# THE USE OF CEMENT FIBRE COMPOSITES IN PROLONGED WET ENVIRONMENTS

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**Abstract**
Over the last twenty five years or so, studies have been conducted on a number of issues relating to cement bonded aggregate and fibre additives. Experiments with various additives to mortars made possible the incorporation of cellulose into mortars and concrete mixes and milled straw and aggregate building blocks were manufactured. The StrawCrete blocks were positioned in a shaded section of the site where the material once soaked took time to dry so that the materials remained wet for prolonged periods. The study continued for over ten years during which it become obvious that the superficial cellulose particles become degraded and supported fungal growths.

Experiments with other cement bonded fibre composites demonstrated a similar fall out of fibers into the environment due to the degrading cement matrix so that fibre contamination occurs across the product range in wet environments. Where the fibers such as asbestos, known to have health concerns are involved, important legal obligations arise that reflect on the manufacturers responsibilities.

Follow up experiments were conducted to reduce the rate of matrix degradation and a series of tests using mortars with increasing porosity and an integral water repellent additive which prevented prolonged wetting was assessed. The addition of the experimental additive did not interfere with the cementing properties of the portland cement used and the crushing strength of the resulting mortar reflected the properties of conventional mortar control. None critical structures were built to test the experimental mortar over a 25 year period.

The paper discuses possible ways of extending the useful life span of cement composite materials to at least double the life time of manufactured cement fibre materials.

**Fibre composites in prolonged wet environments.**
Initial efforts at manufacturing StrawCrete building blocks approximately fifteen years ago used Crete Grades [2] of wheat straw particles in a 30% by volume ration.  Other cellulose concrete mixtures have been in existence for many decades and in the UK, standard sized building blocks manufactured for the medium density concrete block market, used selected imported wood that had been allowed to stand for several months before use. Cellulose additives to concrete impart a warm, delicate, pleasant color to the finished product as well as reducing the weight of the block. Such additives therefore are used for fine faced exposed block construction that, provides a visually pleasing surface which does not need additional surface treatment. These blocks were used for internal applications only and we now have a manufacturer [4] who can make any number of blocks to order. The 440x215x100mm blocks comply with UK Building Regulations.



Manufactured StrawCrete building blocks.
Pat. 2340125.

Fig 1

In an attempt to provide a cement bonded cellulose composite that could use up the vast amounts of surplice agricultural waste generated by the UK farming industry, experiments were undertaken using wheat straw. Provided that the straw was milled to particles of 5mm to dust in size (Crete Grades), complete homogeneity was achieved between the binder, cellulose and aggregates. Large quantities of straw could be mixed with cement and concrete slurries to provide building blocks that had excellent uses for dry internal applications. The load bearing properties of these blocks met the required $3.5N/mm^2$ standards and had good dimensional stability.

Continuing the experiments, sheet material were manufactured that contained up to 80% volume of straw and 20% by volume of high alumina cement. Materials manufactured with such high quantities of cellulose additive were found not to support fires, so that they could be used as fillers that have good insulation properties   manifesting thermal conductivity of about $0.11w/m/^0K$.



Cement wheat straw composite board

Fig2

The fire tolerance of these high cellulose and high alumina composites, stimulated interests so that other fire tolerating composites were examined and in the end a composite of high alumina cements as the binder and fibo (a baked clay manufactured material) was used to manufacture a batch (see Fig 3) of building blocks. Other heat tolerating aggregates can be useful e.g. crushed brick, crushed volcanic ash, basalt, clay, fuel ash and other suitable heat tolerating aggregate, to produce fire retardant building blocks that endure heat stress for prolonged periods. Tests in kilns over a 24 hour period at temperatures in excess of $1000^0C$, showed that the given composites provide suitable fire tolerating building materials that do not collapse in prolonged high intensity fires. The same compositions using prepared grades of fines, provide suitable mortars, renders, plaster board etc to provide an entire system  that   tolerates fires for prolonged periods and respond to heat stress in a similar way to the prepared blocks. The advantage being that the mortar and block are made from the same material and in any given heat stress situation expand and contract at the same rate.



