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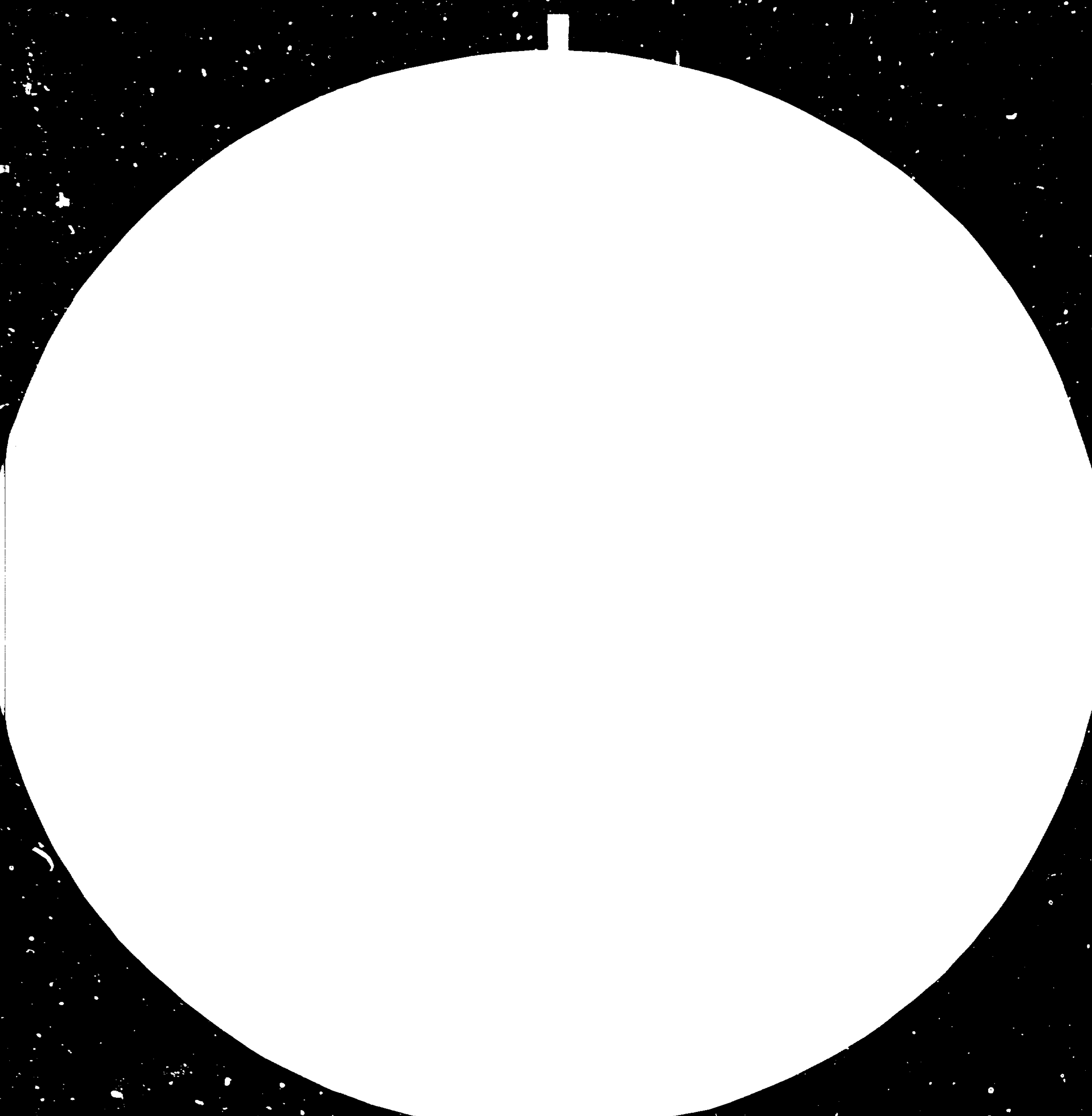

