

**Zeitschrift:** IABSE bulletin = Bulletin AIPC = IVBH Bulletin  
**Band:** 8 (1984)  
**Heft:** B-31: IABSE bulletin

**Vereinsnachrichten:** A new foundation system named CAKAR AYAM Foundation

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## 5. A New Foundation System Named CAKAR AYAM Foundation

### Introduction

During the last decades many new foundation systems have been developed with various and sophisticated equipments. All of them have the same goal, i.e. more bearing capacity, quicker and easier to execute, more economical as regard to the costs and less problems with the neighbouring buildings. But very few, if any, deal with foundation system which can solve the problems on soft soil without looking for hard layers underneath.

The following system has been invented to meet this «soft soil problems». It is a simple method with a good bearing capacity, named by the inventor as CAKAR AYAM (literally Chicken Foot) foundation.

### CAKAR AYAM in Brief

For those who is not familiar yet with this foundation system, the following explanations may be useful. This Cakar Ayam foundation consists of a reinforced concrete slab of 10 to 15 cm thick, depending on the construction that should be borne and the condition of the soil underneath.

Underneath the slab reinforced concrete pipes are monolithically fitted with a distance between the axes of each pipe of 2 or 2,50 m while the length of the pipe varies between 1,50 to 3,50 m. The length of the pipe also depends on the load and the soil condition. The pipe diameter is 1,20 m or 1,50 m and the thickness of pipe is 8 cm.

The reinforcement for the pipes is single, while that for the slab is double. Fig. 1 gives a typical illustration. In principle, the Cakar Ayam foundation is applicable on the soft-test soil to the hardest soil, but according to our experience it is most economical if applied on soils with a bearing capacity of 1,5 to 3,5 ton/m<sup>2</sup> although many times we also use for harder soils as it still money saving.

### Basic Idea

The basic idea of the Cakar Ayam foundation is utilizing the soil characteristic that is not or not properly utilized by other types of foundation, namely the passive-soil pressure. The thin concrete slab is floating on the soil and its stiffness is obtained through the pipes underneath and the pipes stay vertical because of the passive-soil pressure in the soil. This combination makes the slab and the pipe in the soil together a stiff construction that is not easy to bend.

If put above the soil it will be a very weak construction so if we compare this system with a slab with stiffening beams the latter has an internal stiffness above the soil which the Cakar Ayam foundation has not, because as mentioned previously the Cakar Ayam foundation obtains her stiffness through the passive-soil pressure. It is clear that this will mean a reduction in volume of the reinforced concrete and is consequently more economical for the same bearing capacity.

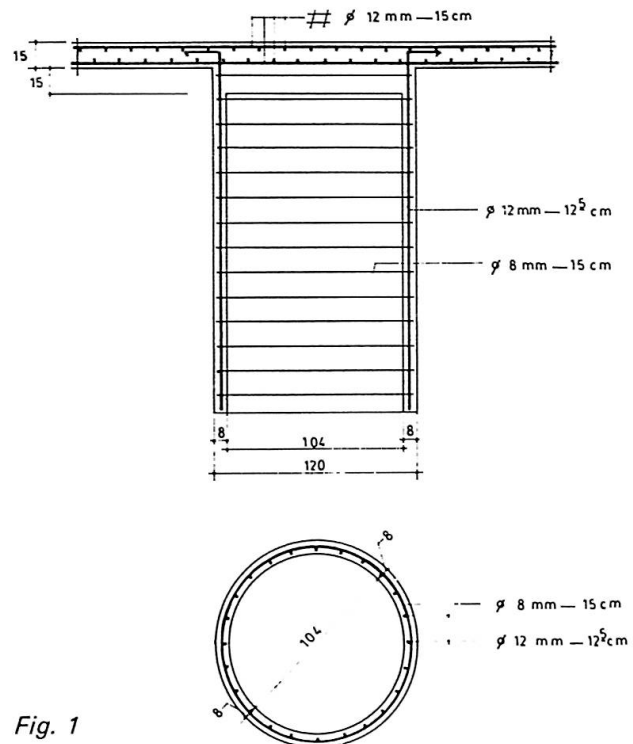


Fig. 1

The function of the pipes underneath the slab is not to support the slab as is the case with a pit foundation, but to maintain the slab stiff and flat because these pipes do not reach hard layer under the slab to stand on, but on the other hand they «hang» on the slab.

