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ABSORPTION OF CEMENT BY ASBESTOS FIBRES

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ABSORPTION of cement or similar fine powders is an important property of asbestos fibres. High absorptive capacity for cements, or high cement-retentive capacity, is considered in the industry as one of the essential prerequisites for these fibres to be used in the manufacture of asbestos–cement products, as the strength of the products is found to depend on adequate retention of cement by the fibres. Absorption of cement by asbestos fibres is taken to be a purely physical process, independent of the nature of the material of the fibre and is linked with the fineness of the fibres[1]. Doubt regarding this view arises when one considers that the cement-retentive capacity of amphibole fibres, though generally less than that of chrysotiles, is not always so. It is found, for example, that cement-retentive capacity of amphiboles from Mysore is much less, while that from Seraikela (Bihar) amphiboles is much higher ($\sim 1\cdot 7$ times) than the cement-retentive capacity of chrysotile asbestos[2].

By treating Seraikela amphiboles with suitable surface-active agents, cement-retentive capacity of these fibres has been increased to about 2·5 times that of untreated Canadian chrysotile, yet asbestos–cement products, particularly sheets, from amphiboles do not have strength comparable with those from chrysotiles. There may be several reasons for low strength of asbestos-cement products from amphiboles. The point which emerges from the foregoing observation is that the absorption of cement as ordinarily understood does not appear to be a crucial factor in the strength development of asbestos–cement products. On the other hand, it is an established fact that an improvement in the cement-retentive capacity of chrysotile fibres through fibreization has a favourable effect on the strength of asbestos–cement products. These facts may indicate that the mechanism of cement retention by chrysotile fibres may not be a purely physical process and that the process of absorption may not be the same in the two types of fibres.

We contend that in addition to what is believed to be physically held, cement may be chemisorbed by the asbestos fibres and the strength of asbestos–cement products is influenced by the amount of cement chemisorbed. Some evidence to support this view are given in this article.

If the mechanism of retention of cement by asbestos fibres were one of chemisorption, then the process of adsorption would depend on the relative positions of Fermi-levels in the adsorbent and adsorbate and would be favoured as the two levels became closer. Position of Fermi-levels in asbestos and in cement clinker minerals are not known and one can only speculate about it. Thus, the dielectric properties of chrysotile and amphibole asbestos indicate that the Fermi-level in crystals of amphibole-type asbestos is probably lower than that in chrysotile crystals. The rates of hydraulic action of cement clinkers indicate that tricalcium aluminate should have higher Fermi-level than tricalcium silicate and the Fermi-level should be lowest in dicalcium silicate[3].

The cement used in the manufacture of asbestos–cement products is normal Portland cement and it contains more of tricalcium silicate than tricalcium aluminate. While using amphibole asbestos with such cement it is necessary, so that adsorption may occur in similar conditions, to have the relative positions of Fermi-levels in amphiboles and clinker crystals the same as with chrysotile and later. This may mean that adjustment of Fermi-level either of the clinker minerals or of asbestos will have to be done.

Measurement of absorption of Portland and high alumina cements by chrysotile and tremolite (Mysore amphiboles) fibres show that both types of fibres retain normal Portland cement more than high alumina cement and that the chrysotile fibres retain more of either type of cements than amphiboles. Other factors being more or less similar, it would indicate, granting that the process of cement retention is a chemisorption process, that the position of Fermi-level in chrysotile is close to that in tricalcium silicate. Further, as amphiboles absorb Portland cement less than chrysotiles and tricalcium aluminate may be taken to have higher Fermi-level than tricalcium silicate, the Fermi-level in amphibole fibres may be lower—perhaps very much lower (as can be judged from quantities of cement retained)—than its position in chrysotiles. This may be the reason for the wide divergence of the cement-retentive capacities of the two types of fibres and for their chemical reactivities (amphiboles are chemically more unreactive than chrysotiles). It would appear from these considerations that there may be two ways of improving the cement-retentive capacity of amphiboles: (1) to use a cement which is rich in minerals with low Fermi-level, that is, to use a cement rich in dicalcium silicate; (2) to raise the Fermi-level of amphibole fibres.