High alumina cement/fibo 440x215x100mm
$3.5N/mm^2$ building block at $1000^0C$ for 24hours.
Pat. No 2377931

Fig 3

Follow up studies exposing StawCrete to the elements continued for the straw based composites and in particular the effect prolonged wetting had on the building blocks. Concrete blocks, 440x215x100mm in size, were manufactured with 30% by volume of wheat straw and 70% sand/cement mixture using accelerated high alumina cement.  Samples were then positioned in a shaded site and left exposed. The intention was to examine the effect the wet environment had on the organic and inorganic mixture in this slow drying situation.



Wood Cement composite building block also grew fungal growth. Fungal growths (Peziza Genus)

Fig 4



StrawCrete composite building block Fungal growths (Peziza Genus)

Fig 5

It was of no surprise to see flora growth on these blocks. The blocks become wet and over the winter months generally remained wet for months on end, with short drying out periods, before the material was again saturated.  Several plant forms were observed and of particular interest was the growth of a fungus. This was totally unexpected because although the exposed surface cellulose particulates (being specified at 5mm-0mm) would no doubt attract wood feeding entities, it was expected that these would be of a diminutive size. The appearance of a complex large fungus[8] on the shaded sites of the block, induced an anxiety that certain life forms might have enzyme systems that could actually damage the concrete mixture These fungal growths remained well contained and short lived and appeared in all cellulose cement bonded composites. The same fungus was seen growing on the wood block but the surprised was the size of the fungus. On closer examination it appeared that the cement, wood, aggregate block used as a control, contained large particles of wood that were 30mm long and up to 5mm thick. The fungus died having consumed the nutrients on which it was growing.

It appeared clear, that the growth of fungus in cement bonded cellulose composites was dependant on the availability of exposed cellulose, in damp conditions. In all cases, all fungal growth died, as the blocks dried out. Control blocks kept in the dry environment, did not develop or sustain any kind of visible organic life forms during the same time span, nor, did they lose the golden color of wheat straw.

Surface straw particles fall out
of the StrawCrete material after
prolonged exposure to British weather.

Fig 6

The availability of water was concluded to be a prime factor in sustaining life forms on cement bonded cellulose composites.

The end result of StrawCrete Blocks being kept in the wet environment for prolonged periods was the loss of all of the surface cellulose particles exposed to the weathering process and a 440 x 215 x 100mm block kept in the wet were seen to show an irregular surface reflecting the shape and form of the surface cellulose particles used in the original mix, see Fig 6.

The weathering process is seen right across the cement bonded composite materials industry. As an example, the asbestos fiber cement bonded manufacturing sector has major problems relating to this abrasive process. Work done on wet roofing tiles demonstrates that weathering removes layers of the composites and this occurs extensively. The wet surface containing the fiber is abraded away to release fibers contained therein. Fig 7 shows a ten year old roofing tile on the right of the picture, next to a new tile manufactured by the same manufacturer, demonstrating the extent of the abrasive process which releases fine asbestos fibers into the environment [5,7,9]. Fig 8 demonstrates an old corrugated roofing asbestos cement sheet and clearly shows the asbestos fibers sticking out of the cement matrix. As the weathering process continues, the asbestos fibers loosen from the cementing matrix, to move about in the wind and snap off, to be released into the environment The process of fiber release continues for the life of the asbestos cement product and accelerates with age, so that the older the product the greater the release of asbestos.
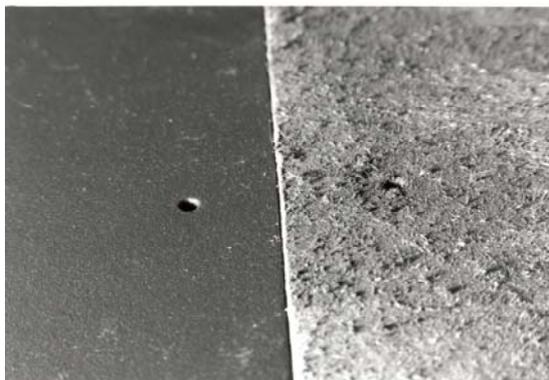


Photograph of a new acrylic coated asbestos cement roofing tile on the left  and a ten year old similar tile demonstrating fall out of asbestos from the cementing matrix on the right.

Fig 7

The above mechanism extends to other asbestos fibre products and is clearly seen in cladding sheets, guttering, cowling and the many other cement bonded materials manufactured.



Asbestos cement corrugated sheeting demonstrating fall out of asbestos fiber.

