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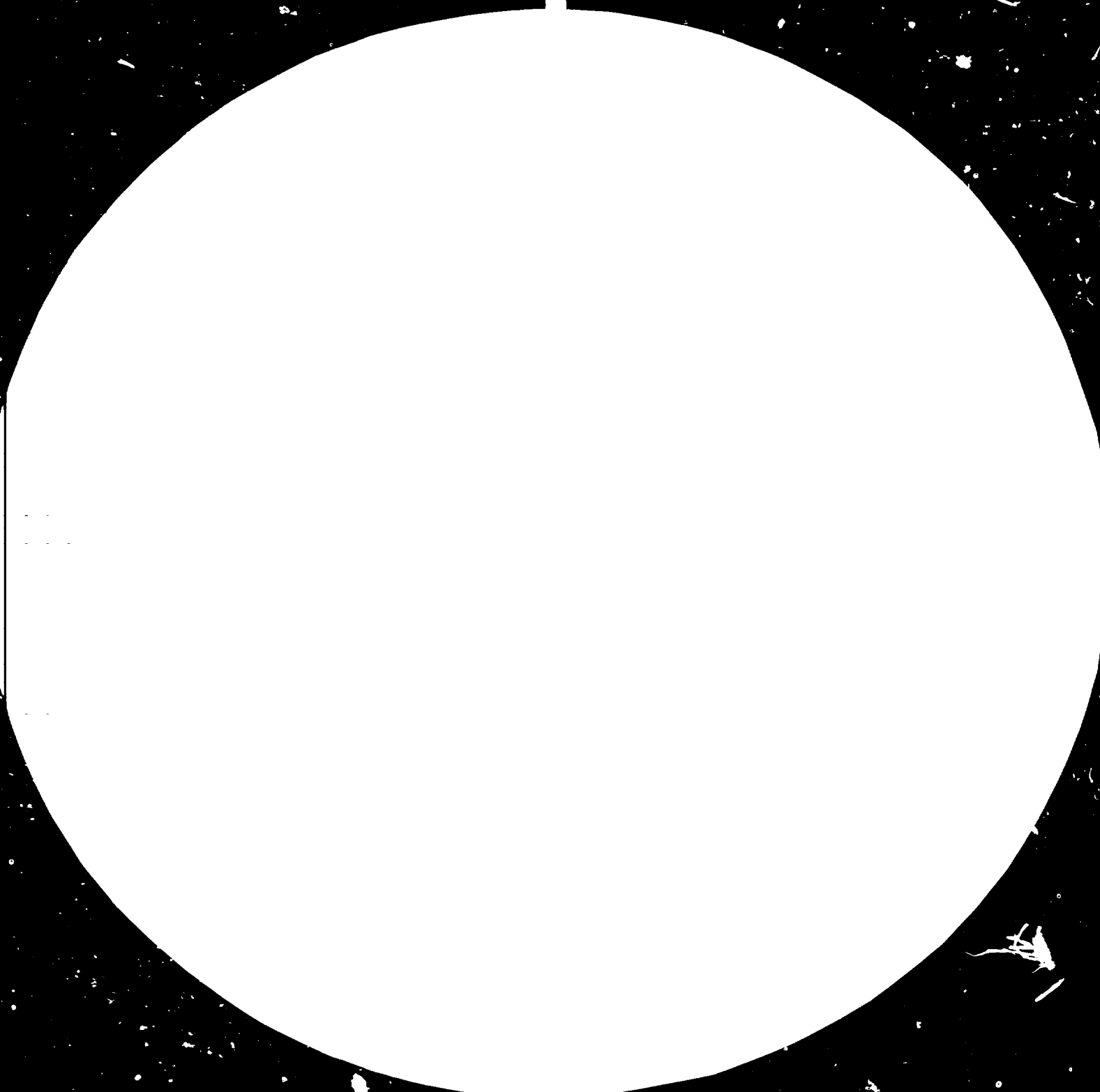

