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ADVICE TO YOUNG RESEARCHERS IN CEMENT AND CONCRETE SCIENCE FROM A SEASONED PRACTITIONER
Introductory Talk to the Cement and Concrete Section of the Young Researchers Forum, Construction Materials Group, Society of Chemical Industry, London, 27th April 2000

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ABSTRACT

Despite cutbacks in research and development in most major companies in recent years, research in cement and concrete is not facing industrial extinction in the U.K. Serious problems with cement and concrete have a nasty habit of revealing themselves periodically and will not go away of their own accord. Times have changed and the effects of extensive downsizing, outsourcing and delayering within industry as well as the implications of the increased globalisation of trade are having to be faced. There are now new opportunities for academia in partnership with industrial concerns to look into the underlying science of products and processes and also to develop new marketable products. Small and medium sized enterprises (SMEs) can be especially assisted by such partnerships. Statutory requirements for certain materials and/or their applications mean that extensive laboratory testing must continue, and this requires regular updating. Cement and concrete science is alive and kicking. There are opportunities for young researchers, who need to be flexible and work increasingly in small teams for defined ends. Rigid distinctions between research, development, technical service and technical troubleshooting are becoming increasingly blurred, so that technical innovations and problems with cement and concrete in the 21st century can be suitably addressed.

INTRODUCTION

The construction industry like the rest of manufacturing industry and also academia underwent what might be termed *'cultural revolutions'* in the 1980s and 1990s. Large companies paid millions of pounds or dollars to receive advice from management schools that, in order to remain competitive in business, they needed to downsize, delayer and outsource wherever possible to improve their *'shareholder value'*. Such companies, supposedly *'leaner and fitter'* to meet the challenges of the future, were deemed to be *'healthier'* as a result of such upheavals and would survive well into the 21st century. Meanwhile in the universities older academics were being encouraged to retire, so that some younger academics could receive lecturing posts and overall costs could be reduced or at least controlled to minimal increases. That was the theory! Meanwhile statutory and other key requirements meant that a great deal of laboratory testing still had to be done.

In the cement and concrete arena much research and development work ceased. Key technical people were *'put out to grass'* and the *'leaner and fitter'* image began to change to one which could be more accurately described as increasingly becoming *'leaner and terminally ill'*. Many other industries went through similar downsizing operations.

More recently the California Business School has promulgated a new concept, that for organisations to succeed in the 21st century, they would need to *'upsize'*. Furthermore, with low investment in technology and in staff with the necessary technical know-how in many major corporations, coupled with international trade agreements leading to increased globalisation of trade, fears arose that, if industry as a whole stood still, it would eventually be overwhelmed by competition from Asia in particular. In those countries such a *'cultural revolution'* in industry has not taken place and there are people with the requisite technical skills available in growing numbers to servi fmassive expansion in industrial development, including that in cement and concrete.

The way to deal with these new situations basically means the application of common sense scenarios to develop what is now possible. History tells us that the past cannot be recreated because the world has moved on. Looking back in time in a nostalgic, romantic way hoping that the past will be recreated is impossible, unproductive and ultimately disastrous. Lessons can be learned from the past, but they must be pragmatic and useful in today's changed working environment. Research and development should play an important part in the future needs of the construction industry (1) and this is set out below.

THE CURRENT SITUATION

Fortunately a sense of pragmatism has started to prevail which is stabilising the situation. Although extensive outsourcing from major companies has taken place, one consequence of this has been the setting up and/or expansion of small and medium sized companies (SMEs). Universities are being encouraged by funding from bodies like EPSRC, the Engineering and Physical Sciences Research Council (in the U.K.) and the European Union to involve industry (including SMEs) in research projects that will benefit all

parties. Industry should benefit from access to equipment and to helpful suggestions from the academics. Academia should benefit from the intellectual challenge and the knowledge that something of national use has been achieved. Young researchers in particular can benefit by such exposure to industry whilst pursuing an intellectually rigorous pathway to success with a suitable research project.

