

Addendum No. 1 to LWB PN 4

Use of PFA in Structural Concrete

Introduction

1. The Lands and Works Branch Practice Note on Concrete Technology No. 4, The Use of Pulverised Fuel Ash in Structural Concrete, was issued in 1983. It was stated therein that the Note would be reviewed when more information on the local use of PFA was available. There is more information available now, but there is nothing which requires the Note to be amended. There are, however, other factors which make the issue of this Addendum desirable.

Experience to date

2. PFA has been used in structural concrete in several Public Works projects in recent years, notably the Tsim Sha Tsui Cultural Centre, the Tuen Mun Hospital, the Pak Kong water treatment facility, the Kwai Chung bypass and in the EHC tunnel units. It is also being used at Daya Bay. Its use is mandatory in Highways Department concrete pavement construction and is actively encouraged in all WSD's water retaining structures, specifically to reduce cracking. There have been no problems with its use to date and the benefits to be derived have been recognised. Road slabs constructed with PFA concrete of only 35 mm slump have shown improved surface finishes and cores have shown continuing increase in compressive strength beyond 12 months. There have, however, been difficulties in persuading some suppliers to produce PFA concrete, either using PFA as a raw material complying with BS 3892: Part 1 or in the form of a blended cement complying with BS 6588.

Economic benefits

3. PFA is a by-product, with limited uses. Its major potential uses are as fill, as a raw material in cement manufacture and as a partial replacement for cement in concrete. The direct economic benefits deriving from the use of PFA as fill are small compared with its use as a cement replacement in concrete.

4. All the cement used in Hong Kong is imported, much of it as clinker which requires a considerable amount of energy to grind. China Cement Co. (HK) Ltd. is planning to fire up its kiln at Tap Shek Kok again to produce clinker from raw materials which, apart from a small quantity of PFA, are imported. This process requires even more energy and thus contributes to the production of more PFA. Replacing cement with PFA therefore reduces the need to import cement, clinker or raw materials, and reduces the amount of energy used in local processing and thus the production of PFA itself. During 1989, Hong Kong used about 4M tonnes of cement, and produced about 1M tonnes of PFA. If 25% of all the cement used in Hong Kong were replaced by PFA, there would be a saving in the cost of imported materials alone of \$300M p.a., and the problem of disposal of ash as a waste material would cease to exist.

5. There is a general shortage of cement in the region at present and it is forecast to worsen. The price of cement is climbing faster than that of most other construction materials.

Technical benefits

6. The benefits of PFA concrete are spelt out in PN No. 4. They include:

- improved long term performance in terms of strength
- improved durability through reduction in mixing water
- improved cohesion and workability for a given water content
- improved surface finish
- improved resistance to sulphate attack
- reduced heat of hydration
- reduced shrinkage and cracking
- reduced bleeding
- resistance to alkali-silica reaction

7. It must be said, however, that PFA concrete is more sensitive to water content and initial curing than conventional concrete, so that extra care must be taken in supervision of its production and curing, but the benefits available are worth the extra effort.

8. In its early days PFA concrete is generally a darker colour than plain OPC concrete, and this fact has been used as an excuse for not allowing its use. However this difference reduces with time and after a year or so of exposure it is difficult to tell the difference. It has also been said that there is more variation in the colour of concrete with PFA than without it. A look around at the camouflage appearance of many OPC structures soon dispels this worry. The colour of concrete is affected more by the formwork, mould oils and stripping times as well as the source of fine aggregate, than by variations in the carbon content of PFA.

9. The normal replacement level is 25%. This means that PFA can be counted as a maximum of 25% of any specified minimum cementitious content, but this does not limit the total PFA content to that quantity. Additional PFA can be used but should be regarded as an admixture or fine aggregate grading corrector. In certain cases, however, for example in mass concrete or in very large sections, it may be beneficial to replace more than 25% of the OPC. Up to 40% replacement has been used successfully elsewhere, but the rate of gain of strength will be significantly slower with such mixes. The advice of the Standing Committee on Concrete Technology should be sought if replacement levels in excess of 25% are contemplated.

Conclusion

10. The benefits to the economy and the environment, the reduction of the effects of the shortage of cement and the improved properties it brings to concrete all indicate that more PFA should be used as a cement replacement material. Classified PFA complying with the General Specification, or PPFAC blended cement complying with BS 6588 should be regarded not only as acceptable in all types of concrete work, but as desirable. In some parts of the world the incorporation of PFA as a cement replacement in concrete (including structural concrete) is mandatory. It is not proposed to follow this path at this stage, but to realise the benefits described above, engineers and architects should encourage their contractors to use PFA wherever practicable. A reduction in the price of concrete when PFA is used may be obtained but should not necessarily be expected.

11. To take full advantage of the gain in strength of PFA concrete beyond 28 days, it is worth considering, when loading conditions permit, designing for later age strengths, e.g. at 56 or 90 days, provided a good correlation between that and the 28 day compliance strength can be established for the particular grade of concrete in question.

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