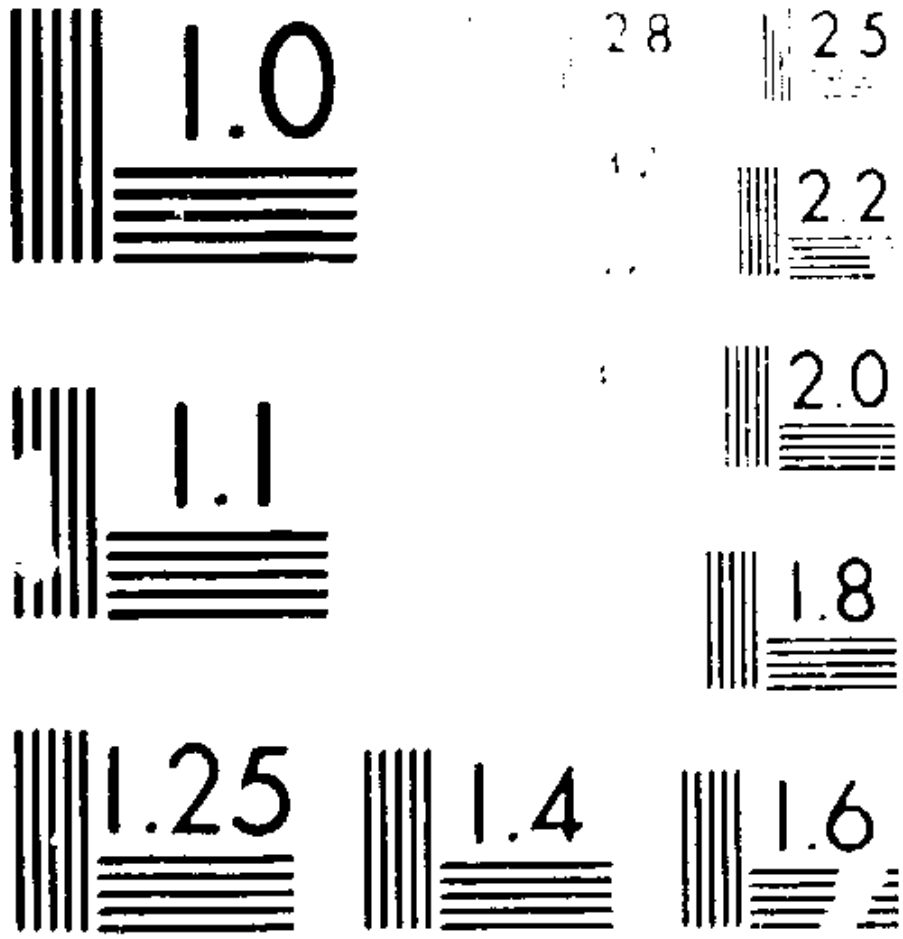
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ON-SITE MIXING OF CONCRETE*

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* The views expressed in this paper are those of the authors and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

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CONTENTS

1.0 SUMMARY

This paper has been prepared for the Australia/UNIDO "Workshop on Cement and Concrete Products" during May 1981. It is intended to cover the general Australian approach to the on-site batching of concrete for projects where no existing alternate is available. No detailed investigations of the commercial aspects of concrete production for individual applications have been covered. Rather, a broad approach has been taken to cover techniques which are probably relevant to most countries and locations. This hopefully will allow experience gained in the Australian scene to be modified and applied to other countries.

2.0 INTRODUCTION

Modern construction projects, whether they be the establishment of major mining facilities, power houses, dams, airports, heavy industry or services, invariably require concrete as a construction material.

By its nature, concrete is one of the first construction materials required, and subsequently its availability should be considered in early programming requirements. Consideration must be given to -

(a) Source of raw materials, ie. cement, sand, gravel and water.

(b) Availability of plant and equipment in planning. Where raw materials are not available, it may be necessary to find suitable deposits and construct processing plants to guarantee the supply of aggregates. The timing of this action, and the manufacture and

commissioning on-site of relevant plant and equipment may form the most critical path in the programming of the early stages of the project.

Having established sources of materials and a construction program, the technology utilised for on-site batching of concrete tends to be an application of that developed in the commercial pre-mix concrete industry. In Australia, the development of refinements in batch plant and transit mixer operations has been achieved by a close association between producers of pre-mixed concrete, such as Pioneer Concrete and specialist manufacturers of plant and equipment for the industry.

On isolated projects, where numerous civil contractors may be working the Engineer/Constructor or Supervising Body, may call tenders to supply concrete for the entire project. This achieves a more competitive price for the supply of concrete and does not disadvantage civil contractors who may have no specialist back-up in concrete manufacture.

3.0 MATERIAL SOURCES

It is essential to choose the sources of all materials early in the planning process. Often a choice must be made between the use of distant established supplies and potential deposits close by which require developing. The final choice is usually a balance between the costs of transportation and production costs of alternate supplies. Alternate supplies should also be located and tested, to cover contingencies which may arise.

3.1 CEMENT

The high capital cost of establishing a cement works limits the number available. The choice of cement is generally determined by transport costs.

3.2 POZZOLANS

In Australia, large quantities of fly ash, which has cementitious properties and is suitable for use in concrete, are available. These are often used for both economical and technical reasons.

3.3 AGGREGATES

Where sufficient quantities of sand and gravel are not available it is necessary to locate suitable material as close as possible to the project. The type of aggregates used depends on the local geology.

