PAVE 92

CONTAINER PAVEMENTS IN INDONESIA USING CEMENT TREATED BASE (CTB) AND CONCRETE BLOCK PAVEMENT (CBP)

(A case study of two of Indonesia's largest container ports)

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SUMMARY

Most Container Yards around the world are built on reclaimed or soft areas which are subject to differential settlements and high changes of water tables.

Concrete Block Pavement (CBP) as the top layer has been well known and proven as a superior pavement compared with others pavement because CBP that is a very strong pavement material is able to withstand high static, dynamic and impact loads, and is able to overcome the effect of differential settlements and lubricant spillage ; giving good durability, and good skid and scuff resistances.

But usually, the problem arises due to the instabitity of the underneath layer a factor, which should be taken into consideration by the pavement designer. The layer that will be chosen underneath should have sufficient flexibility in order to accommodate future differential settlements without cracking, insenstive to the changes of moisture content surrounding the pavement, and sufficiently strong to withstand loads imposed on it.

Cement Treated Base (CTB) is considered as an excellent material for be the layer underneath CBP, because similar to CBP, CTB is a semi-rigid pavement which has characteristics that are able to fulfill the above mentioned requirements, and permeable enough to let the water infiltrate through it due to the hair-lined cracks that inherently occurred in CTB.

In 1988 for the first time in Indonesia, CBP combined with CTB were employed in the Container Yard Pavement at Tanjung Priok Port, Jakarta , in lieu of Asphaltic Pavement, with an area of more than 130.000 sqm. The original design is Asphaltic concrete and Unbound Base Course. During the construction, the contractor was able to convince the Engineer and the Client i.e. Perumpel II (Port Authority Corporation II) to change the design to CBP and CTB.

Subsequent to that success, in 1989, the International Container Terminal (ICT), at Tanjung Perak Port, Surabaya was designed using the CBP and CTB for an area more than 350.000 sqm. These two projects are the largest applications of CBP and CTB to date in Indonesia, where the traffic loadings are the heaviest in Indonesia.

1. INTRODUCTION :

The fast growth of Indonesia's economy has encouraged the increase of port activities in recent years in loading and unloading of goods in containers.

This situation has created the need for Container Yards, whether built by Government or the Private Sector.

Generally Container Yards are located near the sea and built on reclaimed areas, which are very soft and subject to considerable settlement and changes in sea water tables.

Before 1985, pavements in Container Yard in Indonesia were mostly designed to use Asphaltic Concrete, Unbound Base Course and Subbase Course. But after a short period of operation (particularly employing top loader) owing the service ability of that kind of pavement easily dropped owing to the structural damage of the pavement.

The main problems were :

- Asphaltic concrete was not able to withstand high static load of container stacking, neither could it accommodate the high dynamic and impact loads, especially during the container loading using top loaders.
- Lubricant spillage made the strength of asphaltic concrete becoming weak.

The factors that should be taken into account by the pavement designers are :

- Surface layer should be strong enough to withstand high static, dynamic and impact loads, insensitive to lubricant spillage and good durability, skid and scuff resistances.
- Base layer should be sufficiently strong to withstand high static and dynamic loads and insensitive to changes in moisture content related to the sea water table changes.

- Also the base layer should be capable to minimize the effects of differential settlements. In the event that some degree of differential settlement has taken place , this base layer must be flexible enough to accommodate without cracking.

The Concrete Block Pavement and Cement Treated Base may be considered as the most suitable materials that are capable to fulfill all the above requirement.

2. LITERATURE REVIEW :

A. Concrete Block Pavement (CBP).

The considerations to choose Concrete Block Pavement as the surface course of container yard pavements are based on the functional requirements, operational conditions and the performance of the Pavement relative to the functional requirements.

Normally are three major types of Pavement Design that may be chosen for Container Yards: each type has its own advantages and disadvantages.

1. Asphaltic Pavement
2. Concrete in Situ/Rigid Pavement
3. Concrete Block Pavement (CBP).

Ad 1. Asphalt Mix Pavement

The Asphalt-Mix Pavement has a "Suitable" rating from the view point of Dynamic wheel-load, skid and scuff resistances and riding quality, but "unsuitable" from the viewpoint of lubricant spillage.

The lubricant spillage will make the physical properties of asphalt pavement change totally to a weak condition. Once some lubricant spills,the pavement becomes weaker, and then finally the above mentioned advantages of using asphaltic pavement will no longer be valid for container yard areas.

Obviously, lubricant spillage can not be avoided in container operations.

Ad 2. Concrete in situ Pavement

Concrete in situ or rigid pavement is considered as a "Suitable" in all aspects, except from the viewpoint of differential - settlement's effects: because the pavement cracks if the differential settlement takes place.

