**4.5 Specific Gravity**

**Table 25: Specific Gravity obtained for CG**

|  |  |  |
| --- | --- | --- |
|  | Test A | Test B |
| Weight of bottle: (gm) | 692.3 | 692.3 |
| Weight of bottle + water (Full): (gm) | 2006.6 | 2006.6 |
| Wt. of bottle + sample (gm) | 1692.7 | 1692.6 |
| Wt. of bottle + sample + Water (gm) | 2626.8 | 2626.7 |
| Wt. of water displaced by sample (gm) | 380.2 | 380.2 |
| Specific gravity (g/cm3) | 2.631 | 2.631 |
| Average Specific gravity (g/cm3) | 2.631 | |

**Table 26: Specific Gravity obtained for KM**

|  |  |  |
| --- | --- | --- |
|  | Test A | Test B |
| Weight of bottle: (gm) | 692.3 | 692.3 |
| Weight of bottle + water (Full): (gm) | 2006.6 | 2006.6 |
| Wt. of bottle + sample (gm) | 1692.4 | 1692.6 |
| Wt. of bottle + sample + Water (gm) | 2630.8 | 2630.9 |
| Wt. of water displaced by sample (gm) | 375.9 | 375.0 |
| Specific gravity (g/cm3) | 2.661 | 2.660 |
| Average Specific gravity (g/cm3) | 2.661 | |

**Table 27: Specific Gravity obtained for LG**

|  |  |  |
| --- | --- | --- |
|  | Test A | Test B |
| Weight of bottle: (gm) | 692.3 | 692.3 |
| Weight of bottle + water (Full): (gm) | 2006.9 | 2006.9 |
| Wt. of bottle + sample (gm) | 1692.7 | 1692.7 |
| Wt. of bottle + sample + Water (gm) | 2625.0 | 2625.1 |
| Wt. of water displaced by sample (gm) | 382.3 | 382.2 |
| Specific gravity (g/cm3) | 2.617 | 2.617 |
| Average Specific gravity (g/cm3) | 2.617 | |

**Table 28: Specific Gravity obtained for GAR**

|  |  |  |
| --- | --- | --- |
|  | Test A | Test B |
| Weight of bottle: (gm) | 692.3 | 692.3 |
| Weight of bottle + water (Full): (gm) | 2006.9 | 2006.9 |
| Wt. of bottle + sample (gm) | 1692.6 | 1692.9 |
| Wt. of bottle + sample + Water (gm) | 2631.2 | 2632.0 |
| Wt. of water displaced by sample (gm) | 376.0 | 375.5 |
| Specific gravity (g/cm3) | 2.660 | 2.665 |
| Average Specific gravity (g/cm3) | 2.663 | |

**Table 29: Specific Gravity obtained for KE**

|  |  |  |
| --- | --- | --- |
|  | Test A | Test B |
| Weight of bottle: (gm) | 692.3 | 692.3 |
| Weight of bottle + water (Full): (gm) | 2006.6 | 2006.6 |
| Wt. of bottle + sample (gm) | 1692.3 | 1692.7 |
| Wt. of bottle + sample + Water (gm) | 2638.6 | 2639.6 |
| Wt. of water displaced by sample (gm) | 368.0 | 367.4 |
| Specific gravity (g/cm3) | 2.717 | 2.723 |
| Average Specific gravity (g/cm3) | 2.720 | |

**Table 30: Specific Gravity obtained for NE**

|  |  |  |
| --- | --- | --- |
|  | Test A | Test B |
| Weight of bottle: (gm) | 692.3 | 692.3 |
| Weight of bottle + water (Full): (gm) | 2006.6 | 2006.6 |
| Wt. of bottle + sample (gm) | 1692.3 | 1692.6 |
| Wt. of bottle + sample + Water (gm) | 2628.1 | 2627.8 |
| Wt. of water displaced by sample (gm) | 378.5 | 379.1 |
| Specific gravity (g/cm3) | 2.642 | 2.639 |
| Average Specific gravity (g/cm3) | 2.641 | |

**Table 31: Specific Gravity obtained for GAW**

|  |  |  |
| --- | --- | --- |
|  | Test A | Test B |
| Weight of bottle: (gm) | 692.3 | 692.3 |
| Weight of bottle + water (Full): (gm) | 2006.9 | 2006.9 |
| Wt. of bottle + sample (gm) | 1692.7 | 1692.9 |
| Wt. of bottle + sample + Water (gm) | 2629.8 | 2629.6 |
| Wt. of water displaced by sample (gm) | 377.5 | 377.9 |
| Specific gravity (g/cm3) | 2.650 | 2.648 |
| Average Specific gravity (g/cm3) | 2.649 | |

**Table 32: Specific Gravity obtained for KW**

|  |  |  |
| --- | --- | --- |
|  | Test A | Test B |
| Weight of bottle: (gm) | 692.3 | 692.3 |
| Weight of bottle + water (Full): (gm) | 2006.9 | 2006.9 |
| Wt. of bottle + sample (gm) | 1692.3 | 1692.3 |
| Wt. of bottle + sample + Water (gm) | 2634.8 | 2635.6 |
| Wt. of water displaced by sample (gm) | 372.1 | 371.3 |
| Specific gravity (g/cm3) | 2.689 | 2.693 |
| Average Specific gravity (g/cm3) | 2.691 | |

**Table 33: Specific Gravity obtained for MA**

|  |  |  |
| --- | --- | --- |
|  | Test A | Test B |
| Weight of bottle: (gm) | 692.3 | 692.3 |
| Weight of bottle + water (Full): (gm) | 2006.9 | 2006.9 |
| Wt. of bottle + sample (gm) | 1692.7 | 1692.6 |
| Wt. of bottle + sample + Water (gm) | 2635.8 | 2635.5 |
| Wt. of water displaced by sample (gm) | 371.5 | 371.7 |
| Specific gravity (g/cm3) | 2.693 | 2.691 |
| Average Specific gravity (g/cm3) | 2.692 | |

**4.6 Density value results**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/N** | **Description** | **Mass (g)** | **Volume (cm3)** | **Density (g/cm3)** |
| 1 | CG | 330 | 124 | 2.661 |
| 2 | KM | 336 | 124 | 2.710 |
| 3 | LG | 326 | 124 | 2.629 |
| 4 | GAR | 339 | 124 | 2.734 |
| 5 | KE | 355 | 124 | 2.863 |
| 6 | NE | 333 | 124 | 2.685 |
| 7 | GAW | 334 | 124 | 2.694 |
| 8 | KW | 342 | 124 | 2.758 |
| 9 | MA | 351 | 124 | 2.831 |

**4.7 Water Absorption Values**

**Table 35: Water Absorption for CG**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Test 1 | Test 2 | Test 3 | Test 4 | Test 5 |
| Weight of Saturated Surface – dry sample [g] | 1000.1 | 1000.3 | 1000.4 | 1000.3 | 1000.3 |
| Weight of oven – dry sample [g] | 996.3 | 996.1 | 995.8 | 996.3 | 996.9 |
| Water absorption [%] | 0.38 | 0.42 | 0.46 | 0.40 | 0.34 |
|  | 0.40 | | | | |

**Table 36: Water Absorption for KM**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Test 1 | Test 2 | Test 3 | Test 4 | Test 5 |
| Weight of Saturated Surface – dry sample [g] | 1000.4 | 1000.0 | 1000.6 | 1000.4 | 1000.8 |
| Weight of oven – dry sample [g] | 996.8 | 996.8 | 996.8 | 997.4 | 997.4 |
| Water absorption [%] | 0.36 | 0.32 | 0.38 | 0,30 | 0.34 |
|  | 0.34 | | | | |