Fig 8



Asbestos cement cladding demonstrating asbestos fibre fallout in old materials

Fig 9

In all cases, fibers are released from cement fibre composites the dropout of fibre being related to the wetting and mechanical abrasive process imposed on the composites. In dry conditions, cement fibre composites retain their composition and fibers such as straw kept in dry conditions are documented to retain their structure for thousands of years. It is the wetting of such materials that causes the problems.

**Containing fibre release .**
Given that wetting of materials is the cause of degradation we refer to earlier experiments with water repellant additives to mortars and the like. In the late 70s and early 80s we were involved in a project to find a way to provide a continuity of adherence across the Damp Proof Membranes (DPC), particularly in tall garden walls and stand alone structures. In the UK there are regular accidents with children in particular, climbing tall stand alone walls, resulting in the structures peeling apart at the physical DPC, to collapse and cause injury. Our brief was to find a way to continue bonding across the DPC layer to prevent this type of collapse and a series of experiments were undertaken to establish a suitable integral mortar based dpc that was the starting point for the work done with the enclosed mortars, see Graphs 1-5.

After much searching one of the few water soluble chemical DPC preparations, the potassium methysiliconate [3], that Imperial Chemical Industries were manufacturing at the time, was selected and on mixing the preparation with the mortar, found that the prepared mortar behaved like conventional mortar. All initial results were promising and when the crushing strength data

came back and showed no difference between the aqueous siliconate and conventional mortar mixes, the concept was subjected to further testing.
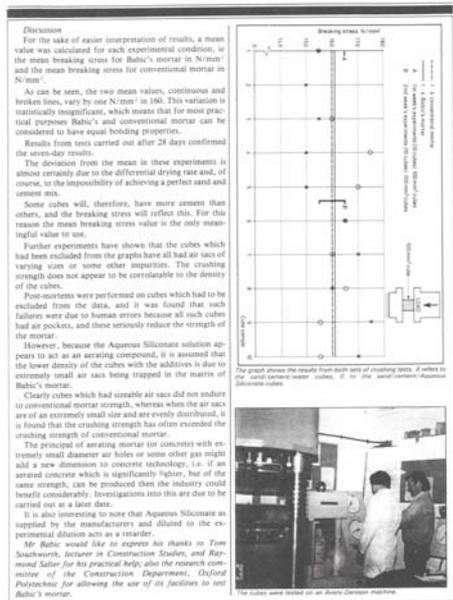


Aqueous Siliconate mortar cubes being crush tested 1982.

Fig 10

**Testing of an integral water repellant additive.**

The testing consisted of immersing brick constructions in water trays for 120 days over which time water transmission via various parameters was measured. The assembly is specified in Graph 1 and consists of test assemblies with two Hammill Multi Red facing bricks, known for their manufactured consistency and picked for the experiments because they are known to transmit rising damp rapidly. The made brick assemblies were left for 48 hours and then placed in trays which contained about 25mm of water and were left in the trays for 120 days, during which time the assemblies were periodically withdrawn, drained for about 5 minutes so that no free water dripped from the construction and weighed. The variation in water absorption was calculated and plotted.

Graph 1 represents the water uptake of the reference assemblies:

(a) when two dry bricks are separated by an absorbent paper tissue placed between the bricks, water is absorbed into the bottom brick across the paper tissue, to saturate the top brick. After about 20 days the water loss by evaporation from the assembly is equal to the water absorption from the tray and there was no change in the weigh of the assembly thereafter.

(b) when two dry bricks are separated by a physical damp proof course (DPC) such as a piece of polythene, the immersed assembly quickly gains weight as the bottom brick becomes saturated but because no water can pass through the DPC thereafter, there is no further change in the weight of the assembly and the graph is again a straight line.

(c) when two bricks separated by a paper tissue were pre-saturated and then places in the test trays, no substantial change was observed over the test period. The unexpected apparent drying out (N.B.), was discovered to be an unplanned draught which was isolated and blocked off from the test tray wherein the measurements settled down to the expected, i.e. no change in the weight of the assembly, demonstrating again that

the water evaporating in the brick assembly was equal to the water absorption and the bricks remind saturated.

(d)   when two saturated bricks were separated by a physical DPC the graph shows the top brick drying out demonstrating a loss in weight which settled to a steady state over the experimental period.