Ad 3. Concrete Block Pavement

Concrete Block Pavement is also given ratings of "Suitable" for all aspects, except from the viewpoint of riding quality, But the riding quality of Concrete Block Pavement is considered 'suitable' if the vehicle speed is less than 80 km/hour.

Tabel 1. The Functional Requirement of The Pavement for Container Operations

Operation		Operating Condition Or Function Required of Pavement						
Operational Type	Operational Area	Static wheel load	Dynamic wheel load	Lubricant spillage	Impact and high 'point' loads	Braking or turning (skidding, scuffing)	Differential settlement	Riding quality
Tranfer (Interface)	Truck/carrier I/F	A	B	A	B	A	A	B
	Carrier/Gantry I/F	A	A	A	A	B	A	A
	Gantry/Trailler I/F	A	A	B	A	B	B	A
Movement	Stack Area Paths	B	A	B	-	A	A	A
	Access Roads	B	A	B	B	A	B	A
Storage	Container Stack	-		-	A	B	A	B
	Vehicle Maintenance Area & Park	A		A	A	B	A	B
	Trailler Park	A		A	A	B	B	B

A: Primary Important
B: Secondary Important

Source: W.D.O. Paterson, B.E., PhD (1976)
Functional Pavement Design For Container Handling Area
ARRB Proceeding, Volume 8, 1976

Tabel 2. Performance of Pavement Types Relative to the Functional Requirement

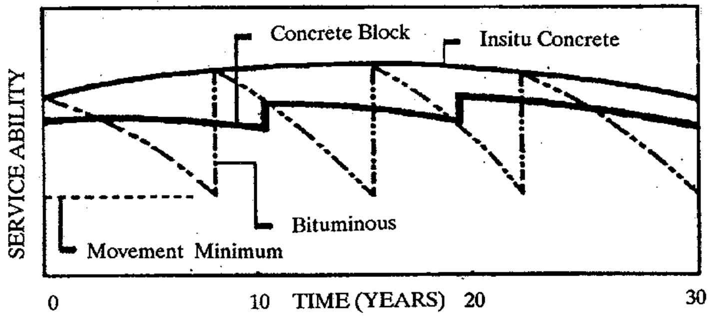
Pavement		Function Required							
Category	Type	Static wheel load	Dynamic wheel load	Lubricant spillage	Impact and high 'point' loads	Skid and scuff resistance	Effect of diff. settlement	Riding quality	Durability
Bituminous	Asphalt Mix	B	A	C	B	A	B	A	B
Concrete	Concrete plate (Steel-edged)	A	A	A	B	A	A	B	B
	Concrete Plates (Chamfered)	A	A	A	A	A	A	B	A
	Concrete Block	A	A	A	A	A	A	B	A
	Concrete in situ	A	A	A	A	A	B	A	A

Rating code :
A : Suitable
B : Conditional suitable
C : Un-suitable

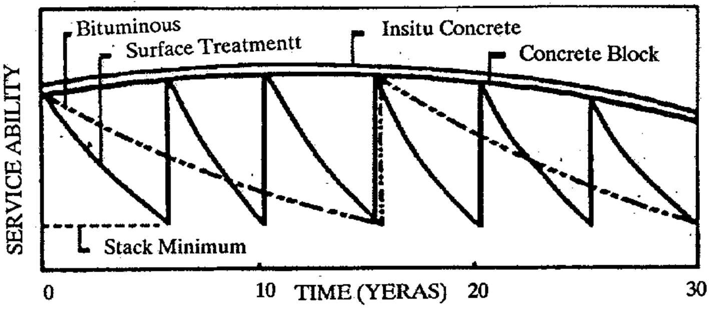
Source : W.D.O. Paterson, B.E., PhD
Functional Pavement Design for Container Handling Area

Figure 1.
Projected performance including maintenance for container terminal pavement under negligible settlement

(a) Transfer & movement area



(b) Stacking area



Source : W.D.O. Paterson, B.E., PhD Functional Pavement Design for Container Handling Area

Figure 1:

Presents various types of pavements with the serviceability viewpoint for 30 years, under a negligible settlement condition. We may assume that there exists a direct relationship between cost and serviceability. Of course, the graphs were based on experince gained in many countries.

ad 1. Asphaltic Pavement

Figure 1, explains that approimately every 8 years, the pavement must need a re-overlay. But in Indonesia, our road pavements are built such that normally after 2 or 3 years the pavement would need a re- overlay. One of the main reasons is that the penetration grade of asphalt that is suitable as a hot country like Indonesia is asphalt grade 40-50. But in fact in Indonesia the asphalt that is mostly available is grade 80-100 and sometimes asphalt grade 60- 70. The high temperature makes such high grade of asphalt easily weak.