Table 1. ABSORPTION OF CEMENTS BY CHRYSOTILE, TREMOLITE AND TREATED TREMOLITE FIBRES (G/G FIBRE)

Fibre	Chrysotile	Tremolite	Tremolite Treat. 1	Tremolite Treat. 2	Tremolite Treat. 3	Tremolite Treat. 4
Normal Portland cement	3·75	0·50	1·90	2·67	2·50	1·77
High alumina cement	1·46	0·31	0·47	0·35	0·87	0·18

One way to raise the Fermi-level of a crystal is to introduce 'donor' type impurities into it. Tremolite asbestos from Mysore was heated with '*n*' type semi-conducting oxides at appropriate temperature, on the lines used for puzzolanas[4], in order to introduce such impurities in the fibres. Cement-retentive capacities of (*a*) chrysotile, (*b*) tremolite and (*c*) tremolite-treated were measured, using normal Portland cement and high alumina cement as follows: A weighed quantity of asbestos was mixed with six times its weight of cement and sufficient water was added to make it into a water-like thin slurry which was immediately stirred for 10 min with a mechanical stirrer. After stirring, the slurry was filtered through a fine cloth and the mix retained was washed in water which was repeatedly changed until the water was almost clear. The mix left was dried at 110° C for 24 h and weighed. The increase in weight was taken as the amount of cement absorbed. The results are given in Table 1. No attempt was made to fibreize the fibres. Surface area of the fibres was also not measured.

The method used is not accurate enough to allow these results to be considered as anything more than indicative of the trend. Absorption of Portland cement by chrysotile fibres is fairly large compared with that by tremolites; treatments improve the absorptive capacity of tremolites for Portland cement to a large extent. Absorption of high alumina cement is less in both chrysotile and tremolite and that most of the treatments improve the absorptive capacity of tremolites for high alumina cement also, but comparatively to a lesser degree. The improvement in absorptive capacity of fibres, so treated, is an indication that the mechanism of absorption of cement by asbestos may be a chemisorption process.

Decreasing the linear size of a crystal is also a means of altering the Fermi-level in a crystal provided it can be lowered below the 'screening length' ($\sim 10^{-4}$ cm). Chrysotile fibres may be fibreized fairly well and the diameter of a single thread may be as low as $0{\cdot}74 \times 10^{-4}$ cm). On the other hand, amphibole fibres cannot be fibreized to anything like this. The improvement observed in the strength of asbestos–cement products from chrysotiles, on fibreization, may be due to enhanced chemisorption of cement by the fibres through a change in the position of the Fermi-level of the fibres as their diameter is reduced—as distinct from any simultaneous improvement of physical adsorption of cement. The observed increase in the cement-retentive capacity of amphiboles on fibreization may be attributed to the increased physical adsorption because of enhanced surface area. The improvement in intake of cement by these fibres may be made as high as 2·5 times that of chrysotiles. Yet the strength of the asbestos–cement products from amphiboles is found very much lower than that in products from chrysotiles. This may mean that though the cement retention by amphiboles has been improved, due to larger physical adsorption, simultaneous improvement in the amount chemisorbed has not taken place as the fibreization has not been carried to the extent as to produce the change in the position of Fermi-level necessary to enhance chemisorption of cement and that the physically held cement does not materially contribute to the strength.

High alumina cement is absorbed less than Portland cement by asbestos fibres; this means that the cements containing minerals which have higher Fermi-level are absorbed less. This indicates that the bond involved in the chemisorption of cement by asbestos is a 'donor' type bond ('hole' capture by fibre). If this were true, the Fermi-level of the clinker minerals involved in adsorption would be raised by the very act of adsorption. A rise in the Fermi-level of a clinker mineral should enhance its rate of reaction with water[3]. Hence, cement should set more rapidly when in contact with asbestos fibres, particularly with chrysotile fibres in which adsorption is large. As tricalcium aluminate and tricalcium silicate have high Fermi-levels, the effect will be more pronounced in cements rich in these minerals. It has been observed that the presence of chrysotile fibres accelerates setting of cement and the acceleration is more in cements richer in tricalcium silicate or tricalcium aluminate or both[5].

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