Graph 2 represents the water uptake of the 1: 3 portland cement and sand mortar:

(a)   The Babic's mortar dry assembly demonstrated a similar uptake but at a slightly higher level. The flat part of the graph demonstrates that the there was no transfer of water across the chemical DPC and the steady state graph was lower than the polythene DPC, again due probably to the lower absorbancy of the bottom brick.

(b)   when the dry assembly with the conventional mortar layer between the two bricks was placed in the tray, there was an uptake of water which is reduced gradually so that by about the 28th day virtually no water was being transmitted through the mortar layer to the upper brick.

(c)   saturating the conventional mortar assembly initially retained water but the top brick dried out after about 28 days providing similar results to conventional DPC.

(d)   saturating the assembly with the Babic's mortar and placing into the water tray, was seen to be effective rapidly, achieving the drying out of the top brick more quickly than conventional mortar, indicating a lower transfer of water across the treated mortar layer. This assembly gave results very similar to the conventional polythene DPC

Graph 3 represents test using 1: 6 portland cement and sand mortar:

(a)   the dry Babic's mortar assembly, produced an uptake of water to give substantially the same trace as a conventional DPC but was slightly wetter than conventional DPC.

(b)   the dry control, conventional mortar using a dry assembly of bricks, indicates an uptake of water which dried slightly during the first 28 days, to give a constant trace to the end of the experiment.

(c)   the control assembly in a saturated condition demonstrated a gradual drying out after about 25 days to provide a steady state towards the end of the experimental period.

(d)   the experimental chemical DPC in a saturated state demonstrated similar behavior to the conventional DPC but was about 4% wetter and attained a similar final state to the saturated control.

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Graph 1 — Reference Assemblies

% Change in Weight

Time in Days

- 2 Dry Bricks in Contact
- 2 Dry Bricks Physical DPC
- 2 Saturated Bricks in Contact
- 2 Saturated Bricks Physical DPC

N.B.



Graph 2 — 1 : 3 Cement : Sand

% Change in Weight

Time in Days

- Babic's Mortar Dry
- Control Dry
- Control Saturated
- Babic's Mortar Saturated

Conventional mortar / polythene DPC
Hammill multi red facing bricks
Babic's mortar DPC
Water tray



Graph 3 — 1 : 6 Cement : Sand

% Change in Weight

Time in Days

- Babic's Mortar Dry
- Control Dry
- Control Saturated
- Babic's Mortar Saturated



Graph 4 — 1 : 9 Cement : Sand

% Change in Weight

Time in Days

- Control Dry
- Babic's Mortar Dry
- Control Saturated
- Babic's Mortar Saturated

Graph 4 represents test using 1: 9 portland cement and sand mortar mix:

In this, an experimental mortar mix, we wanted to test the concept in an extreme situation. Certainly such mortars have no value in standard construction practice and the use of such mortar for structural purposes is inconceivable but it nevertheless remained a useful indicator of the effectiveness of the siliconate molecule in this extremely porous and absorbent mortar:

(a)    initially the dry control demonstrated a large pick up of water which resulted in the top brick drying out by about the 20th day and thereafter leveled out at about 30 days, meaning that the top brick attained an equilibrium of water absorption and evaporation. The assembly was drawing water from the tray to remain wet for the duration of the experiment.

(b)    the saturated control showed a slight additional pickup of water transmitted from the tray to remain wet for the duration of the experiment again showing that the conventional 1:9 mortar mix transmitted water across the mortar layer.

(c)    adding the aqueous siliconate to the 1: 9 cement sand mortar mix  in the dry assembly resulted in the rapid uptake of water in the lower brick to allow only a small transfer across the chemical DPC into the top brick, which then dried out to achieve a steady state that resulted in the assembly being bout 1% wetter than the conventional DPC assembly.

(d)    The Babic's mortar saturated assembly allowed the top brick in the water tray to dry out during the first 20 days to give a stable graph indicating that the mortar layer was acting as a DPC even though the trace did not fall to a value of 0 and was therefore not as effective as the polythene DPC.

## Conclusions from water bath tests.

Most usefully these experiments indicate that the 1:9 mortar mix with the chemical additive prevent the upward passage of water across the modified mortar layer. The conventional 1:9 mortar mix does not prevent the upward passage of water across the mortar layer and therefore the brick assembly remained wet.