Ad 2. In- Situ Concrete Pavement

There will be a very small maintenance cost during the 30 years life of the pavement. But again this phenomena will not be valid if there occurs a differential settlement. Other matter is that in Indonesia the initial cost of in situ concrete pavement will be much higher (30 - 50% higher) compared to Asphalt or Concrete Block Pavements.

Ad 3. Concrete Block Pavement

In this figure, it shows that the pavement serviceability drops to a small degree during a 10 year course. that means that every 10 years the cost to bring up the pavement serviceability to the initial level is very small.

This phenomena may be understood because after 30 years use the very same blocks may still be re- usable, provided that the CBP's qualities conform to the standard requirements.

B. Cement Treated Base. (CTB)

Cement Treated Base is described as a Cemented Base Material or a zero slump concrete with low cement content and low water contant.

The principal difference with conventional concrete is the fact that conventional concrete is densified under the influence of gravity with some assistance from interparticle friction reduction by means of extrenally imposed vibration.

CTB material are generally force densified by means of a roller or other form of high energy compactor. With conventional concrete therefore it can be seen that larger stones reach their orientation of greatest convenience, and that voids between those stones must be filled by progressively smaller stones. In CTB, however, larger stones are forced into their optimum orientation and the need for smaller stones in exactly the right place at the right time is less significant. It is therefore possible to achieve significantly higher densities with force compacted CTB materials.

Experimental work has shown that the achievement of maximum density is of primary and most significant importance. Increased dry density leads to increased strength. The achievement of this greater strength can allow a reduction in both water and cement contents which can minimize the problem of shrinkage cracking.

Experiences indicated that there is a strong correlation between maximum dry density and maximum strength, with regard that the moisture content necessary to produce optimum density will lead to optimum strength as well.

In general, much lower water content, lesser cement content and force compaction, allow CTB material to be placed with considerably less shrinkage than is the case with conventional concrete.

It is therefore, not usually necessary to design in slab joints, and for a pavement, experience has indicated that random cracks often have less deleterious effects on the performance of the structure than do formal joints.

Because of the force compacted nature of CTB, and the reduced width of shrinkage cracks resulting from low water and cement contents, a strong granular interlock can be maintained across cracks.

If the CTB was made from materials free of plastic fines, and is of sufficient strength , the shear capacity of the structure can be substantially preserved, thus preventing differential movement between slabs resulting from shrinkage cracks. Problem with shrinkage cracks in pavements are therefore often more cosmetic than real.

From the above explanations, it can be seen that CTB pevement has some following advantages :

1. Compared with Unbound Base Course, CTB is less sensitive to the effect of water, much more durable and can bear much higher static, dynamic and impact loads.

2. Compared with conventional concrete, CTB is much cheaper, and faster in construction period.

3. CTB is relatively thin, so avoiding disturbancesto utility service.

4. Since CTB is a semi-rigid pavement, CTB can minimize the effect of differential settlements but flexible enough to accomodate the settlements without cracking.

3. THE FIRST PROJECT : UTC (UNIT TERMINAL CONTAINER)TANJUNG PRIOK PORT, JAKARTA

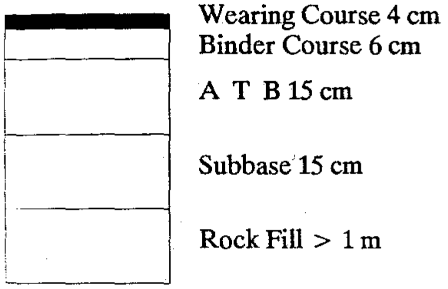
This Project is located at North of Jakarta City Indonesia, at Tanjung Priok Port : covering a total pavement area of some 130,000 sqm.

In 1988 for the first time in Indonesia, CBP and CTB were used for Container Yard Pavement in Tanjung Priok, Port of Jakarta, in lieu of Asphalt Pavement. The original design was Asphaltic Concrete and and Unbound Base Course.

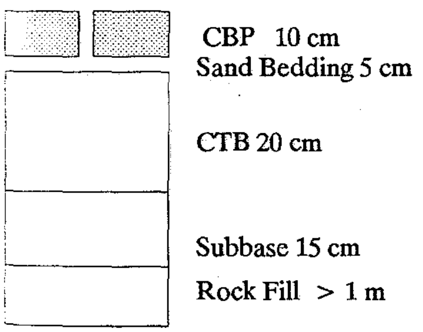
During the construction, PT CONBLOC INDONESIA was able to convince the main contractor, Kumagai Nindya - Nikki J.O; the Engineer: Peter Fraenkel International and Wiratman and Associates; and the Client "Perumpel II" (Port Authority Corporation II)as well, to change the original design into CBP and CTB. PT CONBLOC INDONESIA was appointed to carry out the CTB and CBP works.

