Unification of ordinary portland cement codes

M.C. Nataraja

The Bureau of Indian standard (BIS) has revised the codes on ordinary Portland cement 33, 43 and 53 grades in 2013, just four years ago. This revision is still not noticed by most students and professionals. From these codes it is observed that the specifications of these three grades cements are more or less similar and comparable. Keeping this in mind, the BIS has now come out with a single code covering the different grades of OPC and the same is released in December 2015. This paper discusses some of the salient points of this code and highlights on the performance improvers suggested in the code based on the literature.

BIS has released IS 269 code in December 2015 on specification of Ordinary Portland Cement [1]. This standard pertains to OPC and covers the requirements such as manufacturing, physical and chemical requirements, packing and making. In this revision the specifications pertaining to 33, 43 and 53 grade cements have been included which were previously covered in separately codes published in 2013 [2-4]. These three codes on 33, 43 and 53 grades will be withdrawn subsequently. As per Indian Gazette the codes on 33, 43 and 53 grade cements published in 2013 [2-4] are invalid after 27th July 2016 [5]. In the new code chemical and physical requirements of OPC for all grades are provided separately in two tables.

Use of industrial by products from copper, steel and zinc industries and from oil refinery, manufacture of cement by interblending process, uniform value of insoluble residue to 5% irrespective of grades of cement, modifications to provisions for railways sleeper cements (43S and 53S), requirement of making the 'best before date' of cement are some of the significant modifications introduced in this code [1].

One of the most interesting things incorporated in the earlier revision of 33, 43 and 53 grades cement [2-4] and in the present IS 269:2015 [1] is the use of performance improvers. In this paper importance of performance improvers based on literature is discussed in brief.

PERFORMANCE IMPROVERS

Many organic compounds are added to the clinker in the cement mill as grinding aids. The main purposes of using these aids are to reduce the energy required to grind the clinker into a given fineness and thereby increasing the efficiency of the cement mill. In addition, some grinding aids also provide important positive effects on the final cement such as, rheology of the fresh cement paste or concrete and improved strength development. Grinding aids that provides these additional properties are called quality improvers or the performance enhancer. Conventional grinding aids are used to increase the production rate in the cement mill. If such additions give beneficial chemical effects during hydration of the final cement (e.g. increased strength, improved workability etc.) the grinding aid is regarded as quality improver or performance enhancer. It is emphasized that several conventional grinding aids today are also claimed to give beneficial chemical effects to a certain extent. Performance enhancers (quality improvers) are supposed to increase the efficiency of the cement mill and at the same time preserve sufficient 'workability' of the dry cement i.e. not giving rise to problems like clogging during storage, packing or offloading from bulk transportation. In addition, the additives shall enhance the rheological and strength properties for fresh and hardened concrete respectively. In regard to the latter, a true quality improver must increase the early strength due to a chemical effect and not only due to increased fineness of the cement. There are few studies where both the cement powder and concrete properties are studied, in particular where the additive is added in the grinding process [6-9].

Desirable effects of using performance improvers in cement making are; increased grindability, increased or maintaining sufficient powder fluidity, workability or rheological effects, hydration effects: retarding/accelerating effects, and increased strength. The revised IS 269:2015 recommends many such performance improvers which are industrial by products from copper, steel and zinc industries and from oil refinery. In addition the manufacture of cement by

interblending process by intimately and uniformly blending the individual ground materials has been permitted. The various performance improvers suggested in the code are; fly ash, ground granulated blast furnace slag, silica fume, metakaoline, rice husk ash, lime stone, copper slag, lead slag, lead-zinc slag and spent fluidized catalytic cracking equilibrium catalyst. Individually or in combination these materials can be used to an extent of 5% by mass. The requirements of these materials as per IS 269 should be checked before use [1]. Some of these performance improvers are recommended in the earlier IS codes as well [2-4].

Extensive studies have been carried out at a steel supply company to evaluate the granulated steel slag as performance improver, as blending material and as raw material at various stages of cement manufacture. Based on the studies by Sathis et. al [10] , it is concluded that up to 5% granulated steel slag can be used as performance improver in cement manufacture, up to 40% by weight can be added during clinker grinding stage to manufacture cement blends with compressive strengths comparable to control OPC. Further they have concluded that, due to the low cost and ease of availability, granulated steel slag can be a good material for cement manufacture.