So the main difference between pit-foundation and Cakar Ayam foundation is that the pipes are slab-stiffeners not slab-supporters.

### Simple to Construct

The construction of the Cakar Ayam foundation is simply explained as follows:

After the locations of the concrete pipes are fixed on the site, exactly above it the form-works for the concrete pipes are placed, after which the pouring of the concrete can be done. So the concrete pipes are not made pre-fabricated but made on site.

After eight hours the form-work is removed and the pipes are put in the ground by digging the soil inside, so that by its own weight the pipes will go down the pit, the hole in the pipe is filled by the earth that comes out of the pit.

Since the passive-soil pressure is very important for the stiffness of the slab, care should be taken that the soil outside the pipe should stay undisturbed. After the pipes in a certain area are put in the proper place, we start to construct the reinforced concrete slab.

The construction is very simple and can be done by any contractor who is familiar with concrete work and what he needs is only a concrete mixer and formworks for the concrete pipes.



The ideal condition will be obtained if the pipes are made pre-fabricated in the workshop and put in the ground by means of a special equipment which press the pipes into the soil, which is mostly soft, without digging the earth inside the pipe.

This special equipment was used for the construction of Jakarta International Airport Cengkareng, which needs not less than 200.000 pipes, all of them to be place in the soil within one year. By using this equipment we would obtain not only ideal condition but would also save considerable time (Fig. 2).

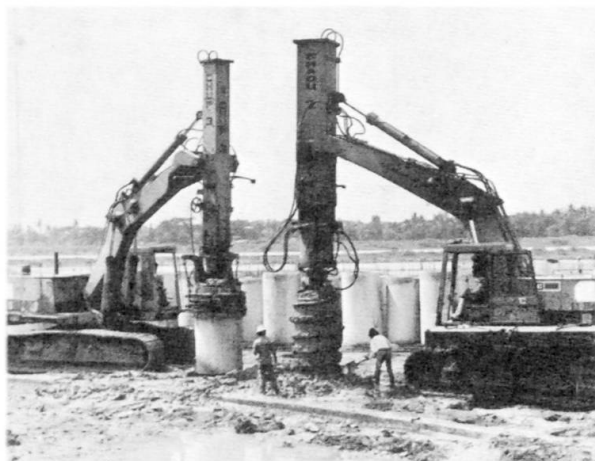


Fig. 2

### Load and Settlements

For equal distributed load the Cakar Ayam foundation is very favourable. But as building-foundation it always has to support concentrated load through the building columns which reach about 500 to 600 tons. In this case we apply concrete footings under the columns which reduce the shear in the slab to an amount within the allowable value. So if there is a concentrated load the thickness of the slab under the load is governed by the shear not by bending moment.

Speaking about settlements, there does occur a settlement under this foundation, but it will settle less if we compare with other foundation systems like slab with stiffening beams.

The soil under a slab with pipes will have a better condition against settlement compared with that under a slab with stiffening beams, because the existing pipes will also prevent the soil from sliding laterally.

### Advantages of this System

Because of its simplicity, this construction is favourable to be used in remote areas in Indonesia or elsewhere where modern equipment and highly skilled labour are seldom or not available and to some extent this system can substitute more complicated systems like pile foundation, etc.

Our experience is that the construction cost of a foundation using this system for a 3 to 4 storey building in Jakarta, where piling equipment are easily available, is similar to that of piling foundation using 12 m piles.

If the piles are longer, the price-increase of pile foundation will be felt very clearly and this price difference will be much more for remote areas where piling equipments and skilled labour are scarce. According to our experiences we can save the foundation cost up to 30%.

As mentioned previously, this system is very suitable for soft soil and its application is not limited for building only but also for roads and runways. A plus-point of this system is that there will be no drainage system needed or expansion joints.

### Jakarta International Airport

This will be the largest airport in Indonesia, located in Cengkareng, 20 km west of Jakarta. The building cost is about 340 billion rupiah (US\$ 540 million).

It has 2 parallel runways East – West, 60 meter wide each, the Southern runway is 3.660 meter long, the Northern one 3.050 meter. Together with the aprons and taxiways, the whole pavement has an area of 1.200.000 m<sup>2</sup>.