**Table 37: Water Absorption for LG**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Test 1 | Test 2 | Test 3 | Test 4 | Test 5 |
| Weight of Saturated Surface – dry sample [g] | 1000.4 | 1000.4 | 1000.2 | 1000.0 | 1000.6 |
| Weight of oven – dry sample [g] | 996.0 | 996.1 | 995.8 | 996.0 | 995.8 |
| Water absorption [%] | 0.44 | 0.43 | 0.44 | 0.40 | 0.48 |
|  | 0.44 | | | | |

**Table 38: Water Absorption for GAR**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Test 1 | Test 2 | Test 3 | Test 4 | Test 5 |
| Weight of Saturated Surface – dry sample [g] | 1000.4 | 1000.3 | 999.6 | 999.8 | 1000.0 |
| Weight of oven – dry sample [g] | 997.7 | 997.0 | 999.34 | 996.6 | 996.8 |
| Water absorption [%] | 0.27 | 0.33 | 0.26 | 0.32 | 0.32 |
|  | 0.30 | | | | |

**Table 39: Water Absorption for KE**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Test 1 | Test 2 | Test 3 | Test 4 | Test 5 |
| Weight of Saturated Surface – dry sample [g] | 1000.0 | 1000.4 | 1000.0 | 1000.6 | 1000.6 |
| Weight of oven – dry sample [g] | 999.1 | 999.3 | 999.5 | 999.3 | 999.4 |
| Water absorption [%] | 0.09 | 0.11 | 0.05 | 0.13 | 0.12 |
|  | 0.10 | | | | |

**Table 40: Water Absorption for NE**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Test 1 | Test 2 | Test 3 | Test 4 | Test 5 |
| Weight of Saturated Surface – dry sample [g] | 1000.4 | 1000.6 | 1000,3 | 1000.8 | 1000.4 |
| Weight of oven – dry sample [g] | 996.8 | 996.6 | 995.9 | 997.4 | 996.8 |
| Water absorption [%] | 0.36 | 0.40 | 0.44 | 0.34 | 0.36 |
|  | 0.38 | | | | |

**Table 41: Water Absorption for GAW**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Test 1 | Test 2 | Test 3 | Test 4 | Test 5 |
| Weight of Saturated Surface – dry sample [g] | 1000.4 | 1000.3 | 1001.0 | 1000.6 | 1000.8 |
| Weight of oven – dry sample [g] | 997.0 | 997.1 | 998.2 | 997.1 | 997.2 |
| Water absorption [%] | 0.34 | 0.32 | 0.28 | 0.35 | 0.36 |
|  | 0.33 | | | | |

**Table 42: Water Absorption for KW**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Test 1 | Test 2 | Test 3 | Test 4 | Test 5 |
| Weight of Saturated Surface – dry sample [g] | 1000.0 | 1000.3 | 1000.4 | 1000.0 | 1000.4 |
| Weight of oven – dry sample [g] | 997.8 | 997.1 | 997.4 | 997.3 | 998.0 |
| Water absorption [%] | 0.22 | 0.32 | 0.30 | 0.27 | 0.24 |
|  | 0.27 | | | | |

**Table 4.38: Water Absorption for MA**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Test 1 | Test 2 | Test 3 | Test 4 | Test 5 |
| Weight of Saturated Surface – dry sample [g] | 1000.3 | 1000.6 | 1000.4 | 999.8 | 1000.6 |
| Weight of oven – dry sample [g] | 997.8 | 998.2 | 997.6 | 997.5 | 998.1 |
| Water absorption [%] | 0.25 | 0.24 | 0.28 | 0.23 | 0.25 |
|  | 0.25 | | | | |

**4.8: Schmidt Hammer Rebound Hardness**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/NO** | **Rock Type** | **No Rebound values** | **Range No** | **Mean** |
| 1 | CG | 34,36,41,36,52,56,58,51,45 | 34 – 58 | 45 |
| 2 | KM | 46,60,49,46,48,46,46,46,52 | 46 – 60 | 49 |
| 3 | LG | 40,48,40,50,50,41,40,48,45 | 40 – 50 | 45 |
| 4 | GAR | 46,51,48,52,56,61,43,46,51 | 43 – 61 | 50 |
| 5 | KE | 56,50,62,51,54,56,50,56,48 | 48 – 62 | 54 |
| 6 | NE | 41,56,48,48,56,50,42,48,48 | 41 – 56 | 49 |
| 7 | GAW | 46,50,57,51,50,52,49,47,43 | 43 – 57 | 49 |
| 8 | KW | 56,56,54,56,50,50,48,46,46 | 46 – 56 | 51 |
| 9 | MA | 61,49,54,56,50,58,51,48,44 | 44 – 61 | 52 |

**4.9 Aggregate Crushing Value (ACV)**

**Table 4.42: ACV obtained for CG**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | | Test 1 | Test 2 | Test 3 | Test 4 | Test 5 | **Average** |
| A | Mass of cylinder + Base Plate + Material | 12860 | 12870 | 12842 | 12896 | 12848 |  |
| B | Mass of cylinder + Base Plate | 10059 | 10059 | 10059 | 10059 | 10059 |
| C | Mass of Surface – Dry Material Sample size 10-14mm (A-B) [g] | 2801 | 2811 | 2783 | 2837 | 2789 |
| D | Mass of Fraction Passing Sieve 2.36mm [g] | 820 | 823 | 802 | 874 | 798 |
| E | Percentage Fine D/C \* 100 [%] | 29.3 | 29.3 | 28.8 | 30.8 | 28.6 | **29.4** |

**Table 4.43: ACV obtained for KM**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | | Test 1 | Test 2 | Test 3 | Test 4 | Test 5 | **Average** |
| A | Mass of cylinder + Base Plate + Material | 12899 | 12892 | 12888 | 12860 | 12850 |  |
| B | Mass of cylinder + Base Plate | 10059 | 10059 | 10059 | 10059 | 10059 |
| C | Mass of Surface – Dry Material Sample size 10-14mm (A-B) [g] | 2840 | 2833 | 2829 | 2801 | 2791 |
| D | Mass of Fraction Passing Sieve 2.36mm [g] | 788 | 786 | 826 | 742 | 773 |
| E | Percentage Fine D/C \* 100 [%] | 27.8 | 27.7 | 29.2 | 26.5 | 27.7 | **27.8** |

**Table 4.44: ACV obtained for LG**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | | Test 1 | Test 2 | Test 3 | Test 4 | Test 5 | **Average** |
| A | Mass of cylinder + Base Plate + Material | 12903 | 12911 | 12896 | 12906 | 12872 |  |
| B | Mass of cylinder + Base Plate | 10061 | 10061 | 10061 | 10061 | 10061 |
| C | Mass of Surface – Dry Material Sample size 10-14mm (A-B) [g] | 2842 | 2850 | 2835 | 2845 | 2811 |
| D | Mass of Fraction Passing Sieve 2.36mm [g] | 1064 | 1072 | 1134 | 1223 | 829 |
| E | Percentage Fine D/C \* 100 [%] | 37.4 | 37.6 | 40.0 | 43.0 | 29.5 | **37.5** |