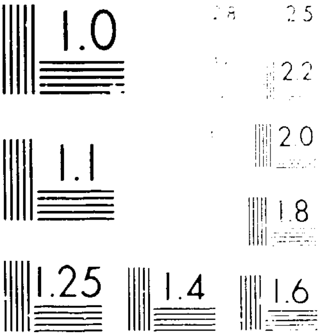

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CEMENT AND CONCRETE PRODUCTION IN INDONESIA*

by

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PREFACE

This country monograph was prepared at the request of the Director General for Housing, Planning and Urban Development, by the Building Research Institute in its capacity as U.N. Regional Housing Centre for the ECAFE Region.

The aim in publishing such a monograph on cement and Concrete Products is to promote a better understanding overseas of the problem, plans and ideals of the Indonesian people in this fields.

The Building Research Institute would be grateful for any suggestions for improving the monograph, and all enquires regarding figures and statements herein, which may need clarification, will be answered by the Institute.

I. Indonesian Concrete Production

Indonesia has entered a phase of booming development. The construction industry has become a major industry and portland cement (P.C.) is becoming one of the main building materials. This is reflected in the yearly consumption of cement (P.C.) which is increasing from 2 million tons in 1973 - 1974 to more than 5 million tons in 1978 - 1979. It is expected that the yearly cement consumption, which incidentally is a traditional economic indicator, will be more than 15 million tons by 1983 - 1984, at the conclusion of Pelita III, the Third Five Year Development Plan.

Assuming that each ton of cement will produces 3 cubic meters of concrete, the yearly concrete production may be expected to increase from 6 million cubic meters to at least 30 million cubic meters in the decade from 1974 to 1983.

Building construction will require a large and increasing percentage of the national budget. Cement is used for most of the reinforced concrete structures required by a developing construction industry It is therefore a matter of national importance that the concrete structures are built as economically as possible in order to reduce initial construction costs, and that the concrete should be of good quality in order to minimize future repair, maintenance, and replacement costs, and to safeguard investments.

An analysis of current concrete production and construction practices in Indonesia have been reported, which has been made on the basis of site surveys and statistical analysis of routine quality control data from typical Indonesian building sites. Also reported were the various efforts which have been made within the Concrete Activity of the UNIDO Building Material Assistance Program (INS/74/034) to improve the general quality of concrete produced in Indonesia.

In order to obtain an objective measure of the quality of concrete produced, a statistical analysis has been carried out of data from the files of the Materials Testing Institute in Bandung. 2190 standard cube test results, which had been obtained from 1970 to 1977 from concrete produced by 33 contractors on 46 Indonesian building sites, were included in this analysis. As a result of these studies the main problem encountered by Indonesian contractors were defined, improvements were suggested, and measures were taken to improve the situation.

Results of statistical analysis of official quality control data from numerous Indonesian building sites, which were obtained at Material Testing Institute from 1960 to 1971, indicate that a majority of Indonesia building contractors do not produce concrete of a sufficiently high quality to ensure strength, durability, economy, and acceptable appearance of building structures. The average coefficient of variation of strength of Indonesian concrete, which is a measure of the quality of such concrete, has remained approximately 25 percent, with no improvement over the last 17 years. According to internationally accepted quality criteria, any concrete which is produced with a coefficient of variation above 20 percent is considered unacceptable.

The low quality of concrete in Indonesia is largely due to widespread use of an outdated concrete code, the PBI-1955, which requires concrete to be batched by volume in nominal mix proportions of 1:2:3 for normal exposure, and of 1:1.5:2.5 for severe exposure, with no control of water-cement ratio, aggregate quality, or grading, and with only vague requirements to site supervision. Experiences from other countries clearly show that concrete produced according to such requirements will have a coefficient of variation of more than 20 percent, and that it will not be of sufficient quality to ensure strength, durability and acceptable appearance of modern building structures.
In addition, a conservative estimate indicates that at least 20 percent of the Indonesian cement consumption, or between US $ 50 and 100 million per year, can be saved by improving current practices in concrete production.