Pavement Design :

a. Original Pavement



b. New Design



This typical pavement design was not used only for Container yard, but for the access roads as well.

Due to the performance of the works, towards the end the constructions of the project there was an additional work of some 30.000 sqm to overlay the existing Asphalt Pavement in the old Container Yard adjacent to the project. In areas where the condition of asphaltic pavement was still considered good and where there was no problem with the elevation, CTB was not used. Instead, CBP and Sand Bedding were placed directly on top of the existing Asphaltic Pavement. In order to avoid water being trapped in the sand bedding, Stripdrains were placed vertically in the Asphaltic layer to let the water through on it. But in areas where the elevation of the existing Asphalt Pavement was too high, it had to be removed and replaced with CTB.

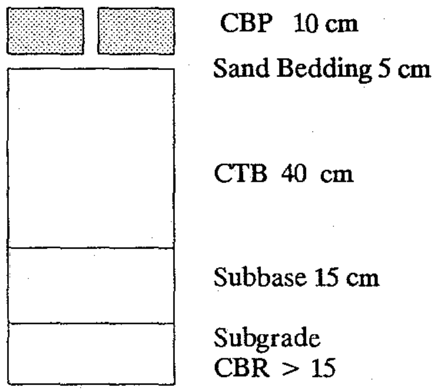
4. THE SECOND PROJECT : ICT (INTERNATIONAL CONTAINER TERMINAL) TANJUNG PERAK PORT, SURABAYA

This project is located at North of Surabaya City in East Java, Indonesia, covering a total pavement area of not less than 350,000 sqm.

This Container Yard Pavement was originally designed using CTB and CBP. The construction of CTB started on 1989.

To date, this is the largest container yard in Indonesia and the second container yard using the CTB and CBP.

Pavement Design of Container Yard



Quite different from UTC Tanjung Priok Port Jakarta, in this project there was a subgrade improvement to accelerate the settlement.

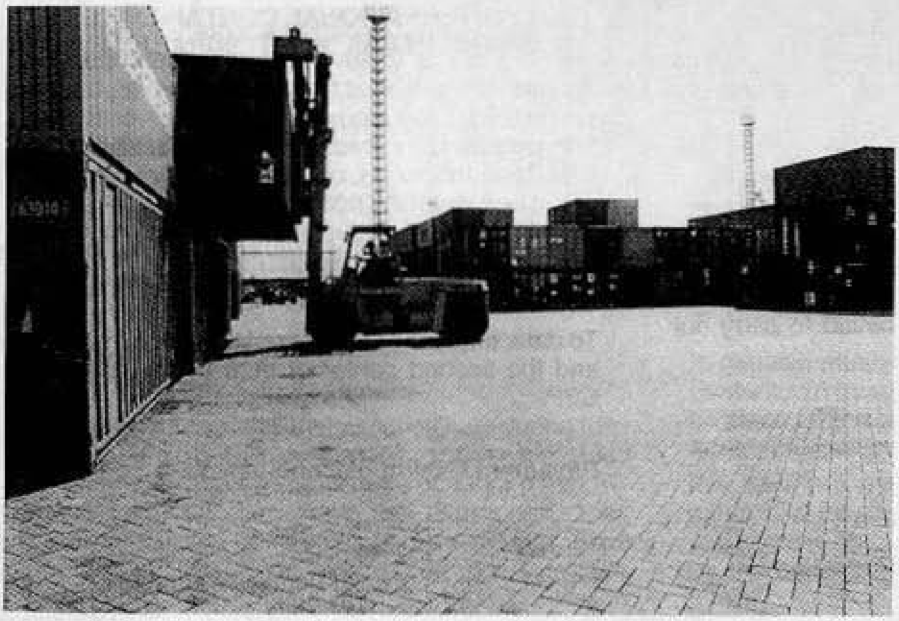
The method of subgrade improvement employed were :

- Installation of the vertical drains until 30 meter depth with a grid pattern of 1,5 to 2 meter distance.
- Placing of a surcharge with 6 to 7 meter height which resulted in settlement 1,5 to 2 meter after 1,5 to 2 years.

The original design of the access roads, truck parking and the other areas which were expected to carry medium traffic was designed asphaltic concrete and Unbound base course.

But during course of the construction, We, PT CONBLOC INDONESIA purpose to change the design into CBP and CTB. And agian all the parties involved were happy to accept the proposed change on the condition that there would be no additional time and cost.

