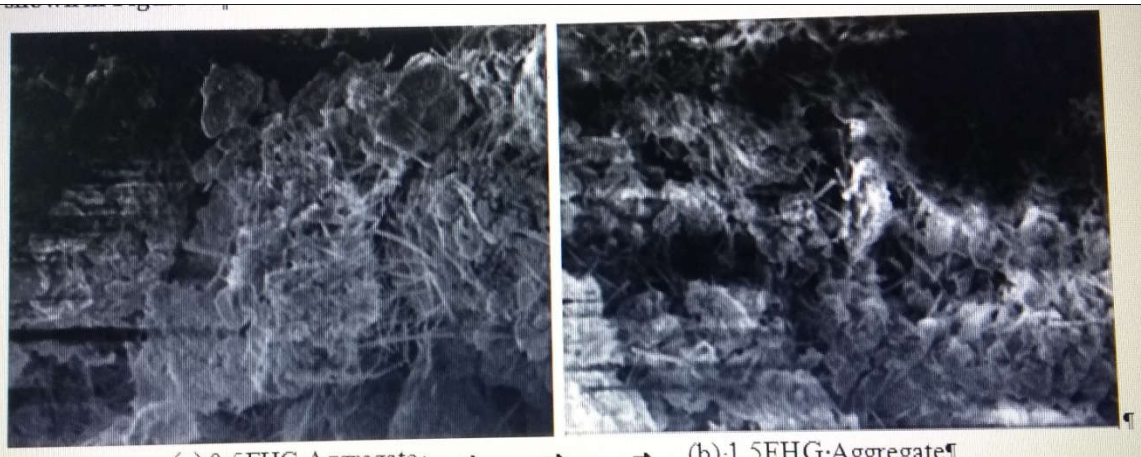
Figure 1 Manufacturing process of artificial lightweight aggregates

Figure 2 Aggregate impact test apparatus

Figure 3 Crushing strength test apparatus



(a) 0.5FHG Aggregate → → → (b) 1.5FHG Aggregate

Figure 4 SEM observations

Table 2 Mix combinations of various aggregates manufactured with and without Nano SiO_2

Combinations	Binder content (%)					Nano SiO_2 (%)
	Fly ash	Hydrated lime	Cement	Metakaolin	Steel slag	
0FHC	80	10	10	-	-	0.0
0FHM	80	10	-	10	-	0.0
0FHG	80	10	-	-	10	0.0
0.5FHC	80	10	10	-	-	0.5
0.5FHM	80	10	-	10	-	0.5
0.5FHG	80	10	-	-	10	0.5
1FHC	80	10	10	-	-	1.0
1FHM	80	10	-	10	-	1.0
1FHG	80	10	-	-	10	1.0
1.5FHC	80	10	10	-	-	1.5
1.5FHM	80	10	-	10	-	1.5
1.5FHG	80	10	-	-	10	1.5

Table 3 Characteristics of Natural aggregate values

Characteristics of Natural aggregate	
24-hr Water Absorption, %	1.17
Specific Gravity	2.69
Loose Bulk Density, kg/m^3	1469
Rodded Bulk Density, kg/m^3	1574
Aggregate Impact Value, %	9.81
Fineness Modulus	7.47

Table 4 Fineness modulus values and Production efficiency of artificial lightweight aggregates

Combinations	Fineness Modulus	Efficiency of aggregate production (%)		
		Fresh pellets	After 24hrs	Before testing
0FHC	6.94	95.5	84.4	88.5
0FHM	6.96	96.2	86.6	86.9
0FHG	7.3	90.1	86.8	92.6
0.5FHC	6.9	97.3	88.6	89.5
0.5FHM	6.92	97.8	89	88.6
0.5FHG	6.9	95.3	89.8	94.7
1FHC	6.93	96.3	85.5	86.7
1FHM	6.93	94.4	81.3	84.1
1FHG	6.9	93.8	87.4	90.2
1.5FHC	6.88	96.8	81.5	84.8
1.5FHM	6.93	97.3	81.8	84.4
1.5FHG	6.9	96.3	85.6	88.3

Table 5 Specific gravity, Water absorption and Bulk density values of artificial lightweight aggregates

Combinations	Specific gravity	Water absorption (%)	Bulk density of aggregates (kg/m^3)	
			L.B.D	R.B.D
0FHC	1.82	29.5	864.5	908.5
0FHM	2.18	23.5	838.9	891.6
0FHG	2.42	16.5	919.4	948.3
0.5FHC	2	22.9	870.9	922.3
0.5FHM	2.33	20.7	844.5	899.2
0.5FHG	2.64	12.5	928	957.6
1FHC	1.88	25.8	855	905
1FHM	2.22	22	831.3	882
1FHG	2.4	15	913.3	940.5
1.5FHC	1.49	30.1	836.8	891.7
1.5FHM	1.91	28.2	814.8	860.2
1.5FHG	1.62	23.8	896.4	919.4

Table 6 Impact and Individual aggregate crushing strength of various lightweight aggregates

Combinations	Impact Strength (%)	Crushing Strength of an individual aggregate (Mpa)					
		20mm	16mm	12mm	10mm	8mm	6mm
0FHC	16.5	19.2	19.7	24	26.7	29.5	34.7
0FHM	20	17.5	19.5	21.2	22.9	26.9	27.2
0FHG	20.2	35.9	36.6	36.7	44.6	45.9	47
0.5FHC	13.6	22.6	25.5	29.1	35.4	45.7	54.7
0.5FHM	16.7	19.8	23.3	27	30.5	33.6	42.8
0.5FHG	15.2	41.5	44.9	49.3	52.5	56	58.9
1FHC	16.1	21	22.6	27.3	33.3	44.5	53.7
1FHM	16.8	19.4	23	26.5	30.1	33.1	40.3
1FHG	16.3	30.3	32.4	35.8	41.7	42.2	50
1.5FHC	15.6	20.8	22.4	26.6	32.1	41.9	50.2
1.5FHM	17.1	19.2	22.8	25.4	27.9	31.6	39.6
1.5FHG	15.9	29.2	31.4	36	39.5	40.4	49.5