Practical experiences from other countries, show that concrete of high and uniform quality, with a coefficient of variation below 15 %, can only be produced under continual supervision of a competent concrete inspector, when at least two sizes of coarse aggregate plus fine aggregate of controlled quality are used, all within reasonable grading limits, and when the water-cement ratio is under control, and weigh bathching or accurate volumetric batching is used. These are the requirements which are introduced in the new Indonesian concrete code, the PBI-71. It is concluded that a significant improvement in the quality of Indonesian concrete can only be achieved by abolishing the use of PBI-1955, and by nationwide adoption and enforcement of PBI-1971. It is recommended that Indonesian contractors must be assisted in their effort to produce quality concrete according to PBI-1971, by official introduction of training programs in concrete mix design and quality control for site supervisors and building inspectors. However, in most of Indonesia, there is no commercial supply of quality aggregate, screened and washed to meet PBI-1971 requirements. It is recommended to extend the activity on concrete technology in order to prepare a plan for development of the Indonesian aggregate industry.

A number of revisions of PBI-1971 are suggested to clarify code requirements to concrete quality control and acceptance testing and to facilitate use of the code by contractors, who are not familiar with principles of statistical quality control.

Finally, the main purpose of the concrete activity is to promote such improvements in the concrete construction industry that will make it possible, by the end of PELITA III, for the majority of Indonesian contractors, to produce concrete of an acceptable international standard.

II. Current Practice in Aggregate Manufacture

Aggregate production in Indonesia is primitive and labor intensive. Most aggregate is supplied by small-scale operators who dig sand and gravel by hand in rivers and streams. All transport is done by labors without assistance of any mechanical equipment.

Proper equipment for washing and screening of aggregate is seldom at hand.

The distribution system is rudimentary. Sand and gravel is commonly deposited at the side of the nearest road and sold in small batches. Grading of both sand and gravel varies from season to season, from digging to digging, and from batch to batch. It is virtually impossible for a contractor to secure a continuous supply of aggregate of reasonably uniform quality.

Coarse aggregate is frequently sold and used without the benefit of any processing at all. Occasionally an attempt is made to remove sand below an approximate maximum size of 7 mm from coarse aggregate. This may be done by hand-screening using a device, and frequently leaves insuffi - cient material in the 5 - 10 mm size range resulting in gap-grading of the combined aggregate. At the request of contractors, suppliers will also attempt to wash out clay and silt from coarse aggregate and to screen out over-size above any specified maximum.

Standard coarse aggregate, commercially available in Indonesia, is typically a naturally graded 7 to 50 mm unwashed river gravel. Grading of the material varies from delivery to delivery and seldom conform to any grading requirements. Frequently, the aggregate is gap-graded with little material between 5 and 10 mm.

Mechanically crushed aggregate, which is generally of better quality is available near some major population centers. When rock or boulders are mechanically crushed in jaw crushers, the product is commonly screened in trommel screen and sold in two or three size fractions from which crusher dust may or may not have been removed. Although the predominantly basaltic or andesitic rock may crush into splintery and elongated particles, the mechanically crushed material is the best available coarse aggregate in Indonesia, and is being increasingly used for concrete production by contractors in the Jakarta area.

However, the modern crushing and screening plant, which is one of the few plants in Indonesia that can produce concrete aggregate of the quality required by the Indonesian Industrial Standard, has been temporaly closed down by local authorities. It was inferred that the large-scale excavation of sand and gravel gave rise to erosion problem in the river from which the materials were taken. It was also inferred that the methods of winning and processing of aggregate were not sufficiently labor intensive. This is an indication that many of the rivers and streams on Java may be over-exploitted and that it will be difficult to secure an adequate supply of river gravels and sands in the future, particularly near major development centers.

