TB-1402 — Using V-MAR® 3 (Rheology Modifying Admixture) to Reduce Concrete Pump Pressure Technical Bulletin

/ concrete / mix design

The successful pumping of concrete is dependent on a number of factors including having a suitable concrete mix. Fine, naturally rounded sand is ideal for producing pumpable concrete, but as the supply of fine, naturally rounded sand decreases, concrete producers are forced to utilize materials such as manufactured sands that are often coarse, angular, and gap-graded. Use of these materials can lead to segregation while pumping, and increased pump pressure. The fundamental reason coarse angular sands do not perform as well as naturally-rounded sand is due to their inability to "flow" within the concrete matrix.

V-MAR®3 has a unique polymeric structure that, under the influence of energy (e.g. vibration or pumping), aligns itself and allows coarse angular sand to flow similarly to naturally-rounded sand. At this point the polymers slide over each other in the direction of flow and reduce the yield stress of the concrete, essentially lubricating the pump hose, reducing internal friction, and reducing the pressure necessary to pump the concrete. As energy is removed, the polymers interlock leaving the concrete as it was before movement. V-MAR®3 has been shown to have a neutral effect on most concrete properties, as evidenced by the setting time, air entrainment, and compressive strength data in Table 1 below.

Table 1 – Neutral Effect of V-MAR 3 on Concrete Properties (SI Units)

Cement, kg/m^3	335	335	335	335	335
Stone, kg/m^3	798	798	798	798	798
Total Sand, kg/m^3	1026	1026	1026	1026	1026
Total Mix Water, kg/m^3	193	193	193	193	193
HRWR Admixture, mL/100 kg	300	300	300	300	300
V-MAR 3, mL/100 kg	—	60	110	170	220
Air, %	1.1	1.5	1.3	1.4	1.6
Initial Set, hrs:min	4:10	3:55	4:10	4:15	4:25

Compressive Strength @ 1 Day, MPa	11.0	10.3	10.9	10.9	10.8
Compressive Strength @ 7 Days, MPa	24.5	25.4	24.9	26.3	27.9
Compressive Strength @ 28 Days, MPa	31.2	32.7	32.5	33.1	35.6

Table 1 – Neutral Effect of V-MAR 3 on Concrete Properties (English Units)

Cement, lb/yd^3	564	564	564	564	564
Stone, lb/yd^3	1345	1345	1345	1345	1345
Total Sand, lb/yd^3	1730	1730	1730	1730	1730
Total Mix Water, lb/yd^3	325	325	325	325	325
HRWR Admixture, oz/cwt	4.6	4.6	4.6	4.6	4.6
V-MAR 3, oz/cwt	—	0.9	1.7	2.6	3.4
Air, %	1.1	1.5	1.3	1.4	1.6
Initial Set, hrs:min	4:10	3:55	4:10	4:15	4:25
Compressive Strength @ 1 Day, lb/in.^{2}	1600	1500	1580	1580	1560
Compressive Strength @ 7 Days, lb/in.^{2}	3560	3680	3610	3820	4040
Compressive Strength @ 28 Days, lb/in.^{2}	4530	4740	4720	4800	5170

The following examples show how the incorporation of manufactured sand in pumped concrete was made possible by utilizing V-MAR®3 as a pumping aid. The addition of V-MAR®3 to the concretes led to pump pressures being maintained at levels equal to or below the pressures produced by the control concrete, which did not contain manufactured sand.

It must be noted that these are examples only. The use of manufactured sand from different sources and/or in different amounts will have different effects on pumping pressure, and the V-MAR®3 requirements will also vary. Tests must be conducted on the various mix designs, replacement amounts of manufactured sand, and dosage rates of V-MAR®3 before the start of a project. An improper mix design, although pumpable, may still be harsh and difficult to place.