The First Project :
Unit Terminal Container (UTC)
Tanjung Priok Port Jakarta - Indonesia



Owner :
Port Authority Corporation II

Engineer :
Peter Fraenkel International
& Wiratman Associate

Main Contractor :
Kumagai - Nindya - Nikki J.O

Specialist CTB + CBP Contractor :
PT. Conbloc Indonesia

Total Pavement Area:
130,000 square meter

The Second Project :
International Container Terminal (ICT)
Tanjung Perak Port, Surabaya - Indonesia

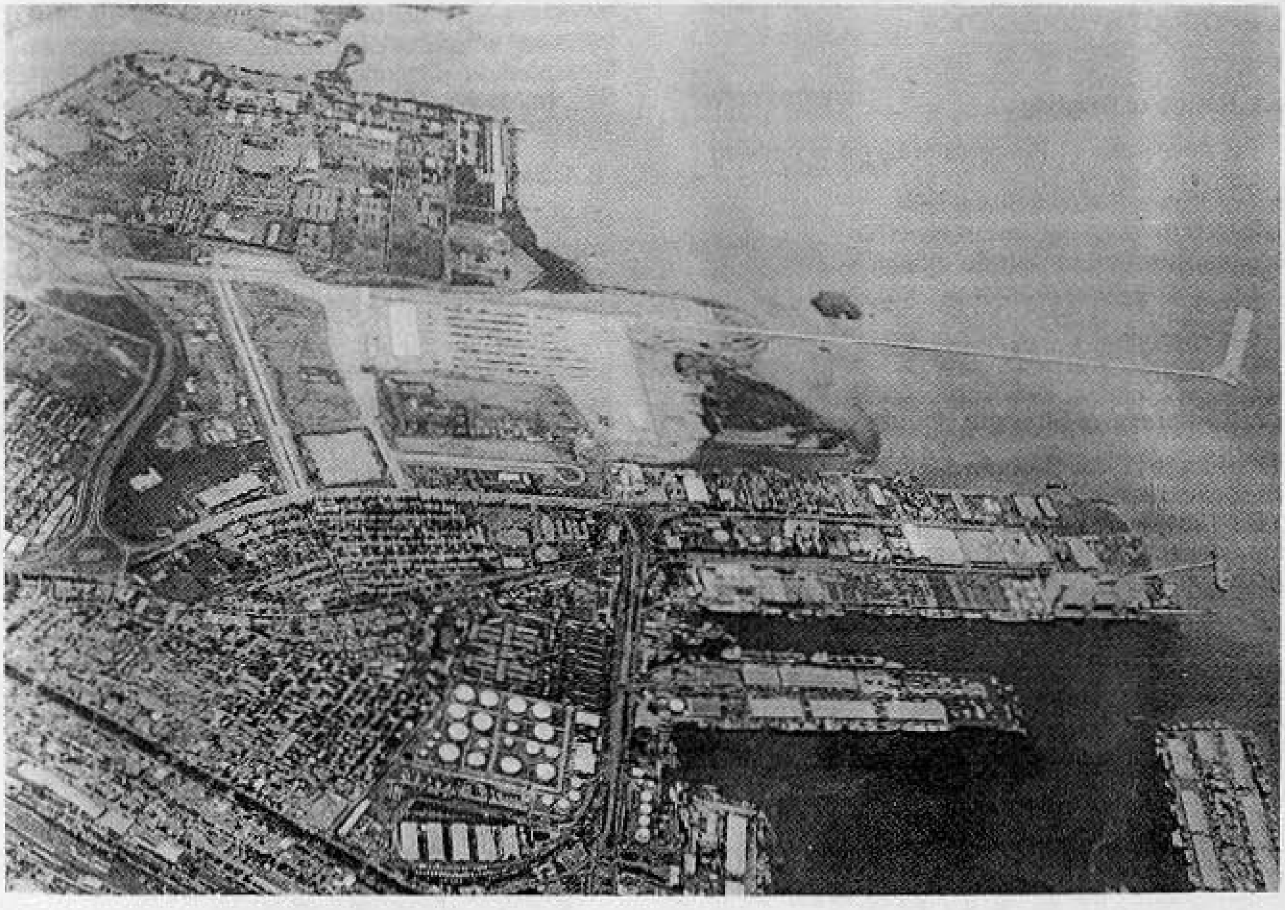
Owner :
Port Authority Corporation III

Engineer :
Randell Palmer Tritton

Main Contractor :
TOA - Corporation

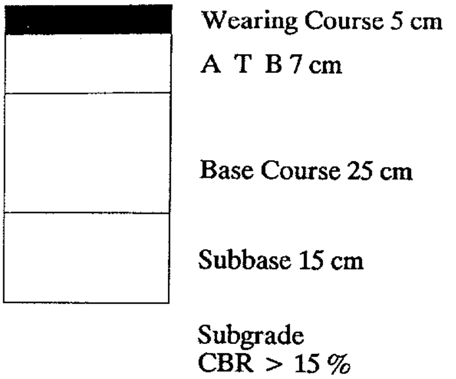
Specialist CTB + CBP Contractor :
PT. Conbloc Indonesia