Most of the future aggregate necessary to sustain continued rapid growth of the construction industry will probably have to come from large deposits of volcanic debris which so far hardly have been touched. But closing of the plant also reveals a serious social problem as hundreds of thousands of people who are currently employed in winning and handling of aggregate may lose their livelihood unless suitable labor-intensive methods are employed in upgrading and expanding the Indonesian aggregate industry.

When coarse aggregate is produced by hand-crushing of rock or boulders, which frequently is the case, the product is seldom screened, and gap-grading is a problem. Particle sizes between 5 and 10 mm are almost always missing, and the gap in grading may be even larger. Hand-crushed aggregates typically produce unworkable, segregating and bleeding concrete mixes.

Sand is dug at selected locations in rivers and streams, and is usually sold without any washing or screening. However, at the request of contractors, suppliers will attempt to remove silt and clay by washing, thereby unfortunately also removing valuable fines between 0.3 mm and no. 200 sieve. If required to do so, suppliers will also attempt to remove oversize from sand. This is commonly done for masonry sand, either at the digging or on the job-site ; but it is seldom or never done for concrete sand.

Natural sands which are sold and used for concrete production, are almost invariably too coarse, with gradings typically within zone I according to British Standard 882, and deficient in material passing the 0.3 mm. sieve.

Finer sands are available, but used almost exclusively for production of mortar and plaster. The fine natural sands are commonly graded between BS zones 2 and 3. They are somewhat too fine for concrete production, with little material retained on the 0.3 mm sieve and a high content of silt and clay. However, when properly washed, the fine sands may be good blending sands. They will yield concrete sands with gradings well within BS zone 2 when blended with coarse sands. Blending of sands is seldom done in practice.

Except for widespread scalling of concrete surfaces in fire- damaged buildings due to flaking of andesitic aggregate, no deterioration of concrete which could be associated with aggregate has been observed. Some andesitic aggregates may be potentially alkali-rective, but no alkali-reactions have been observed. Although sometimes porous and weathered, the majority of Indonesian aggregates appear to be reasonably strong and durable.

Rapid increase in Indonesian concrete production will require a five-fold increase in supply of quality aggregate over a decade. Increasing demand and resulting pressure on sand and gravel producers to deliver more aggregate than rivers and streams can replenish already cause erotion problems near some major cities in Indonesia.

Material Testing institute has made an extensive survey of the quality of aggregate from all diggings and quarries which are currently in operation on Java. Results of pilot studies indicate that most coarse aggregate materials from Java are suitable for production of normal concrete. MTI also studied the quality of sands, gravels and crushed rock on Java, little is known about the magnitude of existing sand and gravel resources, or the rate at which material in rivers and streams is being replenished ; and almost nothing is known from the point of view of concrete production about the quality of the huge deposits of volcanic debris which are found on Java.

It is recommended that a comprehensive survey be made by the Indonesian Geological Survey in cooperation with MTI and other interested parties of the magnitude and quality of all existing and possible future sources of aggregate near major population centers in Indonesia, and that a master plan be prepared for future development of the aggregate industry.

III. Cement Industry in Indonesia

All cement manufactures are members of the Indonesian Cement Association which is very active. One committee of the association deals with price policy ; another with marketing. At the present time only ordinary portland cement is produced in Indonesia. The variations in mineralogical composition and strength of Indonesian cements are fairly large. This is one of many reasons why it is difficult for users to maintain a uniform concrete quality. The Indonesian Cement Standard includes five different strength levels four of which are based on the characteristic strength in Kg/cm2 of a standard mortar obtained at 28 days (S_{325}, S_{400}, S_{475}, S_{550}) and one on the basis of 1 and 7 days strength test, i.e. SS 1 day 225 and SS 7 days 525, when tested according to Indonesian cement specifications. In the master plan for the Indonesian Cement Industry the Industrial Department also called for the production of Portland Pozzolan Cements, Lime-Possolan Cement and Sulphate Resisting Cements for marine structures as well as White Cement. In Indonesia there are many plans for dams and other massive concrete structure requiring the use of Low Heat Cement. Marine structures invariably requiring the use of Sulphate Resisting Cement are produced locally at the moment.

