THE RAW MATERIALS ACT AND CONCRETE AGGREGATES.

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This paper contains a brief desciption of the Raw Materials Act and the activities concerning raw materials mapping and investigations into the technological developments of the relevant industries - from recovery of the raw materials to the final applications of these materials. These activities are part of the planning aspekts of the Raw Materials Act.

1. A BRIEF HISTORY OF THE RAW MATERIALS ACT.

The Danish Raw Materials act covers those raw materials which were exploited before February 23rd 1932. This primerily means sand, gravel, stone and clay. The act on Search for and Exploitation of Raw Materials in the Subsoil of the Kingdom of Denmark regulates the exploitation of other resources which have been discovered after February 23rd 1932. The most important of these resources are oil and gas.

Those materials which are covered by the "Subsoil Act" belong to the State of Denmark, while raw materials covered by the Raw Materials Act belong to the owner of the land on which they are found. Dredging of raw materials from the bottom of the sea requires a permit from the Danish National Agency for the protection of Nature, Monument and sites. After recovery the raw materials belong to the dredging company.

In 1972, the first Raw Materials Act was passed in the Danish Parlament. As a consequence of this act, the free right to private exploitation of raw materials was apolished. The Act laid down that permission to exploit raw materials has to be granted by the relevant authorities. Furthermore, the authorities can refuse permission to exploit without compensation. However, the 1972 Act was deficient in some points.

In the beginning of the 1970's, a law reform of the physical planning system was carried out. The idea was, that all areas should be developed according to and overall plan. The Raw Materials Act of 1972 did not contain provision on mapping and planning, which would ensure that the Raw Materials Authorities were able to constribute to the overall physical planning in a qualified way. At the same time the scarcity of raw materials was discussed and documented. In this connection, different ways of ensuring a resource-economical use of the raw materials were considered. Consequently an economization on the raw materials had to be effekted, which could ensure:

- that the materials are not used in greater quantities than necessary,
- that the materials are used according to their quality,
- that limited types of material are not used when other materials, which exist in greater quantities, may be used,
- that a given deposit is fully utilized,
- that efforts are made to find suitable substitute materials for the natural materials, further

- that, where possible, materials are re-cycled and wasteproducts are used.

The Raw Materials Act of 1977 contains provisions or mapping and planning, and provisions on an economizations on raw materials. The purpose of this Act is, in short to ensure:

a. that the exploitation of Danish raw materials deposits is based on overall planning and on an overall evaluation of the social considerations mentioned in section 3.

b. a resource-economical use of deposits, and

c. that the public authorities co-ordinate the handling of issues in regards to the exploitation of raw materials.

This mapping and planning concerning land-based recovery occurs regionally in the counties under the coordination of the National Agency, while raw materials from the sea occurs centrally in the National Agency. The Raw materials Act furhtermore contains a §6, which amplifies the resource-economical considerations. According to this paragraph, the Minister of enviroment can, after consultation with the Minister of Housing and the Minister of Public Works, lay down rules:

1. as to the quantity and quality of the raw materials which may be used in connection with housing construction and other types of construction,

2. as to whether waste products or substitutes are to be used or whether recycling is to take place in connection with housing or other types of construction.

This provision authorizes the Minister for the Enviroment to ensure the implementation of an adequate economization on the raw materials. This means boths an ensurance of the delivery of the high-quality materials to those industries who need it, such as the concrete industries, and the use of residual products where it is possible and justifiable, for example with fly-ash in concrete.

This section of the Act has hitherto not been applied. However, the ideas of economizing on raw materials has become more widespread througt the past decade, both because of the intentions of the Raw Materials Act and because of other social circumstances. The societal aspects relating to the consupmtion of domestic raw materials are primarily reflected in the aforementioned mapping and planning, where the mapping out of raw materials also includes those raw materials qualities which are discussed in the following. Planning on the other hand, is rendered visible as the regulation and reservation of land areas based on considerations of supply.