Total Pavement Area:
350,000 square meter

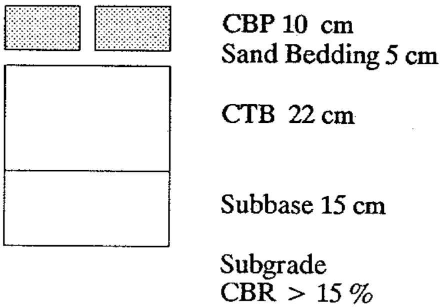


Pavement design of medium traffic

Original Design



Proposed Design



5. PRODUCT SPECIFICATION

A. CTB

a.1. Range of Grading

BS sieve sizes	Percentage by mass passing
75 mm	100
37,5 mm	95 - 100
20 mm	45 - 80
5 mm	30 - 40
600 microns	8 - 30
150 microns	0 - 6

a.2. Compressive Strength Requirements

The average 28 day strength of groups of three cubes determined in accordance with the method described in BS 1881, shall be such that not more than one in any consecutive five such averages is less than 15 N/sqm nor more than 20 N/sqmm.

a.3. Dry Density of Compacted Material

The average density obtained from groups of three determinations carried out in accordance with the method described in BS 1377, shall be not less that 95 % of the density of cubes determined on the above method.

B. Concrete Paving Block

b.1. Sand Bedding

Range of grading

BS Sieve Size	Percentage by mass passing
5 mm	90 - 100
2.36 mm	75 - 100
1.18 mm	55 - 90
600 microns	35 - 59
300 microns	8 - 30
150 microns	0 - 10

b.2. Dimensions and Tolerances of Concrete Paving Block

The length	shall be	210 mm $\pm$ 2 mm
The width	shall be	105 mm $\pm$ 2 mm
The thickness	shall be	100 mm $\pm$ 3 mm

Each side of the blocks within the sample were be tested for squareness.

b.3. Strength of Concrete Paving Block

b.3.1. Compresive Strength

The average compresive strength of the blocks on delivery, when sampled and tested in accordance with the method described in BS 6717, shall be not less than 49 N/sqmm. No individual block strength shall fall below 40 N/sqmm.

b.3.2. Flexural Strength

The average flexural strength of the blocks on delivery, when sampled and tested in accordance with the method described in NEN 7000 (the DUTCH standards for CBP) shall be not less than 60 kg/sq cm.

b.4. Sand Filler

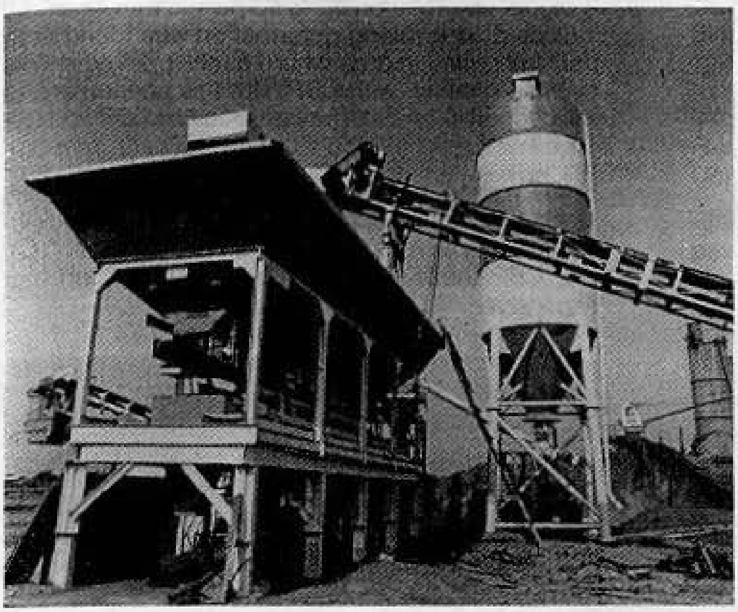
The Sand Filler material shall be graded with maximum particle size no greater than 1.18 mm and containing approximately 10 % by weight passing the 75 micron sieve.

6. METHOD OF CONSTRUCTION

A. CTB

a.1. Mixing Plant

A continuous mixing palnt with a twin shaft mixer was erected on site for those two projects. In order to maintain the combined gradation of the CTB mix, the Plant had four hopper aggregate bins to facilitate four different kinds of aggregates. The plant was equipped by a Gob Hopper to avoid the segregation and to maintain the continuity of the process of material discharging onto the tipper trucks. The maximum capacity of this plant was 300 ton per hour.