**Table 4.45: ACV obtained for GAR**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | | Test 1 | Test 2 | Test 3 | Test 4 | Test 5 | **Average** |
| A | Mass of cylinder + Base Plate + Material | 12906 | 12908 | 12962 | 12981 | 13004 |  |
| B | Mass of cylinder + Base Plate | 10059 | 10059 | 10059 | 10059 | 10059 |
| C | Mass of Surface – Dry Material Sample size 10-14mm (A-B) [g] | 2847 | 2849 | 2903 | 2922 | 2945 |
| D | Mass of Fraction Passing Sieve 2.36mm [g] | 737 | 735 | 784 | 783 | 722 |
| E | Percentage Fine D/C \* 100 [%] | 25.9 | 25.8 | 27.0 | 26.8 | 24.5 | **26.1** |

**Table 4.46: ACV obtained for KE**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | | Test 1 | Test 2 | Test 3 | Test 4 | Test 5 | **Average** |
| A | Mass of cylinder + Base Plate + Material | 12892 | 12888 | 12920 | 12872 | 12886 |
| B | Mass of cylinder + Base Plate | 10061 | 10061 | 10061 | 10061 | 10061 |
| C | Mass of Surface – Dry Material Sample size 10-14mm (A-B) [g] | 2831 | 2827 | 2859 | 2811 | 2825 |
| D | Mass of Fraction Passing Sieve 2.36mm [g] | 569 | 565 | 532 | 596 | 588 |
| E | Percentage Fine D/C \* 100 [%] | 20.1 | 20.0 | 18.6 | 21.2 | 20.8 | **20.2** |

**Table 4.47: ACV obtained for NE**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | | Test 1 | Test 2 | Test 3 | Test 4 | Test 5 | **Average** |
| A | Mass of cylinder + Base Plate + Material | 12918 | 12902 | 12970 | 12886 | 12890 |
| B | Mass of cylinder + Base Plate | 10061 | 10061 | 10061 | 10061 | 10061 |
| C | Mass of Surface – Dry Material Sample size 10-14mm (A-B) [g] | 2857 | 2841 | 2909 | 2825 | 2829 |
| D | Mass of Fraction Passing Sieve 2.36mm [g] | 806 | 802 | 876 | 768 | 789 |
| E | Percentage Fine D/C \* 100 [%] | 28.2 | 28.2 | 30.1 | 27.2 | 27.9 | **28.4** |

**Table 4.48: ACV obtained for GAW**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | | Test 1 | Test 2 | Test 3 | Test 4 | Test 5 | **Average** |
| A | Mass of cylinder + Base Plate + Material | 12905 | 12901 | 12881 | 12911 | 12904 |
| B | Mass of cylinder + Base Plate | 10061 | 10061 | 10061 | 10061 | 10061 |
| C | Mass of Surface – Dry Material Sample size 10-14mm (A-B) [g] | 2844 | 2840 | 2820 | 2850 | 2843 |
| D | Mass of Fraction Passing Sieve 2.36mm [g] | 800 | 806 | 778 | 866 | 761 |
| E | Percentage Fine D/C \* 100 [%] | 28.1 | 28.4 | 27.6 | 30.4 | 26.75 | **28.25** |

**Table 4.49: ACV obtained for KW**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | | Test 1 | Test 2 | Test 3 | Test 4 | Test 5 | **Average** |
| A | Mass of cylinder + Base Plate + Material | 12841 | 12838 | 12854 | 12848 | 12840 |
| B | Mass of cylinder + Base Plate | 10059 | 10059 | 10059 | 10059 | 10059 |
| C | Mass of Surface – Dry Material Sample size 10-14mm (A-B) [g] | 2782 | 2779 | 2795 | 2789 | 2781 |
| D | Mass of Fraction Passing Sieve 2.36mm [g] | 704 | 700 | 738 | 672 | 704 |
| E | Percentage Fine D/C \* 100 [%] | 25.3 | 25.2 | 26.4 | 24.1 | 25.3 | **25.3** |

**Table 4.50: ACV obtained for MA**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | | Test 1 | Test 2 | Test 3 | Test 4 | Test 5 | **Average** |
| A | Mass of cylinder + Base Plate + Material | 12911 | 12902 | 12891 | 12908 | 12916 |
| B | Mass of cylinder + Base Plate | 10059 | 10059 | 10059 | 10059 | 10059 |
| C | Mass of Surface – Dry Material Sample size 10-14mm (A-B) [g] | 2852 | 2843 | 2832 | 2849 | 2859 |
| D | Mass of Fraction Passing Sieve 2.36mm [g] | 680 | 687 | 668 | 724 | 658 |
| E | Percentage Fine D/C \* 100 [%] | 23.8 | 24.2 | 23.6 | 25.4 | 23.0 | **24.0** |

**4.10 Brittleness Test Results**

**Table 4.53: Brittleness Test Results - CG**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Description** | **Test 1** | **Test 2** | **Test 3** | **Test 4** | **Test 5** |
| **Oversize [g]** | 84.2 | 149.1 | 159.6 | 101.2 | 62.1 |
| **Undersize [g]** | 426.0 | 361.7 | 352.0 | 410.0 | 449.3 |
| **Total mass [g]** | 510.2 | 510.8 | 511.6 | 511.2 | 511.4 |
| **Brittleness Value [%]** | 83.50 | 70.80 | 68.80 | 80.20 | 87.85 |
| **Average** | **78.23** | | | | |

**Table 4.54: Brittleness Test Results - KM**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Description** | **Test 1** | **Test 2** | **Test 3** | **Test 4** | **Test 5** |
| **Oversize [g]** | 178.1 | 125.5 | 234.5 | 228.5 | 174.1 |
| **Undersize [g]** | 340.5 | 393.4 | 283.3 | 290.9 | 343.1 |
| **Total mass [g]** | 518.6 | 518.9 | 517.8 | 519.4 | 517.2 |
| **Brittleness Value [%]** | 65.66 | 75.82 | 54.72 | 56.01 | 66.34 |
| **Average** | **63.71** | | | | |

**Table 4.55: Brittleness Test Results - LG**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Description** | **Test 1** | **Test 2** | **Test 3** | **Test 4** | **Test 5** |
| **Oversize [g]** | 127.6 | 61.2 | 77.0 | 109.4 | 102.0 |
| **Undersize [g]** | 387.7 | 459.2 | 440.2 | 406.2 | 416.4 |
| **Total mass [g]** | 515.3 | 520.4 | 517.2 | 515.6 | 518.4 |
| **Brittleness Value [%]** | 75.24 | 88.24 | 85.11 | 78.79 | 80.32 |
| **Average** | **81.54** | | | | |

**Table 4.56: Brittleness Test Results - GAR**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Description** | **Test 1** | **Test 2** | **Test 3** | **Test 4** | **Test 5** |
| **Oversize [g]** | 212.4 | 171.9 | 202.4 | 166.6 | 230.9 |
| **Undersize [g]** | 296.4 | 337.3 | 306.0 | 343.5 | 280.5 |
| **Total mass [g]** | 508.8 | 509.2 | 508.4 | 510.1 | 511.4 |
| **Brittleness Value [%]** | 58.26 | 66.24 | 60.18 | 67.33 | 54.84 |
| **Average** | **61.37** | | | | |

