URGC - MATERIAUX

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ANALYSIS OF THE NLK PROJECT EA 2860
ECOSMART CONCRETE PROJECT
METAKAOLIN PRE-FEASIBILITY STUDY

The project aims at the calcination of kaolin contained in oil sands tailings ponds in northern Alberta in order to produce metakaolin (MK), a very reactive pozzolan. The report of NLK Consultants Inc. deals with a pre-feasibility study.

I - **TECHNICAL STUDY**.

MK is produced by heating kaolin to drive off its hydroxyl groups not the water of hydration, as written by NLK. MK can be a substitute for silica fume, but not at the same content in concrete. Our experience of more than 20 years of research shows that a MK content lower than 15-20 %, in substitution of cement, is not very efficient to improve concrete properties, and specially when MK is not pure, like in this project.

From a technical point of view :

a) NLK is right when saying that kaolin has to be separated from silt, but is it possible to add bitumen to kaolin before calcination ? Some of our studies have shown that kaolin heated in contact of organic matter yielded more reactive MK, due to the formation of superficial defects which increase the topochemical reactions between cement and MK. Is the Tynebridge process able to re-introduce bitumen in kaolin after separation or not ? If bitumen is not separated, this would decrease the natural gas demand: gas would only be needed to start the reaction and thus, the process will be energy self sufficient, as shown by burning de-inking sludge to produce MK. Had laboratory tests been conducted on the production of MK by calcining kaolin mixed with bitumen ?

b) Multi-hearth furnace is perfectly adequate to produce MK. We have tried such equipment at NESA facilities (Belgium) to calcine paper sludge. The first step, before investing for a large-scale plant, should therefore be a pilot-scale test in a multi-hearth furnace to verify the conditions of calcination and the properties of the final product. All the properties described in the project are only based on laboratory tests, not anyone refers to pilot-scale studies using the same equipment as that scheduled for industrial production. Such tests should confirm or not energy consumption, entire destruction of organics, relationship between input and output of matter, and color of the final product.

c) Color of the product is a key factor for the success of the project. The whiter the metakaolin the easier its introduction in concrete industry. Dark metakaolin can only be used in low-tech concrete (substitution of fly ash, for example), while white metakaolin will interest precast industry, and specially colored concrete premixed mortar producers, and glass-fibre reinforced concrete (GFRC) producers. White product is that required for construction in foreign countries as Japan and Singapore.

d) Ternary blend of cement, fly ash and metakaolin, prepared at ready-mix concrete plant is not technically viable. Indeed, those powders present different specific surface areas and it is therefore very difficult to get a homogeneous mixture. The production of a blended cement at industrial scale is better to get expected properties.

e) When looking at the chemical analyses presented in Table 4.01, it appears that mineral ash is very impure metakaolin: the high K_2O content (> 3 %) indicates that mica is present in the product, the presence of quartz is illustrated by high silica content (57 %). Mica and quartz are inert materials, regarding the pozzolanic reaction. The Al_2O_3 content is only 31 %; assuming that it is essentially present in MK (which is not true because alumina is also present in mica), it can be estimated that pure metakaolinite is only present at a content of 70 %, which is a limiting factor for pozzolanic activity.

f) Nothing deals with the particle size distribution and specific surface area of the final product. It should be interesting to verify if any agglomeration occurs during calcination. In case of such event, it is necessary to de-agglomerate or grind the final product, which will increase the cost of the final product.

g) The reduction of the cementitious material content in concrete is not recommended. The robustness of the mixture is affected: a slight increase in the water content can lead to segregation of coarse aggregate and bleeding, and consequently, to strength decrease. Tests are absolutely necessary to verify this statement.

II - <u>ECONOMICAL STUDY</u>.

From my point of view, only two ways of MK utilization are economically viable:

1) if low-grade material is yielded (dark color, presence of impurities, coarse material), it must be produced at very low cost and compete with fly ash to be used in ready-mix concrete plants. The technology presented in this project cannot lead to such product. It is too expensive because of the level of production, which is quite low. To get a low-cost product, MK has to be produced in a rotary-kiln at cement manufacturing facilities. It should be done after maintenance of the kiln, when re-starting it. Within one or two months, it is possible to get 60,000 to 100,000 tonnes of MK. The scale effect is very important, regarding the production of such product. We have followed such way with VICAT Cement Company to produce low-grade MK and its works.

2) if high-grade material is produced (white color, fine particles, high reactivity), large perspectives are open and the cost of the product is not a major problem. But applications do not concern the ready-mix concrete industry. The most interesting sectors are therefore: colored concrete, premix mortar, GFRC composites.

The market research presented in this project is not sufficient to cover all possible applications of MK. The ready-mix concrete industry is that which needs a low-cost product and I am not sure that RMC industry is interested to use a product more technical than fly ash (more superplasticizer used, more difficult handling) and whose advantages are not yet clearly established.

It is the reason why a pilot-scale study is recommended in order to produce sufficient quantities of MK and supply RMC plants. Ready-mix concrete producers must be associated to the project, in order to state on its acceptability, from an industrial point of view. The production of MK at the same cost as Portland cement does not present any interest for usual concrete. Our studies carried out in Europe have shown that MK use is interesting in the following conditions:

a) avoid the use of an addition silo,

b) same cost as fly ash or ground slag, if used at lower content because more superplasticizer is needed to get good dispersion,

c) same cost as white cement in colored concrete,

d) no cost restriction for use in premix mortars or GRFC composites.

The cost of transportation is also an important parameter.

III - ENVIRONMENTAL ISSUES.

All the arguments developed by NLK are acceptable but they have to be verified at pilot-scale test, and specially particulate emissions.

IV - CONCLUSION.

Before any final decision, a pilot-scale production of MK has to be undertaken in a multiple-hearth furnace. This will allow to confirm some assumptions presented in this study: energy consumption emissions, destruction of organics, color, fineness and reactivity. Some tonnes of MK should be produced and RMC plants should be supplied with sufficient quantities to state on MK industrial acceptability (properties and cost). Moreover, such tests will show if light MK with extended properties may be produced by the technology reported by NLK. Therefore, the market study should be improved.

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