Another interesting performance improver which is of recent interest to the researcher is the spent fluid catalytic cracking (FCC) catalyst. It is an oil industry by-product from fluidised-bed catalytic cracking units. This residue is mainly formed by an active component in an amorphous aluminosilicate matrix. It mainly consists of up to 90% silica and alumina. Many investigators have reported on the characterization, mechanical and durability properties of mortar and concrete containing FCC. FCC has been studied lately due to its pozzolanic characteristics and the good performance of concrete mixtures using FCC as cement replacement. Different compositions of calcium silicate hydrates (CSH), calcium aluminate hydrates (CAH) and calcium aluminosilicate hydrates (CASH) have been found to be the main hydration products for lime-catalyst systems. These products are very similar to those found in pastes containing metakaoline. The same products appeared to be present in cement-FCC systems as well [11-13].

CONCLUSION

Three codes on 33, 43 and 53 grade cements which were earlier published in 2013 are clubbed in to one code under IS 269:2015. Importance of performance improvers and their effects are briefly discussed. With this revision, one need to follow only one code IS 269 for ordinary Portland cement and sleeper cement specifications.

References

1. _____*Ordinary Portland Cement- Specification*, IS 269:2015, Bureau of Indian standard, New Delhi, December, 2015
2. _____*Ordinary Portland Cement, 33 Grade- Specification*, IS 269:2013, Bureau of Indian standard, New Delhi, 2013
3. _____ *Ordinary Portland Cement, 43 Grade- Specification,* IS 8112:2013, Bureau of Indian standard, New Delhi, 2013
4. _____ *Ordinary Portland Cement, 53 Grade- Specification,* IS 12269:2013, Bureau of Indian standard, New Delhi, 2013
5. Indian Gazette No. 311, New Delhi, Thursday, February 4, 2016
6. S. Sohoni, R. Sridhar, G. Mandal, 'The Effect of Grinding Aids on the Fine Grinding of Limestone, Quartz and Portland-Cement Clinker', Powder Technology, Vol. 67 (3), 1991, pp. 277- 286.
7. D. Revuelta, L.F. Luco, F. Dorrego, M.P. De Luxan, 'Influence of clinker grinding-aids on the intrinsic characteristics of cements and on the behaviour of mortars', Materials and Construction, Vol. 53, 2003, pp. 81-90.
8. K. Erdogdu, M. Tokyay, P. Turker, 'Comparison of intergrinding and separate grinding for the production of natural pozzolan and GBFS-incorporated blended cements', Cement and Concrete Research, Vol. 29 (5), 1999, pp. 743-746.
9. Quality improvers in cement making-State of the art, COIN Project P1 Advanced cementing materials, COIN Project report 2 – 2008.
10. D Satish Kumar, R Sah, Ganapathi Prasad, S M R Prasad, D Yadav, S Gupta and S K Chaturvedi, 'Use of granulated steel slag in manufacture of cement', JSW Steel Ltd, and NCCB, India, (http://www.ncbindia.com/pdf_seminar/050-FP.pdf)
11. M. Bukowska, B. Pacewska and I. Wilinska, 'Influence of spent catalyst used for catalytic cracking in a fluidized bed on sulphate corrosion of cement mortars', Cement and Concrete Research, Vol. 34, 2004, pp. 759-767.
12. J. Paya, J. Monzo, and M. Borrachero, 'Physical, chemical and mechanical properties of fluid catalytic cracking catalyst residue (FC3R) blended cements', Cement and Concrete Research, Vol. 31, 2001, pp. 57-61.
13. H. L. Chen, Y. S. Tseng and K. C. Hsu, 'Spent FCC Catalyst as a Pozzolanic Material for High Performance Mortars'. Cement and Concrete Composites, Vol. 26, pp. 657-664.

Dr. M.C. Nataraja is a Professor in the Department of Civil Engineering and HOD, Department of Construction Technology and Management, Sri Jayachamarajendra College of Engineering, Mysore. He is the recipient of many awards including the prestigious ICI-Outstanding concrete technologist award for the year 2012-13 and ICI best technical paper award for 2015. He has research experience of 25 years and published over 160 technical papers in national and international journals and conferences in his research field. His areas of interest are SFRC, concrete mix design, HPC, GPC and controlled low strength materials. He has travelled different countries in connection with academic and technical assignments.