**Table 4.57: Brittleness Test Results - KE**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Description** | **Test 1** | **Test 2** | **Test 3** | **Test 4** | **Test 5** |
| **Oversize [g]** | 347.0 | 333.6 | 349.0 | 313.0 | 330.3 |
| **Undersize [g]** | 164.4 | 176.6 | 160.5 | 197.4 | 179.5 |
| **Total mass [g]** | 511.4 | 510.2 | 509.5 | 510.4 | 509.8 |
| **Brittleness Value [%]** | 32.15 | 34.62 | 31.5 | 38.68 | 35.20 |
| **Average** | **34.43** | | | | |

**Table 4.58: Brittleness Test Results - NE**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Description** | **Test 1** | **Test 2** | **Test 3** | **Test 4** | **Test 5** |
| **Oversize [g]** | 143.5 | 158.2 | 180.1 | 141.6 | 172.5 |
| **Undersize [g]** | 361.9 | 348.7 | 323.6 | 364.8 | 334.0 |
| **Total mass [g]** | 505.4 | 506.9 | 503.7 | 506.4 | 506.5 |
| **Brittleness Value [%]** | 71.60 | 68.78 | 64.24 | 72.04 | 65.94 |
| **Average** | **68.52** | | | | |

**Table 4.59: Brittleness Test Results - GAW**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Description** | **Test 1** | **Test 2** | **Test 3** | **Test 4** | **Test 5** |
| **Oversize [g]** | 174.4 | 205.6 | 166.8 | 179.0 | 175.2 |
| **Undersize [g]** | 326.8 | 296.0 | 335.7 | 323.8 | 328.2 |
| **Total mass [g]** | 501.2 | 501.6 | 502.5 | 502.8 | 503.4 |
| **Brittleness Value [%]** | 65.2 | 59.0 | 66.8 | 64.4 | 65.2 |
| **Average** | **64.12** | | | | |

**Table 4.60: Brittleness Test Results - KW**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Description** | **Test 1** | **Test 2** | **Test 3** | **Test 4** | **Test 5** |
| **Oversize [g]** | 181.1 | 182.6 | 192.4 | 188.1 | 175.5 |
| **Undersize [g]** | 232.4 | 229.8 | 219.3 | 224.7 | 236.9 |
| **Total mass [g]** | 413.5 | 412.4 | 411.7 | 412.8 | 412.4 |
| **Brittleness Value [%]** | 56.21 | 55.72 | 53.26 | 54.42 | 57.44 |
| **Average** | **55.41** | | | | |

**Table 4.61: Brittleness Test Results - MA**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Description** | **Test 1** | **Test 2** | **Test 3** | **Test 4** | **Test 5** |
| **Oversize [g]** | 251.7 | 256.5 | 262.7 | 265.5 | 244.0 |
| **Undersize [g]** | 259.7 | 253.1 | 247.4 | 243.7 | 265.5 |
| **Total mass [g]** | 511.4 | 509.6 | 510.1 | 509.2 | 509.5 |
| **Brittleness Value [%]** | 50.78 | 49.66 | 48.50 | 47.86 | 52.1 |
| **Average** | **49.78** | | | | |

**4.11 Siever J (SJ) Test Result**

**Table 4.64: Siever J Values (mm)**

|  |  |  |  |
| --- | --- | --- | --- |
| **S/N** | **Samples** | **Siever’s J Values (mm)** | **Avg. Siever’s J Values (mm)** |
| 1 | CG | 0.69,0.75,0.70,0.71 and 0.65 | 0.70 |
| 2 | KM | 0.67,0.70,0.65,0.66 and 0.67 | 0.67 |
| 3 | LG | 0.66, 0.73,0.72,0.69 and 0.70 | 0.70 |
| 4 | GAR | 0.62,0.65,0.63,0.65 and 0.60 | 0.63 |
| 5 | KE | 0.56,0.58,0.58,0.61 and 0.60 | 0.58 |
| 6 | NE | 0.68,0.68,0.62,0.70 and 0.67 | 0.67 |
| 7 | GAW | 0.71,0.61,0.72,0.65 and 0.67 | 0.67 |
| 8 | KW | 0.64,0.62,0.60,0.60 and 0.64 | 0.62 |
| 9 | MA | 0.60,0.56,0.55,0.55 and 0.74 | 0.60 |

**4.12 Drilling Rate Index (DRI)**

**Table 4.65: Drilling Rate Index Result for CG**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No.** | **Brittleness** | **Siever’ J-Value** | **Drilling Rate Index** | **Classification** |
| CG 1 | 83.50 | 0.69 | 65 |  |
| CG 2 | 70.80 | 0.75 | 57 |
| CG 3 | 68.80 | 0.70 | 55 |
| CG 4 | 80.20 | 0.71 | 64 |
| CG 5 | 87.85 | 0.65 | 63 |
| **Average** | | | **61** | **HIGH** |

**Table 4.66: Drilling Rate Index Result for KM**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No.** | **Brittleness** | **Siever’ J-Value** | **Drilling Rate Index** | **Classification** |
| KM 1 | 65.66 | 0.67 | 48 |  |
| KM 2 | 75.82 | 0.70 | 60 |
| KM 3 | 54.72 | 0.65 | 40 |
| KM 4 | 56.01 | 0.66 | 40 |
| KM 5 | 66.34 | 0.67 | 52 |
| **Average** | | | **48** | **Medium** |

**Table 4.67: Drilling Rate Index Result for LG**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No.** | **Brittleness** | **Siever’ J-Value** | **Drilling Rate Index** | **Classification** |
| LG 1 | 75.24 | 0.66 | 60 |  |
| LG 2 | 88.24 | 0.73 | 67 |
| LG 3 | 85.11 | 0.72 | 63 |
| LG 4 | 78.79 | 0.69 | 66 |
| LG 5 | 80.32 | 0.70 | 64 |
| **Average** | | | **64** | **High** |

**Table 4.68: Drilling Rate Index Result for GAR**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No.** | **Brittleness** | **Siever’ J-Value** | **Drilling Rate Index** | **Classification** |
| GAR 1 | 58.26 | 0.62 | 43 |  |
| GAR 2 | 66.24 | 0.65 | 46 |
| GAR 3 | 60.18 | 0.63 | 42 |
| GAR 4 | 67.18 | 0.65 | 44 |
| GAR 5 | 54.84 | 0.60 | 40 |
| **Average** | | | **43** | **Medium** |

**Table 4.69: Drilling Rate Index Result for KE**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No.** | **Brittleness** | **Siever’ J-Value** | **Drilling Rate Index** | **Classification** |
| KE 1 | 32.15 | 0.56 | 18 |  |
| KE 2 | 34.62 | 0.58 | 19 |
| KE 3 | 31.50 | 0.58 | 18 |
| KE 4 | 38.68 | 0.61 | 23 |
| KE 5 | 35.20 | 0.60 | 22 |
| **Average** | | | **20** | **Extremely Low** |

**Table 4.70: Drilling Rate Index Result for NE**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No.** | **Brittleness** | **Siever’ J-Value** | **Drilling Rate Index** | **Classification** |
| NE 1 | 71.60 | 0.68 | 57 |  |
| NE 2 | 68.78 | 0.68 | 55 |
| NE 3 | 64.24 | 0.62 | 47 |
| NE 4 | 72.04 | 0.70 | 60 |
| NE 5 | 65.94 | 0.67 | 51 |
| **Average** | | | **54** | **Medium** |