In applications using the chemical additive where saturated assemblies were placed in the water trays, it was found that the assemblies dried out at about the same rate as the assemblies with physical DPC, to prevent the upward passage of water across the modified mortar layer, during the experimental time scale.

In applications using dry brick assemblies that were then placed into the water trays it was found that the conventional and the experimental mortars prevented the passage of water across the mortar layer during the experimental time scale.

Clearly conventional mortars fail during prolonged use so that long term tests were required to asses the long term effectiveness of conventional mortar mixtures as compared with identical mortar mixes to which was added the aqueous siliconate chemical DPC. Test examining the effectiveness of aqueous siliconate in old failing mortars will yield useful data.

Our findings were submitted to the UK Agrement Board for independent testing and a report [1] presents their findings in some detail.

## Long Term Follow Up

With that in mind we built walls using the Babic's mortar as a DPC and are delighted to be in a position to present a follow up that has lasted almost twenty five years.
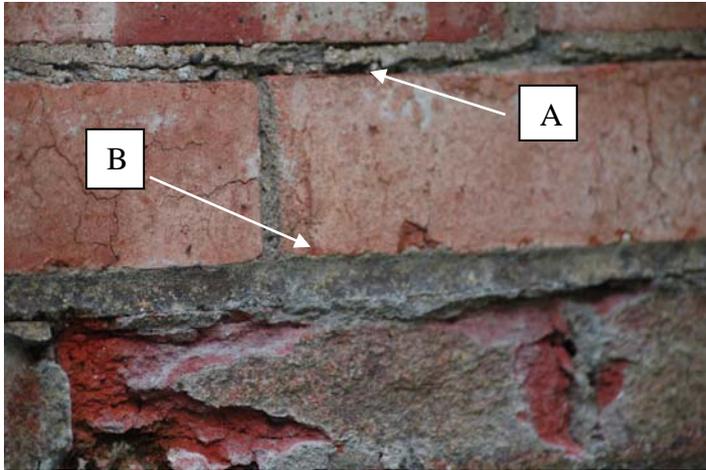


Example of conventional mortar "A" and chemical DPC mortar layer "B" after almost 25 years of exposure to British weather.
N.B. Spalling brick "C" August 2006.

Fig 11

Item "B" represents the water soluble aqueous siliconate additive (the Rhone-Poulenc subsequently took over the manufacture of  Rhdosil Siliconate R 333 the aqueous solution of potassium methysiliconate [3], 5% w/w preparation) to the mortar layer. The mix consisted of a 1:3 portland cement builders sand mixture which was separated into the conventional and experimental mortar piles, the same procedure that was used to prepare the cubes for the crushing tests, see Fig 10. To the conventional mortar "A"  was added water and the mortar was mixed until the experienced bricklayer decided that the consistency was suitable for the given job. To the second portion of the above mixture, was added the R333 solution and mixed until the same workable consistency was achieved. The wall was built using the R333 mixture at the DPC level only and above that, was used the conventional mortar.

 To this day the surface of the experimental mortar layer remains in an exceptionally good condition and in fact does not show any deterioration in the cementing matrix. Remarkably, the layer still shows the original brick layers finishing tooling marks as he closed off the surface. The regions of the layer that are bonded to the spalled brick "C" indicate that where there was spalling the bond between the mortar and the brick was so strong that the chemically modified mortar fractured, allowing the spalled section to fall away. That indicates that the treated mortar retains its structural strength and in fact retains sharp edges and continues to adhere to the brick either side of the mortar and spalled brick sections. At "A" the conventional mortar layer is seen to have responded to the weathering process and exhibits the typical long term deterioration seen in such materials.

The above astonishing finding indicates that cement bonded composites retain their structure without degradation for the nearly 25 year duration of this experimental follow up. There is every indication that no substantial change will occur in the immediate future so that if the water repellant characteristics of this mixture continue, then there will be no change in the nature of the treated mortar until the chemical structure of the formed aqueous siliconate molecular lattice established during the curing process, starts to break down and the efficacy of the water repellence starts to abate. Normal degradation over the following 25 years or so is expected to occur and follow a similar degradation pattern to the conventional mortar layer as demonstrated at Item "A". That water is penetrating the wall below the DPC mortar layer is demonstrated by the fact that the bricks below the DPC are spalling, Item "C", so that the weathering process is clearly having a severe effect on the wet structure below but not above the DPC mortar layer.