One healthy outcome of this is that old barriers that prevented collaboration between industry and academia in the past are rapidly breaking down, which is to the benefit of young researchers in areas like cement and concrete science. Even in the 1970s it was still common for academics to regard industrial research as *'inferior'* and to look down on industrial scientists with disdain. Industrial engineers were regarded even more contemptuously as being *'beyond the pale'* in this prejudicial atmosphere! After all, much less industrial research was published then, and ignorance of the real situation fed these prejudices. From the industrial angle academics were frequently regarded as *'theoretical, aloof, unworldly eccentrics who should never be let loose inside an industrial plant'*! Since the academics were rarely, if ever, involved in industrial science, they could not generally be expected to know much about it. This led to many young researchers at the time being put off from pursuing an industrial career.

The image of cement and concrete science still tends to be very mundane as compared with other areas of scientific research. People often seem surprised if told that cement and concrete are complex materials and that investigating the science of them can be very intellectually challenging. The main textbook on the chemistry of cement and concrete now needs a multiplicity of authors to give the appropriate authoritative balance [(2)].

Unlike in the chemical industry, the cement industry has still not fully grasped the idea that added value products can significantly enhance the product portfolio and their own longer term stability. Profitability is still largely thought of in terms of how many millions of tonnes per annum of each type of cement can be produced. Bulk products tend to attract lower prices but are better for regular cash flow. Added value products involve smaller tonnages and higher prices, but are more susceptible to economic climates. There are some added value products manufactured within the U.K. cement industry like oilwell cements, calcium sulphoaluminate cements and ultrafine cements, but considerably less than in the past. As a result various new types of *'added value'* cements have been developed outside of the traditional cement industry and often within the chemical industry, such as Sorel (magnesium oxchloride) and magnesia ammonium phosphate cements which have their own specialist niche markets. Such cement development and production outside of the traditional cement industry can provide opportunities for young researchers to develop their careers further.

In the world of concrete the recent thaumasite sulphate attack problems that have been experienced in the Cheltenham and Gloucester areas, in particular in some concrete motorway bridges, caused widespread alarm and led to a Government report being commissioned [(3)]. Serious panics seem to occur about every decade in the U.K. In the

1970s there was high alumina cement in structural beams, in the 1980s calcium chloride corrosion of reinforcement and in the 1990s, as aforementioned, thaumasite sulphate attack. All these problem areas attracted much investigational work in universities and in industry. The problems and their solutions have highlighted the need for ongoing research and associated investigative work on concrete science.

Also, the encapsulation of toxic and radioactive waste in cement and concrete has by its very nature to be ongoing, because the underlying problems cannot simply go away. It is an area in which many young researchers are working and will continue to do so.

FUTURE PROSPECTS

SMEs are the biggest growth area in new business development at present and a number of these operate in the cement and concrete arena. Whilst EPSRC, the European Union and other organisations are quite rightly increasingly involving SMEs in research activity, this means that a niche should be available for qualified young researchers to join SMEs. Not only would they be involved with the particular business of the SME, but also could be involved in the cooperative research with academia and larger companies of the type that EPSRC and the European Union already sponsor. This would increase their breadth of experience and enable them not only to participate in research as such, but from the experience gained to add value to their position within the particular SME.

Research, development, technical service and technical troubleshooting used to be considered separately, but increasingly now and in the future their distinctions need to become more blurred, because of their strong interrelationship. Often the best industrial research work comes from the investigation of customer complaints. Research does not have to be always very expensive and grandiose. It needs to be focused upon improving product quality, often by taking the complaint scenarios into consideration, and the identification of niche market areas where new products of value to the construction industry would have advantageous uses. Very large projects need to be well managed, otherwise they can quickly degenerate into situations where the key actions seem to be producing agendas and minutes of meetings, endless discussion and little to show in real terms of technical improvements and breakthroughs.

Speciality cements are likely to make further impacts, but the bulk tonnage cements will continue to be utilised extensively. Higher strength and better workability concrete is certain to attract added interest in the future.