Continuous Mixing Plant

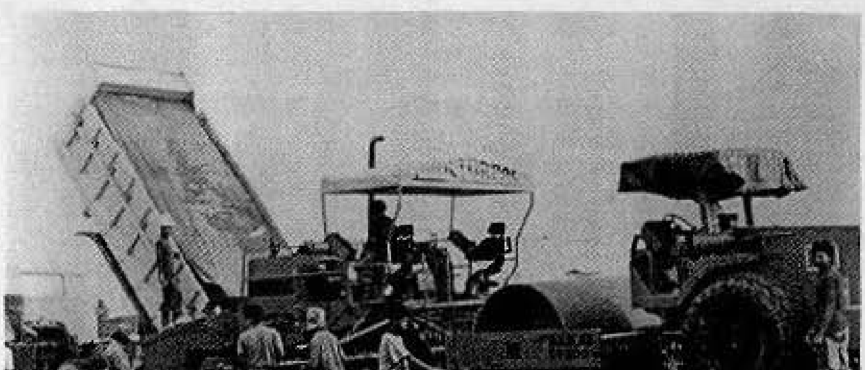
a.2. Transportation

30 tons capacity of Tipper Trucks were used to transport the CTB material from the Mixing Plant to the site.

During transportation, the material was covered by terpaulin sheets to avoid the loss in moisture content.

a.3. Placing and Compacting

A high Density Screed Paver was used to place the CTB material. This paver which had a 7.5 m screed width capable to be operated at a speed of 1.5 to 2 meters per minute with 20 cm of compacted CTB thickness. This paver generated a capacity of 180 cu. mt. per hour.



Placing and Compacting CTB Material

With this kind of Paver, the density of material behind the paver reached 90 % already. In order to meet the density requirement, i.e. 95 %. Vibrating Rollers of 20 tons capacity were used to compact the layer following directly behind the Paver.

For the layer with thickness of 40 cm, two layers of 20 cm thick were placed, with joints overlapped by at least 30 cm from the position of the joints in the preceding (bottom) layer. Joints may either be cold, or fresh joints, depending on the situation of the site condition.

a.4. Curing Method

There are two kinds of method of Curing :

1. Spraying a thin layer of Bituminous Emulsion.
2. Covering the whole compacted material with terpaulin sheets.

With the latter, the curing time of three to five days would generally suffice.

b. Concrete Paving Block

b1. Sand Bedding Layer

The bedding sand was spreaded loose in a uniform layer, thickness of which was determined on the basis of field trials to give a depth after compaction (of the CBP units) of 50 mm.

b2. Laying Concrete Paving Block

CBP units were be laid by manually and placed on the uncompacted screeded sand bed in herringbone laying pattern.

b3. Compaction

After laying the CBP units they were compacted to achieve consolidation of the sand bedding and brought to design levels and profiles by not less than three passes, employing a suitable plate compactor. It must have a plan area of not less that 0,23 sqm and shall transmitt an effective force of 30-65 N per sqm. The frequency shall be within the range of 75-100 H.

Then the sand for joint filling was spreaded out over the pavement. The jointing sand was brushed to fill the joint. Excess sand was then be removed from the pavement surface and the jointing sand was be compacted by not less than two passes of the plate vibration.

7. EVALUATION OF PAVEMENT AFTER 2 YEARS OF USE

7.1. UTC Tanjung Priok Port Jakarta

The evaluation was made on Desember 1990, wich means after more than 2 year of operations.

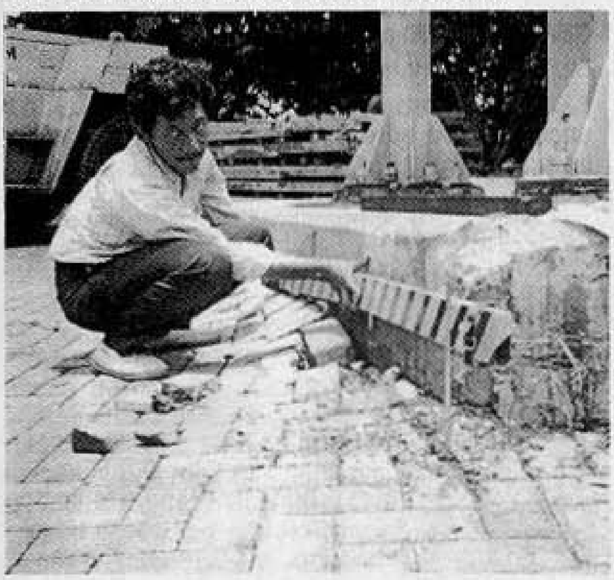
The evaluation was subjected to the following items :

a. Total settlement of the area
b. Surface Irregularity and rutting
c. Broken and Spalling of CBP
d. CTB condition
e. Polishing effect of CBP surface
f. Deformed joints
g. Loss of sand filler

Ad. a. Total settlement of the area

As mentioned in the previous chapter that the sub-grade of this project was not subject to pre-loading. When this evaluation was made the settlement had reached some 30 cm already.