**Table 4.71: Drilling Rate Index Result for GAW**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No.** | **Brittleness** | **Siever’ J-Value** | **Drilling Rate Index** | **Classification** |
| GAW 1 | 65.20 | 0.71 | 49 |  |
| GAW 2 | 59.00 | 0.61 | 44 |
| GAW 3 | 66.80 | 0.72 | 55 |
| GAW 4 | 64.40 | 0.65 | 50 |
| GAW 5 | 65.20 | 0.67 | 52 |
| **Average** | | | **50** | **Medium** |

**Table 4.72: Drilling Rate Index Result for KW**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No.** | **Brittleness** | **Siever’ J-Value** | **Drilling Rate Index** | **Classification** |
| KW 1 | 56.21 | 0.64 | 42 |  |
| KW 2 | 55.72 | 0.62 | 38 |
| KW 3 | 53.26 | 0.60 | 36 |
| KW 4 | 54.42 | 0.60 | 38 |
| KW 5 | 57.44 | 0.64 | 36 |
| **Average** | | | **38** | **Low** |

**Table 4.73: Drilling Rate Index Result for MA**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No.** | **Brittleness** | **Siever’ J-Value** | **Drilling Rate Index** | **Classification** |
| MA 1 | 50.78 | 0.60 | 32 |  |
| MA 2 | 49.66 | 0.56 | 32 |
| MA 3 | 48.50 | 0.55 | 28 |
| MA 4 | 47.86 | 0.55 | 32 |
| MA 5 | 52.10 | 0.74 | 36 |
| **Average** | | | **32** | **Very Low** |

**4.13 Uniaxial Compressive Strength**

**Table 4.74: Uniaxial Compressive Strength for CG**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sample No.** | **Failure Load [kN]** | **Cross Sectional Area [mm2]** | **Mass before test [g]** | **Compressive Strength [MPa]** |  |
| CG 1 | 200 | 22.9 | 351 | 87.3 |  |
| CG 2 | 185 | 22.9 | 350 | 80.8 |  |
| CG 3 | 220 | 22.9 | 350 | 96.1 |  |
| CG 4 | 220 | 22.9 | 352 | 96,1 |  |
| CG 5 | 190 | 22.9 | 355 | 83.0 |  |
| **Average** | | | | **88.66** | **Moderate Strength** |

**Table 4.75: Uniaxial Compressive Strength for KM**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sample No.** | **Failure Load [kN]** | **Cross Sectional Area [mm2]** | **Mass before test [g]** | **Compressive Strength [MPa]** |  |
| KM 1 | 220 | 22.9 | 331 | 96.1 |  |
| KM 2 | 230 | 22.9 | 337 | 100.4 |  |
| KM 3 | 230 | 22.9 | 335 | 100.4 |  |
| KM 4 | 240 | 22.9 | 332 | 104.8 |  |
| KM 5 | 240 | 22.9 | 331 | 104,8 |  |
| **Average** | | | | **101.3** | **High Strength** |

**Table 4.76: Uniaxial Compressive Strength for LG**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sample No.** | **Failure Load [kN]** | **Cross Sectional Area [mm2]** | **Mass before test [g]** | **Compressive Strength [MPa]** |  |
| LG 1 | 160 | 22.9 | 333 | 69.9 |  |
| LG 2 | 110 | 22.9 | 333 | 48.0 |  |
| LG 3 | 135 | 22.9 | 332 | 59.0 |  |
| LG 4 | 135 | 22.9 | 333 | 59.0 |  |
| LG 5 | 135 | 22.9 | 333 | 59.0 |  |
| **Average** | | | | **59.0** | **Moderate strength** |

**Table 4.77: Uniaxial Compressive Strength for GAR**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sample No.** | **Failure Load [kN]** | **Cross Sectional Area [mm2]** | **Mass before test [g]** | **Compressive Strength [MPa]** |  |
| GAR 1 | 250 | 22.9 | 330 | 109.2 |  |
| GAR 2 | 260 | 22.9 | 332 | 113.5 |  |
| GAR 3 | 260 | 22.9 | 329 | 113.5 |  |
| GAR 4 | 250 | 22.9 | 330 | 109.2 |  |
| GAR 5 | 270 | 22.9 | 335 | 117.9 |  |
| **Average** | | | | **112.7** | **High Strength** |

**Table 4.78: Uniaxial Compressive Strength for KE**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sample No.** | **Failure Load [kN]** | **Cross Sectional Area [mm2]** | **Mass before test [g]** | **Compressive Strength [MPa]** |  |
| KE 1 | 380 | 22.9 | 332 | 165.9 |  |
| KE 2 | 420 | 22.9 | 353 | 183.4 |  |
| KE 3 | 380 | 22.9 | 336 | 165.9 |  |
| KE 4 | 400 | 22.9 | 350 | 174.4 |  |
| KE 5 | 420 | 22.9 | 348 | 183.4 |  |
| **Average** | | | | **174.4** | **High Strength** |

**Table 4.79: Uniaxial Compressive Strength for NE**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Sample No.** | **Failure Load [kN]** | **Cross Sectional Area [mm2]** | **Mass before test [g]** | **Compressive Strength [MPa]** |  |  |
| NE 1 | 190 | 22.9 | 339 | 83.0 |  |  |
| NE 2 | 230 | 22.9 | 339 | 100.4 |  |  |
| NE 3 | 220 | 22.9 | 332 | 96.1 |  |  |
| NE 4 | 220 | 22.9 | 336 | 96.1 |  |  |
| NE 5 | 200 | 22.9 | 340 | 87.3 |  |  |
| **Average** | | | | **92.58** | **Moderate Strength** |  |

**Table 4.80: Uniaxial Compressive Strength for GAW**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sample No.** | **Failure Load [kN]** | **Cross Sectional Area [mm2]** | **Mass before test [g]** | **Compressive Strength [MPa]** |  |
| GAW 1 | 230 | 22.9 | 311 | 100.4 |  |
| GAW 2 | 210 | 22.9 | 340 | 91.7 |  |
| GAW 3 | 220 | 22.9 | 315 | 96.1 |  |
| GAW 4 | 220 | 22.9 | 316 | 96.1 |  |
| GAW 5 | 220 | 22.9 | 311 | 96.1 |  |
| **Average** | | | | **96.1** | **Moderate Strength** |

**Table 4.81: Uniaxial Compressive Strength for KW**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sample No.** | **Failure Load [kN]** | **Cross Sectional Area [mm2]** | **Mass before test [g]** | **Compressive Strength [MPa]** |  |
| KW 1 | 285 | 22.9 | 335 | 124.5 |  |
| KW 2 | 270 | 22.9 | 335 | 117.9 |  |
| KW 3 | 280 | 22.9 | 336 | 122.3 |  |
| KW 4 | 270 | 22.9 | 339 | 117.9 |  |
| KW 5 | 285 | 22.9 | 335 | 124.5 |  |
| **Average** | | | | **121.42** | **High Strength** |

**Table 4.82: Uniaxial Compressive Strength for MA**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sample No.** | **Failure Load [kN]** | **Cross Sectional Area [mm2]** | **Mass before test [g]** | **Compressive Strength [MPa]** |  |
| MA 1 | 280 | 22.9 | 336 | 122.3 |  |
| MA 2 | 250 | 22.9 | 335 | 109.2 |  |
| MA 3 | 340 | 22.9 | 335 | 148.5 |  |
| MA 4 | 290 | 22.9 | 336 | 126.6 |  |
| MA 5 | 290 | 22.9 | 335 | 126.6 |  |
| **Average** | | | | **126.6** | **High Strength** |