2. RAW MATERIALS MAPPING.

If the intensions of the mapping of raw materials concerning supplyplanning are to be be realised, then it is a prerequisite that there will be carried out an extensive mapping of the country's raw materials. The Danish Raw Material Act marks out the following instructions for the mapping.

The mapping is built up in phases. Phase 1 consists of a division of the whole country, according to how good the possibilities are judged to be for finding raw materials. Phase 2 consists of a detailed mapping of selected areas of the raw materials deposits. It is also the National Agency's task to coordinate the mapping by the counties in such a way as to ensure that this work is carried out according to a uniform procedure. In this way, the results can be integrated and form the basis for a raw materials mapping of the hole country.

As part of the solution to this task, the National Agency prepares guidelines concerning the specific subjects in the mapping. The guidelines are drawn up in collobaration with the autorities, the raw materials industry and institutes of higher education. At the moment, the National Agency is completing it's work with two sets of guides relating to the phass 2 mapping: "The use of Geophysics in the Mapping of Raw Materials" and "The Quality of Sand, Gravel and Stone Materials." The main contents of "The Quality of Sand, Gravel and Stone Materials", which is the most relevant in this connection, will be discussed in the following.

The mapping is undertaken on a technical-geological basis. Existing and possible future deposits of raw materials are described with regards to:

- the extent, thickness and amount of raw materials,

- the conditions relating to recovery - first and foremost the thickness of the overburden, as well as irregularities in the stratification.

- charracteristics of the material in the deposits.

The extend of the mapping is determined by it's purpose, which is to supply the authorities with the knowledge necessary for the planning of the recovery sequence for a number of years in the future. In practice, this is done by assigning areas to excavation. The analyses shall therefore be carried to a level whereby the authorities have sufficient knowledge to determine the possible applications of a prospective deposit. It is subsequently the actual producer who undertakes the more detailed analyses in the actual produktion phase, which are necessary for the production itself. As the model is constructed, it encourrages a pronounced interaction between the public authorities and the private entrepreneur.

Quality Analyses.

It is crucial to both the authorities and the private entrepreneur that the quality of the deposits and the spheres of application are determined. For example, it should be determined if a given sand can be used as aggregate material for concrete in exposed enviroments, for concrete in indoor units, or perhaps only as filler material.It is stands to reason that the analyses that one chooses to perform will in part be determined by the needs of the concrete industry. On the other hand, only one-third of the total Danish production of gravel is consumed by the concrete industry and others who needs high quality. The construction of roads and highways also use a third and the remainder is used for other purposes.

Finally, the analyses must be within reason economically in order to carry them out in large numbers.

In light of these thoughts, the National Agency has first and foremost chosen to analyse three qualities:

1. the distribution of grainsize,

2. composition of the grain, particularly the content of harmful grain,

3. impurities - humus analyse.

These are fundamental, but is further proposed that the following analyses be carried out:

4. SE-value, which supplies easily accessible and useful information concerning the fine grain material. This is widely used in road and highway construction,

5. chalk content. This analysis is traditionally carried out, but is scarcely of technical importance. The analyse can possibly disclose whether or not the composition of a material varies from what was expected.

All the analyses are performed on raw gravel.
Some comments are necessary concerning the three primary analyses.

Grain size is the single most important analyse and already gives the first qualitative estimate regarding the possibilities of the deposit in question. It is especialy the National Agency's feeling that the traditional 4mm border between sand and gravel is in pratice sliding downwards. In this way, one can operate with:
- filler: less than 0.06 (0.07) mm.
- sand: 0.06 (0.07) - 2 mm.
- gravel/stone: greater than 2 mm.

Grain composition. The ideal is to perform an analysis stone content of the sand as well as each individual fraktion of the coarce material - 2/4, 4/8, 8/16 etc. The analyses of the sand is performed in thin section and the 2/4-fraction under a microscope. The material is graded partly according to the composition of the rock and partly according to physical properties, for example porosity.