The indication is that cement bonded composites can in practice have their life time performance doubled by addition of admixtures during the production stage. The implications of these finding are enormous, right across the cement bonded fibre composite technology and a patent application has been registered. It seems that adding such admixtures to the mix during the production process, provides a means of substantially improving material performance over time and in all weathering conditions and will in any case gives substantial advantages over current coating technology in retaining added fibers.

In retrospect, it becomes obvious as to what industry needs to do to contain fibre loss in cement fibe composites and with this in mind an old cement fibre roofing tile was examined and gave a rough sweep with a wire brush. Not surprisingly, the exposed surface resulted in deep gauge marks, asbestos flying out in a dusty plume whilst the



A single old asbestos cement roofing tile. On the left the area of tile exposed to the elements and on the right the area of tile covered by the overlapping tiles.

Fig 12

covered area of the same tile, barley showed scratches. This action demonstrated that the area of roofing tile that was covered by the overlapping tiles above it prevented wetting, so that the normal weathering mechanisms could not take effect. This excellent example of experimental controls, wherein the single tile, made by the same methodology, of the same batch composition and at the same time, acted as the best form of control to the wet and dry condition that the material was subjected to. This tile clearly demonstrated the effect of wetting one half of the product and exposing it to the weathering process, whilst keeping the other half of the tile dry. Embarrassingly obvious but the evidence was clear for all time and indeed demonstrates the outcome of reducing wetting, on cement fibre composites.


**Water repellent additives**
There are very many additives that the construction industry uses but for the sake of simplicity the available preparations are summarised into basic groups. Water repellents act by a variety of means but all are directed at reducing the water ingress into the substance of the material. When mixed with cement fibre composites, mortars, concretes and the like, the admix is spread throughout the matrix of the material to achieve its effect at each site the additive is precipitated. Once cured the water repellent additives are effective for the duration of the given additive's lifespan.

The many currently available additives supplied by the UK admix manufacturers provided for integral cement composites, can be classified into basic groups:

1. Chemical formulations that form electrostatic mesh constructs, which repel water to reduce the diffusion coefficients.
2. Compositions that block the pores within the formed material to configure physical barriers.

Available integral water proofing formulations:

1. Silicone resins
2. Fluoropolymers
3. Lignosulphates and sterates
4. Soaps and fatty acid composites
5. Acrylic preparations
6. Colloid silicates
7. Styrene Butadiene Rubbers
8. Oil based emulsions
9. Inorganic additives
10. Other

More specifically, examples of additives used:

1. Silicon resin formulations, modifications and innovations such as aqueous siliconates, silanes, siloxanes emulsions as supplied by eg. WAKER Gmbh
2. Fluoropolymers as provided by the DuPONT Group.
3. Lignosulphates and sterates as provided by DEGUSSA Gmbh.
4. Soaps and fatty acid composites such as Brunolene SP, as supplied by the WYKAMOL Group.
5. Acrylic polymers such as mixtures of vinyl chloride, ethylene, vinyl esters, and
   proactive colloids and copolymers, supplied by WYKAMOL Group.
1. Colloids of for example the SEKA 1 range, provided by BSF Construction Chemicals, UK.
7. The many SBR formulations as provided by for example, FOSROC UK.
8. Linseed oil composites.
9. Inorganic solid additives that increase the density by blocking up the pores of the material to reduce porosity and permeability.
10. Many other formulations mixtures and preparations are sold by the damp proof industry. Research continues and bitumen based water soluble emulsions are being experimented with.

As always with admixtures, the user must assess the available additives to confirm that the proposed application is suitable for the purpose for which it is intended. The additive must be examined for compatibility of all constituents within the proposed composite.

We greatly look forward to long term results with water repellent additives admixed with high alumina cement. Samples of high alumina cement and more specifically Lafarge Cement Fondu, demonstrate that provided the finished product is not exposed to water, that the product retains its properties and that there is no degradation of the cement matrix during the experimental time scale. It seems to us that adding selected integral water repellents during production, will reduce water ingress to extend the life of such composites. The crystal structure of high alumina cement remains stable provided water is prevented from contaminating the finished product. The range of uses for such cements could be extended provided water ingress is prevented.