**4.14 Los Angeles Abrasion Result**

**Table 4.86: Los Angeles Abrasion Result of CG**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No** | **Weight of Sample (g)** | **Weight of Under Size (g)** | **Weight of Over size (g)** | **Wear (%)** |
| 1 | 5000 | 2360 | 2640 | 47.2 |
| 2 | 5000 | 2390 | 2610 | 47.8 |
| 3 | 5000 | 2425 | 2575 | 48.5 |
| 4 | 5000 | 2440 | 2560 | 48.8 |
| 5 | 5000 | 2335 | 2665 | 46.7 |
| **Average** | | | | **47.8** |

**Table 4.87: Los Angeles Abrasion Result of KM**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No** | **Weight of Sample (g)** | **Weight of Under Size (g)** | **Weight of Over size (g)** | **Wear (%)** |
| 1 | 5000 | 2230 | 2770 | 44.6 |
| 2 | 5000 | 2135 | 2865 | 42.7 |
| 3 | 5000 | 2270 | 2730 | 45.4 |
| 4 | 5000 | 2310 | 2690 | 46.2 |
| 5 | 5000 | 2105 | 2895 | 42.1 |
| **Average** | | | | **44.2** |

**Table 4.88: Los Angeles Abrasion Result of LG**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No** | **Weight of Sample (g)** | **Weight of Under Size (g)** | **Weight of Over size (g)** | **Wear (%)** |
| 1 | 5000 | 2960 | 2040 | 52.9 |
| 2 | 5000 | 3085 | 1915 | 61.7 |
| 3 | 5000 | 2840 | 2160 | 56.8 |
| 4 | 5000 | 2980 | 2020 | 59.6 |
| 5 | 5000 | 2860 | 2140 | 57.2 |
| **Average** | | | | **58.9** |

**Table 4.89: Los Angeles Abrasion Result of GAR**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No** | **Weight of Sample (g)** | **Weight of Under Size (g)** | **Weight of Over size (g)** | **Wear (%)** |
| 1 | 5000 | 2120 | 2880 | 42.4 |
| 2 | 5000 | 2060 | 2940 | 41.2 |
| 3 | 5000 | 2165 | 2835 | 43.3 |
| 4 | 5000 | 1975 | 3025 | 39.5 |
| 5 | 5000 | 2080 | 2920 | 41.6 |
| **Average** | | | | **41.6** |

**Table 4.90: Los Angeles Abrasion Result of KE**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No** | **Weight of Sample (g)** | **Weight of Under Size (g)** | **Weight of Over size (g)** | **Wear (%)** |
| 1 | 5000 | 1160 | 3840 | 23.2 |
| 2 | 5000 | 1080 | 3920 | 21.6 |
| 3 | 5000 | 1065 | 3935 | 21.3 |
| 4 | 5000 | 1105 | 3895 | 22.1 |
| 5 | 5000 | 1140 | 3860 | 22.8 |
| **Average** | | | | **22.2** |

**Table 4.91: Los Angeles Abrasion Result of NE**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No** | **Weight of Sample (g)** | **Weight of Under Size (g)** | **Weight of Over size (g)** | **Wear (%)** |
| 1 | 5000 | 2510 | 2490 | 50.2 |
| 2 | 5000 | 2335 | 2665 | 46.7 |
| 3 | 5000 | 2190 | 4210 | 43.8 |
| 4 | 5000 | 2360 | 2640 | 47.2 |
| 5 | 5000 | 2380 | 2620 | 47.6 |
| **Average** | | | | **47.1** |

**Table 4.92: Los Angeles Abrasion Result of GAW**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No** | **Weight of Sample (g)** | **Weight of Under Size (g)** | **Weight of Over size (g)** | **Wear (%)** |
| 1 | 5000 | 2370 | 2630 | 47.4 |
| 2 | 5000 | 2420 | 2580 | 48.4 |
| 3 | 5000 | 2330 | 2670 | 46.6 |
| 4 | 5000 | 2115 | 2885 | 42.3 |
| 5 | 5000 | 2340 | 2660 | 46.8 |
| **Average** | | | | **46.3** |

**Table 4.93: Los Angeles Abrasion Result of KW**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No** | **Weight of Sample (g)** | **Weight of Under Size (g)** | **Weight of Over size (g)** | **Wear (%)** |
| 1 | 5000 | 1680 | 3320 | 33.6 |
| 2 | 5000 | 1740 | 3260 | 34.8 |
| 3 | 5000 | 1680 | 3320 | 33.6 |
| 4 | 5000 | 1730 | 3270 | 34.6 |
| 5 | 5000 | 1770 | 3230 | 35.4 |
| **Average** | | | | **34.4** |

**Table 4.94: Los Angeles Abrasion Result of MA**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No** | **Weight of Sample (g)** | **Weight of Under Size (g)** | **Weight of Over size (g)** | **Wear (%)** |
| 1 | 5000 | 1660 | 3340 | 33.2 |
| 2 | 5000 | 1575 | 3475 | 30.5 |
| 3 | 5000 | 1670 | 3330 | 33.4 |
| 4 | 5000 | 1580 | 3420 | 31.6 |
| 5 | 5000 | 1640 | 3360 | 32.8 |
| **Average** | | | | **32.3** |

**4.15 Bit Wear Index Results**

**Table 4.97: Determination of Bit Wear Index (BWI) – CG**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No** | **DRI** | **LAV** | **BWI** | **CLASSIFICATION** |
| CG 1 | 65 | 47.2 | 28 |  |
| CG 2 | 57 | 47.8 | 38 |
| CG 3 | 55 | 48.5 | 38 |
| CG 4 | 64 | 48.5 | 28 |
| CG 5 | 63 | 46.7 | 28 |
| **Average** | | | **32** | **MEDIUM** |

**Table 4.98: Determination of Bit Wear Index (BWI) – KM**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No** | **DRI** | **LAV** | **BWI** | **CLASSIFICATION** |
| KM 1 | 48 | 44.6 | 42 |  |
| KM 2 | 60 | 42.7 | 30 |
| KM 3 | 40 | 45.4 | 52 |
| KM 4 | 40 | 46.2 | 53 |
| KM 5 | 52 | 42.1 | 40 |
| **Average** | | | **43** | **MEDIUM** |

**Table 4.99: Determination of Bit Wear Index (BWI) – LG**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No** | **DRI** | **LAV** | **BWI** | **CLASSIFICATION** |
| LG 1 | 60 | 52.9 | 33 |  |
| LG 2 | 67 | 61.7 | 26 |
| LG 3 | 63 | 56.8 | 30 |
| LG 4 | 66 | 59.6 | 30 |
| LG 5 | 64 | 57.2 | 30 |
| **Average** | | | **30** | **LOW** |

**Table 4.100: Determination of Bit Wear Index (BWI) – GAR**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No** | **DRI** | **LAV** | **BWI** | **CLASSIFICATION** |
| GAR 1 | 43 | 42.4 | 45 |  |
| GR 2 | 46 | 41.2 | 44 |
| GAR 3 | 42 | 43.3 | 48 |
| GAR 4 | 44 | 39.5 | 44 |
| GAR 5 | 40 | 41.6 | 51 |
| **Average** | | | **46** | **HIGH** |