This method of analyse is very comprehensive and one can therefore attemt to carry out varius simplified investigations:

- Preliminary results point to the possibility of using an analysis of the 8/16 fraction to predict the composition of the remaining fractions - apart from sand - with a reasonable amount of confidence. The question is currently being examined.
- Poreus flint is regarded as the real problem by both the concrete- and in road building industries. Poreus flint can be seperated from the remaining material in the coarce material because of its low density. It is therefore possible to combine manual sorting of some of the stone with density sorting. It is also possible that density sorting will render some of the other forms of analysis superfluous.Density sorting by industry may also in the future become a standard part of the treatment of the gravel materials.
- In addition, poreus flint can be seperated from other white particles by coloring in with mythyle blue in hydrochloric acid.
- A measure for the content of poreus flint in sand is obtained with mortar-bar experiment or by chemical determination of the dissolved materials.

Humus analyse for impurities. Humus-analyses are recommended because humus often indicates that there are to be found other impurities, such as roots and stumps. However, the humus content varies at random and cannot be predicted. This analysis is among other things, important for material from the bottom of the sea.

It is not the intension that all of these analyses should be performed on every deposit. At excavation sites that will supply larger geographic regions with many types of products, wil the hole program be carried out though. For local sites, a simple analyse of the distribution of grain size suffice, naturally, the open up the possibility that, for example valuable sand will be overlooked or underutilized. In practice this situation is not expected to occur, as a great deal of knowledge and experience has been collected relevant to this.

3. EXAMINATION OF THE TECHNOLOGICAL DEVELOPMENT CONCERNING THE USE OF GRAVEL AND SAND ON AN INDUSTRIAL BASIS IN DENMARK.

As an additional aspect of the National Agency's reaction to the developments concerning the recovery and supply of sand and stone materials - beyond mapping and recovery planning - the National Agency has ordered an investigation of the technological developments to the recovery, preparation and consumption of gravel and sand materials. It was initially the development within the recovery process itself that was investigated. In an extension of this investigation is now initiated an investigation of the technological development in the industrial branch where the gravel and sand materials are processed. The background for this is among other things, that the development within the preparatory branch of industry is of great importance for the conditions under which the recovery branch of industry developes.

In the investigation of the industrial application of gravel and sand, which is described in the following, the main emphasis is placed upon the concrete industries.

The investigation is being carried out by the Institute for Enviroment, Technology and Social Science at the University of Roskilde. The purpose of this investigation is to describe the relationship between the industrial development within the respective branches of industry and the consumption of raw materials. The understanding of this development, in regards to both the absolute consumption of raw materials and the more specific qualitative demands to gravel and sand materials, will therefore be able to enter into the planning of raw material consumption in the future. It will also help to ensure the correct raw material qualities to those branches of industry were the highest quality gravel products are required.

The quality demands to the raw materials are determined partly by the concerned product's demands in the end-use of the concrete and partly by the development in the competition, economi and tecnological processes in different periods. It is primarily the latter problem the investigation into the technological development is directed towards. In the preceding chapter in this paper has been mentioned the National Agency's work corcerning the product demands to the gravel and sand materials and with that concrete, as a part of the raw materials mapping.

The preliminary results of the investigation can be summarized in an understanding of the technological development within the Danish concrete industries, which is characterised by a major development, where there occurred distinct improvements in the applied technology - first around 1960 and again in the middle of the 1970's.

Upto 1960. The labor market was characterized by a large reserve of workers, wherefore the industrial development occured via an expansion of production, without major changes in the production technology or by changes in the use of raw materials. After 1960. It was no longer possible to incorporate more manpower in production and the processes inside the housing and construction industries are altered, so that a large portion of the productions processes are moved to factories. This is partly attributable to the altered basic condition s for production and partly a result of the increased building and constuction activity in the periode after 1960. Characteristic for this development is that concrete becomes more attractive material for the factory production techniques which arise. The technological developments occured via extensive investments in the development of the production processes. The result of this is, among other things, that it often became profitabel to use rela-

tively more expensive raw materials to ensure an effective utilazation of the investments in the productionapparatus. After 1974.The basic societal conditions for the technological development of production is altered. In the concrete industry, it is in the way no longer possible to increse the capicity and extent of the total production, and the main emphasis of the concrete industies' internal competition is altered from being a question of maximum utilization of the production plant to the realisation of savings in labor and raw materials, and the technological developments are redirected accordingly.

