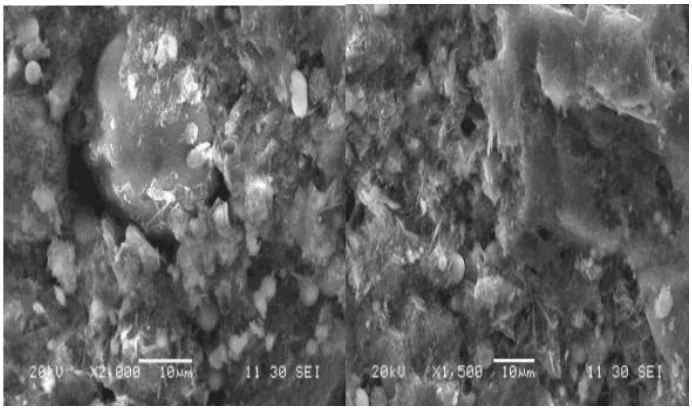
Chequered tiles are cast by putting stage 1 and stage 2 material in a mould of size 300*300*30 mm size mounted on Chequered tile making machine. After casting the tiles are cured for 28 days and then tested for various parameters confined to IS:13801-1993 (Reaffirmed 2006).

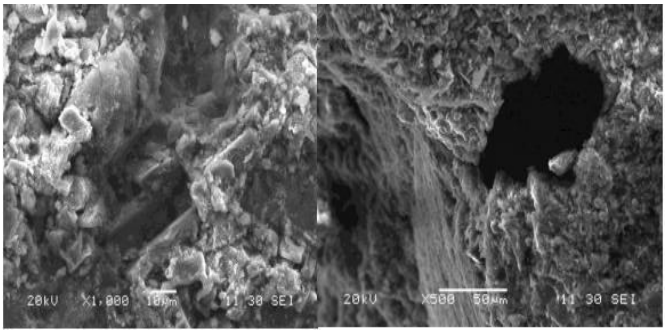
Table 2: Batching of ingredients of chequered tile for top and bottom part.

Sr. No.	Material	Requirement per cubic meter of material for full tile	Requirement of material only for base of tile	Batch size per cubic meter of base	Batch size of 60 kg for percentage replacement of cement with red mud for bottom course of chequered tile (Kg)				
					0%	5%	10%	15%	20%
1.	Cement	400 kg	280 Kg	400 Kg.	10	9.5	9	8.5	8
2.	Red mud	--	--	--	--	0.5	1	1.5	2
3.	Crushed sand	1700kg	1365 Kg	1950 Kg.	48.75	48.75	48.75	48.75	48.75
4.	Dolomite powder	200 kg	--	---	---	--	--	--	--
5.	Crushed dolomite	50 kg	--	---	---	--	--	--	--
6.	Coloring pigments	4 kg	--	--	---	--	--	--	--
7.	Water	120 Kg	42 Kg	60 Kg	1.5 Kg	1.5Kg	1.5Kg	1.5Kg	1.5Kg

4. RESULTS AND DISCUSSIONS:

Cement content is reduced and replaced by 0%, 5%, 10%, 15% and 20% in composite mix prepared for base course in chequered tile. All the 10 characteristics indicated in table 3 are considered to determine the effect of replacement of cement with red mud in varying proportion.



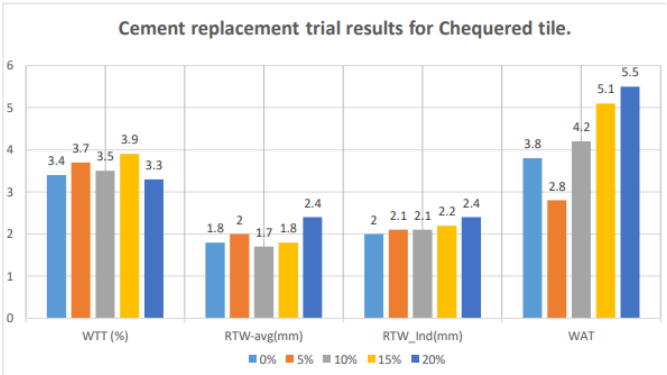


Wet transverse strength (WTT), percentage water absorption, resistance to wear for individual tile, resistance to abrasion as an average value are the key indicators for determining the properties of chequered tile. Out of twelve tiles cast for each replacement, six tiles are subjected to various tests and average values are tabulated in table 3.Results of replacement of cement with red mud in varying proportion from 0 to 20% are prepared in accordance with IS:13801-1993 (reaffirmed 2006)

Table 3: Effect of replacement of cement with red mud in base part of chequered tile.

Sr No	Tests	IS:13801-1993 Requirements	Replacement of cement with red mud by % wt. (Average value of six tiles tested for each %)				
			0%	5%	10%	15%	20%
1.	Length, mm	300+1	299.4	299.6	299.5	299.6	299.7
2.	Width, mm	300+1	300	300	300	300	300
3.	Thickness, mm	30+5	30.5	30.9	30.8	31.2	31.2
4.	Wet transverse test, N/mm2(WTT)	3 Min	3.4	3.7	3.5	3.9	3.3
5.	Flatness, mm	1 Max	0.1	0.15	0.15	0.16	0.15
6.	Perpendicularity, %	2 Max	0.07	0.07	0.07	0.06	0.06
7.	Straightness, %	1 Max	0.05	0.10	0.15	0.25	0.2
8.	Water absorption, % by mass (WAT)	10 Max	3.8	2.8	4.2	5.1	5.5
9.	Resistance to wear- average in mm (RTW-avg)	2 Max	1.8	2.0	1.7	1.8	2.0
10.	Resistance to wear- individual specimen in mm. (RTW-Ind)	2.5 Max	2.0	2.1	2.1	2.2	2.4

Graph 2; Chart showing Wet transverse strength (WTT), average resistance to wear (RTW-avg), resistance to wear for individul tile (RTW-Ind) and water absorption (WAT).



Percentage water absorption and resistance to wear are two of the most prominent characteristics that determines the quality of chequered tile. It is found that even after replacement of cement up to 20% with red mud, all the values obtained for parameters are much within permissible limits as per IS:13801-1993.

5. CONCLUSSION

It can be concluded that, Cement could be replaced up to 20% with an industrial waste (red mud) and there is further scope for higher percentage cement replacement with red mud. Reduction of consumption of cement is associated with energy saving, reduction in carbon footprints, reduction in pollution and assist in sustainable developments of construction and housing sector. Millions of cement concrete chequered tiles are being manufactured and used at various locations in India. Each chequered tile consists of minimum one Kg. of cement. For each five thousand cement concrete lot, we can replace one ton of cement with one ton of red mud with just 20% replacement of cement. One ton of carbon emissions can be reduced per 5000 production lot of chequered tile and subsequent large energy savings becomes possible. Thus utilization of highly alkaline industrial waste (bauxite residue) as a partial replacement to cement will reduce the wastage of emery in cement production and will also minimise the environmental pollution and will resolve sustainability issues of natural resources.

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