**Table 4.101: Determination of Bit Wear Index (BWI) – KE**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No** | **DRI** | **LAV** | **BWI** | **CLASSIFICATION** |
| KE 1 | 18 | 23.2 | 76 |  |
| KE 2 | 19 | 21.6 | 74 |
| KE 3 | 18 | 21.3 | 74 |
| KE 4 | 23 | 22.1 | 75 |
| KE 5 | 22 | 22.8 | 75 |
| **Average** | | | **75** | **EXTREMELY HIGH** |

**Table 4.102: Determination of Bit Wear Index (BWI) – NE**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No** | **DRI** | **LAV** | **BWI** | **CLASSIFICATION** |
| NE 1 | 57 | 50.2 | 33 |  |
| NE 2 | 55 | 46.7 | 37 |
| NE 3 | 47 | 43.8 | 46 |
| NE 4 | 60 | 47.2 | 31 |
| NE 5 | 51 | 47.6 | 42 |
| **Average** | | | **38** | **MEDIUM** |

**Table 4.103: Determination of Bit Wear Index (BWI) – GAW**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No** | **DRI** | **LAV** | **BWI** | **CLASSIFICATION** |
| GAW 1 | 49 | 47.4 | 43 |  |
| GAW 2 | 44 | 48.4 | 37 |
| GAW 3 | 55 | 46.6 | 48 |
| GAW 4 | 50 | 42.3 | 42 |
| GAW 5 | 52 | 46.8 | 39 |
| **Average** | | | **42** | **MEDIUM** |

**Table 4.104: Determination of Bit Wear Index (BWI) – KW**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No** | **DRI** | **LAV** | **BWI** | **CLASSIFICATION** |
| KW 1 | 42 | 33.6 | 46 |  |
| KW 2 | 38 | 34.8 | 51 |
| KW 3 | 36 | 33.6 | 57 |
| KW 4 | 38 | 34.6 | 51 |
| KW 5 | 36 | 35.4 | 57 |
| **Average** | | | **52** | **HIGH** |

**Table 4.105: Determination of Bit Wear Index (BWI) – MA**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No** | **DRI** | **LAV** | **BWI** | **CLASSIFICATION** |
| MA 1 | 32 | 33.2 | 70 |  |
| MA 2 | 32 | 30.5 | 68 |
| MA 3 | 28 | 33.4 | 73 |
| MA 4 | 32 | 31.6 | 68 |
| MA 5 | 36 | 32.8 | 62 |
| **Average** | | | **69** | **VERY HIGH** |

**4.16 Cutter Life Index Results**

Tables 4.107 to 4.115 show the CLI values of the different rock types.

**Table 4.107: Determination of Cutter Life Index (CLI) – CG**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No** | **S.J** | **LAV** | **CLI** | **CLASSIFICATION** |
| CG 1 | 0.69 | 47.2 | 16.02 |  |
| CG 2 | 0.75 | 47.8 | 16.46 |
| CG 3 | 0.70 | 48.5 | 15.94 |
| CG 4 | 0.71 | 48.5 | 16.03 |
| CG 5 | 0.65 | 46.7 | 15.72 |
| **Average** | | | **16.03** | **HIGH** |

**Table 4.108: Determination of Cutter Life Index (CLI) – KM**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No** | **S.J** | **LAV** | **CLI** | **CLASSIFICATION** |
| KM 1 | 0.67 | 44.6 | 16.19 |  |
| KM 2 | 0.70 | 42.7 | 16.74 |
| KM 3 | 0.65 | 45.4 | 15.89 |
| KM 4 | 0.66 | 46.2 | 15.88 |
| KM 5 | 0.67 | 42.1 | 16.55 |
| **Average** | | | **16.25** | **HIGH** |

**Table 4.109: Determination of Cutter Life Index (CLI) – LG**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No** | **S.J** | **LAV** | **CLI** | **CLASSIFICATION** |
| LG 1 | 0.66 | 52.9 | 15.07 |  |
| LG 2 | 0.73 | 61.7 | 14.76 |
| LG 3 | 0.72 | 56.8 | 15.16 |
| LG 4 | 0.69 | 59.6 | 14.64 |
| LG 5 | 0.70 | 57.2 | 14.96 |
| **Average** | | | **14.92** | **MEDIUM** |

**Table 4.110: Determination of Cutter Life Index (CLI) – GAR**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No** | **S.J** | **LAV** | **CLI** | **CLASSIFICATION** |
| GAR 1 | 0.62 | 42.4 | 16.02 |  |
| GR 2 | 0.65 | 41.2 | 16.49 |
| GAR 3 | 0.63 | 43.3 | 15.99 |
| GAR 4 | 0.65 | 39.5 | 16.76 |
| GAR 5 | 0.60 | 41.6 | 15.93 |
| **Average** | | | **16.24** | **HIGH** |

**Table 4.111: Determination of Cutter Life Index (CLI) – KE**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No** | **S.J** | **LAV** | **CLI** | **CLASSIFICATION** |
| KE 1 | 0.56 | 23.2 | 19.42 |  |
| KE 2 | 0.58 | 21.6 | 20.24 |
| KE 3 | 0.58 | 21.3 | 20.35 |
| KE 4 | 0.61 | 22.1 | 20.45 |
| KE 5 | 0.60 | 22.8 | 20.08 |
| **Average** | | | **20.11** | **HIGH** |

**Table 4.112: Determination of Cutter Life Index (CLI) – NE**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No** | **S.J** | **LAV** | **CLI** | **CLASSIFICATION** |
| NE 1 | 0.68 | 50.2 | 15.55 |  |
| NE 2 | 0.68 | 46.7 | 15.99 |
| NE 3 | 0.62 | 43.8 | 15.82 |
| NE 4 | 0.70 | 47.2 | 16.11 |
| NE 5 | 0.67 | 47.6 | 15.79 |
| **Average** | | | **15.85** | **HIGH** |

**Table 4.113: Determination of Cutter Life Index (CLI) – GAW**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No** | **S.J** | **LAV** | **CLI** | **CLASSIFICATION** |
| GAW 1 | 0.71 | 47.4 | 16.17 |  |
| GAW 2 | 0.61 | 48.4 | 15.13 |
| GAW 3 | 0.72 | 46.6 | 16.36 |
| GAW 4 | 0.65 | 42.3 | 16.33 |
| GAW 5 | 0.67 | 46.8 | 15.89 |
| **Average** | | | **15.98** | **HIGH** |

**Table 4.114: Determination of Cutter Life Index (CLI) – KW**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No** | **S.J** | **LAV** | **CLI** | **CLASSIFICATION** |
| KW 1 | 0.64 | 33.6 | 17.73 |  |
| KW 2 | 0.62 | 34.8 | 17.28 |
| KW 3 | 0.60 | 33.6 | 17.30 |
| KW 4 | 0.60 | 34.6 | 17.10 |
| KW 5 | 0.64 | 35.4 | 17.38 |
| **Average** | | | **17.36** | **HIGH** |

**Table 4.115: Determination of Cutter Life Index (CLI) – MA**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sample No** | **S.J** | **LAV** | **CLI** | **CLASSIFICATION** |
| MA 1 | 0.60 | 33.2 | 17.38 |  |
| MA 2 | 0.56 | 30.5 | 17.48 |
| MA 3 | 0.55 | 33.4 | 16.77 |
| MA 4 | 0.55 | 31.6 | 17.13 |
| MA 5 | 0.74 | 32.8 | 18.93 |
| **Average** | | | **17.54** | **HIGH** |