(i) Coarse Aggregates

Coarse aggregates may be either river gravel or crushed rock. River gravels are normally located by a visual inspection of the region. This can be done quickly from light aircraft. An inspection of previous geological reports may assist in locating hard rock deposits. Where such information is not available outcrops may indicate potential supplies, prior to test drilling. Typical hard rock used for concrete in Australia includes -

(a) Basalt

(b) Granite

(c) Diorite

(d) Greywacke

(e) Limestones

(f) Rhyolite

Having located a potential deposit, tests should be conducted to determine its suitability for concrete and the size and type of crushing and screening operation required. The principle tests for acceptance are:

(a) Alkali - Reactivity

(b) Abrasion - Resistance (L.A. Abrasion)

(c) Aggregate Crushing Value

(d) Soundness

(e) Bulk Density

(f) Water Absorption

(ii) Fine Aggregates

Where available, sands are normally found in creek and river beds, or wind blown dunes. Where natural sands are not available in close proximity to the project, it may be necessary to use manufactured sands from the quarry deposit. These consist of "crusher dust" produced in crushing larger rocks for coarse aggregates.

Sands usually require washing and screening to meet the required levels of acceptance for -

(a) Grading

(b) Silt content

(c) Organic Impurities

3.4 WATER

A suitable supply of potable water should be secured.

3.5 CHEMICAL ADMIXTURES

Admixtures which improve the performance of concrete can be obtained from a number of producers. Their use should be based on performance with local materials.

4.0 BATCH PLANT

There are many types of batch plants which may suit particular project applications. The final choice of plant is determined by the following design parameters:

(a) Production Rates - both hourly and daily

(b) Specification of Concrete Required - the need for automatic or semi automatic weighing systems etc.

(c) Material Supply - availability and variety of aggregates
- delivery of aggregates
- whether bulk or bagged cement is available

(d) Duration of Project

(e) Availability and Size of Front-end Loader

(f) Size and Topography of Site

(g) Geographical Extent of Project

(h) Availability of Water and Electricity

(i) Lead Time in Mobilisation of Batch Plant

Batch plants for project or concrete work can be basically categroised as follows:

4.1 AGGREGATE WEIGH BATCHER ONLY ("A" SECTION)

The use of mobile "A" Sections involves utilising a front-end loader to feed sand, gravel and bag cement into the hopper. It is highly mobile and capable of about 15-20 m^3 per hour.

4.2 "A" SECTION AND CEMENT SILOS

Aggregates are still weighed with a front end loader, but cement is stored in bulk and separate weigh batching facilities are available. It is possible to have mobile silos which require no permanent foundations. The production rate for this type of plant is about 35-40 m^3 per hour.

4.3 OVERHEAD BIN PLANT

This incorporates the same plant as that described above, but aggregates are stored in bins supported above the "A" Section. Aggregates are transported to these bins via conveyors. This provides a more accurate system for weighing, and also allows automatic controls to be installed. Plants of this nature are basically static, requiring significant foundations. Production rates vary from 60-90 m^3 per hour depending on the degree of automation employed.

4.4 CENTRAL MIX OPERATIONS

Central mixers are normally of the tilt-drum type and discharge into either agitators or dump trucks. This type of plant provides a more consistent mixing of the concrete.

5.0 MATERIAL STORAGE

Having chosen the general type of batch plant, it is necessary to incorporate sufficient storage facilities to maintain continuity of production. The quantities of materials stored on site should be such that temporary interuptions to the supply of raw materials, whether fo processing plant or transport breakdowns or delays, will not cause an immediate halt to concrete production. The availability of alternate supplies should also be considered.

The supply of each component in concrete should be investigated individually, as all are essential to the production of concrete and their relative availabilities may vary greatly. Raw Material sources should be assessed by the following criteria:

(a) Ability of source to product projected quantities in the time required.

(b) Distance of source from batch plant.

(c) How the material is transported.

5.1 CEMENTITIOUS MATERIAL (CEMENT AND FLY ASH)

This is normally stored in weatherproof silos. The type of silo, e.g. overhead or elevator type, being dependent on whether cement is delivered in bulk tankers or bags. Where only one regular source is available, particularly if the lead time in transporting the cement is great, the maximum possible storage should be achieved. Where bags are used, weatherproof sheds and tarpaulins should be used for protection against moisture.

5.2 SAND AND GRAVEL

Sand and Gravel may be stored in ground stockpiles and overhead bins, the number of which are determined by the variety of types of aggregates required. Normally project batch plants with overhead bin storage have either six or eight compartments and an all up capacity of 200-250 tonnes. This may be supplemented by ground storage, the size of which should be capable of producing four or five days of concrete.

5.3 WATER

The supply of water may often be erratic, particularly on isolated projects and tanks can be either on ground with pumps, or elevated to gravity feed into mixers.

6.0 MATERIAL HANDLING

The handling of materials should be efficient and flexible, yet minimise possible contamination or damage.