Last year, Indonesia manufactured 8 million tons of cement. Approximately 90 % of this total output was consumed domestically. The map of Fig. 1. shows the location of existing and future cement plants and their estimated capacity up to the end of PELITA III (1983/1984).
Problems such as cracking of mass concrete structures and deterioration of marine structures were experienced because unsuitable cements have been used. The UNIDO team in cooperation with the Gresik Cement Research Centre recently visited the centre for consultations on matters of research and development. Excerpts from the findings and recommendations of those visit are presented below :

> " It is recommended that the Indonesian Cement Industry should make a thorough market survey in order to estimate the demand for special cements in Indonesia, such as Portland-pozzolan cements and Sulphate Resisting cements for marine structures, Lime-pozzolan cements for low-cost housing, Low-heat cement for

massive concrete structures, and White Cement for architectural and exposed concrete.
The market survey could be made in cooperation with the Directorate of Building Research where the need for such cements is being studied within the framework of the UNIDO Building Materials Programme."

" It is also recommended that a field survey be carried out in order to locate alternative sources of pozzolana suitable for use in cement production, and that material from promising sources be evaluated by the Gresik Cement Research Centre."

Due to extensive volcanic activity there is an ample supply of natural pozzolana deposits in Indonesia. By adding pozzolana to standard portland cement, both Low-heat and Sulphate Resisting cements can be produced. The pozzolana deposits in Indonesia have been surveyed and studied in a systematic way. The deposits which have been tested so far can be strongly considered for commercial exploitation. An extensive study has already been made by the Gresik Cement Research Center. This includes strength and heat development properties, as well as sulphate resistance of concrete made with Gresik cement in to which was added different amounts of local pozzolana.
A study of pozzolanas for use in cement and concrete production is in accordance with the national goal for development of the Indonesian cement industry, as outlined by the Ministry of Industry.
As the use of cement increases, problems with concrete will also be multiplied. Concrete is the end product for which most cement is used.
It is realized that a sound development of the concrete construction industry is essential to secure growth of the cement industry itself.

In Indonesia, about 30 % of the cement are absorbed by ready mix producers, 70 % for concrete block, precast/prefabricated units, pipe andrelated underground concreting. Roughly 40 % of all this production is used in West Java especially in Jakarta. Approximately 50 % of all block output is lightweight using natural and artificial lightweight aggregates. Also about the same percentage of the industry total goes into basement construction.

An award program for architects, based on residential designs incorporating Alwa blocks was recently instigated. Precast/prestressed elements constitute a fast growing segment of concrete field. Unlike other Australian asian countries, less than 25 % of all new housing in Indonesia is two stories or higher. Moreover, the public is traditionally oriented towards wood and brick when it comes to building material preference.

As a result, only 20 % of the Industry's precast/prestressed tonnage is used for housing. To make up for this producers have aggressively gone after other building types. For example, nearly 50 % of all industrial buildings are constructed with plant-fabricated components.

Overall, this market now takes some 45 % of the total industry volume.

Roofing tiles are another kind of product. The roof tile plant also rises fast, mass-volume production method. Another new, related product, still undergoing tests is submarine concrete. This, then, is our report on Concrete in Indonesia.

IV. Preference

1. Technical Report No. 22 :
Sumardi K., Head of the Building Materials Laboratory - Materials Testing Institute, Prof. T. C. Hansen, UNIDO Adviser.
" Current Practice in Indonesian Concrete Production Implementation of some recommended improvements ".

2. Technical Report No. 36 :
Prof. T. C. Hansen, UNIDO Adviser
" Concrete Aggregate in Indonesia ".

3. Technical Report No. 35 :
Prof. T. C. Hansen, UNIDO Adviser
" Concrete Technology Progress Report ".

4. Albert Kartahardja, DBR Expert.
" Development of the Building Materials Industry in Indonesia ".
(SIBEX 1978).