**4.17 Point Load Results**

**Table 4.116: Point Load results for CG**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **D [mm]** | **D2 [mm]** | **P [kN]** | **Is [MPa]** |
| CG 1 | 54 | 2916 | 17.05 | 5.85 |
| CG 2 | 54 | 2916 | 20.1 | 6.89 |
| CG 3 | 54 | 2916 | 24.10 | 8.27 |
| CG 4 | 54 | 2916 | 22.20 | 7.61 |
| CG 5 | 54 | 2916 | 19.25 | 6.6 |
|  |  |  | Average | 7.04 |

**Table 4.117: Point Load results for KM**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **D [mm]** | **D2 [mm]** | **P [kN]** | **Is [MPa]** |
| KM 1 | 54 | 2916 | 17.56 | 6.02 |
| KM 2 | 54 | 2916 | 16.56 | 5.68 |
| KM 3 | 54 | 2916 | 12.03 | 4.13 |
| KM 4 | 54 | 2916 | 12.56 | 4.31 |
| KM 5 | 54 | 2916 | 9.56 | 3.28 |
|  |  |  | Average | 4.68 |

**Table 4.118: Point Load results for LG**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **D [mm]** | **D2 [mm]** | **P [kN]** | **Is [MPa]** |
| LG 1 | 54 | 2916 | 20.14 | 6.91 |
| LG 2 | 54 | 2916 | 22.05 | 7.56 |
| LG 3 | 54 | 2916 | 15.06 | 5.17 |
| LG 4 | 54 | 2916 | 18.20 | 6.24 |
| LG 5 | 54 | 2916 | 20.24 | 6.94 |
|  |  |  | Average | 6.56 |

**Table 4.119: Point Load results for GAR**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **D [mm]** | **D2 [mm]** | **P [kN]** | **Is [MPa]** |
| GAR 1 | 54 | 2916 | 14.56 | 4.99 |
| GAR 2 | 54 | 2916 | 12.05 | 4.13 |
| GAR 3 | 54 | 2916 | 12.41 | 4.26 |
| GAR 4 | 54 | 2916 | 15.08 | 5.17 |
| GAR 5 | 54 | 2916 | 18.40 | 6.31 |
|  |  |  | Average | 4.97 |

**Table 4.120: Point Load results for KE**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **D [mm]** | **D2 [mm]** | **P [kN]** | **Is [MPa]** |
| KE 1 | 54 | 2916 | 14.10 | 4.84 |
| KE 2 | 54 | 2916 | 11.56 | 3.96 |
| KE 3 | 54 | 2916 | 14.20 | 4.87 |
| KE 4 | 54 | 2916 | 12.56 | 4.31 |
| KE 5 | 54 | 2916 | 15.45 | 5.3 |
|  |  |  | Average | 4.66 |

**Table 4.121: Point Load results for NE**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **D [mm]** | **D2 [mm]** | **P [kN]** | **Is [MPa]** |
| NE 1 | 54 | 2916 | 12.09 | 4.15 |
| NE 2 | 54 | 2916 | 20.28 | 6.96 |
| NE 3 | 54 | 2916 | 15.56 | 5.43 |
| NE 4 | 54 | 2916 | 18.31 | 6.28 |
| NE 5 | 54 | 2916 | 20.01 | 6.86 |
|  |  |  | Average | 5.92 |

**Table 4.122: Point Load results for GAW**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **D [mm]** | **D2 [mm]** | **P [kN]** | **Is [MPa]** |
| GAW 1 | 54 | 2916 | 16.28 | 5.58 |
| GAW 2 | 54 | 2916 | 17.42 | 5.97 |
| GAW 3 | 54 | 2916 | 15.04 | 5.16 |
| GAW 4 | 54 | 2916 | 18.40 | 6.31 |
| GAW 5 | 54 | 2916 | 14.56 | 4.99 |
|  |  |  | Average | 5.60 |

**Table 4.123: Point Load results for KW**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **D [mm]** | **D2 [mm]** | **P [kN]** | **Is [MPa]** |
| KW 1 | 54 | 2916 | 21.12 | 7.24 |
| KW 2 | 54 | 2916 | 22.50 | 7.71 |
| KW 3 | 54 | 2916 | 18.56 | 6.36 |
| KW 4 | 54 | 2916 | 20.10 | 6.89 |
| KW 5 | 54 | 2916 | 15.45 | 5.30 |
|  |  |  | Average | 6.70 |

**Table 4.124: Point Load results for MA**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S/No.** | **D [mm]** | **D2 [mm]** | **P [kN]** | **Is [MPa]** |
| MD 1 | 54 | 2916 | 20.56 | 7.05 |
| MD 2 | 54 | 2916 | 22.45 | 7.7 |
| MD 3 | 54 | 2916 | 18.10 | 6.21 |
| MD 4 | 54 | 2916 | 20.24 | 6.94 |
| MD 5 | 54 | 2916 | 20.30 | 6.96 |
|  |  |  | Average | 6.97 |

**4.20: Laboratory and *In situ* Penetration Rate**

Table 4.129 shows the results of the Laboratory and In situ Penetration Rate

**Table 4.129: Results of Laboratory and *In situ* Penetration rate.**

|  |  |  |  |
| --- | --- | --- | --- |
| **S/NO** | **Location** | **Penetration Rate (Lab)**  **(cm/min)** | **Penetration Rate (*In site)***  **(cm/min)** |
| 1 | CG | 3.15 | 16.67 |
| 2 | KM | 2.44 | 13.45 |
| 3 | LG | 3.43 | 20.10 |
| 4 | GAR | 2.32 | 9.75 |
| 5 | KE | 1.88 | 7.14 |
| 6 | NE | 3.06 | 15.6 |
| 7 | GAW | 2.78 | 14.77 |
| 8 | KW | 2.32 | 8.99 |
| 9 | MA | 2.25 | 8.67 |

**Table 4.132: Using Brittleness Value (S20) Siever J-value (SJ) and Drilling Rate Index to predict Drillability.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Rock Code** | **Brittleness Value (S20) (%)** | **Siever J-Value (SJ)** | **Drilling Rate Index (DRI)** | **Drillability Characterization** |
| CG | 78.23 | 0.70 | 61 | High |
| KM | 63.71 | 0.67 | 48 | Medium |
| LG | 81.54 | 0.70 | 64 | High |
| GAR | 61.37 | 0.63 | 43 | Medium |
| KE | 34.43 | 0.58 | 20 | Extremely Low |
| NE | 68.52 | 0.67 | 54 | Medium |
| GAW | 64.12 | 0.67 | 50 | Medium |
| KW | 55.41 | 0.62 | 38 | Low |
| MA | 49.78 | 0.60 | 32 | Very Low |

**4.24: Determination of Drillability using Protodyakonov Established relationship.**

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**Table 4.133: Using Protodyakonov established relationship to predict rock hardness for drillability**

|  |  |  |  |
| --- | --- | --- | --- |
| **Rock Code** | **UCS (MPa)** | **Rock Hardness**  **(*f*)** | **Drillability Characterization** |
| CG | 88.0 | 8.8 | Hard |
| KM | 101.3 | 10.13 | Very Hard |
| LG | 59.0 | 5.9 | Rather Hard |
| GAR | 112.7 | 11.27 | Very Hard |
| KE | 174.4 | 17.44 | Highest |
| NE | 92.58 | 9.26 | Very hard |
| GAW | 96.1 | 9.61 | Hard |
| KW | 121.42 | 12.14 | Very Hard |
| MA | 126.6 | 12.66 | Very Hard |