**Discussion**
The addition of straw fibre to building blocks requires the use of accelerated high alumina cement to overcome the retardation problem hydroxyl groups exercise in a slurries. It is the hydroxyl groups attached to the molecular skeletons of the many compounds found in plant life

that cause retardation of setting of cements. The powerful effect the dipolar group exercises in its immediate environment has an effect on the water molecules attached to the cement hydrate, preventing the cement crystal forming. To overcome this problem our research demonstrated that providing an alternative focus allows rapid precipitation of the high alumina cement crystal, allowing the cement to set and provide a suitable cellulose cement manufactured building material.

Unfortunately, all subsequent work demonstrates that because of the problem of miscibility of straw particles with aggregates, in the original trials more water had to be added than was recommended by the manufacturers of high alumina cements. Once the crystal formation starts to set, there is rapid setting of cement to provide a fast turn around from mixing to stacking the blocks. This rapid crystal formation results in poor quality crystals which when combined with extended wetting of materials and after about ten years of being moved about in the yard, resulted in an unsatisfactory block. The surface layers seem to lose their strength and could easily be dislodged by mechanical pressure.

The broken up pieces of high alumina, straw cellulose building blocks, that were kept in the wet and used as a "football" about the yard, did not wear well. There appears to be a complexity that we have not been able to isolate because the research facilities needed for identification of the exact problem, requires well established facilities and know-how. A suitably equipped university department, ought to research excess water has on the properties of high alumina straw fibre composites. The fast crystal formation also needs to be controlled in such applications and requires recommendations. In particular, a detailed study into the size and formation of accelerated high alumina crystal in excess water is awaited.

The crystal structure of high alumina cement undergoes conversion to form the thermodynamically stable final form. In the process of converting from the metastable crystal forms of $CAH_{10}$ and $C_2AH_8$ to the cubic $C_3AH_6$ crystal form, there is a reduction in the volume of the crystal so that additional spaces are created within the substance of the composite [6]. These spaces increase the porosity of the material so that more water can penetrate the material. The water freezes during low temperature cycles to damage the material so that these materials fail in prolonged wet conditions. There is no information on what happens in wet situations during reversion from the metastable crystalline phase into the ionic state in solution and how excess water effects the chemistry of CAC. The molecules forming the metastable crystals must revert into the ionic state before they can recombine to form the thermodynamically stable final crystal form. Provided water is prevented from contaminating the finished product the range of uses for calcium aluminate cements could be extended.

## Conclusion

All cement fibre composites release fibre into the environment because the weathering process breaks down the cement matrix to release material contents into the environment and contaminate the surrounding area so that methods of reducing the fibre fallout due to weathering become useful.

Long term studies suggest that reducing the weathering process by adding water repellent preparations to fibre cement mixtures, extends the lifespan of cement bonded composites, to at least double the expected lifespan of conventional methodology. This patent application has very substantial commercial and environmental implications.

We are not confident about the use of accelerated high alumina cements in combination with straw that is required to be kept in prolonged wet conditions. Similar materials kept in the have to date, not shown any adverse effects.

**References**
1	Agrement Board Test Report No 500, 1982, Report of Tests Carried out on Babic's Mortar.
2	Babic B R, Cement cellulose composites, 1996, Vol 5: 49-63.
3	Lankaster P J, 2004, Silicone technology for the construction industry, Inorganic Bonded Wood and Fibre Composite Materials. Vol 8, 302-313.
4	Lignacite Ltd, Norfolk House, High Street, Brandon, Suffolk IP27 0AX UK.
5	Health and Safety Executive UK, Control of Asbestos Regulations 2006. Recommendations Following Consultations, HSE/06/56. Health and Safety Guidance Notes MS13 2005.
6	Scrivener K L, Capmas A, 1997, Calcium Aluminate Cements, Lee's Chemistry of Cement and Concrete, 4th Edition, Hewlett PC, ed, 709-778.
7	Shuker L, Harrison P, Poole . 1997, Health effects of asbestos and man made mineral fibers, Institute of Environment and Health, Leicester University UK.
8	Spooner B, Roberts P 2005. Fungi. The New Naturalist Library. Collins, London UK.
9	Spurny K, Marfels H, Boose C, Weiss G, Opiela H, Wulbeck FJ. 1989 Fiber emissions from weathered asbestos cement products. 1. Fiber release in ambient air. Zentralbl Hyg Umweltmed. May;1988(1-2):127-43. German.