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Conference Report

10th INTERNATIONAL CONGRESS ON THE CHEMISTRY OF CEMENT, GÖTEBORG SWEDEN, 2–6 JUNE 1997.

The Chemistry of Cement Congress started with a 1 day meeting in London in 1918 when setting of cements and plasters were discussed, which was followed by International Symposia and Congress; Stockholm 1938, London 1952, Washington 1960, Tokyo 1968, Moscow 1974, Paris 1980, Rio de Janeiro 1986 and New Delhi 1992. Swede was the honored host of the 10th anniversary of the International Congress on the Chemistry of Cement ICCC. The Jubilee congress was organized at the Swedish Congress Center (Svenska Mässan Congress) in Göteborg from 2nd June to 6th June 1997.

There were 400 delegates excluding the accompanying persons from 45 countries. The major delegations were from Japan (36), Germany (36), France (33), Sweden (26), USA (21), UK (21), Italy (13), India (13). Three hundred and thirty papers from 40 countries were accepted for presentation and publication in the proceedings after careful scrutiny by a team of leading international scientists. The proceedings have been published in 4 volumes and are available through the ed. and congress secretary H. Justness, SINTEF, Trondheim, Norway.

The congress was divided under five main themes which includes introduction of two new topics focusing on "Utilization of admixture" and "Developments in characterization techniques". Three plenary lectures were delivered by invited speakers; Wieker *et al.* "Recent results of solid state NMR and its possibilities of use in cement chemistry", Scrivener "Microscopy methods in cement and concrete science", and Mullick "Why concrete is not always durable". The other papers were presented in five parallel sessions.

The five themes of the congress were:

Clinker production; New process, Low energy clinker formation, Utilization of industrial by products and wastes, Application of mineralizers, modifiers and activators, correlating process parameters with clinker properties, Clinker structure and mineralogy.

In this section new processes for making clinker were high-lighted. Development of special cements, use of kiln dust for clinker production, thermo-chemical activation of clinker formation, melting process for clinkerization are reported. Influence of grinding on the quality of cements is also shown. Cement clinker formation from fly ash using microwave processing has attracted the attention as it cut short the sintering process very much. Low energy clinker formation, high quality cement with low energy consumption and the formation kinetics of $-C_2S$ by liquid state reaction are reported. Use of industrial waste as a fuel for production of cement is also highlighted.

Portland, blended and special cements; Rheology, Hydration kinetics and microstructure development, Structural models for hydrated cementitious pastes, Chemical and physical shrinkage, influence of blends or additions of combustion ash, slag, silica fume, colloidal silica or rice husk ash, influence of mixing techniques and curing conditions.

It was reported that there is flocculation of silica fume in cement paste which can lead to alkali–silica reaction. There are no current methods for preventing the flocculation of silica fume. This flocculation creates uneven distribution of water which subsequently leads to uneven hydration creating more hetrogeneity in the concrete. Consequently standard deviation increases. Besides this, there is aesthetical problem in using silica fume. It is shown that the Silica Colloid newly developed by Eka Chemicals, Sweden reacts spontaneously with the calcium hydroxide to produce C–S–H. This being synthetically produced, is chemically pure and has a very high specific surface area. Its small amount addition produces early high strength mortars and concretes. It does not influence the color, and hence its use in white portland cement, high alumina cement and lime base mortars will be unique.

Utilization of admixtures, water reducers and polymers; Mechanisms; chemical admixtures and cement interactions, influence of admixtures in the microstructure development, combined admixture and their mixing techniques, influence of type, dose, addition time and mixing time.

It is getting more attention and concern at the same time as the mechanisms of interaction involved with different binder systems and their influence of the microstructure development instead of getting clearer became more complicated. Dose of admixture, their addition time and mixing time play decisive role in the properties of concrete at fresh and at hardened state. Pre-trails before use ae recommended.

Performance and durability of concrete and cement based systems; Pore structure and its influence on the permeability and diffusivity of gasses (CO_2), liquid (water), and dissolved ions (chlorides), Physico-chemical (sulphates), thermal (freeze-thaw) and biological degradation including environmental and synergistic effects, Cement aggregates compatibility (e.g. alkali aggregate reactions) and structure < > performance relationships, influence of physico-chemical aspects during early material history on durability (e.g. high curing temperature-secondary ettringite formation), modelling of degradation process, life cycle analyis.

There are synergistic effects which affect the modelling of degradation process and consequently the life cycle analysis becomes difficult.

Development in characterization techniques; Nuclear magnetic resonance (NMR), X-ray diffraction (XRD), diffraction by synchrotron radiation or neutrons, Scanning microscopy, other techniques.

Use of NMR has been very much increased in the last 5 years in characterization technique. Many papers have been presented, showing possibilities and limitations of this technique. The last day was devoted to the parallel open discussion groups on special topics like "Delayed ettringite formation, Chloride binding and ingress, Autogenous and or chemical shrinkage; Alkali aggregate reaction; Active Belite[11]. Summary of these groups discussions as presented in the plenary session are briefly presented below;

Alkali Activation; Alkali activation of slag reported is with the addition of sodium silicate, NaOH, Na_2CO^3, KOH etc. It is shown that the setting time and the early strength are improved. Early hydration and the microstructure development depends upon the nature of the activator used. The activation mechanism proposed is an attack on the SiO_2 or Al_2O_3–SiO_2 framework by OH ions, and the most possible hydration products are CSH gel and Hydrotalcite type phase. It is also reported that sodium sulphate rich waste can also be used as activator. It increases the early strength of blast furnace slag cements without affecting long term compressive stength. Activation of metakaoline is also presented. It is shown that the activation depends upon the metakaolines reactivity, which consequently depends upon the specific surface area. High strengths are obtained using hydrothermal conditions (85°C, 2 h). It is a debatable subject and needs more research.