This phenomena was clearly visible when obseved in the spot adjacent to the lighting pole area. Since the lighting pole used a piling foundation, the settlement had not taken place, but the CBP pavement adjacent to the lighting pole has settled considerably.



Settlement of some 30 cm observed in areas adjacant to the highting pales

Ad. b. Surface Irregularity

Even though the whole pavement area had settled some 30 cm , generally the surface irregularity was relatively still even or flat. Some spots covering an area of less then 2% of the total pavement showed a deformation of some 20 mm to 25 mm.

A bigger deformation up to some 100 mm which w indicated as a rutting deformation was found at t transtainer line in area where asphalt pavement w overlaid directly with CBP. But this phenomena c not happen in areas of pavement using CBP and CT

Finally a special treatment only for the transtainer lir steel reinforced concrete beams with 80 cm thick a 1.50 m wide were built. Of course compared with CT and CBP those concrete beams were much mo expensive.

Rutting of some 100 mm a long the transtainer track - where CBP placed Directly on top of the old Asphaltic pavement

A new Transtainer track was being constructed

Ad. c. Breaking and Spalling of CBP

From the investigation that was made on site the breaking and spalling of CBP was extremely small, less that 1% of total area.

Also in the trantainer line where the rutting of some 100 mm, the CBP was still able to be reused again. This was understandardly because all the CBP strengths met the specified standards. Random sampling gave an average compersive strength of 510 kg/sqm and an average flexural strength of 65 kg / cm2.

Surface damage of the CBP due to excessive dropping of loaded containers from some high by top loader.

Ad. d. CTB Condition

Generally the CTB was still in a good condition. Only in the area adjacent to the lighting pole, where subjected to a deferential settlement of 30 cm, cracks were found on the CTB.

Ad. e. Polishing Effect of CBP Surface

Generally there was no indication that pollishing effect of CBP surface had already taken place, because the CBP was subjected to meet the Abrasion Index of less than 1,5 (measured by Australian method).

Ad. f. Deformed joints

From the invastigation that was made, except in the spots where the deformation had occured the joint deformation was very small.less than 1% of the total pavement area.

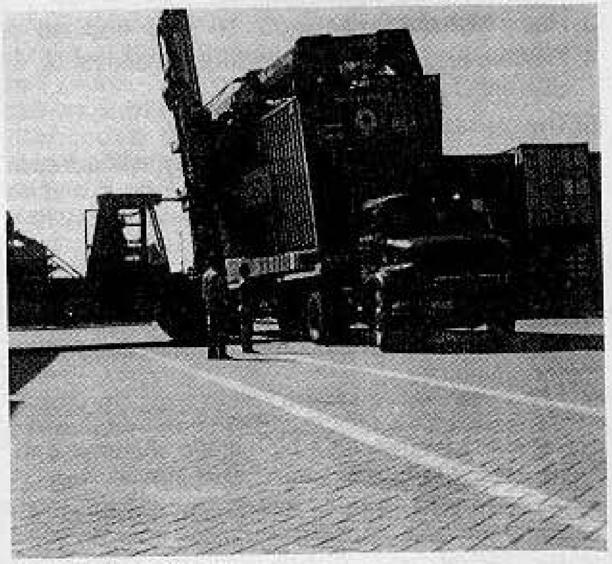
Ad. g. Loss of Sand Filler

It was found that generally the loss of sand filler in the amount of some 10 mm deep. This was quite extensive some 58% of the curative actions had been taken of to spread more sand filler into the joints.

7.2. ICT Tanjung Perak Port, Surabaya

Since this project has just completed on Desember 1990, no evaluation had been done. Due to the intensed activities of the use of containers, the client decided to use the truck Parking Area that was completed by the end of March 1990, for a temporary Container Yard.

After one year of operation, there was no indication of pavement deformation, settlement, loss of sand filler etc.



Performance of pavement after 1 year operational

Handling Containers by using Top Loader

8. CONCLUSION :

Concrete Block Paving has been considered as the most suitble surface layer for container pavement due to the following reasons:

1. Capable to withstand a high static, dynamic, impact and point loads.
2. Capable to resist skid and scuff movements and lubricant spillage as well.
3. Has a high durability.
4. Flexible enough to accomodate the effects of diferential settlement.
5. The maintenance cost his very low.
6. The maintenance work is very easy, without needing special equipments or skilled labour, and also does not disrupt the container handling operations for a long time.

Cement Treated Base has been considered as the most suitable underneath layer of CBP due to these major advatages :

1. Capable to withstand a high static, dynamic and impact load (high bearing capacity).
2. Much durable and less sensitive to the effect of water infiltration into the pavement.
3. Flexcible enough to follow the CBP without Cracking, and capable of minimizing the effect of differential settlement.

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