Environmental improvements will continue by employing more industrial waste products in the manufacture of cements, which is energy intensive, like chemical plant and refinery wastes as supplementary fuels for the firing of cement kilns and also as secondary raw materials in numerous instances. Extended cements containing fly ash, ground granulated blastfurnace slag, metakaolin, condensed silica fume (microsilica) and other pozzolanic wastes, together with the alternative procedure of additions of these

extenders to Portland cement at the mixer, will more commonly be used in concrete, because of their lower permeability and higher later strengths as compared with neat Portland cements under comparable conditions. Admixtures will more frequently be employed in concrete mixes to optimise performance. Since these admixtures affect the basic cement science, more needs to be known about cement-admixture interactions in concrete. By-product gypsums [(4)] will increasingly be utilised in Portland cement manufacture. Many of these influence the cement science in a different way from natural gypsums. There should be plenty of opportunities for young researchers here with manufacturers, suppliers and user companies to understand more fully what is happening with particular construction materials in order to avoid pitfalls and improve performance.

Further understanding is required of concrete durability and the various forms of concrete attack. After all, the recent occurrences of thaumasite sulphate attack created a state of alarm in the construction industry, because so many engineers were not familiar with this particular form of sulphate attack. Concrete durability is an area where young researchers can usefully contribute scientifically to the gathering of important knowledge to improve durability and repair of existing structures.

With the likely introduction of the new European standard for common cements EN 197-1 before long, some new types of cement may appear in use in the U.K. It is important that their properties, including durability in concrete structures, are well understood. A precursor of this standard, the European Prestandard ENV 197-1 has already been in circulation as a voluntary standard for several years [(5)]. EN 197-1 will basically be an update of this prestandard, but will replace all existing national standards within the CEN *(Comité Européen de Normalisation)* area.

ANALOGIES WITH OTHER CONSTRUCTION MATERIALS

Although this paper has concentrated on the ‘white top’ area of construction (cement and concrete), many of the underlying basic situations and opportunities for younger researchers are applicable to the ‘black top’ side of construction (asphalt and bitumen). To some extent they also apply to other building materials like bricks, lime and gypsum plaster and to paints, glass and timber products. With all these construction materials, most basic knowledge and experience is now vested in persons aged over 50.

Opportunities will surely arise for more younger researchers to experience these areas, where there is still a need for innovation, particularly with regard to environmental matters, otherwise much of the construction industry will decline or be taken over from outside the U.K. where the future innovation would then take place. It is not too late for innovation with what are perceived to be traditional construction materials to continue at an acceptable level, if common sense and long term thinking with industrial investment prevail.

Opportunities are beginning to appear for young researchers in the current scenario and more positive thought is being directed towards the need for more developments in the construction arena. However, at this moment in time more awareness and positive effort is needed, so as to re-establish a vibrant construction sector in U.K. industry. Opportunities exist. There just needs to be more careful planning, encouragement and uptake of innovative ideas for new materials and processes, particularly where assistance with environmental friendliness could and should prevail, in order to create a more positive future era for the use of construction materials.

CONCLUSION

It is clear from the situations surveyed in this paper that there are a wide range of opportunities for young researchers to prosper in the world of cement and concrete science. After all, cement and concrete are likely to be with us for many, many years to come. Better quality for existing cements and new innovative niche cement products will be needed in numerous applications and particular situations. SMEs will need to be more closely involved in developments. Universities, with their extensive instrumental facilities will also become increasingly involved in partnership with industry in the following areas:

- Researching various areas of cement and concrete science of direct interest to the particular collaborative company or organisation.
- Solving difficult technical problems for a given company.
- New product innovation and development.

We do not *"know it all"* in cement and concrete science. If anybody should claim that we do, then they would have clearly *"passed their sell-by date"!!*

The aforementioned areas show where opportunities exist now and in the future for young researchers to develop their expertise in cement and concrete science.

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