6.1 CEMENTITIOUS MATERIAL

Cement is the most important component of concrete and care in handling it is essential, particularly where rainfall is high. It is normally handled in one of three ways:

(a) Bagged Deliveries/No Silos - Bags are broken into the bucket of a front-end loader loaded on top of the aggregates batched in the "A" Section.

(b) Bagged Deliveries/Cement Silos - Bags are broken into the "boot" of the bucket elevator, which takes cement to a storage bin.

(c) Bulk Deliveries - Pneumatic tankers blow cement directly into silos.

6.2 AGGREGATES

Care should be taken to avoid segregation of sand and gravel. Aggregates are normally delivered by tip truck, although railways are used in particular circumstances. The economics of the size of the vehicle used relates to the distance between the source and the batch plant.

Ground stockpiles should only be established on a firm, free-draining base. Individual materials should be separated by partitions, whether timber, concrete blocks or precast walls. Aggregates can be batched in a number of ways in differing types of plants:

(a) Overhead Bin Plant/Ground Bins

Trucks tip into ground bins, the number and size of which relate to the means of transportation, production rates and the distance from the supply to the batch plant. Aggregates are then conveyed to individual compartments situated above the aggregate weigh hopper. Although the need for a front-end loader is eliminated, the supply of material is determined by the promptness of deliveries. In isolated areas, it is normally not economical to have available, the number of tip trucks required to achieve this, unless other work is available during non-peak production periods.

(b) Overhead Bin Plant/Front-End Loader Fed

A front end loader picks up material from a ground stockpile and feeds it onto a conveyor, via a ground boot. Its design should be compatible with the capacity of the front-end loader. This type of plant allows flexibility in deliveries, while still enjoying the accuracy and speed of an overhead bin plant.

(c) Front End Loader Plant

A front end loader feeds directly from the stockpiles into the weigh hopper. Each material is weighed cumulatively.

In hot weather conditions, aggregates may require cooling to control concrete temperatures. A simple technique is to dampen coarse aggregate with water sprays and utilize evaporative cooling.

6.3 WATER

Water may be either metered, through a simple mechanical meter or weighed. High production plants utilize the speed of water weighing.

In hot weather, it may be necessary to add crushed ice or to chill water to reduce final concrete temperatures. In line chilling units are now economically available to achieve this.

7.0 TRANSPORT

Concrete on most Australian projects is delivered in truck mounted agitators. Mixer capacities tend to vary from five to eight cubic metres and are driven by a separate engine to that of the truck.

Mixers are commercially available from a number of manufacturers. The design of the mixers are strictly controlled by Australian Standards.

Central Mix Batch Plants may use dump trucks to transport concrete from plant to site. This type of operation is, however, seldom used.

8.0 QUALITY CONTROL

To achieve quality concrete, it is necessary to monitor raw materials, as well . concrete. It is essential to have access to a well equipped concrete laboratory, whether "on site" or previously established in the area. Having established raw material sources, their suitability for use in concrete should be determined. Tests should be done on:

(a) Cement for
- chemical composition
- setting time
- soundness
- constancy of volume
- compressive strength
- fineness
- heat of hydration

(b) Fly Ash for
- chemical analysis
- fineness

(c) Coarse Aggregates

(d) Fine Aggregates

(e) Water for - suspended solids

- dissolved salts (sulphates and chlorides)

- organics (sugars)

(f) Admixtures

Trial mixes for concrete mix designs are then conducted to achieve target strengths.

Once mix designs have been chosen, monitoring of both raw materials and concrete strengths should be maintained. Whilst raw materials' sources are constant, random testing is sufficient with no major mix alterations required. However, if for any reason, sources are changed, mix designs may require a complete overhaul. This action during a project should be avoided if possible, as the basis for statistical records built up, becomes void.

8.1 RAW MATERIALS

Cement

Graphical records can easily be maintained of one, three seven and twenty eight day results of a standard mix. These results are available from cement works and should be supplied for each batch delivered.

Coarse Aggregates

Regular gradings and checks for shape and foreign matter should be done.

Fine Aggregates

Gradings, organic impurities and silt contents should be checked regularly.

8.2 CONCRETE

While raw materials remain constant, a history of test results on concrete may be established. These should be analysed regularly, and the degree of control assessed. Seven day test results allow predictions to be made fairly accurately of twenty days' results.

Sales should also be tested on a two or three month basis to ensure design mixes are adhered to.

9.0 CONCLUSION

This paper does not attempt to detail recommended practices for concrete batching, which may be found in numerous texts, manuals and standards.

It is hoped, however, that it will assist to form a practical basis for approaching the batching of on-site concrete.

10.0 ACKNOWLEDGEMENTS

Fowler Rax Pty. Ltd

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