For these runways, taxiways and aprons, the Indonesian Government has decided to use the Cakar Ayam System.

Using this construction system, we can save about 6.000.000 m<sup>3</sup> of fill, which is originally needed for the conventional construction method.

Figure 3 shows the typical cross section of runway. We can see clearly that the dimension of the pipes, reinforcement and subgrades are the same as that of Medan; only the thickness of the slab is 20 cm instead of 15 cm.

The extra 5 cm is meant for the operational margin; if something happens on the runway, for instance: blow-out a B-747 tire.

Three France contractors and one Indonesian contractor, who have formed one group, have won the tender late 1980 and have now started the execution. The building time is scheduled four years for the whole airport while the Cakar Ayam pavement should be finished within 3 years. A Cakar Ayam test-slab was made and inside the slab and pipes many kinds of gauges and meterings were installed to enable us to monitor the behaviour of any part of the structure. As test loads were used hydraulic jacks put on four plates representing 4 tire prints of B-747 which simulate one bogie of this jumbo-jet. Two sets of this bogie were placed on distances similar to the real airplane-bogies.

In brief the result of the test is as follows:

- The direction of the loads composition as regard to the Cakar Ayam pipes-position does not matter, so the Cakar Ayam system is an almost isotropic system.
- Static loads with 2 bogie A and B of 90 tons per bogie (equivalent to full load B-747) gave a deflection not more than 2,52 mm.
- Repetitive loads with 2 bogie of 90 ton per bogie with 1.000 repetition gave a deflection 2,348 mm + 0,64 mm.
- Static load of ¼ bogie (single wheel load) of 150 ton (equivalent with bogie load  $\pm$  450 ton) gave deflection 10 mm and no crack appeared.

e). The test-slab can withstand three time or more the load of full loaded B-747 without any problem.

With this-report we are more confident than ever that our Cakar Ayam System will be a successful one. When the Cakar Ayam pavement are finished, the Jakarta

International Airport Cengkareng will be the first international airport in the world who has reinforced concrete runways using continuous reinforcement.

(R. P. Hadmodjo)