Active Belite; Active belite has been produced by rapid quenching of clinker. Activation increases with increase in the fineness. Its production by liquid state (hydrothermal) reaction between lime and silicic acid via synthesis of intermediate C_2SH and by thermo chemical stabilization of the more active high temperature modification of C_2S are reported. Formation kinetics of active belite and their properties are discussed. Research has been done at various levels but there are many questions yet to be answered for industrial production of active belite.

Autogenous-Chemical Shrinkage; Autogenous shrinkage (AS) of concrete is a macroscopic volume reduction caused by hydration of cement. ACS is significantly affected by the type of cement and the hydration process. Because AS strain of cement paste depends on the hydration of each mineral compound and that it is equal to the sum of the strains due to these hydrations. The AS in the case of concrete is lower than that of the cement paste because of the presence of the aggregate particles. Model for calculating AS at a certain age by the mineral composition and the hydration ratio of each compound are proposed. It is shown that As increases with increase in C_3A and C_4AF content. It will enable to calculate As of concrete with different type of cement at various water to binder ratios. It is further shown that the external chemical shrinkage value of hydrating cement paste are highly dependent on the measuring procedure. For example; the static method is unable to deal with the influence of bleeding at medium and high W/C ratio,

whereas the rotation method does not take into consideration the bleeding of the cement pastes. It is emphasized that the rotation method is the best to obtain a "true" AS curve, especially to establish the knee where the AS curve "flattens out" and deviates from the chemical shrinkage curve, indicating that a skeleton is formed by the hydration allowing empty pores to form. Exothermic hydration of cement is accompanied by a chemical shrinkage leading to the internal volume change. A strength model based on chemical shrinkage volume is introduced for cement paste.

It is shown previously that the AS increases with decrease in W/C and for the concrete containing Silica fume. Further it is shown that the AS is dependent on the type of aggregate also for example it is larger with lime stone aggregate than with sandstone. It is shown that in the case of high performance concrete the AS is dependent on the age, W/C and type and content of silica fume. It is also related to the decline in the internal relative humidity. Use of some shrinkage compensating admixtures was also reported.

It was concluded that there is a need for a more clear definition. We are still at a very early stage in research. It is a real issue specially when we deal with a low water to cement ratio. More data are required relating Material properties; influence of chemical and mineralogical admixtures, water to cement ratio on the Autogenous-Chemical Shrinkage.

Delayed Ettringite Formation (DEF); Delayed ettringite formation is drawing attention and is a debatable subject. Many times the conclusions are drawn based upon for example microscopic pictures showing phases without support of complementary data. It is insufficient to postulate the distress of concrete due to the DEF. It is shown that the DEF formation is related to the cement composition and curing conditions specially the temperature. Microanalysis has supported the hypothesis of DEF formation within CSH gel. In another paper it is reported that the DEF formation is not only temperature dependent, it can occur when the hardened concrete is exposed to varying climatic conditions like frequent wetting and drying or freezing and thawing. It depends amongst other upon the moisture transport and other substances within the concrete structure. This enables the primary ettringite dissolution in the pore liquid and recrystallization in the bigger pores and cracks. This process is however accelerated in higher temperature due to intensive drying. The artificial air voids produced by the use of air entraining admixtures can also be filled by DEF and consequently will not be available to fulfill their role in enhancing freeze-salt resistance of concrete. Thus DEF can also be a party in freeze-salt damage of concrete. It is also shown that the ASR can promote DEF formation. Basing upon some research it is suggested that precuring at 65°C for 3 h avoids delayed ettringite formation.

It is inferred that; the nomenclature of DEF is to be made, Causes of delayed ettringite formation like insufficient precuring time and temperature, role of alkali, influence of alkali–silica reaction and carbonization are to be established, and Measurement and identification methods are to be explored.

Chloride Binding and Ingress; Chloride diffusion is tested by different methods which are very controversial. There is no good internationally accepted test method. Use of mineral admixtures on the one hand improves the resistance to chloride ingress but it needs more water for making the concrete. This is optimized with the use of superplasticizers which increases the shrinkage. Further more the chloride intrusion into concrete is a time-dependent phenomenon which involves both physical process and chemical interactions. Swamy has shown that the chloride diffusion measurements are based on the assumption that chloride penetration is a one dimensional process and the diffusion coefficient derived from the tests does not represent what happens in practice. The process involves chloride transportation both in the vertical and lateral directions. A two dimensional diffusion model is proposed basing upon the tests results obtained after long time exposure of reinforced concrete slabs comprised of cyclic ponding with 4% sodium chloride solution for 7 days and drying in ambient air for 3 days.

It is needed to make a criteria for assessing the quality of concrete. More research is needed to develop a more realistic and reliable test method of international understanding.

This was followed by a special session led by Mrs. H. Seniz Yalcindag of UNIDO, Vienna, Austria emphasizing upon the environmental and ecological problems of vital global interest. In the western world people are more conscious about the atmospheric pollution and take some

measures to reduce it. Whereas in the developing countries it is more of concern and needs attention of the international organizations. Use of industrial and agro-waste was also elaborated which do not only solve the ecological problem but also significantly increase the durability properties of the building materials. However there are problems in their use as the technology is still not very well developed. Therefore pre-trials are to be done before use even if the technic is known at some places.

Dr. A. K. Chatterjee has briefed that in India special care is taken in controlling the environmental problems. One of the example given was the use of CO_2 emitted from the cement kilns in making CHN. The production is about 4000 million tons per year. Similarly Dr. Y. Kihara, of Brasileira Cimento Portland informed about the use of 18000 tons of waste in Brasilien kilns with out hampering the cement quality. The next ICCC will take place in South Africa in the Year 2003.

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