Example 1 – Portland Cement Concrete (SI Units)

Manufactured Sand Content	0%	40%	40%	60%	60%
Cement, kg/m³	274	282	272	275	271
Stone, kg/m³	964	979	957	946	955
Total Sand, kg/m³	883	905	914	921	907
Total Mix Water, kg/m³	196	201	201	206	201
WR Admixture, mL/100 kg	190	190	190	190	190
V-MAR 3, mL/100 kg	—	—	185	—	185
Slump, mm	114	95	127	114	127
Air, %	1.1	0.8	0.8	0.8	0.8
Pump Pressure, MPa	6.5	7.6	6.5	10.9	4.8

Example 1 – Portland Cement Concrete (English Units)

Manufactured Sand Content	0%	40%	40%	60%	60%
Cement, lb/yd³	462	475	459	464	457
Stone, lb/yd³	1625	1651	1613	1594	1611
Total Sand, lb/yd³	1488	1526	1542	1553	1530
Total Mix Water, lb/yd³	330	338	340	347	339
WR Admixture, oz/cwt	3	3	3	3	3
V-MAR 3, oz/cwt	—	—	2.8	—	2.8
Slump, in.	4.50	3.75	5.00	4.50	5.00
Air, %	1.1	0.8	0.8	0.8	0.8
Pump Pressure, lb/in.²	950	1100	950	1580	700

Example 2 – Portland Cement/Fly Ash Concrete (SI Units)

Manufactured Sand Content	0%	40%	40%	60%	60%	80%*	80%*
Cement, kg/m³	248	248	252	253	243	246	244
Fly Ash, kg/m³	65	65	66	66	64	66	64
Stone, kg/m³	967	968	970	939	926	917	922

Total Sand, kg/m³	887	899	880	926	926	931	935
Total Mix Water, kg/m³	178	181	180	177	182	180	186
WR Admixture, mL/100 kg	260	260	260	260	260	260	260
V-MAR® 3, mL/100 kg	—	—	165	—	165	—	165
Slump, mm	127	115	140	127	127	115	115
Air, %	1.1	0.8	0.9	1.3	0.9	0.8	0.8
Pump Pressure, MPa	7.6	8.6	7.6	9.0	7.6	19.3	7.9

Example 2 – Portland Cement/Fly Ash Concrete (English Units)

Manufactured Sand Content	0%	40%	40%	60%	60%	80%*	80%*
Cement, lb/yd³	417	418	425	427	410	415	411
Fly Ash, lb/yd³	110	110	111	111	108	111	108
Stone, lb/yd³	1630	1632	1636	1583	1562	1547	1555
Total Sand, lb/yd³	1496	1515	1483	1560	1562	1570	1577
Total Mix Water, lb/yd³	300	305	303	298	306	304	313
WR Admixture, oz/cwt	4	4	4	4	4	4	4
V-MAR® 3, oz/cwt	—	—	2.5	—	2.5	—	2.5
Slump, in.	5.0	4.5	5.5	5.0	5.0	4.5	4.5
Air, %	1.1	0.8	0.9	1.3	0.9	0.8	0.8
Pump Pressure, MPa	1100	1250	1100	1300	1100	2800	1150

* In the extreme case of using 80% manufactured sand in these lean mixes, the untreated concrete segregated during the pumping process, and pump pressures rose to unsustainable levels. However, even though the use of V-MAR ® 3 reduced the pump pressure to "normal" levels, and the concrete was placeable, it remained more difficult to place than the control mix.

Conclusion

The use of V-MAR®3 in pumped concretes incorporating different levels of manufactured sand reduced the resultant pumping pressures back to the same level as the control concrete, which did not contain manufactured sand.

Since V-MAR®3 is treating the free water in the mix and not the cement (as most concrete admixtures do), dosage rates were originally quoted based on the free water in the concrete. Although accurate, this nomenclature has proved confusing to those used to the more familiar dosage units for admixtures. Thus, typical V-MAR®3 dosages required for pumping applications are found in the range of 1.95 - 3.90 mL/L (¼ - ½ fl oz/gal) of water in the concrete, or 96 - 160 mL/100 kg (1½ - 2½ fl oz/100 lbs) of cementitious materials.

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