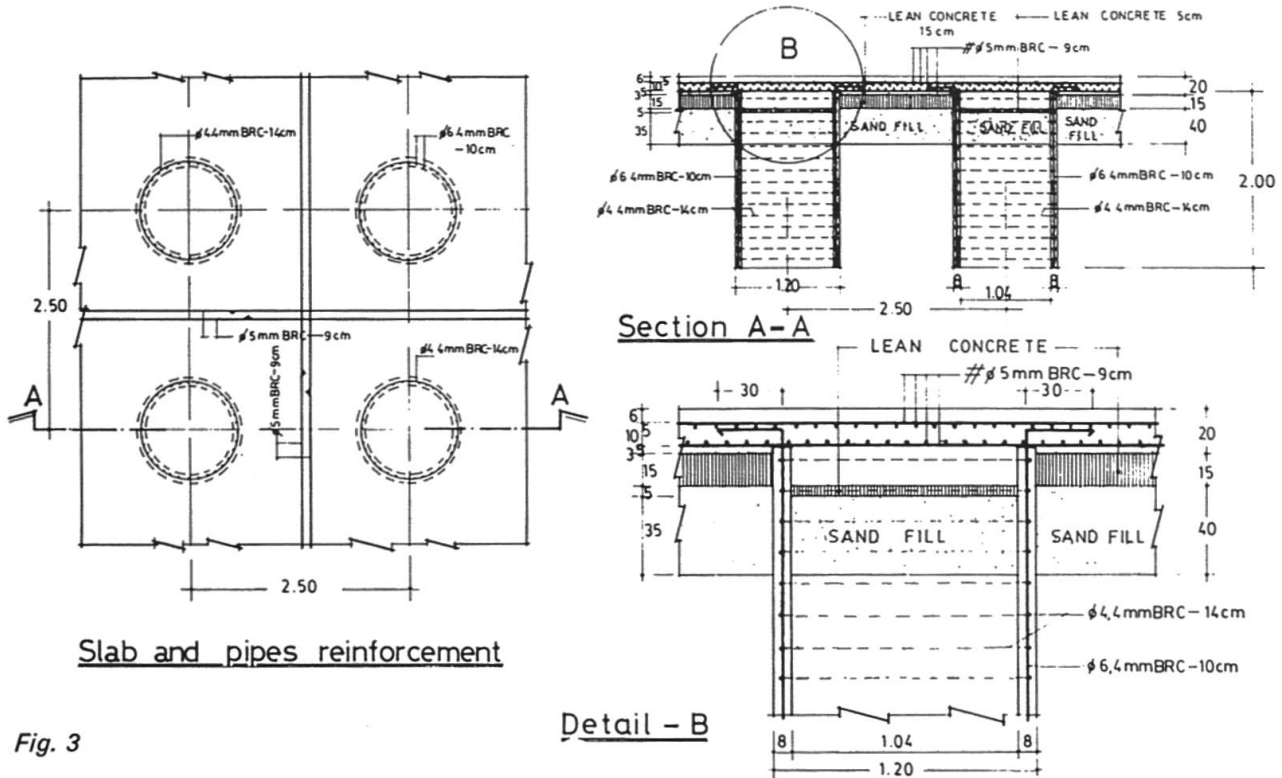


Fig. 3

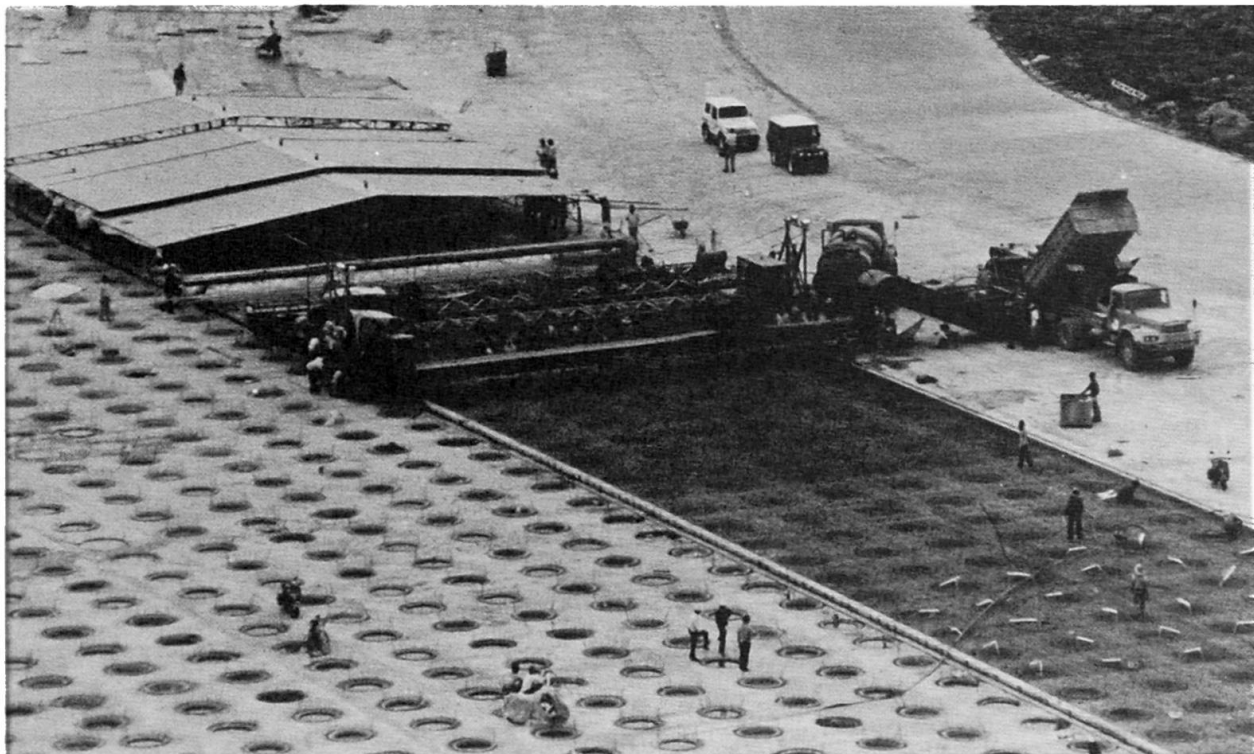


Fig. 4