In the following, the technological developments concerning the consequences of the demands placed upon the gravel and sand materials industrial qualities in the two periodes - from 1960 to 1974 and after 1974 - will be reviewed, along with some examples.

The main point concerning the consequences of the technological developments relating to the use of gravel and sand materials in the priliminary investigations of the industrial uses of these materials, including the concrete industries, is that the technological developments entail increasingly sharper demands to the quality of the gravel and sand materials. The reason for this are however different for the two previously mentioned periods, depent upon the tendencies contained there in.

In order to improve the utilization of the production plant, which as mentioned before was the main tendency in the economising efforts from 1960 to about 1974,it was necassary to increase the flow in the technical processes. This could bedone for example, by reducing the concrete's setting time and by increasing the total operating time of the production apparatus, in order to realise a greater utilization factor of the total investment. The greater rate of production demanded the application of a more precise and drier concrete composition, as well as a forced hardening time. However, these efforts meant that demands regarding the quality of the aggregates grain size, grain shape and uniformity from shipment to shipment must also be tightened. the concrete composition's workability must also be improved in order to compensate for the drier concrete composition's relatively reduced workability. It is therefore also important for this period that a substantial part of the technological development is directed towards the improvement of compression and casting techniques. Dosage methods are corresspondingly developed in order to realise a more precise proportioning of the concrete's composition. The result of these developments is that there is typically used increasingly expensive gravel and sand materials.

After 1974, economic savings concerning labor and raw materials are realised, as part of the concrete industries' mutual competition. The importance of the high degree of plant utilization is somewhat modified. In the case of economising with raw materials, the concrete industry in Denmark primarily concerns itself with savings in the most expensive portion of the raw materials composition, namely cement. The reduction in the use of cement further necessitates a tightening of the demands concerning concrete and thereby the aggregate's proportioning. For example, further specifications of the materials grain size and the use of drier concretes are demanded. It is among other things in order to realise a more precise concrete composition and savings concerning the amounts of cement - in addition to savings in labor - that the technological development in this period are directed towards the automating of the dosage and process control systems. The automated control systems itself further increase the demands concerning the definition and homogenity of the gravel and sand materials from shipment to shipment.

Another aspect concerning cement savings is the realising of absolute cement-

savings, in which fly-ash is substituted for cement. The reduction of the absolute cement content by, among other things the addition of fly-ash, involves a longer hardening time for the concrete - not as a result of the addition of the fly-ash , but as the result of the lower cement content - and thereby a relatively poorer utilization of the investment in the production systems. In other words, savings in cement weigh more than a high rate of utilization og machines and the rest of the production systems.

The tendencies concerning the economical and technological processes are in this way, in importent respects, determinative for the use of raw materials and for the eventual advantages for production and society, for example with the use of fly-ash. An eventual future development, where the competitive forces within the concrete industries involves the reactualisation of efforts to improve the degree of utilization of production systems and to increase capacity, will also deactualise economising efforts with cement and with that, the use of fly-ash as well.

Summarising the actual tendencies in the technological development concerning efforts to economise with raw materials in the concrete industries, it can be said that it is not possible for the individual factory to relax the quality demands placed upon the gravel and sand materials that concerns the technical processes and economising efforts with cement. On the other hand, it is possible that segments of the concrete industry will, due to reasons of competitions, find it necessary to relax some of the demands to the raw materials which exclusively concern product-quality, with subsequent consequences for the durability of the concrete.

Corresponding to this development, it is possible that, in periods where the mutual competition within the concrete industries concerns increasing the rate of production, that these productions processes can also have consequences for the durability of the concrete. In conclusion, it can therefore be said that the dynamics of the technological processes have different consequences for problems related to the durability of concrete, depending upon the production conditions of the actual historical period.

The different investigations, some of which have been mentioned in this paper, can be ordered by applying to:

The National Agency for the protection of Nature,
Monuments and Sites.
Amaliegade 7,
DK 1256 København K.
Danmark.